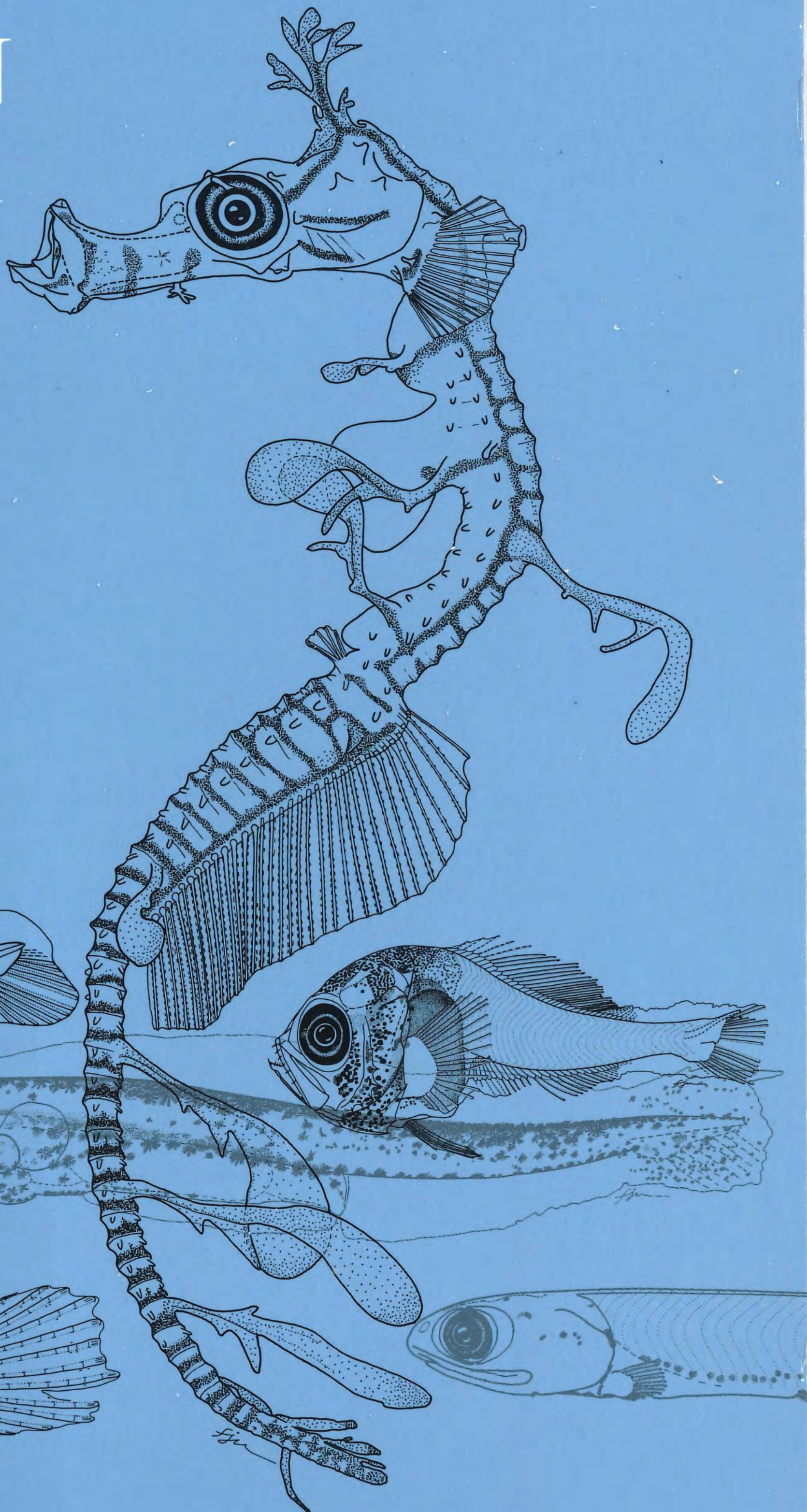
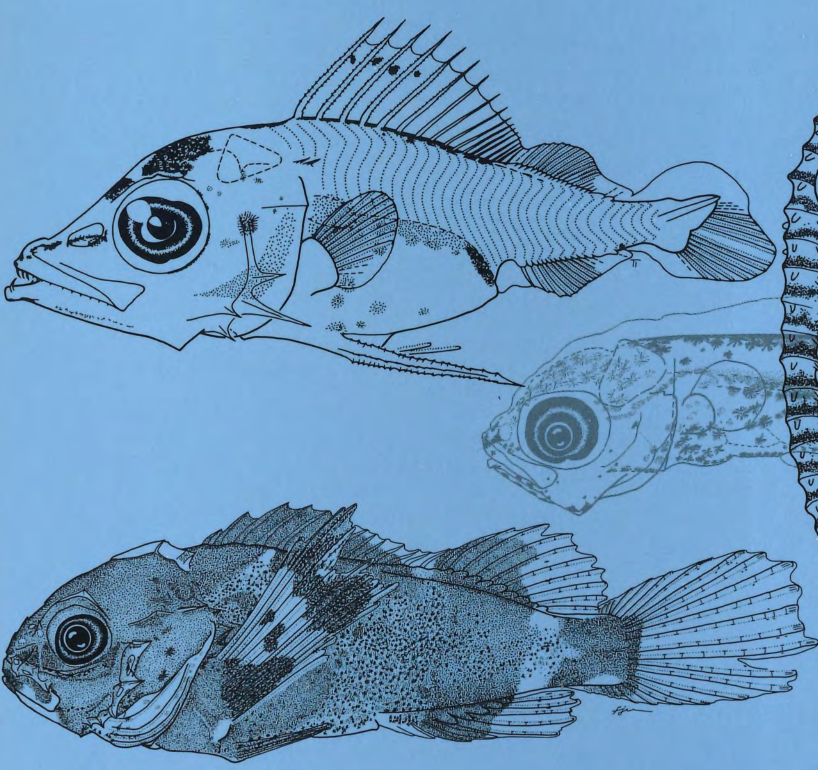
Larvae *of* TEMPERATE AUSTRALIAN FISHES

Laboratory Guide for Larval Fish Identification

Francisco J. Neira
Anthony G. Miskiewicz
Thomas Trnski





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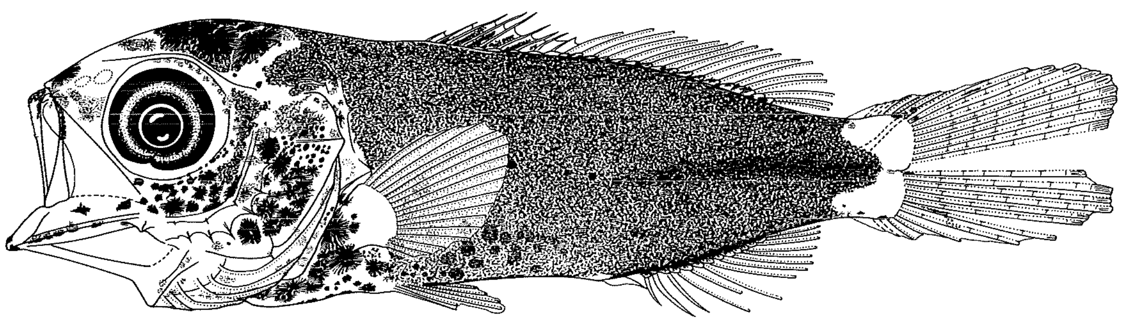

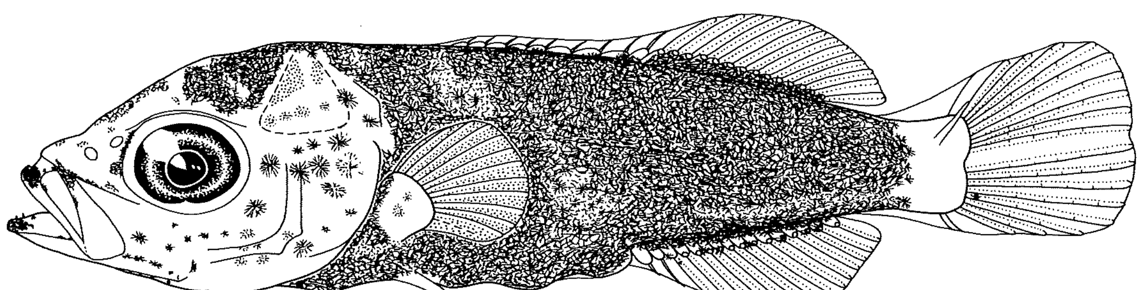

Larvae *of* TEMPERATE AUSTRALIAN FISHES

Laboratory Guide for Larval Fish Identification

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FOREWORD

Australia has one of the world's most diverse fish faunas (the best estimate is over 4500 species), and the vast majority of species are marine, bony fishes that have a pelagic larval stage, regardless of the adult habitat. The temperate marine portions of Australia possess a very high percentage of this amazing diversity due to the large number of endemic taxa (right up to the Family level), and the influence of the warm, poleward currents that parallel both east and west coasts of the continent. Until now, the larval stages of the temperate fishes of Australia have been virtually undescribed. It is a truism that good taxonomic work underpins all other biological research, and research work on larvae in the temperate waters of Australia has been underpinned by the unpublished knowledge of a few dedicated workers. The lack of wider availability of this knowledge, and the risk of its loss, has been a serious impediment to work on the biology of larvae in this region, work that is sorely needed from both a scientific and a management point of view.

Francisco 'Pancho' Neira has done the marine science community a great service by conceiving this identification guide, gathering the resources needed to produce it, and together with his co-editors, Tony Miskiewicz and Tom Trnski, and other contributors, actually creating the descriptive text and excellent illustrations and shepherding it to publication. It has been a huge task, one that is only partially evident from the completed work. The effort in putting together the developmental series of specimens and establishing identifications in the first place is mind-boggling, never mind the immense work necessary by all concerned to bring it to a publishable state. Neira *et al.* have documented a massive amount of previously unavailable knowledge between the covers of this book, and those who use it will have occasion to thank them for establishing such a firm foundation for further work. Systematists, ecologists, fisheries biologists and those who investigate anthropogenic impact on the marine and estuarine environment will all need to use the information contained in this book. For good measure, the development of a number of freshwater species is also documented here. Because of the overlap of the Australian and New Zealand fish faunas, the book will find extensive use on both sides of the Tasman Sea, and a number of the species or genera are widespread enough that workers around the world will want access to a copy.

It is worth noting that almost none of the contributors to this book have the conduct of taxonomic research on larval fishes as part of their job description. Most of the taxonomic work documented in this book was done as a means to the end of conducting ecological or fisheries-related work, and few of the chapters were written during working hours. This is a measure of the dedication of the contributors and it makes the high quality product all the more remarkable.

This work is not the final word on taxonomy of Australian temperate fish larvae – many more species remain to be documented. However, the contributors to this volume have managed to describe a remarkably high percentage of the important commercial and recreational species of the region. This will not only encourage the important applied research waiting to be done, but will also stimulate and facilitate further taxonomic progress. Perhaps as important as all the rest, this book sets a standard for other workers, and will help ensure that future taxonomic work on Australian fish larvae will be of the high quality that is necessary for it to be truly useful.

Jeffrey M. Leis
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The compilation of this book was funded by the generous support of the Australian Biological Resources Study and the Fisheries Research and Development Corporation.

ABRS

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ACKNOWLEDGMENTS

This book is the product of the effort, determination, dedication and support of many people and institutions during the six years that it took to complete it. The idea of this book was born during the 1986 conference of the Australian Society for Fish Biology (ASFB) held in Darwin. On that occasion, some of the contributors to this book met informally and talked about the possibility of publishing a book describing and illustrating the larvae we had identified. At that time, we were all working on diverse projects involving ecology of larval fishes across temperate Australia and we discussed the need for a book that could help us and future workers to identify larvae of temperate Australian fishes. Although we talked about 'the book' at every single annual ASFB conference since 1986, its production did not start until early 1992. Finally, after all those years, this is the product of that informal meeting in 1986.

The compilation of this book was possible thanks to a two-year grant provided by the Australian Biological Resources Study (ABRS) to FJN in 1992, and another grant to FJN provided by the Fisheries Research and Development Corporation (FRDC) in 1994. We are deeply indebted for the financial support of both these Australian Federal Government bodies, especially to Jan Just (ABRS) and Peter Dundas-Smith (FRDC). Special thanks are also due to Richard Stevens, of the Western Australian Fishing Industry Council (WAFIC), whose encouragement and support made it possible for FJN to obtain the FRDC grant; WAFIC was also responsible for the administration of this grant. We would also like to thank the Australian Geographic Society for the financial support provided for this project.

We are very grateful for the resources and support provided by all the institutions in which the senior editor (FJN) worked during the preparation of this book between 1992 and 1997. In chronological order, these were Murdoch University (MU, 1992–93), The Western Australian Museum (WAM, 1994) and the Australian Museum (AMS, 1994–1995). The book was finally completed while the senior editor was employed at the Marine and Freshwater Resources Institute (MAFRI). We are particularly grateful to all members of the Estuarine Research Group at MU, to Gerald R. Allen and Barry Hutchins at WAM, to Douglass F. Hoese, Jeffrey M. Leis, John R. Paxton and all other members of the Fish Section at AMS, and to all in the Fisheries Section at MAFRI.

Many people helped us with the collection and loan of specimens for this book. We would particularly like to thank Jeffrey M. Leis, Mark McGrouther and Sally E. Reader (AMS), Justine M. Johnston (ANU), Rudie H. Kuiter (AP), Gay Mardsen (BIARS), Gina M. Newton (BRS), David Evans and Alastair Graham (CSIRO), David Mills (DPIF, Tas), Rick J. Fletcher, Phillip J. Gibbs, Ken Graham, Charles A. Gray, Nick Otway and Aldo S. Steffe (FRI), Greg I. Jenkins (FMC), Howard S. Gill and Liesl J. Jonker (MU), Lynnath E. Beckley (ORI), Steve Battaglene (PSRC), Paul Mayes (QUT), Frank E. Hoedt and David Short (SARDI), Patricia Dixon, David Rissik, Kim Smith and Iain M. Suthers (UNSW), Michael J. Kingsford (US), Paul Devine (UT), Daniel J. Gaughan (WAFD), and Mark Cassoti and Barry Hutchins (WAM).

Apart from chapters authored and co-authored by the editors, 17 other people contributed to this book as authors and co-authors in one or more chapters. Many thanks to all of them for their contributions, and for meeting deadlines and providing additional information when required.

Chapters in this book were reviewed by many people from various institutions, and to all we are very grateful. Our sincere thanks to M. Norma Freinberg (AMNH), Douglass F. Hoese and Jeffrey M. Leis (AMS), Martin G. White (BAS), Peter R. Last (CSIRO), Izumi Kinoshita (FAKU), Bronwyn Gillanders (FRI), Seishi Kimura (FRLM), William D. Anderson Jr. (GMBL), Ronald A. Fritzsche (HSU), F. Javier Gago and Gerry E. McGowen (LACM), James G. Ditty (LSU), David Ruple (MDWFP), Jun-ichi Kojima (MERI), Randall Mooi (MPM), Howard S. Gill (MU), Jonathan A. Hare (NMFSB), Bruce C. Mundy (NMFSH), David A. Ambrose, H. Geoffrey Moser, Elaine

M. Sandknop-Acuña and William Watson (NMFSJ), William J. Richards (NMFSM), Chris Paulin and Clive D. Roberts (NMNZ), Helen K. Larson and Barry C. Russell (NTM), Yoshinobu Konishi (SNFRI), Hiroshi Arai (TSLP), G. David Johnson and Jeffrey T. Williams (USNM), and Muneo Okiyama (ZUMT).

A few people reviewed major sections of this book and provided invaluable information on the taxonomy and distribution of temperate Australian fishes. Special thanks to Jeffrey M. Leis (AMS), Barry D. Bruce, Ross Daley and Peter R. Last (CSIRO), and to Martin F. Gomon (NMV).

Thanks also to Sally E. Reader (AMS) who prepared Figure 1, Rachel Campbell (NMV) for Figure 32, Jack C. Javech (NMFSM) for Figure 47, and to Malcolm Ricketts for the group photo.

Special thanks are also due to Janine and Ian Drakeford of University of Western Australia Press, who were always willing to publish this book and who promoted and supported us during the years prior to its publication, and to Patricia Sellar, for the painstaking job of professionally editing the whole manuscript before going to press.

We asked Jeffrey M. Leis (AMS) to write the Foreword in appreciation of all his help, guidance and encouragement, and as acknowledgment of his influential contribution to larval fish studies in Australia over the past 17 years. Many thanks, Jeff.

Finally, we would also like to thank our families, partners and friends, as well as many current and past members of the ASFB and all those people that assisted us through the years but who could not be named here individually. This publication could have not been finished without their assistance and constant support.

Francisco J. Neira
Anthony G. Miskiewicz
Thomas Trnski
January 1998

Some of the contributors to this book at the 1995 International Larval Fish Conference in Sydney, Australia. *From left to right:* William J. Richards, Alan R. Jordan, Howard S. Gill, John M. Kalish, Aldo S. Steffe, Francisco J. Neira, Anthony G. Miskiewicz, David Rissik, Thomas Trnski, Sally E. Reader, Martin F. Gomon, Barry D. Bruce and Caroline A. Sutton. *Absent:* Carole C. Baldwin, Paul Brown, Dianne M. Furlani, Peter C. Gehrke, Mark Lintermans, Masato Moteki and William Watson.

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ACRONYMS OF INSTITUTIONS*

* Acronyms from Leviton *et al.* (1985) and Leviton & Gibbs (1988), for institutions listed in these publications.

ABRS	Australian Biological Resources Study, Canberra, ACT, Australia.
AMNH	American Museum of Natural History, New York, NY, USA.
AMS	Australian Museum, Sydney, NSW, Australia.
ANU	Australian National University, Canberra, ACT, Australia.
AP	Aquatic Photographics, Seaford, Vic, Australia.
BAS	British Antarctic Survey, Cambridge, United Kingdom.
BIARS	Bribie Island Aquaculture Research Station, Bribie Island, Qld, Australia.
BLIH	Biological Laboratory, Imperial Household, Tokyo, Japan.
BRS	Bureau of Resource Sciences, Barton, ACT, Australia.
CSIRO	Commonwealth Scientific and Industrial Research Organisation, Hobart, Tas, Australia.
DPIF (Tas)	Department of Primary Industries and Fisheries, Hobart, Tas, Australia.
FAKU	Kyoto University, Kyoto, Japan.
FMC	Fremantle Maritime Centre, South Metropolitan College of TAFE, Fremantle, WA, Australia.
FRDC	Fisheries Research and Development Corporation, Canberra, ACT, Australia.
FRI	New South Wales Fisheries Research Institute, Cronulla, NSW, Australia.
FRLM	Mie University, Mie, Japan.
GMBL	Grice Marine Biological Laboratory, Charleston, SC, USA.
HSU	Humboldt State University, Arcata, CA, USA.
LACM	Los Angeles County Museum of Natural History, Los Angeles, CA, USA.
LSU	Louisiana State University, Baton Rouge, LA, USA.
MAFRI	Marine and Freshwater Resources Institute, Queenscliff, Vic, Australia.
MDWFP	Mississippi Department of Wildlife, Fisheries and Parks, Biloxi, MS, USA.
MERI	Marine Ecology Research Institute, Chiba, Japan.
MPM	Milwaukee Public Museum, Milwaukee, WI, USA.
MU	Murdoch University, Murdoch, WA, Australia.
NFC	Narrandera Fisheries Centre, Narrandera, NSW, Australia.
NMFSB	National Marine Fisheries Service, Beaufort Laboratory, Beaufort, NC, USA.
NMFSH	National Marine Fisheries Service, Honolulu, HI, USA.
NMFSJ	National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, CA, USA.
NMFSM	National Marine Fisheries Service, Southeast Fisheries Center, Miami, FL, USA.
NMNZ	National Museum of New Zealand, Wellington, New Zealand.
NMV	Museum of Victoria, Melbourne, Vic, Australia.
NTM	Museum and Art Galleries of the Northern Territory, Darwin, NT, Australia.
ORI	Oceanographic Research Institute, Durban, South Africa.
PSRC	Port Stephens Research Centre, Port Stephens, NSW, Australia.
QUT	Queensland University of Technology, Brisbane, Qld, Australia.
SARDI	South Australian Research and Development Institute, Henley Beach, SA, Australia.
SFRL	Sea Fisheries Research Laboratories, Taroona, Tas, Australia.
SNFRI	Seikai National Fisheries Research Institute, Nagasaki City, Japan
TSLP	Tokyo Sea Life Park, Tokyo, Japan.
UNSW	The University of New South Wales, Sydney, NSW, Australia.
US	The University of Sydney, Sydney, NSW, Australia.

USNM	National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA.
UT	The University of Tasmania, Hobart, Tas, Australia.
WAFD	Western Australian Fisheries Department, Marmion, WA, Australia.
WAFIC	Western Australian Fishing Industry Council, Perth, WA, Australia.
WAM	The Western Australian Museum, Perth, WA, Australia.
ZUMT	University of Tokyo, Tokyo, Japan.

ABBREVIATIONS USED IN TEXT

A	Anal fin
ACT	Australian Capital Territory
BD	Body depth at pectoral-fin base
BDA	Body depth at anus
BL	Body length
C	Caudal fin
D	Dorsal fin
D_1	First dorsal fin
D_2	Second dorsal fin
ED	Eye diameter
FL	Fork length
HL	Head length
NSW	New South Wales
NT	Northern Territory
PAL	Preanal length
P_1	Pectoral fin
P_1L	Pectoral-fin length
P_2	Pelvic fin
Qld	Queensland
SA	South Australia
SL	Standard length
SnL	Snout length
sp.	Species (singular)
spp.	Species (plural)
Tas	Tasmania
TL	Total length
V	Vertebrae
VAFL	Gap length
Vic	Victoria
WA	Western Australia

1 INTRODUCTION

OBJECTIVE OF THIS BOOK

Australia contains one of the largest fish faunas in the world, with over 3600 confirmed species belonging to some 300 families (Paxton *et al.*, 1989). The actual number of species, including hagfishes, lampreys, sharks, rays and bony fishes, is now over 4500 (Paxton *et al.*, 1989; Hoese *et al.*, in prep). In terms of distributional patterns, 58% of the 1800 species included in Paxton *et al.* (1989) are tropical while 34% are temperate, suggesting that the actual number of Australian temperate species may be approximately 1500, including deep sea and oceanic species, if we take 4500 as the total for Australia. Considering only teleost fishes recorded from freshwater, estuarine and coastal inshore marine habitats in the temperate region of Australia, we estimate there are over 700 species belonging to some 117 families, many of which are endemic.

Literature pertaining to adults of marine and freshwater teleost fish species throughout mainland temperate Australia and Tasmania is extensive, and several texts are available describing the adults of most of these species (e.g. Allen, 1982, 1989; Scott *et al.*, 1980; Last *et al.*, 1983; Hutchins & Swainston, 1986; Kuiter, 1993, 1996; Gomon *et al.*, 1994; McDowall, 1996). By contrast, published information describing larvae of temperate Australian fishes is sparse and has, until now, been restricted to a few publications on larval development of a small number of species (see following section). The paucity of information on larvae of temperate Australian fishes becomes even more evident when we compare the situation in other geographical areas. For example, the northeast Pacific and the temperate Australian regions contain a similar number of marine teleost species and yet published descriptions exist for larvae of more than 40% of the species in the former (Kendall & Matarese, 1994) and for only less than 5% in the latter. Even in the tropical Indo-Pacific region, where fish diversity is almost four times higher than in temperate Australia, larvae have been described for nearly 10% of the species (Leis & Rennis, 1983; Leis & Trnski, 1989; Kendall & Matarese, 1994).

Early life history of fishes has become a major component of research in fisheries biology as well as fish ecology and systematics. Larval fish data are essential, for example, to determine areas and seasons of spawning and recruitment, and may also be useful when elucidating systematic relationships among fish groups (Richards, 1985; Kendall & Matarese, 1994). The fundamental prerequisite for utilising larval fishes in any study is, undoubtedly, their accurate identification. However, identification of larval fishes to genus and/or species can be difficult as larvae are often morphologically different to their adult counterparts. To date, identifications of larval fishes from temperate Australia had to rely (and still do to some extent) mostly on descriptions contained in several comprehensive larval fish guides published during the last 20 years for different geographical regions (e.g. Russell, 1976; Miller *et al.*, 1979; Fahay, 1983; Leis & Rennis, 1983; Moser *et al.*, 1984; Ozawa, 1986a; Okiyama, 1988a; Leis & Trnski, 1989; Olivar & Fortuño, 1991; Moser, 1996a). Although these guides are useful for identifying larvae of taxa common to temperate Australia to at least the family level, particularly those of Leis & Rennis (1983) and Leis & Trnski (1989) for the Indo-Pacific region, they are still of limited use due to the high proportion of endemic fish species (about 56%) in temperate Australia.

In this book, the larval stages of 124 fish species from temperate Australia are described. These comprise 116 marine and 8 freshwater species belonging to 53 and 4 families, respectively. Larvae of 93 of these species (75%) are described for the first time and 53 (43%) belong to species that have commercial and/or recreational importance. Although the number of species covered in this book represents just over 17% of the estimated number of teleost species recorded from freshwater, estuarine and coastal marine habitats throughout temperate Australia (n = 714), they belong to nearly half (49%) of the estimated number of families in that area (n = 117).

To help identify the larval stages of the species included, we provide a comprehensive, user-friendly guide based on a simplified descriptive format assisted by a large number of illustrations. We do not present full descriptions of the larval development for each species, but provide sufficient information to identify not only the larvae of the species covered but also those of closely related taxa not included here, to at least the family level. Considering the affinities between the fish faunas of temperate Australia and those of New

Zealand, southern South America and southern Africa, this book should also help in the identification of larval fishes from those areas. We hope this book, the first major contribution describing larval fishes from temperate Australia, will promote further research on the early life history of fishes as well as stimulate the interest of new scientists in this field of fish biology.

ICHTHYOPLANKTON RESEARCH IN TEMPERATE AUSTRALIA

Research on larval fishes in temperate Australian waters commenced around the 1910s with the survey of Regan (1916) in Port Phillip Bay (Vic), followed by those of Dakin and Colefax (1934, 1940) and Dakin (1937) in waters off New South Wales in which eggs and larvae of the clupeid *Sardinops sagax* (as *S. neopilchardus*) were described. Later, Blackburn (1941) described eggs and early larvae of the engraulid *Engraulis australis*, and larvae of the clupeid *Etrumeus teres* (as *E. jacksoniensis*) as part of a clupeoid resources survey in temperate Australia. The most important of the early studies on larval fishes in temperate Australia were those conducted by I.S.R. Munro between the early 1940s and the mid 1950s. These comprised descriptions of eggs and larvae of several estuarine and marine species in temperate waters, including the sparids *Acanthopagrus australis* and *A. butcheri*, the girellid *Girella tricuspidata* and the terapontid *Pelates quadrilineatus* (Munro, 1942, 1944, 1945, 1950, 1954, 1955). Other studies around this period include those by Thomson and Bennett (1953) and Milward (1966). Studies on ecology of larval fishes in temperate Australia have since increased steadily, particularly in the last two decades during which time a number of studies have been carried out in estuaries and inshore coastal waters (Table 1).

A great deal of knowledge of early life history of temperate Australian fishes has also been gained from the rearing of freshwater and marine fishes. Aquaculture research on freshwater species has been aimed mainly at inducing spawning and rearing larvae for restocking programs in inland waterways. Important research centres include the Narrandera Fisheries Centre (NSW Fisheries) and the Port Stephens Research Centre (NSW Fisheries). Rearing at these centres has included several freshwater species: the eleotrid *Hypseleotris klunzingeri* (Lake, 1967a,b); the percicthyids *Nannoperca australis* (Llewellyn, 1974), *Maccullochella peelii peelii* (Dakin & Kesteven, 1938; Lake, 1967b; Rowland, 1983a, 1988), *Macquaria novemaculeata* (Van der Wal, 1985; Van der Wal & Nell, 1986; Battaglene *et al.*, 1987, 1989, 1992; Battaglene & Talbot, 1990, 1993; Battaglene & Allen, 1990; Talbot & Battaglene, 1992), and *Macquaria ambigua* (Rowland, 1983b, 1996; Arumugam & Geddes, 1987); the percid *Perca fluviatilis* (Lake, 1967a,b); the plotosid *Tandanus tandanus* (Lake, 1967a,b); the protroctid *Prototroctes maraena* (Bacher & O'Brien, 1989); and the terapontids *Bidyanus bidyanus* and *Madigania unicolor* (Lake, 1967a,b; Llewellyn, 1973; Rowland, 1984a).

Rearing of various marine temperate Australian fishes has been conducted at the Department of Primary Industries and Fisheries (Tas), Port Stephens (NSW Fisheries), and the Fremantle Maritime Centre (WA). Rearing has included species such as the latrid *Latris lineata* (Ruwald *et al.*, 1991; Furlani & Ruwald, submitted); the pleuronectids *Ammotretis rostratus* and *Rhombosolea tapirina* (Crawford, 1984, 1986); the sciaenid *Argyrosomus japonicus* (Battaglene & Talbot, 1994, as *A. hololepidotus*); the sillaginids *Sillago ciliata* and *S. maculata* (Battaglene *et al.*, 1994); and the sparids *Acanthopagrus australis, A. butcheri, Pagrus auratus* and *Rhabdosargus sarba* (Battaglene & Talbot, 1992; G.I. Jenkins, FMC, pers. comm.; S. Battaglene, PSRC, pers. comm.).

Table 1 Summary of ecological and larval development studies on fish eggs and larvae in temperate Australian waters since 1977 (studies related to aquaculture are excluded).

State/region	Locality/area	Type of study	Reference(s)
Western Australia	Blackwood River Estuary	Ecological	Lenanton (1977)
	Swan Estuary	Ecological/larval development	Neira (1988*)
	Swan Estuary	Larval development	Neira (1989, 1991), Neira & Gaughan (1989)
	Swan Estuary	Ecological	Gaughan (1987*), Gaughan *et al.* (1990), Neira *et al.* (1992)
	Upper Swan Estuary	Adult biology/larval development	Potter *et al.* (1994)
	Wilson Inlet	Ecological/transport	Neira & Potter (1992a,b)
	Wilson Inlet	Ecological/feeding	Gaughan (1992*)
	Wilson Inlet	Adult biology/larval development	Hyndes *et al.* (1992), Laurenson *et al.* (1993)
	Nornalup–Walpole Estuary	Ecological	Neira & Potter (1994)
	Cockburn Sound	Ecological	Jonker (1993*)
	Southwest (freshwater habitats)	Larval development	Gill & Neira (1994)
	Albany	Ecological	Fletcher & Tregonning (1992)
	Southwest coast	Ecological	Fletcher *et al.* (1994), Gaughan *et al.* (1996a), Tregonning *et al.* (1996)

State/region	Locality/area	Type of study	Reference(s)
South Australia	Great Australian Bight	Ecological	Stevens *et al.* (1984)
	Spencer Gulf and Gulf of Saint Vincent	Ecological/larval development	Bruce (1989c, 1995), Bruce & Short (1992)
	Murray River	Larval development	Puckridge & Walker (1990)
Victoria	Port Phillip Bay	Ecological	Langly (1984*), Jenkins (1986a*,b, 1987a,b), Jenkins & Black (1994), Jenkins & May (1994), Hamer & Jenkins (1996)
	Phillip Island	Ecological	Hoedt & Dimmlich (1995)
	Hopkins River Estuary	Ecological	Willis (1991*), Newton (1994*), Newton (1996)
	Gippsland Lakes	Ecological	Arnott & McKinnon (1985), Ramm (1986*)
	Murray River	Larval development	Reid & Holdway (1995)
Tasmania	Tasmanian waters	Ecological	Thresher *et al.* (1988), Gunn *et al.* (1989), Furlani *et al.* (1991)
	Western coast	Larval development	Bruce (1988)
	Eastern coast	Ecological/larval development	Thresher *et al.* (1989), Gunn & Thresher (1991), Marshall & Jordan (1992), Young & Davis (1992), Bulman & Koslow (1995), Furlani (1997)
	Eastern coast	Age and growth	Jordan (1994)
New South Wales	Botany Bay	Ecological	State Pollution Control Commission (1981), Steffe (1982*,1989, 1990 1991*), Steffe & Pease (1988)
	Coastal waters off Sydney	Ecological	Bruce (1982*) Druce (1990*), Gray *et al.* (1992, 1996), Gray (1993, 1995*, 1996a,b,c), Kingsford *et al.* (1993, 1997), Dempster (1994*), Kingsford & Suthers (1994, 1996), Rissik & Suthers (1996), Kingsford & Gray (1996)
	Tuggerah Lakes	Ecological	Marsden (1986*)
	Lake Macquarie	Ecological	Powles (1973), Miskiewicz (1986)
	Lake Macquarie	Ecological/larval development	Miskiewicz (1987*, 1989)
	Northern and central coastal waters	Ecological	Gorman & Graham (1985), Gorman *et al.* (1987), Miskiewicz *et al.* (1996)
	Darling River	Ecological	Gehrke (1990a,b, 1991, 1992, 1994), Gehrke *et al.* (1993)
Southern Australia	Western Australia to southern and eastern Tasmania (offshore)	Ecological	Belyanina & Kovalevskaya (1978)
Eastern Australia	NSW and Tas	Larval development	Jordan & Bruce (1993)
	NSW, Vic and Tas	Ecological/larval development	Bruce *et al.* (1996)
	NSW, Vic and Tas	Larval development/	Bruce (1989a,b), Neira *et al.* (1997c)

* Studies carried out as postgraduate projects.

GEOGRAPHICAL REGION COVERED

This book deals with fishes from temperate Australia. For our purposes, we have defined temperate Australia as the region from Geraldton in Western Australia (29°S; 114°E), around the southern coast to about Coffs Harbour in New South Wales (30.5°S; 153°E), including the waters around Tasmania (Figures 1A, B and C). This region lies within the Southern Australian Warm Temperate Province, which extends north and overlaps to some extent the Northern Australian Tropical Province on the west and east coasts (Wilson & Allen, 1987; Morgan & Wells, 1991). The northernmost limits of the 'temperate' zone defined here were arbitrarily selected since the biogeographical boundaries of the tropical/temperate ichthyofauna on the western and eastern coasts are difficult to define. Indeed, the 'temperate fish fauna' in Australia includes a mixed, transitional fauna along the lower west and east coasts of the temperate Australian region, with tropical species in the north being gradually replaced on both coasts by mostly temperate species in the south (Wilson & Allen, 1987). The presence of this transitional ichthyofauna is largely due to the influence of warm, south-flowing currents which regularly transport larvae and adults of many tropical species into cooler, southern waters (Morgan & Wells, 1991). Along the west coast, the southward, predominantly winter-flowing Leeuwin Current reaches Cape Leeuwin and

Figure 1A Map of Australia showing the locations mentioned throughout the text: see inserts for locations in southwest Western Australia (Figure 1B) and New South Wales (Figure 1C).

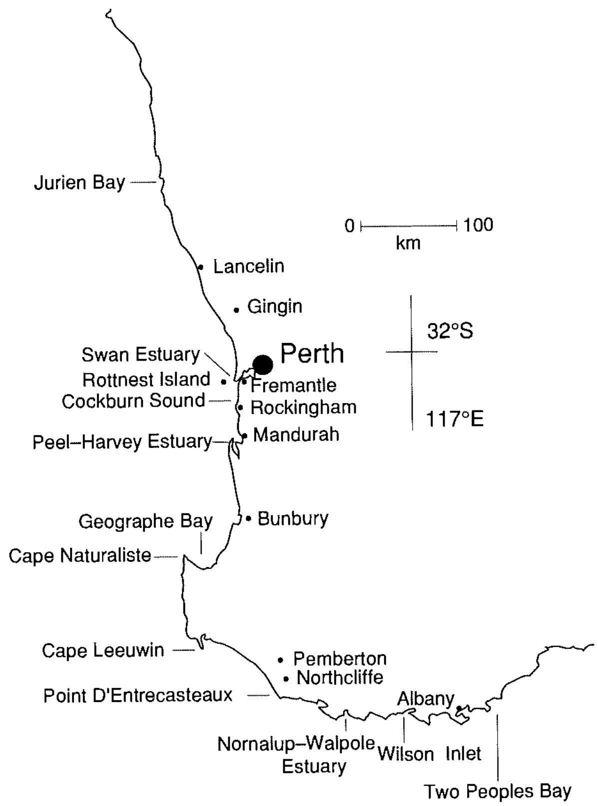


Figure 1B Southwest Western Australia

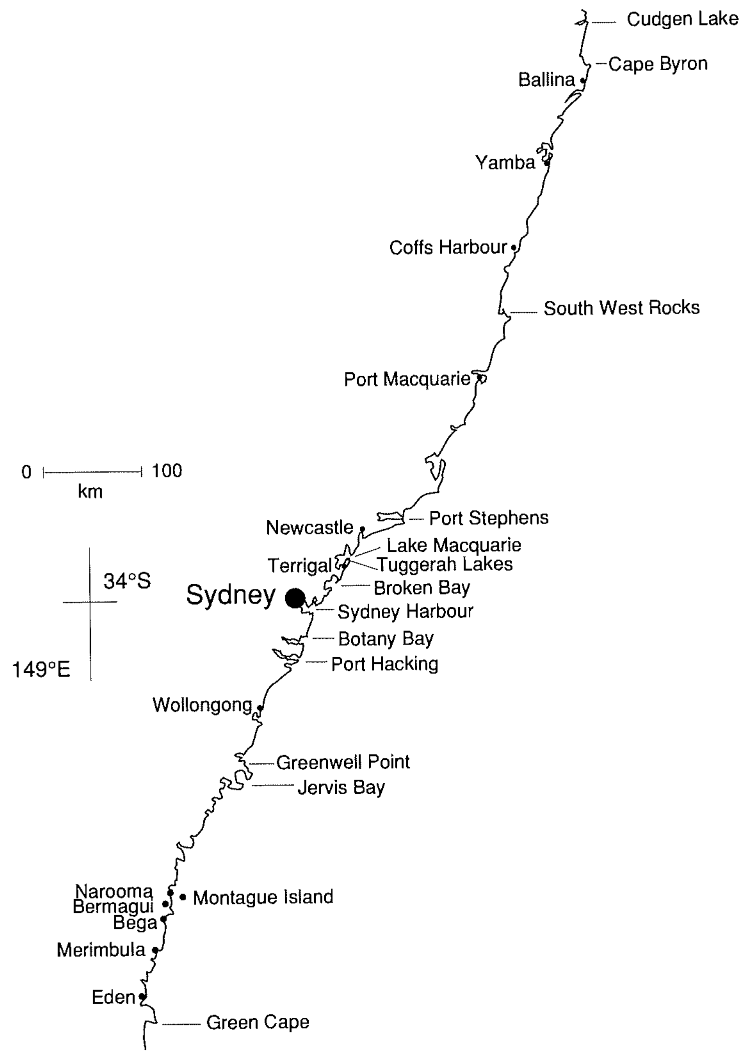


Figure 1C New South Wales

then turns eastward along the southern Australian coast, bringing with it taxa normally found in tropical, more northern areas of Western Australia (Hutchins, 1991; Pearce, 1991). Off the east coast, the presence of the summer-flowing East Australian Current supports a high diversity of tropical fishes along the southeast coast although the southern limit of the tropical fauna in this region lies slightly north (26°–27°S) to that of the west coast (Wilson & Allen, 1987). All localities mentioned throughout this book are shown in Figures 1A, B and C.

SPECIES INCLUDED

This book provides descriptions of the larvae of 124 teleost fishes from 57 families and 11 orders. Of the species included, 82 are primarily marine, 34 occur in both estuarine and coastal marine waters, and the remaining 8 are native freshwater species. The selection of these species follows four major criteria or a combination of these: (1) all spend their entire life cycle in temperate waters of Australia; (2) we had sufficient material comprising most developmental stages to confirm their identifications and provide accurate descriptions; (3) larvae of most of the marine/estuarine species are common in ichthyoplankton surveys carried out in temperate Australia; and (4) a large proportion have commercial and/or recreational importance. We also included a few temperate Australian species whose larvae had previously been described.

The larvae of nine species included in this book could not be positively identified to species. Reasons for our inability to identify these larvae to species level include the poorly known taxonomy of the adults of the group considered (e.g. Trachichthyidae), and/or the lack of a complete developmental series. In the case of larvae of one species, Gobiid sp. 1 (see Gobiidae, page 394), allocation to species was omitted since this taxon is a new genus and species (A. Iwata, BLIH, pers. comm.) and its formal description is beyond the scope of this book.

Marine and estuarine species

Most of the 116 marine species whose larvae are described here occur in estuaries and in coastal (shelf) marine waters, i.e. those contained within the 200 m depth contour of the continental shelf. As we only deal with 116 of the approximately 645 species of coastal marine fishes resident in temperate Australia (Last *et al.*, 1983; Hutchins & Swainston, 1986; Paxton *et al.*, 1989; Kuiter, 1993, 1996; Gomon *et al.*, 1994), the reader is advised to consult additional references in conjunction with this book when identifying larval fishes from this region (see Table 2). In addition to larvae of coastal marine species that were not included, the reader should also bear in mind that larvae of tropical stragglers and oceanic species are often present in temperate Australian waters.

Freshwater species

Larvae of the eight native freshwater fish species belonging to four families are described for the first time. Larvae of these species were obtained from reared and/or field-collected material. The freshwater fish fauna of Australia contains almost 200 species, with 16 families and about 69 species represented in temperate Australia including Tasmania (Allen, 1982, 1989; Paxton *et al.*, 1989; Fulton, 1990; McDowall, 1996). The Galaxiidae is the most diverse family in the temperate region, comprising almost one third of the freshwater species in this area (McDowall & Frankenberg, 1981; McDowall & Fulton, 1996).

Taxa omitted

Several taxa that are commonly found as larvae in ichthyoplankton surveys in temperate Australia were excluded from this book. Among others, these taxa include atherinids, callionymids, monacanthids and labrids (e.g. Jenkins, 1986b; Steffe & Pease, 1988; Neira *et al.*, 1992; Neira & Potter, 1992a,b, 1994). These taxa were omitted due to the lack of a full series of development, time constraints in producing such a publication, or because the larvae are not yet known. In other cases, larvae are well known and published descriptions are readily available for some species. Relevant references to larvae of families that were not included in this book but which occur in coastal marine and fresh waters of temperate Australia are provided in Table 2.

Table 2 Families represented in coastal marine and fresh water across temperate Australia, the approximate number of species in each (n), the number of species in the families for which larvae are described in this book, and references to larvae of families not included in this book. Families treated in this book are in bold. Coastal species column may also include estuarine representatives (e.g. Gobiidae, Bovichtidae). Oceanic taxa which are occasionally found in temperate coastal waters (e.g. some bramids and macrourids) were excluded from the list. Introduced freshwater families are not included (e.g. Percidae). The information included was compiled from Allen (1982, 1989), Last *et al.* (1983), Hutchins & Swainston (1986), Paxton *et al.* (1989), Kuiter (1993, 1996), Gomon *et al.* (1994), and McDowall (1996).

Family	Coastal species		Freshwater species		References to larvae of families not included in this book						
	n	No. described in this book (page)	n	No. described in this book (page)	Leis & Rennis (1983)	Moser *et al.* (1984)	Okiyama (1988a)	Leis & Trnski (1989)	Matarese *et al.* (1989)	Moser (1996a)	Additional references
Acropomatidae	1	1 (166)									
Anguillidae			2				●				Smith (1979), Fahay (1983)
Antennariidae	11						●	●		●	Martin & Drewry (1978)
Aploactinidae	2						●				
Aplochitonidae			1			●					
Aplodactylidae	3	1 (170)									
Apogonidae	13	2 (174)									
Aracanidae*	7										
Argentinidae	1					●	●		●	●	

* Families for which larvae are not known.

Family	Coastal species: n	Coastal species: No. described in this book (page)	Freshwater species: n	Freshwater species: No. described in this book (page)	References to larvae of families not included in this book: Leis & Rennis (1983)	Moser *et al.* (1984)	Okiyama (1988a)	Leis & Trnski (1989)	Matarese *et al.* (1989)	Moser (1996a)	Additional references
Arripidae	3	1 (180)									
Atherinidae	5		3		●	●	●		●	●	Ivantsoff *et al.* (1988)
Aulopodidae	1						●				
Batrachoididae	6								●	●	Martin & Drewry (1978)
Berycidae	6	1 (104)									
Blenniidae	8	6 (368)									
Bothidae	6					●	●	●		●	Ozawa & Fukui (1986)
Bovichtidae	3	2 (338)									
Brachionichthyidae*	2										
Bramidae	2	1 (184)									
Bythitidae	2				●	●			●	●	
Caesioscorpididae*	1										
Callanthiidae	2	1 (189)									
Callionymidae	5				●	●	●			●	
Carangidae	8	5 (192)									
Carapidae	1				●	●				●	Robertson (1975b), Brownell (1979), Markle & Olney (1990)
Centrolophidae	9	2 (422)									
Cepolidae	1						●	●			
Chaetodontidae	5				●		●			●	Leis (1989)
Chandidae	2	2 (204)	1								
Cheilodactylidae	9	1 (210)									
Chironemidae	3	1 (215)									
Clinidae	40								●	●	Gunn & Thresher (1991)
Clupeidae	8	7 (38)	3								
Congiopodidae	1					●					Brownell (1979), Ehrlich (1982)
Creediidae	5	3 (346)									
Cynoglossidae	2						●	●	●	●	

Table 2 (Continued)

Family	Coastal species: n	Coastal species: No. described in this book (page)	Freshwater species: n	Freshwater species: No. described in this book (page)	References to larvae of families not included in this book: Leis & Rennis (1983)	Moser *et al.* (1984)	Okiyama (1988a)	Leis & Trnski (1989)	Matarese *et al.* (1989)	Moser (1996a)	Additional references
Dinolestidae	1										
Diodontidae	3				●	●	●				Leis (1978)
Eleotridae	1		13	1 (383)							
Emmelichthyidae	2						●				
Engraulidae	1	1 (54)									
Enoplosidae	1	1 (218)									
Gadopsidae			2	1 (223)							
Galaxiidae			21	3 (70)							
Gempylidae	6	2 (406)									
Gerreidae	2	2 (226)									
Girellidae	4	1 (232)									
Glaucosomatidae	2										Juvenile in Hutchins (1993)
Gnathanacanthidae*	1										
Gobiesocidae	14				●	●	●		●	●	
Gobiidae	45	8 (386)									
Gonorhynchidae	1	1 (60)									
Hemiramphidae	2					●	●	●		●	
Isonidae	1					●	●				
Kyphosidae	4	1 (236)									
Labridae	32				●	●	●			●	Fahay (1983)
Latridae	3	1 (240)									
Lepidogalaxiidae			1								Gill (1997)
Leptoscopidae	3	1 (354)									
Lophiidae	1					●	●			●	Fahay (1983)
Macroramphosidae	2					●	●				Hardy (1978b)
Macrouridae	3						●		●	●	
Macruronidae	2	1 (88)									
Melanotaeniidae			3								Crowly *et al.* (1986), Ivantsoff *et al.* (1988), Reid & Holdway (1995)
Microcanthidae	4	2 (244)									
Microdesmidae	1				●	●				●	

Family	Coastal species		Freshwater species		References to larvae of families not included in this book						
	n	No. described in this book (page)	n	No. described in this book (page)	Leis & Rennis (1983)	Moser *et al.* (1984)	Okiyama (1988a)	Leis & Trnski (1989)	Matarese *et al.* (1989)	Moser (1996a)	Additional references
Monacanthidae	20				●	●	●			●	
Monocentridae	2					●					Yamada *et al.* (1979)
Monodactylidae	3	1 (250)									
Moridae	5					●	●		●	●	
Mugilidae	4						●	●		●	Brownell (1979), Kingsford & Tricklebank (1991)
Mullidae	2				●		●			●	
Nemipteridae	1	1 (254)									
Odacidae	10	4 (326)									
Ophidiidae	4	2 (80)									
Opistognathidae	1							●		●	
Oplegnathidae	1					●	●				
Ostraciidae	2				●	●	●			●	Leis & Moyer (1985)
Paralichthyidae	1					●	●	●	●	●	Liew *et al.* (1988)
Pataecidae	3					●					
Pegasidae	3	2 (117)									
Pempheridae	5				●		●				
Pentacerotidae	5						●		●		Moser & Mundy (1996)
Percichthyidae			13	3 (259)							
Percophidae	1	1 (358)									
Phycidae	2	1 (92)									
Pinguipedidae	3	1 (362)									
Platycephalidae	13	2 (134)									
Plesiopidae	10	3 (266)									
Pleuronectidae	7					●	●	●		●	Crawford (1986)
Plotosidae	3	1 (65)	1								
Polyprionidae	2					●				●	
Pomacentridae	11					●	●			●	
Pomatomidae	1	1 (274)									
Protroctidae			1			●					Berra (1982), McDowall (1996)

Table 2 (Continued)

Family	Coastal species		Freshwater species		References to larvae of families not included in this book						
	n	No. described in this book (page)	n	No. described in this book (page)	Leis & Rennis (1983)	Moser *et al.* (1984)	Okiyama (1988a)	Leis & Trnski (1989)	Matarese *et al.* (1989)	Moser (1996a)	Additional references
Retropinnidae			2			●					Milward (1966)
Sciaenidae	2	2 (278)									
Scomberesocidae	1	1 (98)									
Scombridae	12	1 (412)									
Scorpaenidae	19	4 (140)	1								
Scorpididae	4	1 (284)									
Serranidae	27	2 (288)									
Siganidae	1				●	●	●				
Sillaginidae	8	5 (294)									
Soleidae	5					●	●	●			Fahay (1983)
Sparidae	4	4 (306)									
Sphyraenidae	2				●	●	●			●	Martin & Drewry (1978)
Syngnathidae	40	4 (122)									
Terapontidae	5	3 (316)	1								
Tetraodontidae	12				●	●				●	Munro (1945)
Trachichthyidae	12	3 (108)									
Trichiuridae	9	1 (416)									
Triglidae	12	6 (150)									
Tripterygiidae	9				●	●	●			●	
Uranoscopidae	5						●	●		●	Munro (1945)
Veliferidae	1					●	●				
Zeidae	4					●	●				Sanzo (1956), Russell (1976), Crossland (1982), Olivar & Fortuño (1991)

2 METHODS

SOURCE OF MATERIAL

Most larval fishes described and illustrated in this book were caught using standard methods commonly employed in ichthyoplankton surveys (see Smith & Richardson, 1973). These include plankton nets, plankton beach seines, dip nets and light traps. Detailed descriptions of the methods used in surveys undertaken in temperate Australia are given in Jenkins (1986b), Miskiewicz (1986), Neira (1989, 1991), Bruce & Short (1992), Gray *et al.* (1992), Neira & Potter (1992a,b; 1994) and Neira *et al.* (1992). Larvae of 12 species were artificially reared (see 'Laboratory rearing' section below). Most larvae used for descriptions and illustrations had been fixed in 4–10% formalin–sea water and preserved in 70% ethanol. Specimens used for the descriptions and illustrations of all species in this book were deposited in the Australian Museum (Sydney) and the I.S.R. Munro Fish Collection (CSIRO, Hobart). A complete list of specimens and catalogue numbers is available from both institutions.

IDENTIFICATION OF LARVAL FISHES

Except for the laboratory-reared larvae, most larvae described in this book were initially identified to family and subsequently to genus/species using published descriptions and the series method (Leis & Rennis, 1983; Leis & Trnski, 1989; see below). Larvae of 13 species were artificially reared, of which 12 were from known adults and thus positively identified (see Table 3 below). The three methods are briefly described below (see Powles & Markle, 1984, for further details on larval fish identification).

Literature descriptions

The use of existing literature is the first step when trying to identify a fish larva. For this book, a large proportion of the initial identifications of larvae to family and genus, and sometimes to species, was carried out using publications describing larval fishes from different geographical areas worldwide. These include publications describing larval fishes from Japan (Uchida *et al.*, 1958; Mito, 1966; Okiyama, 1988a), the British Isles (Russell, 1976), southern Africa (Brownell, 1979), the Hawaiian Islands (Miller *et al.*, 1979), the Southern Ocean (Efremenko, 1983), northwest Atlantic (Fahay, 1983), the Indo-Pacific (Leis & Rennis, 1983; Leis & Trnski, 1989), South China Sea (Zhang *et al.*, 1985), Western North Pacific (Ozawa, 1986a), northeast Pacific (Matarese *et al.*, 1989), southeast Atlantic (Olivar & Fortuño, 1991), and the California Current region (Moser, 1996a). The comprehensive publication of Moser *et al.* (1984) covers all teleost fish groups and summarises most of the literature on fish eggs and larvae up to 1983. Journal articles describing larval fishes by individual taxon were also used. Caution is advised, however, when using only these publications to identify larval fishes since the quality of descriptions and illustrations in some, particularly earlier references, is rather poor and could lead to misidentifications.

Series method

The series method consists of positively identifying the largest available larva, or the smallest juvenile, using known adult characters such as fin, scale and gill raker meristics, and subsequently linking this specimen with progressively smaller specimens by using general morphological and pigment characters until a developmental series is assembled. As the series regresses to smaller specimens, adult characters become less useful whereas larval characters become increasingly important (Leis & Rennis, 1983; Leis & Trnski, 1989). The most useful characters for assembling a larval fish developmental series, although not necessarily in order of importance, are general morphology, number of myomeres, morphometrics and pigment, and the development of fin spines and rays and head spines (see later sections). Although this method is perhaps the most useful to identify larval fishes to genus/species, it often requires a large number of specimens of a wide range of sizes which may need to be obtained using a variety of collecting methods. Identifications to species level using this method are not always successful; this may occur when the most advanced larval stage is lacking (e.g. fishes which rapidly settle after a short planktonic larval life), or when the adult taxonomy of the group is unclear. In addition, this method could lead to incorrect identifications when larvae of similar species are mixed in a supposed series (Leis & Rennis, 1983). The series method relies on the 'integrated image approach'('gestalt' of Leis &

Table 3 Species for which descriptions and illustrations of larval stages were based solely on laboratory-reared material or on both reared and field-caught material. 'R' and 'W' indicate stages described and/or illustrated from laboratory-reared and wild-caught material, respectively. A dash (–) indicates stage not illustrated in this book.

Family *Species*	Reared from: Eggs from known adults	Unidentified eggs	Larval stages described and/or illustrated: Yolk sac	Preflexion	Flexion	Postflexion	Settlement stage/juvenile
Gadopsidae							
Gadopsis bispinosus	X		R	R	R	R	W
Latridae							
Latris lineata	X		R	R	R	R	–
Macruronidae							
Macruronus novaezelandiae	X		R	W	W	–	–
Percichthyidae							
Maccullochella macquariensis	X		R	R	R	R	R
Maccullochella peelii peelii	X		R	R	R	R	R
Macquaria ambigua	X		R	R	R	R	R
Sciaenidae							
Argyrosomus japonicus	X		–	W	W	W, R	R
Serranidae							
Acanthistius serratus		X*	–	R	R	R	R
Sillaginidae							
Sillaginodes punctata	X		R	R	R	R	W
Sillago ciliata	X		–	R	R	R	–
Sillago maculata	X		–	R	R	R	R
Sparidae							
Acanthopagrus butcheri	X		–	–	–	R	R
Centrolophidae							
Seriolella punctata	X		–	W,R	W,R	W	–

* Eggs obtained from public aquarium.

Rennis, 1983) to identify larvae, an approach which combines external and internal features of a fish larva (Sandknop *et al.*, 1984).

Laboratory rearing

Rearing larvae from known adults is undoubtedly the best method for accurately identifying fish larvae. In this book, larvae of 13 species were reared in the laboratory, 12 from known adults and one, *Acanthistius serratus* (Serranidae), from eggs belonging to unknown adults (Table 3). In the case of four species, i.e. *Gadopsis bispinosus* (Gadopsidae), *Macruronus novaezelandiae* (Macruronidae), *Argyrosomus japonicus* (Sciaenidae) and *Sillaginodes punctata* (Sillaginidae), both laboratory-reared and field-caught larvae were used to assemble the developmental series. Caution is advised, however, with series that have been described solely from reared larvae since laboratory conditions do affect development to some extent. For example, laboratory-reared larvae are frequently more heavily pigmented and show greater meristic variation than field-caught larvae (Blaxter, 1984; Hunter, 1984).

DESCRIPTION OF LARVAL FISHES

The main purposes of describing larval fishes is (a) to help other workers to identify larvae and (b) to provide an accurate description of the morphological changes during larval development. The latter provides relevant information that may assist in studies involving systematics and phylogenetic relationships of the group. The recommended method to describe larval fish development is the 'dynamic approach', which consists of taking one structure at a time, a fin for example, and describing its changes as larvae grow. In this way, major changes that may occur over very small size increments can be documented from observations of a complete size series. Changes in morphology and pigmentation, formation of head spines and, on some occasions, developmental osteology are also described. A detailed account of the requirements to describe development of larval fishes using this approach is given in Sandknop *et al.* (1984) and Leis (1993).

In order to include a large number of species in a user-friendly format, our descriptions are brief and follow an abbreviated form of the dynamic approach. However, we do not recommend the use of our system for detailed descriptions of larval development (for examples of thorough descriptions see Bruce (1988), Neira (1989), Leis & Lee (1994), Reader & Leis (1996)).

TERMINOLOGY OF DEVELOPMENTAL STAGES

The terminology used to name and describe the different developmental stages in teleost fishes varies greatly depending on the author. In this book, we adopted the terminology used by Leis & Trnski (1989). The term 'larva' is defined as the developmental stage between hatching (or birth) and the attainment of full external meristic characters (fins and scales), including the loss of temporary specialisations to larval life. In the case of taxa in which structures change position as larvae develop (e.g. dorsal fin in clupeoids), full attainment of external meristic is considered complete only once these structures assume their ultimate position on the fish. The term 'larva' includes the yolk-sac, preflexion, flexion and postflexion stages as defined by Leis & Trnski (1989).

The transitional stage between the larval and juvenile stages, which in many fish species is accompanied by a change from planktonic to demersal or pelagic habitats, may be short or prolonged (Kendall *et al.*, 1984). For many demersal and benthic fishes, the morphological transition from larvae to juvenile is often short and occurs over a small size range, with the larval period usually ending when they settle into their juvenile habitats. For these species, we use the term 'settlement stage' to refer to this period. For those species with pelagic larvae whose juveniles and adults remain pelagic (e.g. clupeiform fishes), we use the term 'transformation' to describe the stage between the end of the larval phase and the attainment of juvenile morphological characters and pigment. Specimens undergoing transformation (i.e. transforming stage) are considered to be larvae. Transforming stage is similar to the 'transition larva' used by Leis & Trnski (1989).

LARVAL FISH CHARACTERS USED IN THIS BOOK

There is a wide range of diagnostic characters which individually or combined can be used to identify larval fishes. Some characters, fin meristics for example, are the same as those used to identify the adults. General body form is also useful, as in the case of many larval scorpaenids in which the elaborate head spination and large, fan-shaped pectoral fins make them look like miniature adults. However, larvae of most groups look very different to their adult counterparts, particularly those of perciform fishes. A complete account of the characters used to identify larvae is given in Powles & Markle (1984) and Sandknop *et al.* (1984).

While in many species some characters present in the larval stage will remain in the juvenile stage, many either disappear or become considerably reduced by the end of larval life. In taxa with pelagic larvae, the morphological larval characters that are totally lost or become greatly reduced in juveniles are regarded as temporary specialisations to pelagic larval life (Leis & Rennis, 1983; Leis & Trnski, 1989). These may include body shape, pigment pattern, head spines, early forming elongate or serrate fin spines, and a gas bladder which may be present during the larval stage but disappear at settlement (Kendall *et al.*, 1984). In some instances, some of these characters might still be present at settlement but are considerably reduced.

The main characters used to describe larval fishes in this book include morphometrics and general body morphology, fin meristics and sequence of development of spines and soft rays, number of myomeres, pigmentation, type and number of head spines, and specialised larval characters such as length and ornamentation of head and fin spines. It is important to bear in mind that the relative importance of each of these different characters will depend on the group being identified; for example, the number of myomeres may be important to distinguish between clupeiform larvae whereas pigment pattern is perhaps more important to separate gobiid larvae. Each of the main characters used in the description of larval fishes throughout this book is summarised in the following sections.

Morphometrics and general body morphology

The length of a larva is defined as body length (BL) and corresponds to the distance from the tip of the snout to the notochord tip (notochord length) in preflexion and flexion larvae, and from the tip of the snout to the posterior margin of the hypural bones (standard length) in postflexion, settlement and transforming larvae, and in juveniles (Leis & Trnski, 1989) (Figure 2). Body length and other measurements of larvae were obtained using a stereomicroscope fitted with an eyepiece micrometer. The body length of each larva measured was expressed in millimetres (mm) and rounded to the nearest 0.1 mm. Standard body measurements recorded for each larva include body depth at the pectoral-fin

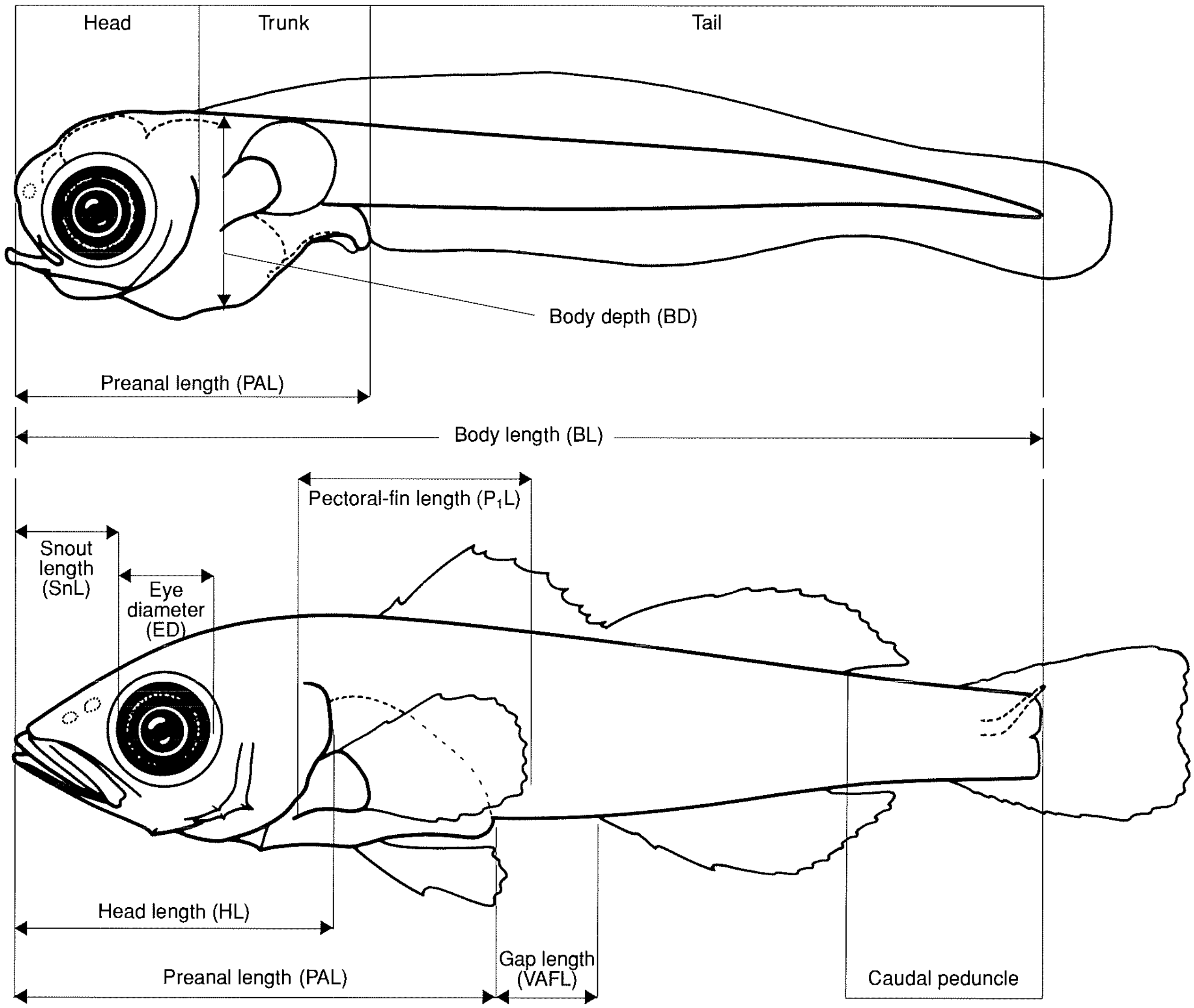


Figure 2 Body regions and standard measurements recorded in larvae described in this book (see text for explanation of measurements).

base (BD), head length (HL) and preanal length (PAL) (Figure 2). These measurements were used to characterise body shape, and head and gut size of larvae, and are given as a percentage (%) of body length in each description. Other measurements, such as snout length (SnL), eye diameter (ED), pectoral-fin length (P_1L), body depth at anus (BDA), and gap length (VAFL), were recorded only when they were required to distinguish larvae of closely related species (Figure 2). Measurements of SnL and ED are given as a percentage of head length, whereas those of P_1L and VAFL are expressed as a percentage of body length.

Body shape The body shape of a larva was classified in terms of the relative body depth as very elongate (BD < 10% BL), elongate (BD 10–20% BL), moderate (BD 20–40% BL), deep (BD 40–70% BL) or very deep (BD > 70% BL), following the categories used by Leis & Trnski (1989).

Head size The size of the head of a larva was classified in terms of the relative head length as small (HL < 20% BL), moderate (HL 20–33% BL) or large (HL > 33% BL), following the categories used by Leis & Trnski (1989).

Gut size and morphology The size of the gut of a larva was classified according to the relative preanal length as short (PAL < 30% BL), moderate (PAL 30–50% BL), long (PAL 50–70% BL) or very long (PAL > 70% BL). The morphology of the gut refers to whether the gut is (a) straight (uncoiled), (b) initially uncoiled but coils later, (c) twisted, or (d) fully coiled throughout development. In some groups, straight guts may have a striated section (e.g. hindgut in clupeids, Figure 3A) or have no striations (e.g. odacids). Coiled guts can be large (voluminous) or small, and either loosely coiled or coiled and compact (the latter is shown in Figure 3B).

Fin meristics

Counts of fin elements, both spines and soft rays, are perhaps one of the most useful tools to link the most developed larva of the series and the juvenile and/or adults of the species being identified (series method). Care must be taken, however, when counting fin elements in larvae because, although all elements may be formed by the end of the larval phase, they might not be in their ultimate form. This, for example, occurs with the last dorsal- and third anal-fin spines of terapontids, in which these spines are initially soft rays but ossify and become spines sometime during the juvenile stage (Leis & Trnski, 1989).

Spines and soft rays Fin spines are often hard and pointed, smooth or serrate, and are usually present in the anterior part of the dorsal (D) and anal (A) fins, in the pelvic fins (P_2) and, in a few groups (e.g. plotosids), in the pectoral fin (P_1). The number of spines is given as roman numerals (e.g. D **XIX**, 13; A **III**, 9; P_2 **I**, 5).

Soft rays are flexible and generally present in all fins. Most soft rays are branched, and the degree of branching increases with ontogenetic development, i.e. rays that are unbranched in larvae may be branched in adults. The last soft ray of the dorsal and anal fins is usually branched from the base and can be mistaken for two rays during counts. The soft rays of the caudal fin comprise the principal (primary) caudal-fin rays, which are the segmented, branched and unbranched rays supported by the hypural bones and the parahypural bone at the base of the tail, and the procurrent rays, which are the small, unsegmented, unbranched rays on the dorsal and ventral edges of the fin (Moser *et al.*, 1977). The number of soft rays in all fins is given as arabic numerals (e.g. D XIX, **13**; A III, **9**; P_1 **14**; P_2 I, **5**).

Fin counts The dorsal fin can be either continuous, in which case the counts of spines and soft rays are separated by a comma (e.g. D XIX**,** 13), or separate, in which case the counts of the two fins are separated by a plus sign (e.g. D XIX **+** I, 12). In both cases, most authors refer to the first (spinous) and second (soft) dorsal fins. The spines and soft rays of the anal fin are continuous in most taxa. However, many carangids have a distinct gap between the first two anal-fin spines and the third spine, in which case some authors prefer to give the counts as **II** + **I**, 20 instead of III, 20. In the case of scombrids, counts of both the dorsal and anal fins include the number of finlets along the dorsal (e.g. D XII, 13 + **7**) and ventral (e.g. A 12 + **10**) surfaces of the caudal peduncle.

In larval fishes, it is often easier and more reliable to count the dorsal- and anal-fin pterygiophores rather than the fin elements to obtain the formulae for both fins. Pterygiophores are the bony elements that support each dorsal- and anal-fin element, and in larval fishes are often easily distinguished by their fleshy, finger-like appearance (Figure 3B). Pterygiophores supporting spines (spine bases) are usually small and triangular-shaped while those supporting soft rays (soft-ray bases) are more elongate and possess a characteristic ball-and-socket joint at the distal end that articulates with the rays (Figure 3B). In addition, spine bases are often well separated while soft-ray bases are adjacent to each other (Leis & Trnski, 1989).

Pectoral fins contain only soft rays except in families such as the Plotosidae, in which the uppermost element is a very large and stout (venomous) spine (**I**, 9–10). In the case of triglids, in which the lower three rays are clearly detached from the rest, counts are given as 11 + **3** instead of 14.

Pelvic fins of most perciform families comprise one spine and five soft rays (I, 5), although some have I, 4 (e.g. odacids), I, 2 (e.g. acanthocline plesiopids), or even 1 (e.g. a single bifid ray in gadopsids). In a few groups (e.g. syngnathids), pelvic fins are vestigial or absent. Clupeoids, gonorynchids and galaxiids have spineless pelvic fins with 4–10 rays.

Counts of caudal-fin rays vary depending on which method is used for the counts. Literature descriptions usually provide the number of segmented, branched and unbranched rays (principal or primary rays) supported by the hypural bones and the parahypural bone, although this is not always the case (see Leis & Rennis, 1983). Counts in adult identification guides are generally given in two ways: the number of dorsal and ventral principal rays separated by a plus sign (e.g. 9 + 8), or the total number (e.g. 17). Most perciform fishes have 9 + 8 = 17 principal caudal-fin rays, whereas clupeoids have 10 + 9 = 19. For consistency, the meristic tables included in each family section in this book provide the total number of principal caudal-fin rays as defined above unless stated otherwise.

Sequence of fin formation Both the sequence of fin formation and the size range at which they start and finish forming are important characters when describing development of larval fishes. In larvae of most perciform fishes the caudal and pelvic fins are often the first and last fins to form, respectively (Johnson, 1984; Leis & Trnski, 1989). However, this is not always the case, and in larvae of some groups the pelvic fins usually develop before all other fins, e.g. phycids, trachichthyids, pempherids and some percophids. Pectoral-fin buds normally develop in the embryonic or the yolk-sac stage while the rays may form very early in the preflexion stage (e.g. scorpaenids) or during the flexion stage (e.g. many perciform fishes), and usually sequentially from dorsal to ventral. The caudal-fin rays start to form with the development of the hypural plates, and this usually corresponds to the period just prior to notochord flexion. However, in many gadiform and in some ophidiiform and trichiurid taxa, the caudal fin is greatly reduced and even absent, and rays form in a different manner (Fahay & Markle, 1984; Leis & Trnski, 1989). Dorsal and anal fins usually commence developing almost simultaneously; the first to appear are the anlagen of both fins, followed by the pterygiophores, and then the rays. Although in most cases the anteriormost spine of the dorsal and anal fins forms last, in some groups (e.g. berycids) these are the first to develop.

Myomeres and vertebrae

The number of myomeres is one of the most useful characters for identifying larval fishes. Myomeres are muscle bands aligned sequentially and in transverse series along the body of larvae, from the nape to the notochord tip area, and separated from each other by partitions of connective tissue called myosepta (Figures 3A and B). In teleost fishes, the importance of this character lies in the fact that the total number of myomeres in a larva closely corresponds to the number of vertebrae of the species and, therefore, it is relatively constant (Berry & Richards, 1973).

The number of myomeres is normally expressed as preanal (trunk) + postanal (caudal) = total, e.g. 10 + 14 = 24 (Figure 3B). The first preanal myomere, immediately posterior to the first myoseptum, lies just posterior to the otic capsule and is often difficult to see. The last preanal myomere corresponds to that whose posterior myoseptum ends at the rear of the anus. If this myoseptum cannot be distinguished, the myomere that lies along the vertical line that passes directly through the anus can be counted as the last preanal myomere. The last postanal myomere in preflexion larvae corresponds to the elongate notochord segment after the posteriormost myoseptum (Figure 3A); partitions along the notochord tip, due mainly to bad and/or prolonged preservation of larvae, may be mistaken for additional myomeres. The last myomere in postflexion larvae corresponds to the urostyle (the last caudal vertebra) in the region where the notochord tip lies upright (Figure 3B). In some taxa, the number of pre- and postanal myomeres is not necessarily equivalent to the respective number of precaudal (trunk) and caudal vertebrae because the anus may move as the gut lengthens or shortens during development, or it may be located anterior to the posterior edge of the abdominal cavity. Myomeres may no longer be visible once pigment spreads all over the body of larvae or when scales form in juveniles.

The total number of myomeres can help allocate an unidentified larva within an order, family, genus, and even species, providing the total number of vertebrae is known. If known, the number of vertebrae for most species in this book is provided as the total number. In several cases when vertebral counts were unavailable, the number of precaudal and caudal vertebrae was counted after clearing the larval tissues with an enzyme, and by staining the cartilage and bones with alcian blue and alizarin red, respectively. This technique, which is widely used in fishes and other small vertebrates (see Potthoff, 1984, for details), is recommended for counting vertebrae of larval fishes too small to be X-rayed. This technique can also be employed to count fin spines and rays, and to identify and count the number of head spines.

Pigment

The pigment described in larval fishes corresponds to melanin, the brown and black pigment contained in specialised nucleated cells named 'melanophores', and which remains in the larvae even after preservation. Live larvae have other types of pigmented cells, such as erythrophores (red), xanthophores (yellow) and iridiophores (silvery). However, fixatives (formalin) and preservatives (ethanol) bleach these colours leaving only the melanin. Pigment in preserved larvae fades over time, especially if larvae have been exposed to light. The number, distribution and location (external or internal) of melanophores are important diagnostic characters used in larval fish identification. Melanophores can be stellate, branched or punctate depending on the degree of expansion of the pigment within these cells (Russell, 1976), and may also be affected by time of capture and preservation of the larvae (day or night). Melanophores present in the yolk and within the oil globule(s) of yolk-sac larvae are important to link late-stage eggs with newly hatched larvae. The terms 'melanophores' and 'pigment' are used interchangeably throughout this book and all pigment described corresponds to that in preserved specimens, unless noted otherwise. The pigment characters used in larval descriptions in this book, including location and type of melanophores, are shown in Figure 4.

Head spines

The main function of head spines in larvae of teleost fishes appears to be defence, which in turn reflects the importance of predation as a major mortality factor during an extended larval period (Moser, 1981). Head spines are named according to the bone from which they originate, and their type, size, shape, number, ornamentation and sequence of development are important characters to identify larvae to family level and beyond. The most common are the spines on the anterior and posterior margins of the preopercle (herein named anterior and posterior preopercular spines, respectively), the medial supraoccipital spine, and the supraorbital, infraorbital, opercular, interopercular, subopercular, parietal and posttemporal spines (Figure 5). Some less common spines include the articular (e.g. blennies) and rostral (e.g. triglids) spines. Other spines which are also described as head spines, although they do not develop from head bones, are the cleithral and supracleithral spines in the upper pectoral girdle. Most if not all spines are gradually lost and disappear by the end of the larval period, although some may be retained in the adult stage.

LARVAL FISH ILLUSTRATIONS

Selection of specimens

The series of larvae illustrated for each species in this book was selected from the same material used for descriptions, and included larvae which best represented the species. The larvae selected for illustrations were those in the best available condition. However, in the few cases when the only available specimens required for the series were twisted or bent, they were illustrated as they were. A damaged section in a larva, for example an incomplete fin, was completed by illustrating the same section from other larvae at a similar developmental stage. Illustrations were made using a camera lucida attached to a dissecting microscope.

Illustrating techniques

Illustrators of larval fishes have their own particular styles

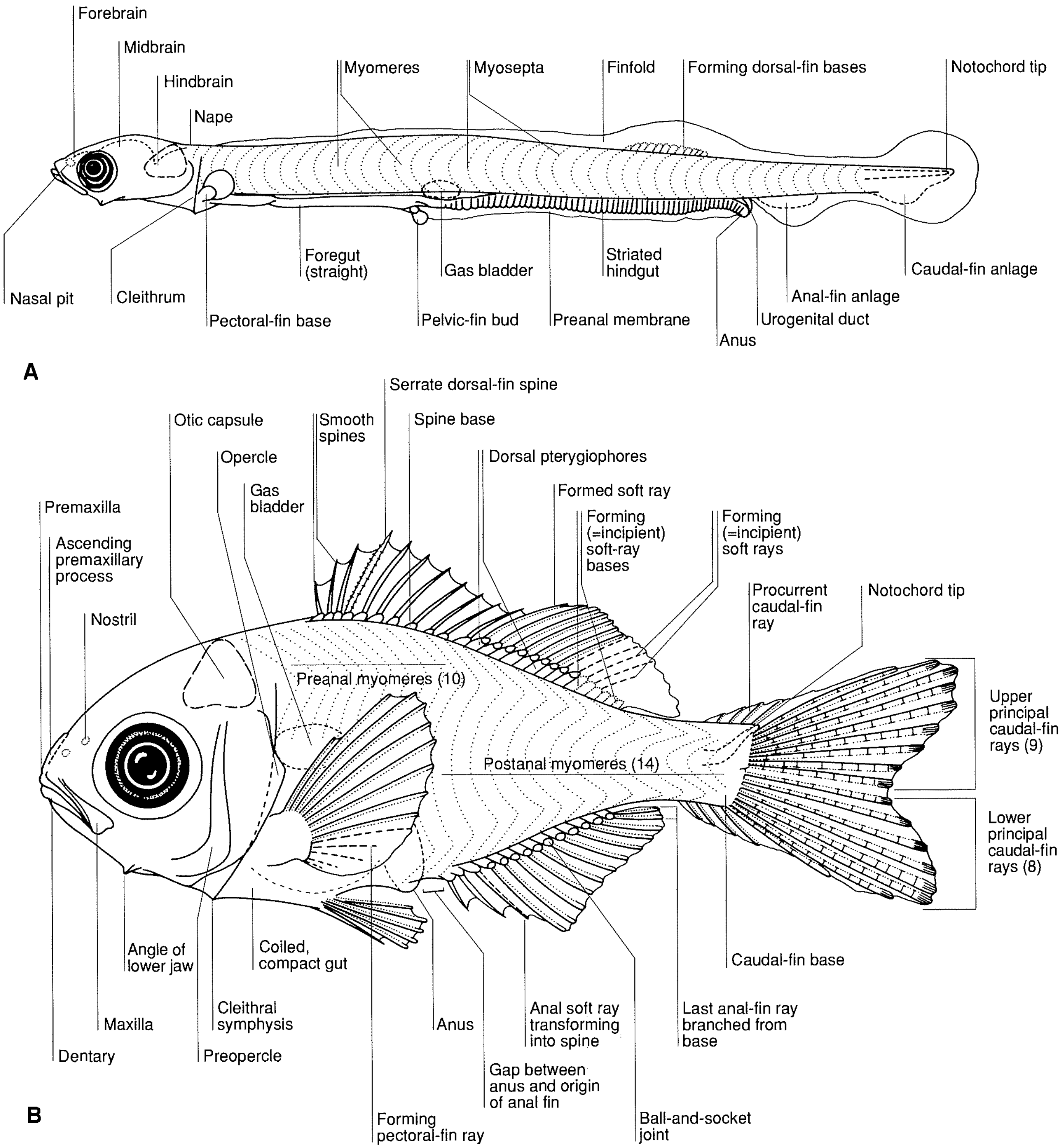


Figure 3 Hypothetical larvae showing major morphological characters used to describe larvae in this book: **A** preflexion; **B** postflexion (see text for explanations).

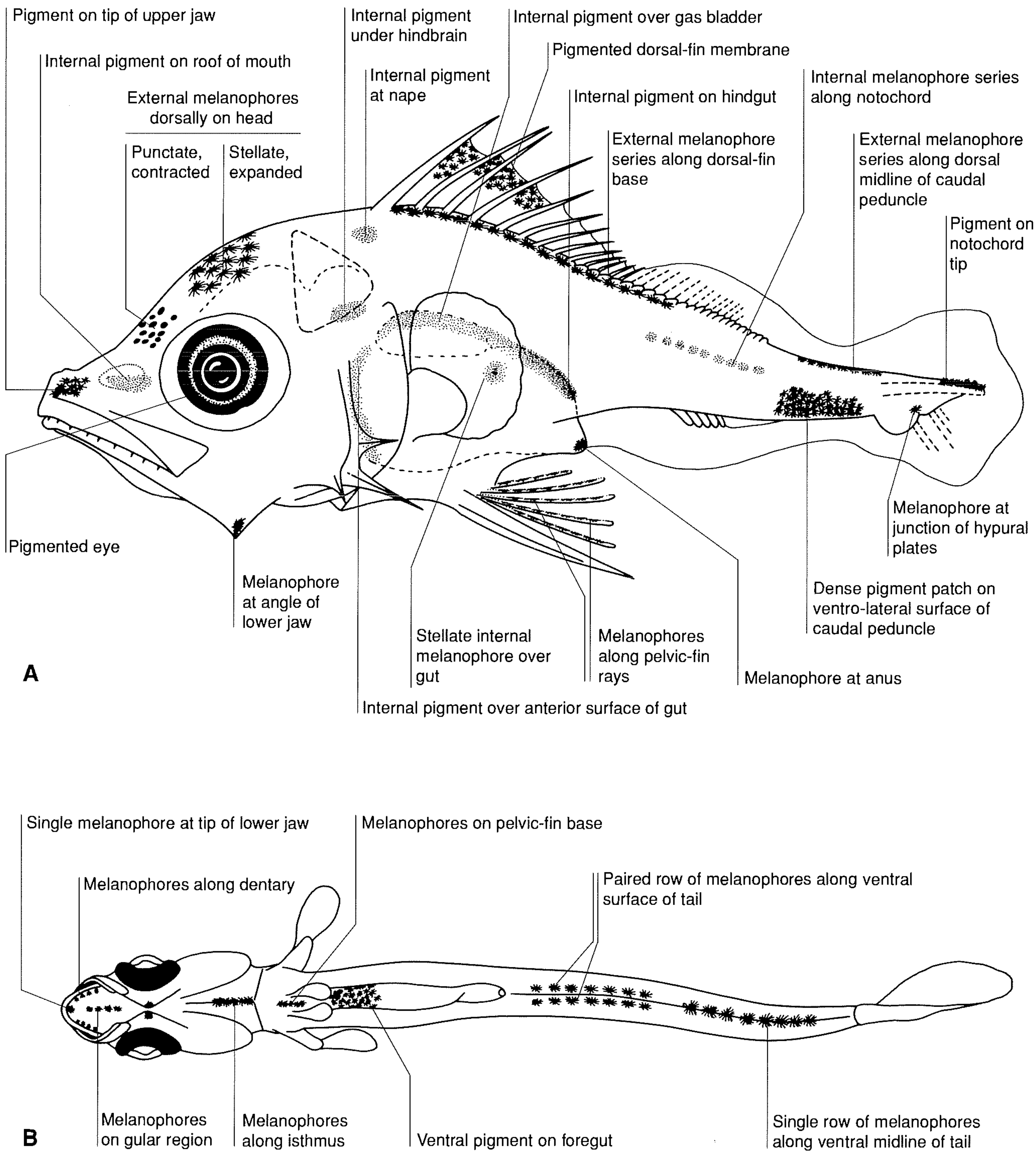


Figure 4 Hypothetical larvae showing major pigment characters used to describe larvae in this book: **A** lateral view; **B** ventral view (see text for explanations).

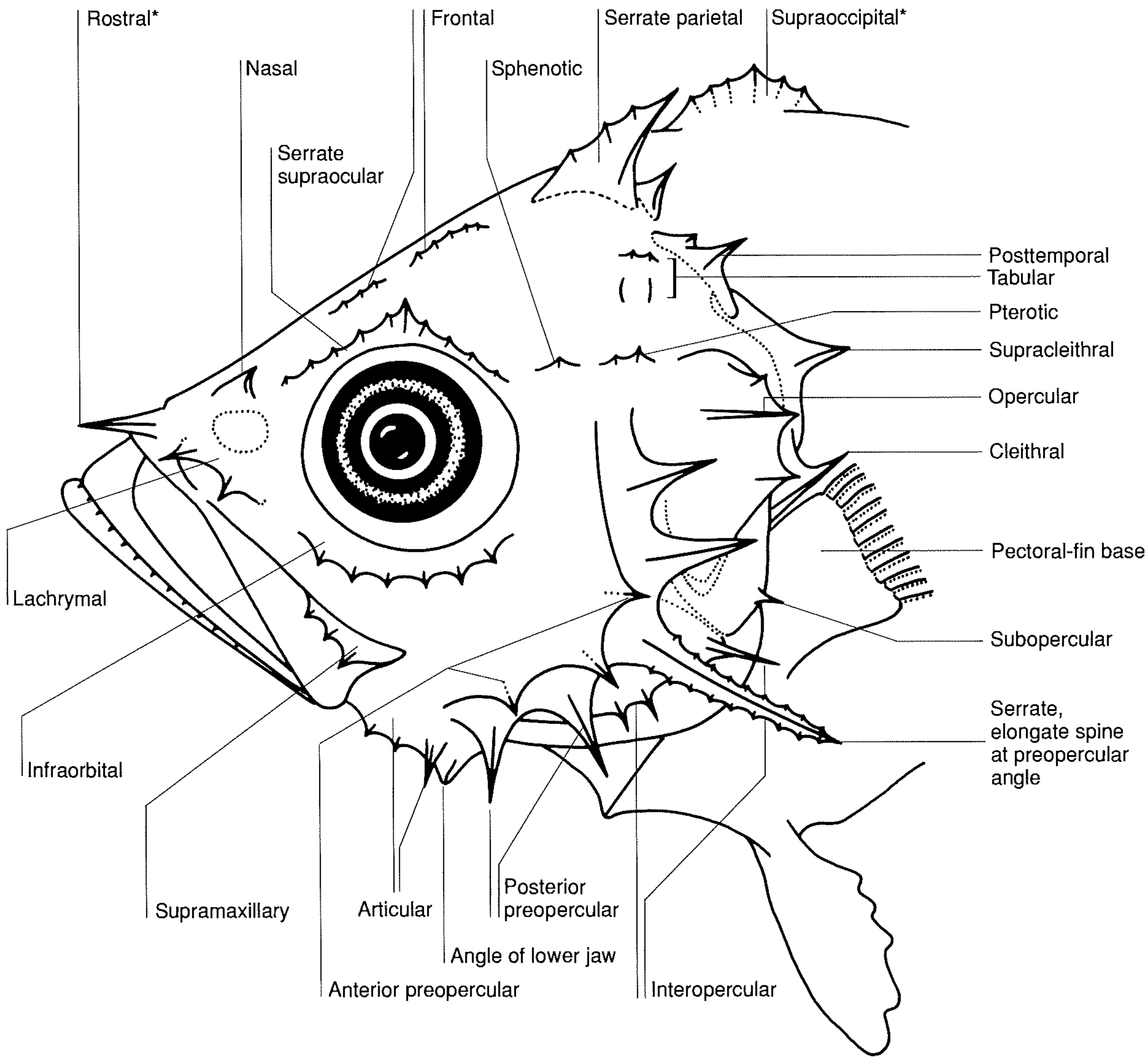


Figure 5 Hypothetical larva showing the type of head spines referred to in this book; *denotes unpaired, medial head spines.

and techniques. Different authors draw eyes, head spines, fin spines and rays, and pigment in different ways and their styles often reflect the groups in which they work, e.g. styles to illustrate clupeid larvae may differ from those used for perciform larvae. The reason for illustrating a fish larva, however, remains the same: to represent accurately a three-dimensional, often transparent larva in a two-dimensional drawing, emphasising the characters that are most useful to identify the larva of the taxon illustrated (Sumida *et al.*, 1984).

Several of the contributors to this book illustrated their own material. Although the styles are quite different, most used similar illustrating conventions. Incipient (forming) spines and soft rays were drawn as broken lines. Formed spines were drawn as solid, pointed structures. Formed soft rays of all fins were drawn combining a solid line for the leading (anterior) edge and either a broken or a dotted line for the trailing (posterior) edge. Segments were usually drawn along caudal-fin rays and sometimes along the soft rays of other fins. The edges of the gas bladder and notochord tip were drawn as broken or dotted lines. External melanophores were drawn with solid lines as branched or stellate, external dense pigment with dark stippling, and internal melanophores and internal pigment with light stippling (Figure 4).

3 LAYOUT OF DESCRIPTIONS

The 11 orders covered in this book were arranged phylogenetically, following Nelson (1994). Due to its large size, the Order Perciformes was subdivided into suborders and its classification and arrangement follows Nelson (1994). Introductory sections to orders and suborders were prepared by the senior editor (FJN). All families within orders or suborders, and all species within families, are arranged in alphabetical order. Families within each order and suborder are treated separately and each includes a section describing the larvae of each taxon and a plate of figures on the facing page. Descriptions of larvae are based only on examined specimens unless stated otherwise. The descriptive format used in each family and species section is outlined below.

FAMILY INTRODUCTIONS

[Family]: [Common name(s)]
[Author(s) of description]

The introduction to each family provides an overview of the adult members of the family, including habitat in which they are found and overall world distribution. It also provides the number of genera and species in the family worldwide, in Australia, and in the temperate region covered by this book. This is followed by a short description of the distinguishing morphological characters of the adults. All references given correspond to the most relevant publications on taxonomy, general biology and distribution of the adults of the family. The remainder of this section provides information on eggs of members of the family followed by a list of the genera for which larvae have been described. A short statement on specialisations of the larvae to pelagic life, if any, is also included.

Meristic characters of [genus/genera] of temperate Australia
This table summarises the meristic counts of the genera, and the number of recognised species (n) in each genus from temperate Australia. For each genus listed, the table provides the range of counts in the dorsal, anal, pectoral, pelvic and caudal fins, and the number of vertebrae for these Australian species. For syngnathid genera, the table provides the number of body rings as trunk (preanal) + tail (postanal) rings instead of vertebrae, and the pelvic-fin column has been omitted since the fin is absent in this group. Most counts were obtained from the literature, whenever possible using Australian literature, and the references have been cited in the family introduction section. When complete counts for all species in a genus were not available, only those for described species are provided. In cases when counts were obtained from cleared and stained specimens, this is indicated at the bottom of the table. The '–' symbol indicates information not available.

Main characters of [Family] larvae
Lists the diagnostic characters that are useful for identification of larvae to family level. Includes characters described for larvae from other geographical areas.

References to [Family] larvae
Reference(s) in which descriptions of the larval stages of members of the family can be found. The '–' symbol indicates that larvae have not previously been described for any member of the family.

Families with similar larvae
This section lists families of teleost fishes found in Australia, including the tropics, whose larvae may be confused with larvae of members of the family being treated, and the characters that will distinguish them. The characters given were obtained from chapters in this book, from personal observations and communications, and published literature (e.g. Fahay, 1983; Leis & Rennis, 1983; Moser *et al.*, 1984; Okiyama, 1988a; Leis & Trnski, 1989; Moser, 1996a). Distinguishing fin meristic characters are restricted to temperate Australian taxa. Families are listed in alphabetical order and those in bold type correspond to families treated in this book.

SPECIES ACCOUNTS

[Family] [Genus – species – Author, date original description]
[Common name(s) in Australia and elsewhere].
The authorship of each of the species treated follows Paxton

et al. (1989) and Hoese *et al.* (in prep). When available, the common names used are those specified by the Recommended Marketing Names for Fish Committee (1995).

Meristic characters D, A, P_1, P_2, C and V. The '–' symbol indicates information not available. If a genus, meristics include the range of counts for all those species in the genus occurring in temperate Australia. Body and tail ring counts are given instead of vertebral counts only in the case of syngnathids.

Adults Describes the geographical distribution of the adults in temperate Australia and elsewhere, habit (e.g. pelagic, benthic, demersal, schooling), and usual habitat (e.g. oceanic, coastal, seagrass, rocky reefs). It also provides their main external morphological characteristics and the maximum length recorded (standard length unless stated otherwise).

Importance to fisheries Summarises the commercial and/or recreational importance of the species treated, main fishing methods and commercial use(s). It also includes other information, such as whether the species is protected by law or if it has importance in the aquarium trade. The '–' symbol indicates the species has no direct commercial importance.

Spawning Describes egg type (pelagic or demersal), morphology and size of the egg of the species. 'Eggs undescribed' means that eggs have not been described for the species. However, if description of eggs are known for closely related species, usually from the same genus, these are provided. This section also includes spawning areas and season(s) of the species in temperate Australia, and the locality and time of year (seasons or months) when eggs and/or larvae have been caught.

Diagnostic characters Lists the distinguishing characters that will assist in identifying the larvae of the species treated.

Description of larvae This part describes the larvae and has been divided into three subsections: *Morphology*, *Size at*, and *Pigmentation*. All descriptions are based on examined specimens unless noted otherwise.

Morphology Describes body shape, head size, as well as gut size and morphology, each with the corresponding range of morphometric values (as %BL) for the preflexion, flexion and postflexion stages. It also provides the main distinguishing characters including teeth, type of head spines, presence of a gas bladder and its relative size, and, if present, the gap between the anus and the origin of the anal fin. Additional information relevant to specific distinguishing developmental features, including size of fins, transformation of soft rays into spines and size at formation of scales, is also included if these are present in the series examined.

Size at This table summarises the range of sizes, in millimetres of body length, at which main developmental events occur. These are size at hatching, notochord flexion, settlement or transformation, and formation of fins. The '–' symbol indicates information not available.

Except for reared larvae, the size at hatching of most species was inferred from field-caught material and is assumed to be smaller than that of the smallest preflexion larva measured. All size values determined in this manner are preceded by the symbol '<'. If size at hatching was obtained from the literature, the source of information is indicated at the bottom of the table.

Size range at notochord flexion includes from the largest late preflexion or the smallest flexion larva, whichever the smaller, to the smallest postflexion larva in which both the notochord tip has flexed and the posterior edge of the hypural bones have assumed a vertical position.

Size at settlement and transformation were usually obtained in more than one way. For species which adopt a demersal or benthic mode of life after completing the pelagic larval period, the settlement size range was determined from the largest postflexion larva examined, and/or from the smallest settled juvenile from field collections, museum collections or published records. It is important to note, however, that the absence of late postflexion larvae from plankton tows does not necessarily imply they have settled. For those species whose pelagic larvae undergo transformation (e.g. clupeoids), the transformation size range given was determined from the largest postflexion larva examined, and/or from the smallest newly transformed juvenile from field collections, museum collections or published records. Values of length at settlement or transformation preceded by the symbol '>' indicate that larvae presumably settle or transform at a greater size than that of the largest larva measured for the species treated.

The size range at which fins develop includes the smallest larva in which the fins start to form to the smallest larva in which all elements are present and ossified (except for procurrent caudal-fin rays), including rays that transform into spines. In the size ranges provided, the commencement of the formation of the dorsal, anal and caudal fins corresponds to the size at which the anlagen first appear, the pelvic fins to when the pelvic-fin buds first appear, and the pectoral fin to when the first incipient ray(s) begin to form.

Pigmentation Describes separately the external and internal pigmentation, and their changes during development of the larvae. Pigment (melanin) is described sequentially from anterior to posterior of the larvae. External pigment includes that anywhere on the surface of the body including fins and around the notochord tip. Internal pigment includes that below the skin (e.g. under nape), inside body cavities (e.g. roof of mouth, under opercle), and over internal structures (e.g. brain, gut, gas bladder, cleithrum, along notochord or vertebrae).

The number of melanophores, followed sometimes by size and shape (e.g. stellate, punctate) is provided only when considered relevant as, for example, in the case of melanophores arranged in a single or paired series along the dorsal and/or ventral midlines of the tail. Pigment is used to describe an area(s) of the body with many melanophores. The terms 'heavily' and 'lightly' pigmented characterise a larva or a body region with densely or sparsely distributed melanophores, respectively.

Material examined States the total number and size range (BL, mm) of specimens examined and the locality(s) where they were caught in temperate Australia or, in the case of laboratory-reared larvae, the place where they were reared. Significant size gaps in the series examined are also noted.

Additional references Reference(s) in which the larval development of the species treated can be found if this has been previously described. The '–' symbol indicates that there are no previous descriptions of larvae of the species.

ILLUSTRATIONS

Illustrations of larvae are organised in a plate facing the species page. A developmental series is presented on each plate, with the larvae arranged from top to bottom in increasing size and stage of development (preflexion to early juvenile). The size in millimetres of body length is indicated next to each illustration. Except for those species for which sufficient material was not available, each plate includes at least a preflexion, a flexion and a postflexion stage, with some also including a yolk-sac and the early juvenile stage when these stages were available. For some species, a dorsal or a ventral view of one of the illustrated larvae was included in order to show diagnostic characters difficult to see in lateral view. Each illustration bears the signature of the artist who drew the series. Drawings with no initials were produced by more than one person.

The figure caption states the genus, species, the stage of development of each larva illustrated and, in some cases, distinguishing morphological features of these stages. Any omissions of morphological characters are also mentioned (e.g. myomeres). It also indicates where in temperate Australia the illustrated larvae were collected or reared. The name of the illustrator is included at the end of each caption.

4 GUIDE TO LARVAE OF FAMILIES IN THIS BOOK

Keys used to identify adult fishes cannot be used to identify larval fishes. The main reason for this is that larval fishes often undergo such dramatic morphological changes throughout development that several, rather complex keys would be required to accommodate all larval stages. However, to facilitate allocation of larvae to at least family level using this book, a pictorial guide which includes only families covered by this book was devised (Figure 6). In combination with the 'Families with similar larvae' section of each family, this guide should help to at least narrow down the identifications of larvae.

Families were split into two main categories based on the presence of dermal plates or body rings. The first (A) category includes families with dermal plates or body rings, i.e. Pegasidae and Syngnathidae. The second (B) category includes families without dermal plates or body rings and

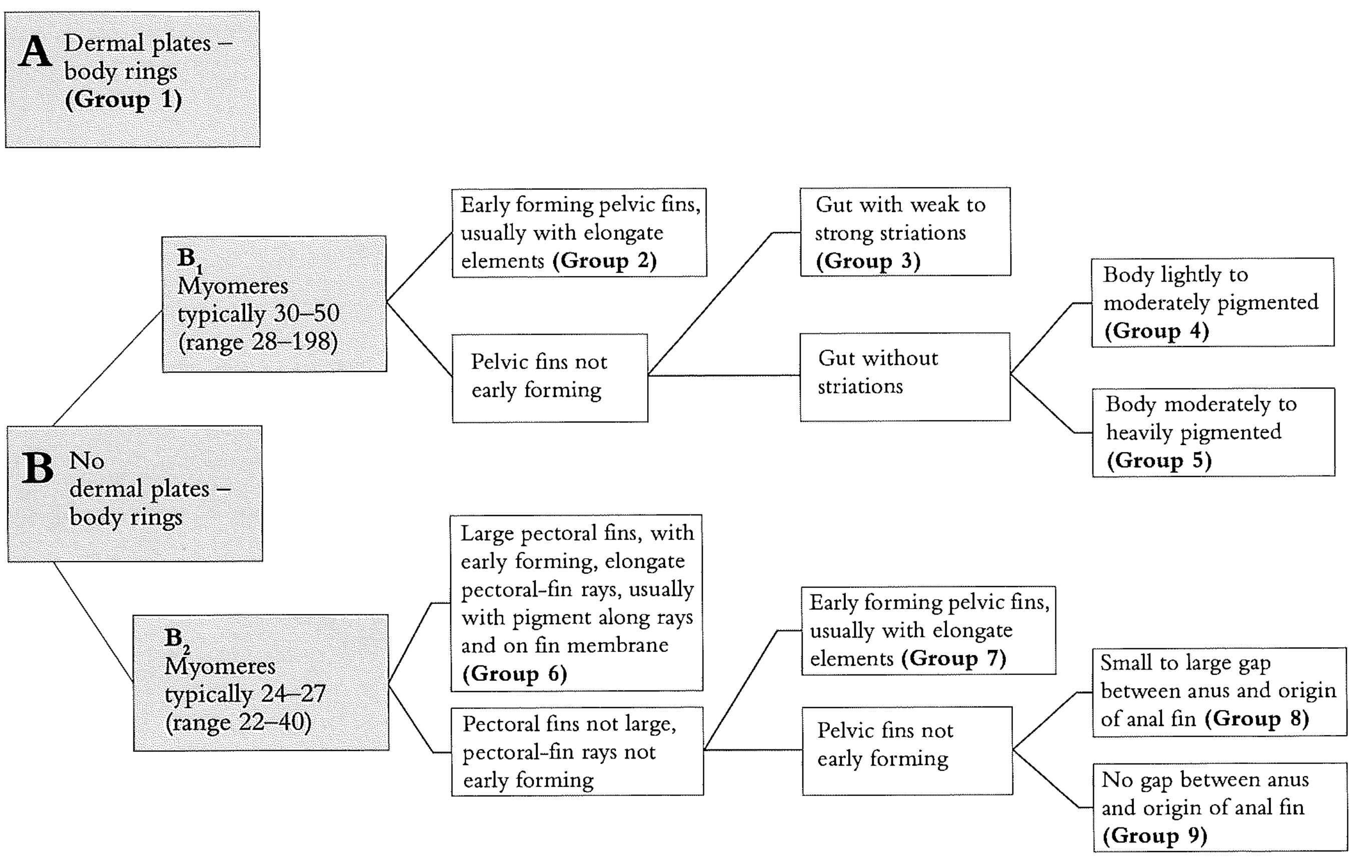


Figure 6 Main categories (A, B), and the subcategories (B_1, B_2) and groups (1–9) in which families in this book were allocated to help in the identification of their larvae (see text for explanations on how to use guide).

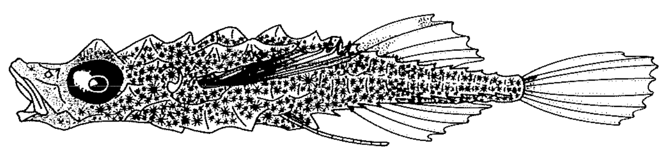
was split into two subcategories (B_1 and B_2) using number of myomeres, the only morphological character that remains constant throughout larval development. Further division from the subcategories B_1 and B_2 was based on developmental characters which unify families into particular groups (Figure 7). The user should bear in mind, however, that most if not all the latter characters change with development or may even be present for a short period of time (e.g. gut striations in sillaginids). The two subcategories include: B_1, larvae from families with typically 30–50 myomeres (range 28–198); and B_2, those from families with typically 24–27 myomeres (range 22–40). Larvae of six of the families treated in this book possess a range of myomeres that overlap the two subcategories: Centrolophidae, Eleotridae, Gobiidae, Percichthyidae, Plesiopidae, and Triglidae. Although these families could have been placed in either subcategory, they were allocated to the B_2 subcategory because most taxa in these families typically possess 30 or fewer myomeres.

All families within the two main categories (A, B) were assigned to one of nine groups (Figure 7). For each group, the guide provides an illustration of an early stage larva (preflexion or flexion stage) representing each family, except in the case of a few families in which these stages were lacking. It is important to note that larvae of species within the same family may look quite different and thus fall in different groups (e.g. bovichtids *Bovichtus* and *Pseudaphritis*, galaxiids *Galaxias* and *Galaxiella*). The typical myomere counts in the family, i.e. the range in most species of that family, is indicated below each illustration followed by the total myomere range (when known) in brackets. Redundancies in the key have been given to the six 'overlapping' families listed above by providing the alternative group(s) to which they belong had they been allocated to the B_1 subcategory. The page in which each family is treated in this book is also provided. Within each group, families are arranged from top to bottom of the page in increasing order of myomere counts.

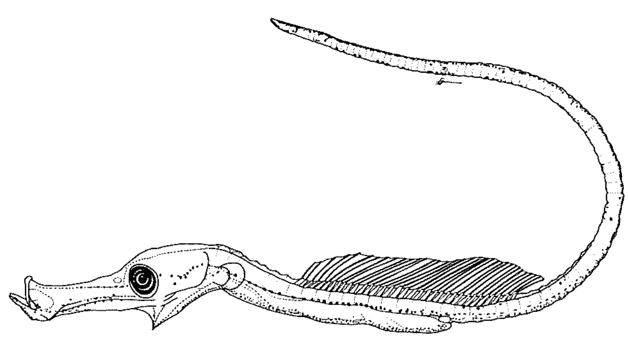
Figure 7 Groups (1–9) and their main distinguishing characters.

CATEGORY A

Group 1 Dermal plates – body rings



Pegasidae
(p. 117)



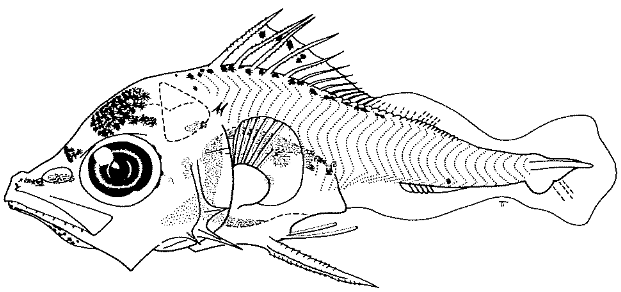
Syngnathidae
(p. 122)

CATEGORY B

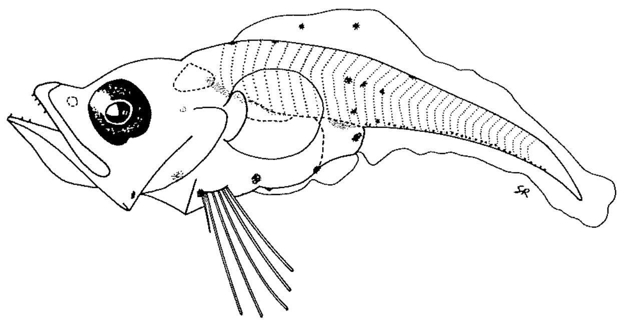
No dermal plates – body rings

B$_1$ Myomeres typically 30–50 (range 28–198)

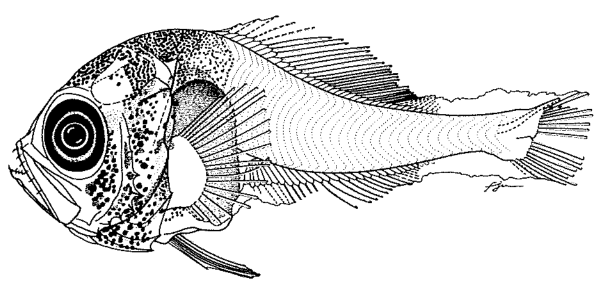
Group 2 Early forming pelvic fins, usually with elongate elements



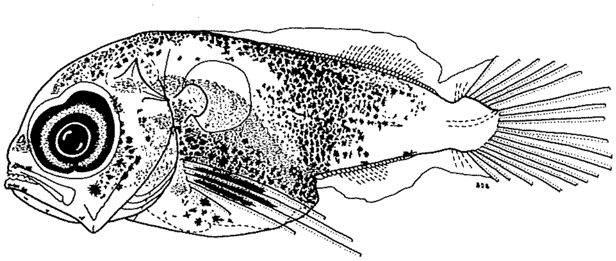
Gempylidae 31–67 myomeres
(p. 406)



Percophidae 32–34 myomeres
(p. 358)



Bramidae 36–54 myomeres
(p. 184)

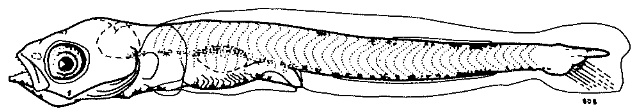


Phycidae 38–55 myomeres
(p. 92)

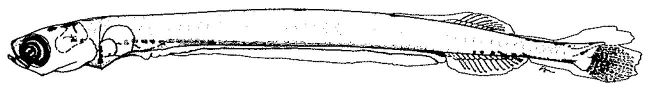
Figure 7 (Continued)

B$_1$ Myomeres typically 30–50 (range 28–198)

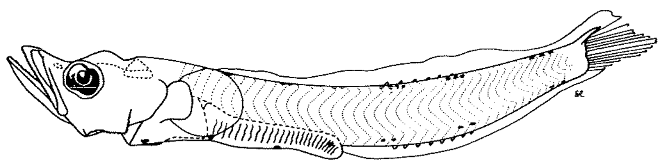
Group 3 Pelvic fins not early forming; gut with weak to strong striations



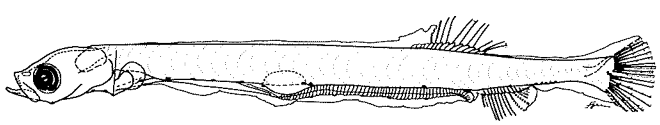
Sillaginidae 32–45 myomeres
(p. 294)



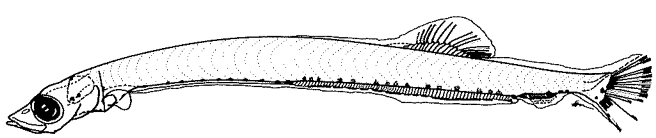
Galaxiidae 36–64 myomeres
(p. 70)



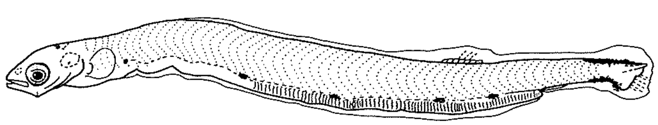
Creediidae 37–59 myomeres
(p. 346)



Engraulidae 38–47 myomeres (38–77)
(p. 54)



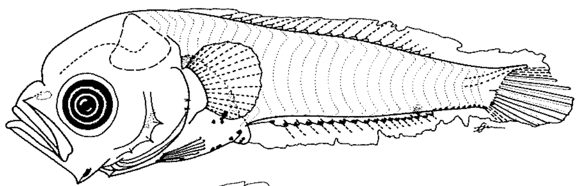
Clupeidae 40–60 myomeres
(p. 38)



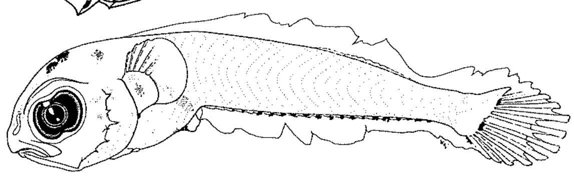
Gonorhynchidae 54–61 myomeres
(p. 60)

B$_1$ Myomeres typically 30–50 (range 28–198)

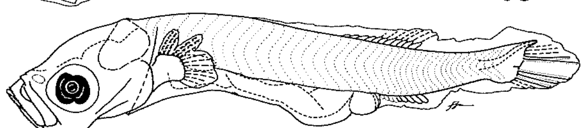
Group 4 Pelvic fins not early forming; gut without striations; body lightly to moderately pigmented



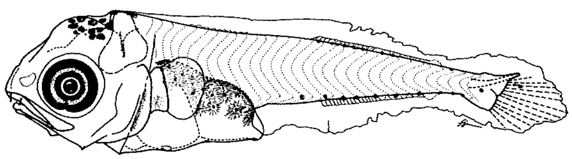
Pinguipedidae 29–34 myomeres
(p. 362)



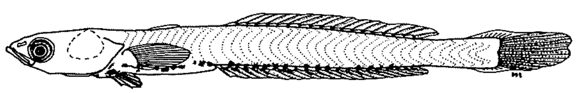
Blenniidae 30–40 myomeres (28–135)
(p. 368)



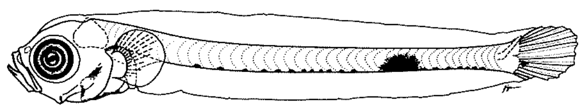
Odacidae 30–54 myomeres
(p. 326)



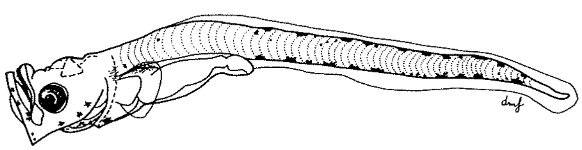
Scombridae 31–46 (30–66)
(p. 412)



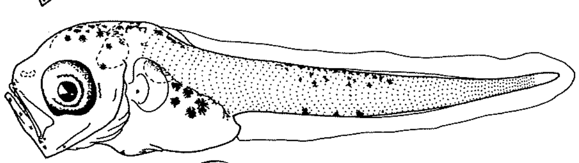
Bovichtidae 37–42 myomeres
(p. 338)



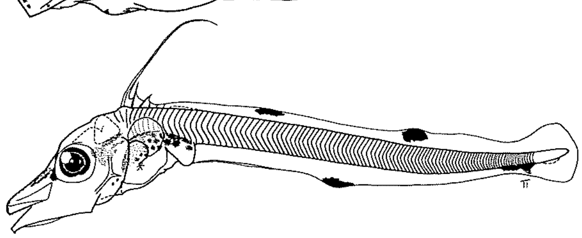
Leptoscopidae 42–48 myomeres
(p. 354)



Ophidiidae 48–87 myomeres
(p. 80)



Macruronidae 78–81 myomeres
(p. 88)

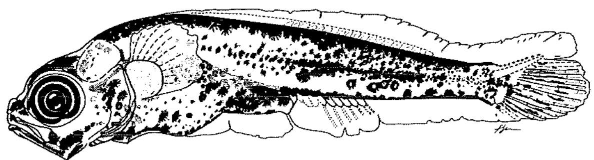


Trichiuridae 84–198 myomeres
(p. 416)

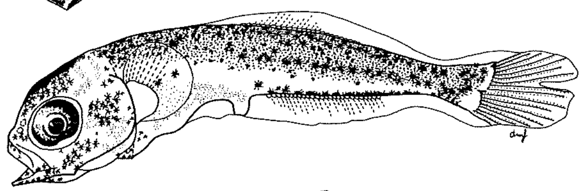
Figure 7 (Continued)

B$_1$ Myomeres typically 30–50 (range 28–198)

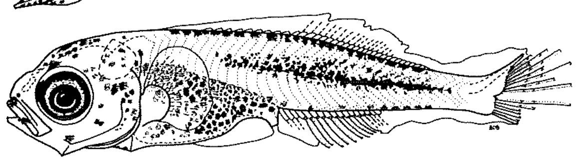
Group 5 Pelvic fins not early forming; gut without striations; body moderately to heavily pigmented



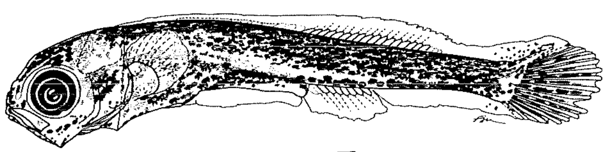
Chironemidae 33 myomeres
(p. 215)



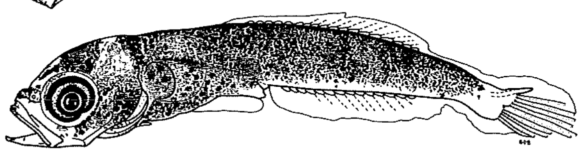
Latridae 33–45 myomeres
(p. 240)



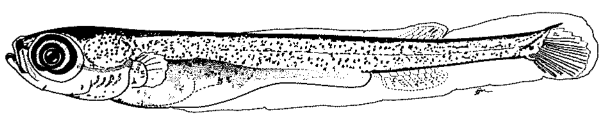
Cheilodactylidae 34–36 myomeres
(p. 210)



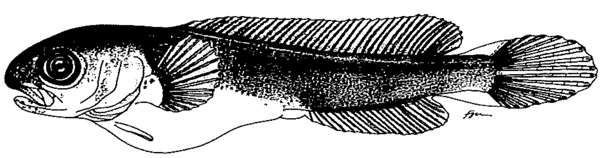
Aplodactylidae 35 myomeres
(p. 170)



Bovichtidae 37–42 myomeres
(p. 338)

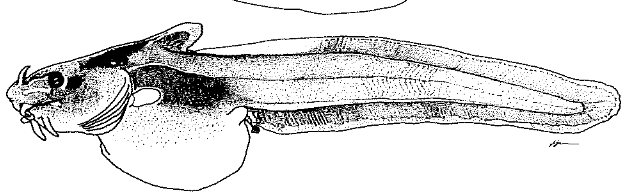


Galaxiidae 36–64 myomeres
(p. 70)



Gadopsidae 40–51 myomeres
(p. 223)

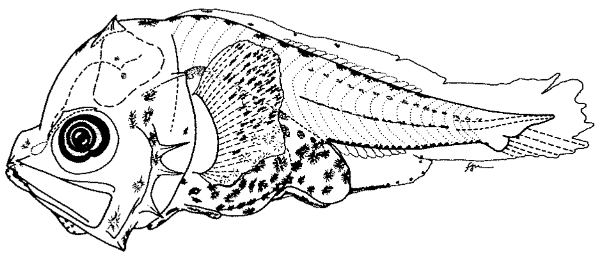
Scomberesocidae 62–70 myomeres
(p. 98)



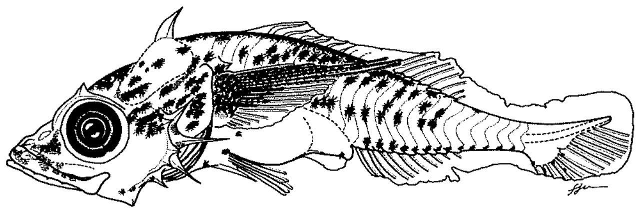
Plotosidae >77 myomeres
(p. 65)

B_2 Myomeres typically 24–27 (22–40)

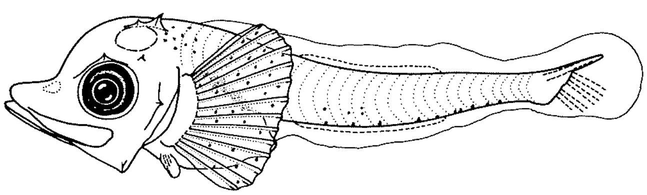
Group 6 Large pectoral fins, with early forming, elongate pectoral-fin rays, usually with pigment along rays and on fin membrane



Scorpaenidae 24–27 myomeres (24–31)
(p. 140)



Platycephalidae 27 myomeres (25–28)
(p. 134)

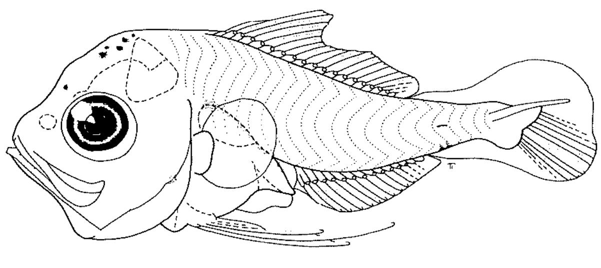


Triglidae 27–35 myomeres (25–39)
(p. 150)

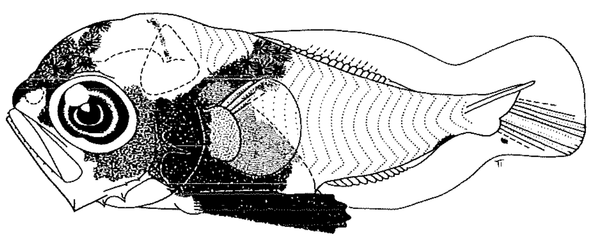
Figure 7 (Continued)

B$_2$ Myomeres typically 24–27 (22–40)

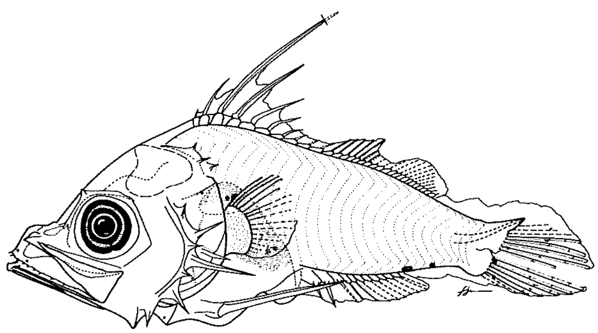
Group 7 Pectoral fins not large, pectoral-fin rays not early forming; early forming pelvic fins, usually with elongate elements



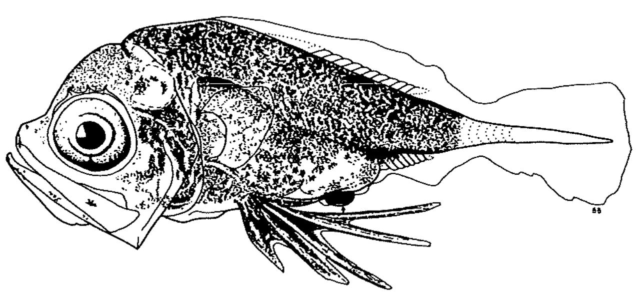
Berycidae 23–24 myomeres
(p. 104)



Monodactylidae 24–25 myomeres
(p. 250)



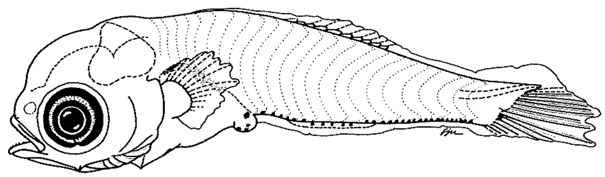
Serranidae 26–28 myomeres
(p. 288)



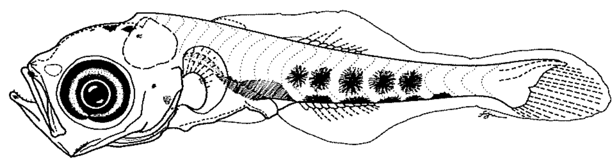
Trachichthyidae 26–30 myomeres
(p. 108)

B_2 Myomeres typically 24–27 (22–40)

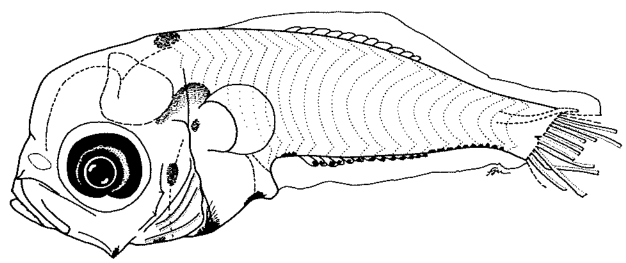
Group 8 Pectoral fins not large, pectoral-fin rays not early forming; pelvic fins not early forming; small to large gap between anus and origin of anal fin



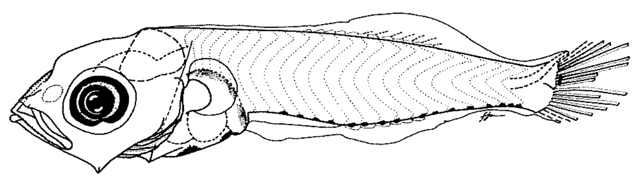
Nemipteridae 22–24 myomeres
(p. 254)



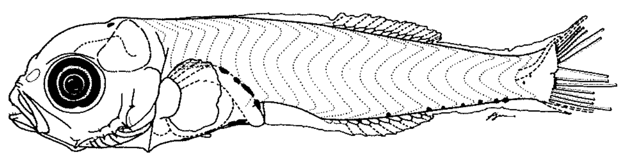
Apogonidae 24 myomeres (23–25)
(p. 174)



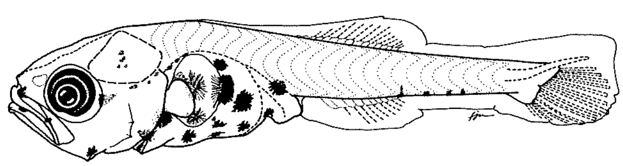
Chandidae 24–25 myomeres
(p. 204)



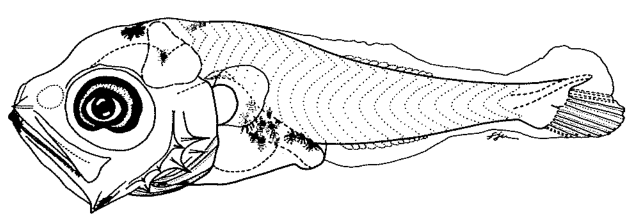
Gerreidae 24–25 myomeres
(p. 226)



Sparidae 24–25 myomeres
(p. 306)



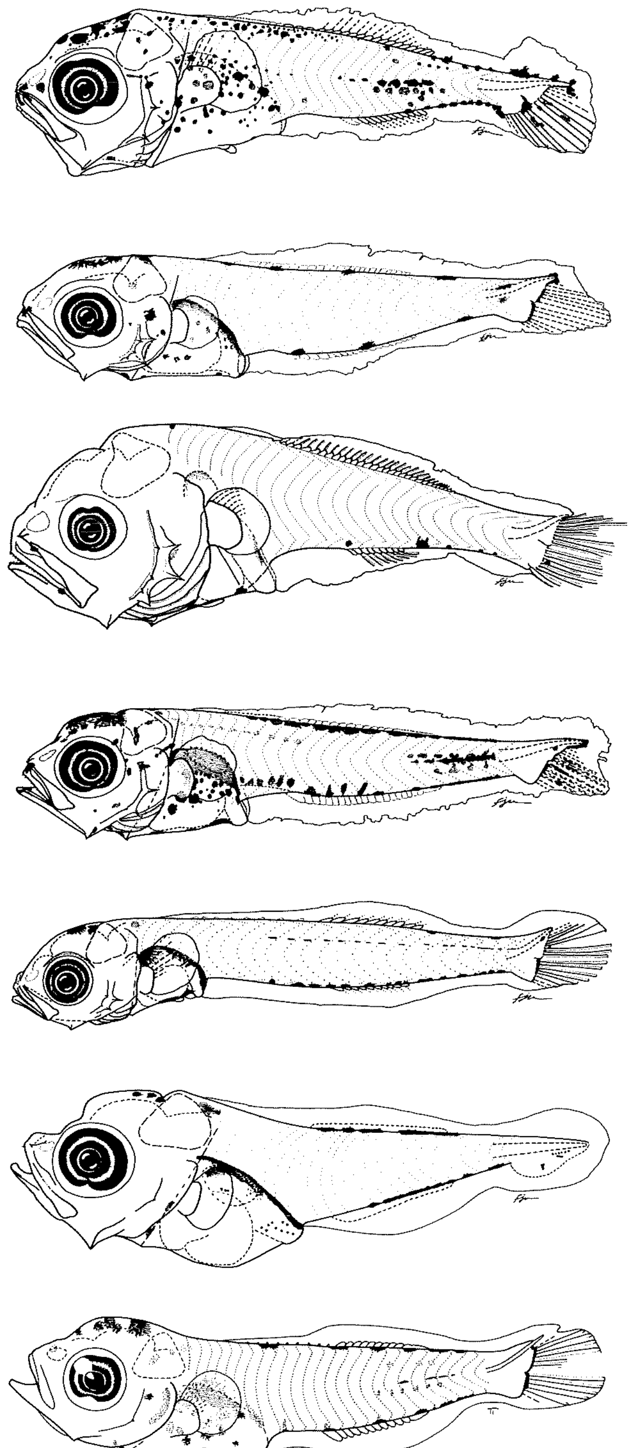
Percichthyidae 24–37 myomeres
(p. 259)
(Group 4)



Acropomatidae 25 myomeres
(p. 166)

Figure 7 (Continued)

(Group 8 continued)



Arripidae 25–26 myomeres
(p. 180)

Microcanthidae 25–26 myomeres
(p. 244)

Sciaenidae 25–26 myomeres (24–29)
(p. 278)

Scorpididae 25–26 myomeres
(p. 284)

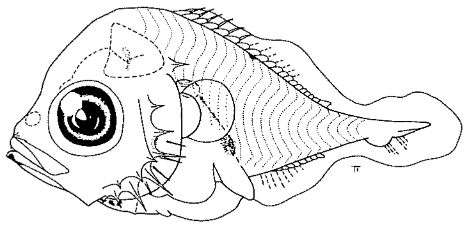
Terapontidae 25–26 myomeres
(p. 316)

Pomatomidae 25–27 myomeres
(p. 274)

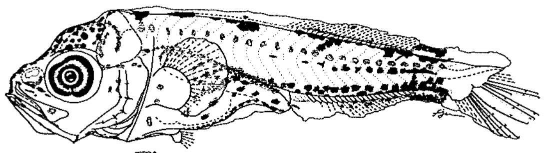
Girellidae 26–27 myomeres
(p. 232)

B$_2$ Myomeres typically 24–27 (22–40)

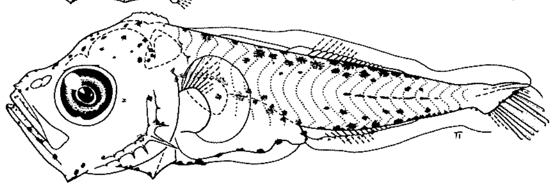
Group 9 Pectoral fins not large, pectoral-fin rays not early forming; pelvic fins not early forming; no gap between anus and origin of anal fin



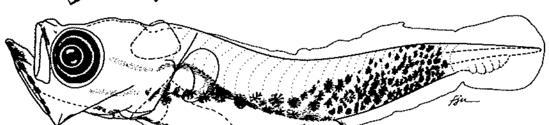
Callanthiidae 22–25 myomeres
(p. 189)



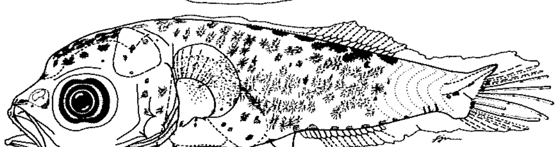
Centrolophidae 23–26 myomeres (23–61)
(p. 422)
(Groups 4, 5)



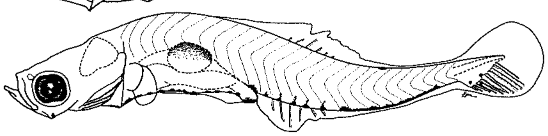
Carangidae 24 myomeres (24–26)
(p. 192)



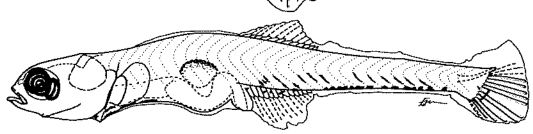
Plesiopidae 24–40 myomeres
(p. 266)
(Groups 4, 5)



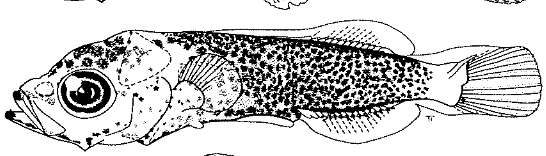
Kyphosidae 25–26 myomeres
(p. 236)



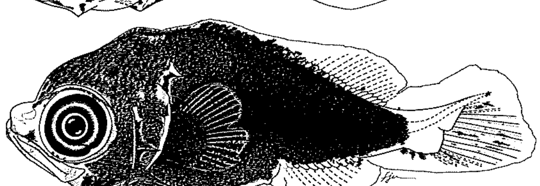
Gobiidae 25–27 myomeres (24–34)
(p. 386)
(Groups 4, 5)



Eleotridae 25–34 myomeres
(p. 383)
(Group 4)



Enoplosidae 26 myomeres
(p. 218)



Serranidae 26–28 myomeres
(p. 288)

5 LARVAL DESCRIPTIONS

CLUPEIFORMES

The Clupeiformes is a small order of pelagic, mostly schooling, primarily marine fishes distributed worldwide, with about 20% of its species confined to fresh water. The order contains 5 families, 83 genera and 357 species (Whitehead, 1985; Whitehead *et al.*, 1988; Nelson, 1994). Families comprise the Clupeidae (herrings, pilchards, sardines, shads), Chirocentridae (wolf herrings), Denticipitidae (denticle herrings), Engraulidae (anchovies) and Pristigasteridae. Representatives of only the Clupeidae and Engraulidae occur in temperate Australian waters (Paxton & Hanley, 1989a,b). Many species have considerable commercial importance worldwide (Whitehead, 1985; Whitehead *et al.*, 1988), although in Australia only species such as *Sardinops sagax* and *Engraulis australis* support small localised purse-seine fisheries (Hall & MacDonald, 1986; Fletcher, 1990, 1991; Neira *et al.*, 1997a,b). Clupeiform fishes are typically small to medium-sized, and have an elongate to moderately deep, slightly to strongly compressed body, posteriorly placed pelvic fins and no true fin spines. Most species are planktivorous, possessing long, often numerous gill rakers for sieving prey.

Clupeiform larvae have been described for representatives of all families except the Denticipitidae (see review of early life history stages by McGowan & Berry, 1984; see also Zhang *et al.*, 1982; Zhang *et al.*, 1985; Fahay, 1983; Takita, 1988; Leis & Trnski, 1989; Watson & Sandknop, 1996a,b). Larvae are elongate, slender and lightly pigmented, and have a small head with no spines, a long and straight gut often with striations along the hindgut, posteriorly placed dorsal and anal fins and, in most taxa, myomeres which have muscle fibres in a cross-hatched pattern. The soft rays of the dorsal fin develop from posterior to anterior and the dorsal fin migrates anteriorly near the completion of the larval phase. As clupeiform larvae undergo dramatic morphological changes during development, different characters must often be used with the different stages to identify larvae to species (McGowan & Berry, 1984; Leis & Trnski, 1989).

Families and species included here

CLUPEIDAE
Etrumeus teres
Herklotsichthys castelnaui
Hyperlophus translucidus
Hyperlophus vittatus
Nematalosa vlaminghi
Sardinops sagax
Spratelloides robustus

ENGRAULIDAE
Engraulis australis

Clupeidae: Herrings, sardines, shads, sprats

A.G. Miskiewicz and F. J. Neira

Clupeids are found in estuaries and coastal waters of all seas between 70°N and 60°S, with a few species in fresh water (Whitehead, 1985). The family comprises 56 genera and over 180 species worldwide (Nelson, 1994). Fifteen genera and about 32 species have been recorded from Australia, 9 genera and 11 species in temperate waters (Whitehead, 1985; Paxton & Hanley, 1989a; Briggs & McDowall, 1996). Adults (2–60 cm) vary from elongate and cylindrical to deep and laterally compressed, have a single, short dorsal fin near midbody, pelvic fins in front of, directly below or just behind the dorsal fin, and a short anal fin well behind the origin of the last dorsal-fin ray. Pelvic scutes are usually present just anterior to the pelvic fins, and the dorsal and anal fins have no spines (McGowan & Berry, 1984; Whitehead, 1985). Eggs are spherical and mostly pelagic except those of *Clupea*, *Dorosoma* and *Spratelloides* which are demersal and adhesive, 0.6–3.8 mm in diameter, with a segmented yolk and oil globules in most taxa (Breder & Rosen, 1966; McGowan & Berry, 1984). Larvae have been described for representatives of most genera (see McGowan & Berry, 1984 and references therein; see also Fahay, 1983; Zhang *et al.*, 1985; Takita, 1988; Leis & Trnski, 1989; Matarese *et al.*, 1989; Watson & Sandknop, 1996a). The relatively large mouth and teeth, and the depressed head of larvae of some dussumieriin clupeids (e.g. *Etrumeus*, *Dussumieria*) constitute specialisations to pelagic life although most clupeid larvae have no obvious specialisations (Leis & Trnski, 1989).

Meristic characters of clupeid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
CLUPEINAE							
Herklotsichthys	(1)	16–19	17–21	14	8	19	41–42
Sardinella	(1)	17–19	16–17	13–16	7–9	19	44–48
Sardinops	(1)	17–20	16–21	16–19	8–9	19	47–53
Sprattus	(1)	15–18	18–21	18	8	19	–
DUSSUMIERIINAE							
Etrumeus	(1)	18–21	9–12	15–16	8–10	19	32–36 + 15–20 = 48–55
Spratelloides	(1)	10–14	9–14	12–13	8	19	46–47
DOROSOMATINAE							
Nematalosa	(2)	14–17	19–24	15–18	8	19	45–49
PELLONULINAE							
Hyperlophus	(2)	15–17	17–22	13–15	7	19	40–48
Potamalosa	(1)	15–18	15–17	15–19	8	19	–

Main characters of clupeid larvae

- 40–60 myomeres; muscle fibres in a cross-hatched pattern in most taxa, more evident in preflexion and flexion larvae
- Body very elongate to moderate (BD 5–23%), cylindrical to slightly compressed
- Head small to moderate (HL 8–31%), without spines
- Gut straight and long to very long (PAL 61–94%), with weakly to strongly striated hindgut
- Gut shortens in some taxa with growth, anus migrates anteriorly by 3–6 myomeres
- Gas bladder over midgut to hindgut, usually inflated
- Dorsal and anal fins posteriorly located; posterior end of dorsal fin and origin of anal fin usually separated by 1–10 myomeres, or overlapping by up to 2 myomeres
- Body lightly pigmented; no pigment dorsally along trunk and tail prior to transformation
- A few melanophores around notochord tip in some taxa

References to clupeid larvae

Dakin & Colefax (1934, 1940), Baker (1972), Houde & Fore (1973), Robertson (1973), O'Toole & King (1974), Miller *et al.* (1979), Fahay (1983), McGowan & Berry (1984), Takita (1988), Leis & Trnski (1989), Watson & Sandknop (1996a).

Families with similar larvae

Ammodytidae – Myomeres without cross-hatched pattern; very small preopercular spines from 10 mm; continuous, long-based dorsal fin, 36–69 rays; gut long (PAL 59–70%), without striations; continuous longitudinal series of melanophores or patches over gut and along ventral surface of trunk and tail.

Aulostomidae – 61–65 myomeres, without cross-hatched pattern; gut moderate to long (PAL 48–65%), without striations; large size at notochord flexion (*ca* 20 mm).

Chanidae – Myomeres without cross-hatched pattern; gut without striations; melanophore series dorsally along trunk and tail.

Chirocentridae – 69–75 myomeres; no pigment ventrally along gut.

Creediidae – Myomeres without cross-hatched pattern; small posterior preopercular spines in 5–10 mm larvae; numerous small melanophores in series or in clusters along dorsal and ventral midlines of trunk and tail.

Engraulidae – Typically 38–47 myomeres; posterior end of dorsal fin overlaps anal-fin origin by 1–4 myomeres (except in *Thryssa*); gut moderate to very long (PAL 48–81%).

Galaxiidae (species with estuarine/marine phase) – Myomeres without cross-hatched pattern; dorsal and anal fins directly opposite; weakly striated gut; some pigment dorsally along trunk and tail.

Gonorhynchidae – Myomeres without cross-hatched pattern; gas bladder not apparent; heavy opposing pigment along dorsal and ventral surfaces of caudal peduncle.

Gonostomatidae (e.g. *Cyclothone*) – 29–33 myomeres, without cross-hatched pattern; gut moderate (PAL ~50%); dorsal and anal fins directly opposite.

Odacidae (early stages) – Myomeres without cross-hatched pattern; gut without striations.

Photichthyidae (some genera, e.g. *Vinciguerria*) – Myomeres without cross-hatched pattern; eyes oval and semi-stalked; no pigment ventrally along gut.

Protroctidae (one species with estuarine/marine phase) – Myomeres without cross-hatched pattern; adipose dorsal fin.

Schindleriidae – 31–44 myomeres, without cross-hatched pattern; gut long to very long (PAL 54–75%), without striations; small size at notochord flexion (2.5–3.5 mm).

Synodontidae – Myomeres without cross-hatched pattern; late-forming dorsal fin (>10 mm); adipose fin from about 10 mm; prominent pigment blotches along dorsolateral surface of gut.

Clupeidae *Etrumeus teres* (De Kay, 1842) Maray, round herring

D 18–21 A 9–12 P_1 15–16 P_2 8–10 C 19 V 48–55

Adults Distributed around southern Australia from Geraldton (WA) to southern Queensland, including Tasmania. Also widespread in tropical and temperate marine waters worldwide, with populations off the Atlantic and Pacific coasts of America, and in Japan, eastern Africa, Hawaii and the Galapagos Islands. Occurs in offshore waters, occasionally moving into coastal waters. Adults have a large eye, a short, posteriorly placed anal fin, and a silver stripe laterally along the body. Maximum size 25 cm (Whitehead, 1963, 1985; Hutchins & Swainston, 1986; Paxton & Hanley, 1989a).

Importance to fisheries Fished commercially in the Gulf of Mexico, southern Africa and Japan (Houde & Fore, 1973; Whitehead, 1985).

Spawning Eggs are pelagic and spherical, 1.4–1.5 mm in diameter, and have a weakly segmented yolk and no oil globule (Miller *et al.*, 1979). Spawning has been recorded in New South Wales from winter through to spring (Blackburn, 1941). Larvae have been caught in coastal waters between Brisbane and Sydney from January to May, with a peak abundance in May (Miskiewicz, 1987), and in coastal waters off Sydney in February, April to August, November and December (Gray, 1995).

Diagnostic characters

- 41–43 + 10–12 = 53–55 myomeres
- Cross-hatched pattern of muscle fibres visible until 14 mm
- Long snout and elongate jaws bearing teeth
- Anus lies under myomeres 41–43 throughout development
- Posterior end of dorsal fin 2–3 myomeres in front of origin of anal fin
- Paired series of internal melanophores dorsolaterally over hindgut in postflexion larvae

Description of larvae

Morphology Body very elongate to elongate (BD 8–12%), initially cylindrical, slightly compressed from flexion stage. Head moderate (HL 20–27%), with a long snout. Large, elongate jaws with numerous small teeth. Gut very long (PAL 83–87%), straight and with striated hindgut. Anus is under myomeres 41–43. Gas bladder inflated only in larvae caught at night. Posterior end of dorsal fin 2–3 myomeres in front of origin of anal fin.

Size at

Hatching [1]	<3.8– ~5.7 mm
Notochord flexion	8.5–11.8 mm
Transformation	>21.2 mm
Formation of fins:	

Caudal 7.1–11.8 mm; Dorsal 8.7–16.1 mm; Anal 8.7–16.1 mm; Pelvic [2] 15.3–45.0 mm; Pectoral [2] 18.7–45.0 mm

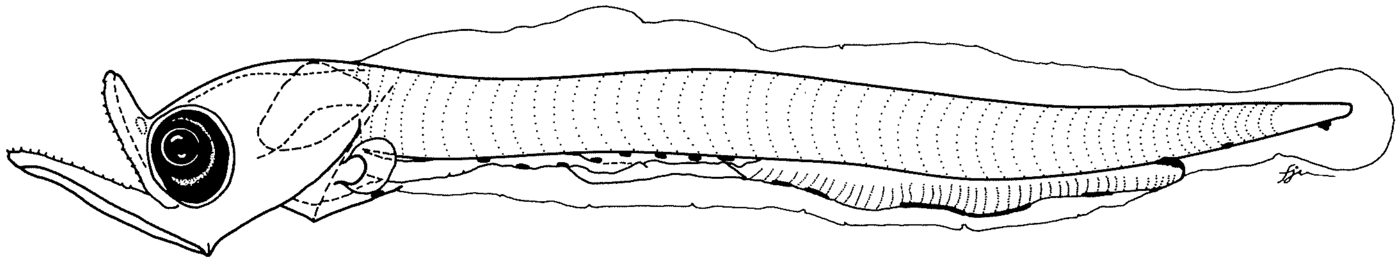
[1] Miller *et al.* (1979)
[2] Leis & Trnski (1989)

Pigmentation Larvae are lightly pigmented. *External:* 3 melanophores on dentary, 1 at tip of dentary and 1 on either side of cleithral symphysis by late preflexion stage. One melanophore posterior to cleithral symphysis in preflexion larvae, up to 3 along isthmus by flexion stage. Paired series of 6-8 elongate melanophores dorsolaterally along foregut, increasing to 15 with development; paired, roughly alternating series along ventral midline of hindgut; 1 melanophore above anus. Continuous series of melanophores dorsolaterally along gut between cleithrum and anus from 15 mm. One melanophore on ventral midline of caudal peduncle in preflexion larvae, up to 6 melanophores along anal-fin base and caudal peduncle in postflexion larvae. Two to five small melanophores below notochord tip, remaining along base of lower caudal-fin rays in postflexion larvae. Melanophores laterally on hindbrain, midlateral surface of body and along upper caudal-fin rays in transforming larvae. *Internal:* 1–2 melanophores in otic region, 3 along cleithrum and 2 in hypural region, 1 below urostyle, in late postflexion larvae.

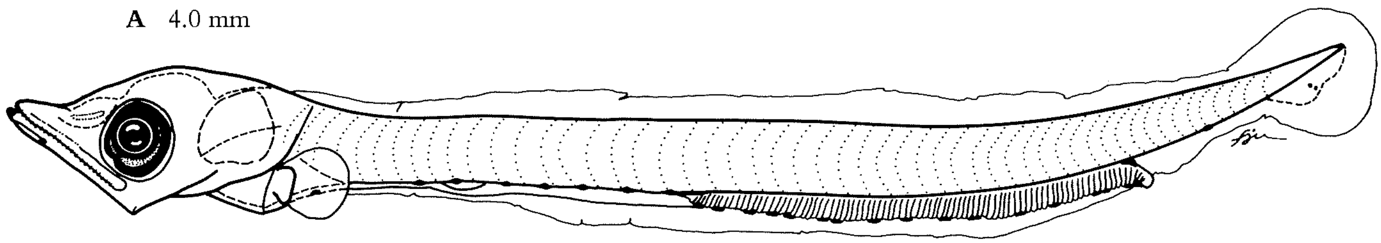
Material examined 18 larvae, 3.8–21.2 mm BL, coastal waters of New South Wales; 2 larvae, 8.1–9.5 mm BL, lower Swan Estuary (WA).

Additional references Blackburn (1941), Houde & Fore (1973), Miller *et al.* (1979), Miskiewicz (1987), Takita (1988), Leis & Trnski (1989).

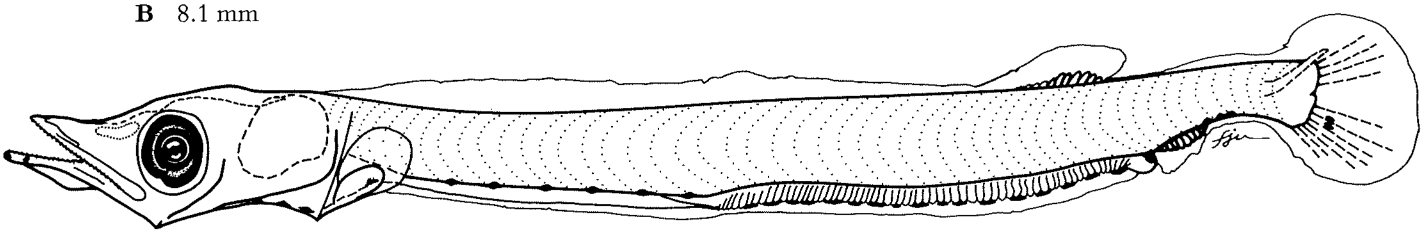
Figure 8 Larvae of *Etrumeus teres.* **A** Preflexion. **B** Preflexion. **C** Flexion; note developing dorsal and anal fins. **D** Ventral view of larva in C. **E** Early postflexion. **F** Postflexion; note developing pelvic fin. A, E, F from Sydney coastal waters (NSW); B, C from lower Swan Estuary (WA). Illustrated by F. J. Neira.



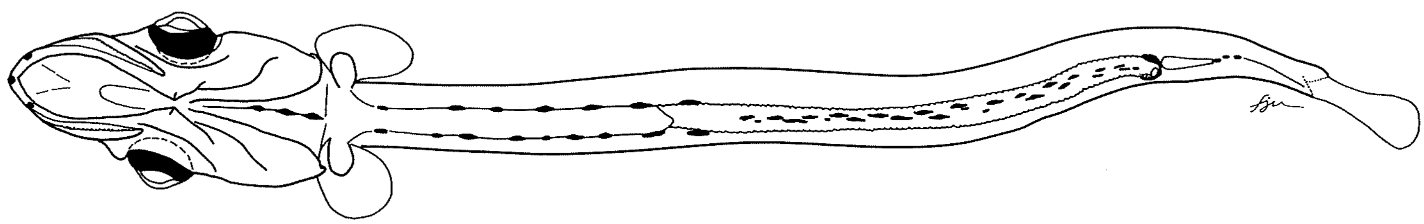
A 4.0 mm



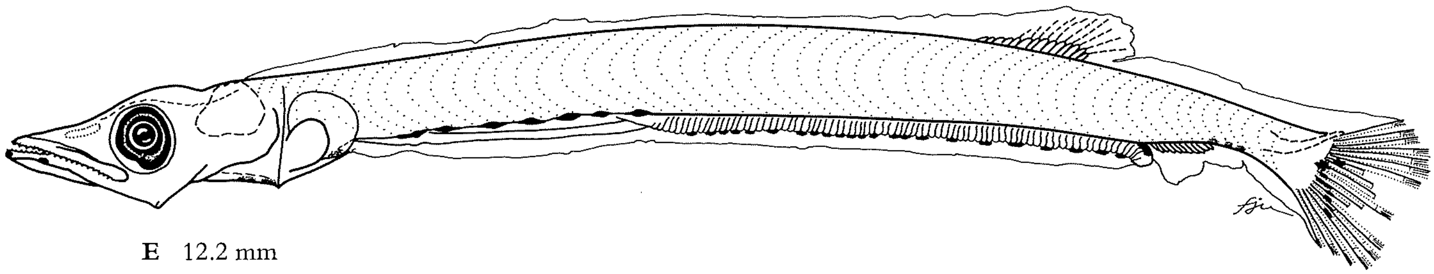
B 8.1 mm



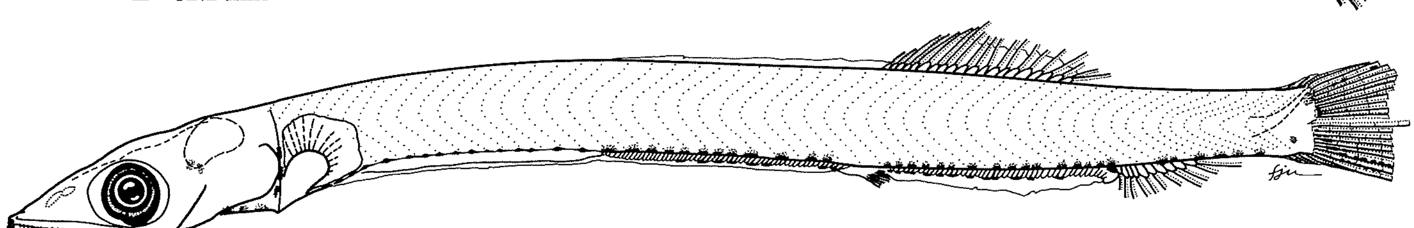
C 9.5 mm



D 9.5 mm



E 12.2 mm



F 19.8 mm

Clupeidae *Herklotsichthys castelnaui* (Ogilby, 1897) Southern herring

D 16–19 A 17–21 P_1 14 P_2 8 C 19 V 41–42

Adults Endemic to eastern Australia from north Queensland to the Gippsland Lakes (Vic). Found in estuarine and coastal marine waters. Adults are deep bodied, and have black pigment on the tip of the dorsal fin and upper lobe of the caudal fin. Maximum size 20 cm, usually to 14 cm (Whitehead, 1985; Paxton & Hanley, 1989a; Kuiter, 1993, 1996).

Importance to fisheries –

Spawning Eggs undescribed. Adults migrate from coastal waters into upper reaches of estuaries to spawn during summer and autumn (Blackburn, 1941; Roughley, 1964; State Pollution Control Commission, 1981). Larvae have been caught in Lake Macquarie (NSW) from September to April, with peak abundances between January and March (Miskiewicz, 1987).

Diagnostic characters

- 30–35 + 6–12 = 41–43 myomeres
- Cross-hatched pattern of muscle fibres visible until 15 mm
- Anus migrates anteriorly from myomere 35 to 30 between 2.5 and 19.1 mm
- Posterior end of dorsal fin 3–6 myomeres in front of origin of anal fin
- Melanophores over gut in postflexion larvae restricted to posteriormost portion of hindgut

Description of larvae

Morphology Body very elongate until late flexion stage (BD 5–10%), elongate from postflexion stage (BD 11–13%), initially cylindrical, slightly compressed by postflexion stage. Head small until late flexion stage (HL 14–17%), moderate from postflexion stage (HL 22–24%). Minute teeth in both jaws by mid-flexion stage. Gut very long (PAL 76–91%), straight and with striated hindgut. Anus migrates anteriorly from myomere 35 to 30 between 2.5 and 19.1 mm. Gas bladder inflated only in larvae caught at night. Posterior end of dorsal fin 3–6 myomeres in front of origin of anal fin.

Size at

Hatching	<3.0 mm
Notochord flexion	6.6–10.4 mm
Transformation	>19.1 mm
Formation of fins:	

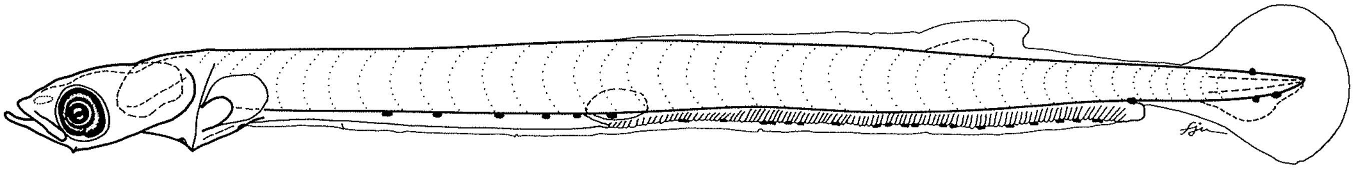
Caudal 5.3–10.0 mm; Dorsal 5.4–10.4 mm; Anal 7.2–11.8 mm; Pelvic 10.4–15.6 mm; Pectoral 15.6–>18.1 mm

Pigmentation Larvae are lightly pigmented. *External:* 1–2 melanophores on isthmus. Paired series of melanophores dorsolaterally along foregut; single series mid-ventrally along hindgut. Three small melanophores laterally on gut anterior to pelvic-fin base by 15.6 mm. One melanophore above anus. Up to 6 melanophores along anal-fin base and ventral midline of caudal peduncle in postflexion larvae. None to two melanophores dorsally and 2–5 melanophores ventrally along notochord tip in preflexion larvae; dorsal melanophores disappear by flexion stage, ventral melanophores remain. Additional melanophores over brain, lower jaw, and caudal-fin rays in postflexion and transforming larvae. *Internal:* One melanophore in otic region, 1–2 on cleithrum, and a series dorsally over hindgut in postflexion larvae. Melanophores dorsally along hindgut obscured by body wall in transforming larvae. One to three melanophores in hypural region, and 1 above urostyle in postflexion larvae.

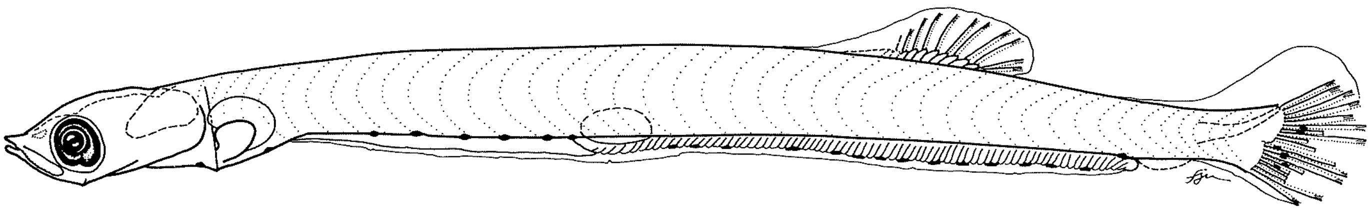
Material examined 18 larvae, 2.5–19.1 mm BL, Lake Macquarie (NSW).

Additional references Miskiewicz (1987), Thorrold & Williams (1989).

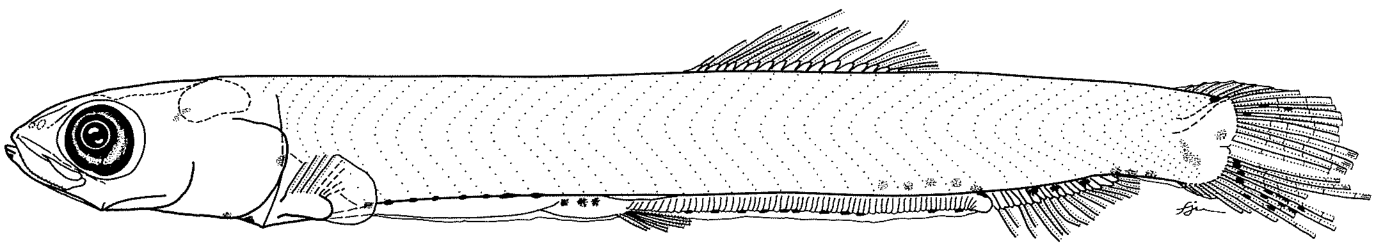
Figure 9 Larvae and transforming stage of *Herklotsichthys castelnaui*. **A** Preflexion; note developing dorsal fin. **B** Flexion; note developing anal fin. **C** Postflexion. **D** Ventral view of larva in C. **E** Transforming stage. A–C, E from NSW coastal waters. Illustrated by F. J. Neira.



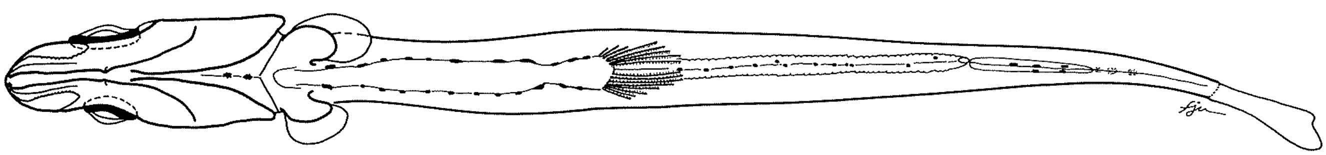
A 5.4 mm



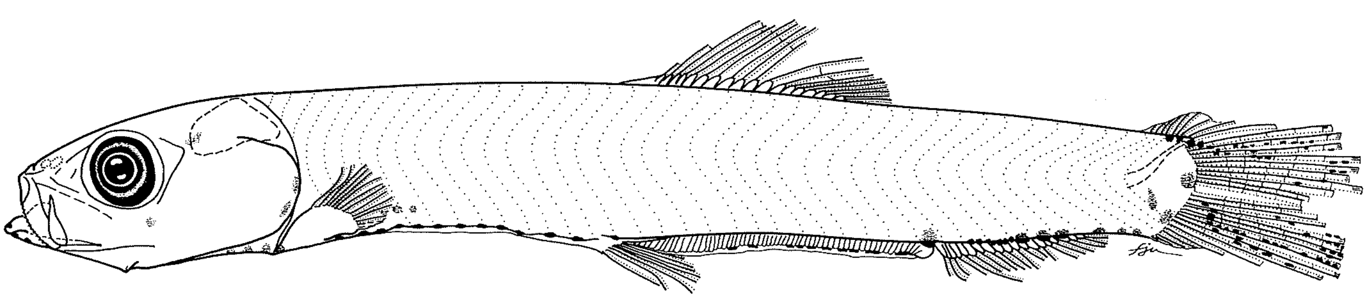
B 8.1 mm



C 15.5 mm



D 15.5 mm



E 19.2 mm

Clupeidae *Hyperlophus translucidus* McCulloch, 1917 Translucent sprat

D 15–16 A 19–22 P_1 13 P_2 7 C 19 V 40–42

Adults Endemic to eastern Australia from Caloundra (Qld) to Botany Bay (NSW). Occurs in estuaries and over shallow sandy areas of bays. Adults have an anal fin originating at or slightly behind the base of the last dorsal-fin ray, and are translucent with a silver stripe laterally. Maximum size about 6 cm (Whitehead, 1985; Paxton & Hanley, 1989a).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in Lake Macquarie (NSW) from September to May, with peak abundances between February and April (Miskiewicz, 1987).

Diagnostic characters

- 24–30 + 11–18 = 40–42 myomeres
- Cross-hatched pattern of muscle fibres visible until 12 mm
- Gut striations extend from posterior of foregut to entire hindgut
- Sheath of tissue on foregut in larvae up to about 15 mm
- Anus migrates anteriorly from myomere 30 to 24 between 3.0 and 30.6 mm
- Posterior end of dorsal fin initially 2 myomeres in front of origin of anal fin, and overlapping origin of anal fin by 1–2 myomeres in transforming stage
- 5–9 small melanophores above and below notochord tip in preflexion larvae
- No melanophores dorsally along gut prior to postflexion stage

Description of larvae

Morphology Body very elongate to elongate (BD 7–13%), elongate from late postflexion stage (BD 13–20%), cylindrical to slightly compressed. Head small to moderate (HL 16–22%). Minute teeth on both jaws from early flexion stage. Gut very long until postflexion stage (PAL 71–78%), long from transforming stage (PAL 61–65%), straight and with striated hindgut, striations from anterior to pelvic-fin base. Sheath of tissue anteriorly on foregut extending posteriorly over entire foregut from 15 mm. Anus migrates anteriorly from myomere 30 to 24 between 3.0 and 30.6 mm. Gas bladder inflated only in larvae caught at night. Posterior end of dorsal fin initially 2 myomeres in front of origin of anal fin, and overlapping origin of anal fin by 1–2 myomeres in transforming stage. Scutes and scales form between 27.0 and 30.6 mm.

Size at

Hatching	<3.0 mm
Notochord flexion	6.3–9.6 mm
Transformation	17.3–30.6 mm
Formation of fins:	

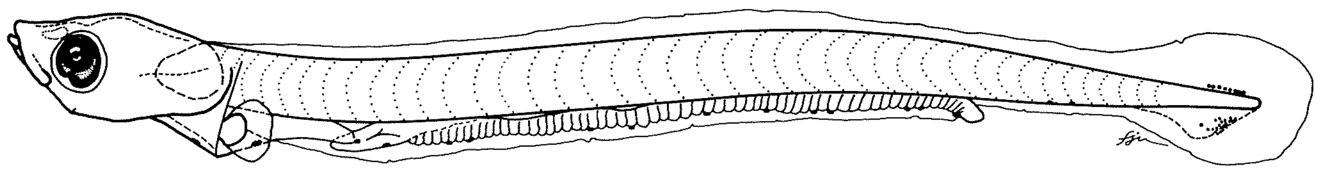
Dorsal 5.0–11.5 mm; Anal 5.0–11.5 mm; Caudal 5.8–9.5 mm; Pelvic 9.5–12.0 mm; Pectoral 16.3–20.8 mm

Pigmentation Larvae are lightly pigmented. *External*: 1 melanophore on isthmus in preflexion larvae, 2 from flexion stage, none in transforming larvae. Two or three melanophores on sheath of tissue over anterior of foregut, increasing in number as sheath extends posteriorly along foregut. Series of melanophores mid-ventrally along posterior of foregut and entire hindgut in preflexion larvae, disappearing during flexion stage. One or two small melanophores along ventral midline of caudal peduncle in preflexion larvae, increasing in number along anal-fin base and on caudal peduncle with growth. Five to nine small melanophores dorsally and ventrally along notochord tip in preflexion larvae; dorsal melanophores disappear, ventral melanophores remain along base of lower caudal-fin rays in postflexion larvae. Melanophores on tip of lower jaw and over midbrain, 2 melanophores posterior to pelvic-fin base, and melanophores along caudal-fin rays in transforming larvae. *Internal*: Melanophores in otic region, 1 lower on cleithrum, along dorsal surface of gas bladder, several dorsally over fore- and hindgut, and 1 above anus from postflexion stage. Melanophores in hypural region in postflexion larvae; additional melanophores along posterior caudal vertebrae in transforming larvae. Pigment along gut, over gas bladder and along vertebrae obscured by body wall in juveniles.

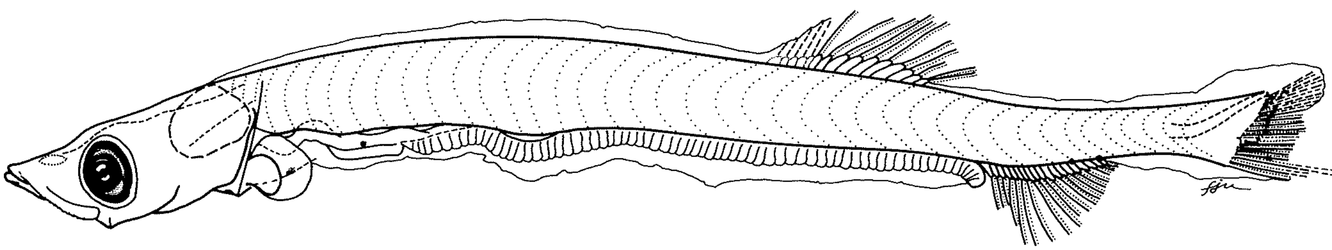
Material examined 20 larvae, 3.0–30.6 mm BL, Lake Macquarie (NSW).

Additional references Miskiewicz (1987).

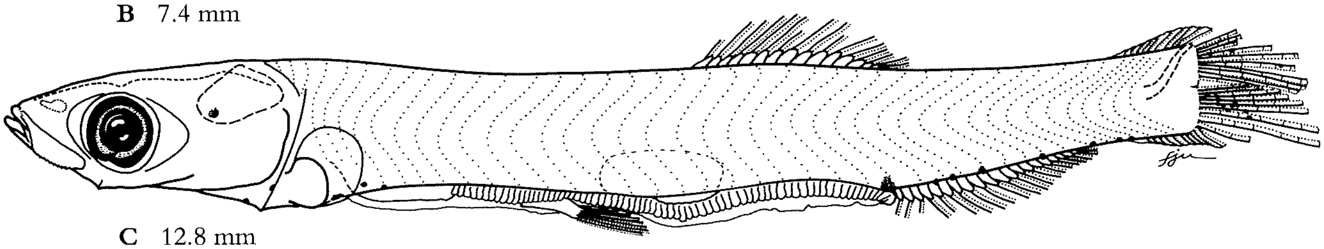
Figure 10 Larvae and transforming stage of *Hyperlophus translucidus*. **A** Preflexion. **B** Flexion. **C** Early postflexion. **D** Ventral view of larva in C. **E** Postflexion. **F** Transforming stage; scales are formed but only predorsal scales and ventral pre- and postpelvic scutes have been illustrated. A–C, E, F from Lake Macquarie (NSW). Illustrated by F. J. Neira.



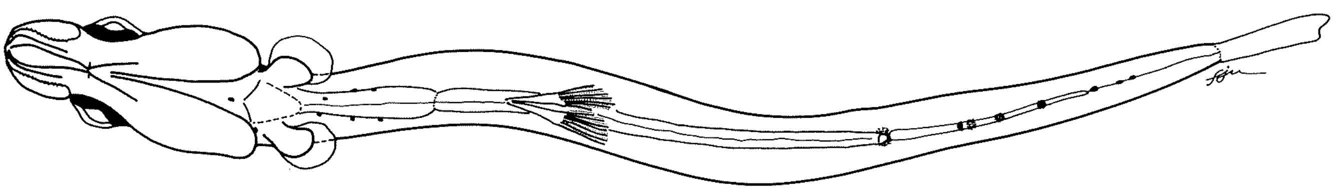
A 4.9 mm



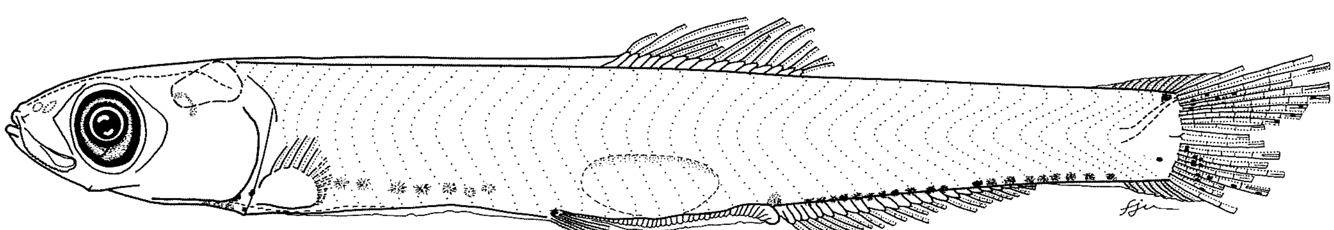
B 7.4 mm



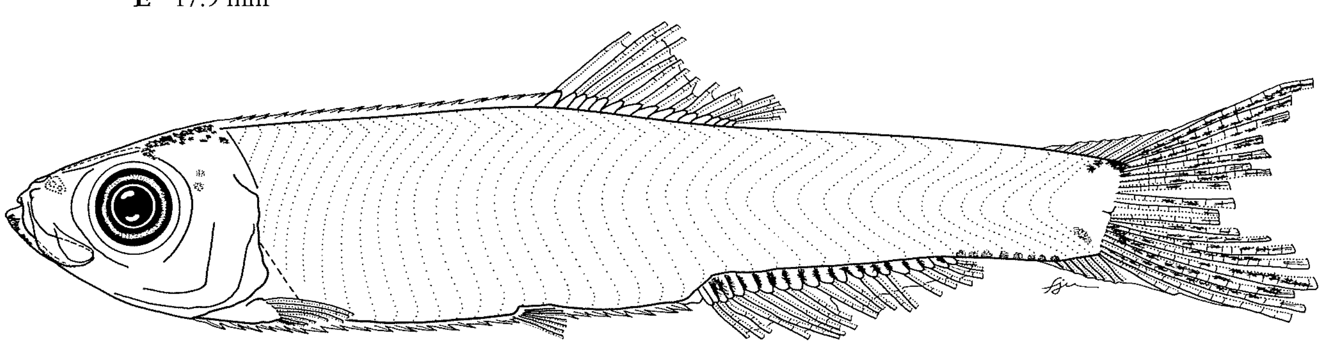
C 12.8 mm



D 12.8 mm



E 17.9 mm



F 29.0 mm

Clupeidae *Hyperlophus vittatus* (Castelnau, 1875) Sandy sprat

D 15–17 A 17–20 P_1 14–15 P_2 7 C 19 V 47–48

Adults Endemic to southern Australia from Kalbarri (WA) to Moreton Bay (Qld), excluding Tasmania. Found in estuaries and over shallow sandy areas of bays. Adults have an anal fin originating well behind the base of the last dorsal-fin ray, and are pale brown with a silver stripe laterally. Maximum size 10 cm (Whitehead, 1985; Hutchins & Swainston, 1986; Paxton & Hanley, 1989a; Kuiter, 1993).

Importance to fisheries Fished commercially mainly in Western Australia and used for bait and human consumption. Annual catches of up to 400 tonnes (Blackburn, 1941; Kailola *et al.*, 1993, Gaughan *et al.*, 1996b).

Spawning Eggs are pelagic and spherical, 0.8–1.0 mm in diameter, and have a smooth chorion, a segmented yolk, and a single oil globule 0.03–0.08 mm (Tregonning *et al.*, 1996). Spawns in nearshore marine waters throughout the year, with a peak activity in late autumn to early spring. Eggs have been collected off southwestern Western Australia in most months of the year, with peak abundances in June and July (Gaughan *et al.*, 1996a). Larvae have been caught in Western Australia in coastal waters off Perth from May to November, with peak abundances between July and September, and in the Swan Estuary in all months except February, with peak abundances in May and October (Gaughan *et al.*, 1990; Neira *et al.*, 1992); and in New South Wales entering Lake Macquarie from September to July (Miskiewicz, 1987), entering Tuggerah Lakes from January to May and October (Marsden, 1986), and in coastal waters off Sydney throughout the year (Gray *et al.*, 1992; Gray, 1993).

Diagnostic characters

- 33–36 + 12–15 = 46–48 myomeres
- Cross-hatched pattern of muscle fibres visible until 13 mm
- Anus migrates anteriorly from myomere 36 to 33 between 4.7 and 30.7 mm
- Posterior end of dorsal fin 1–3 myomeres in front of origin of anal fin, not overlapping anal fin
- 2–5 melanophores above and below notochord tip

Description of larvae

Morphology Body very elongate in preflexion and flexion larvae (BD 6–9%), elongate in postflexion larvae from 16 mm (BD 10–17%). Head small (HL 14–19%), moderate in transforming larvae and juveniles (HL 19–23%). Minute villiform teeth by 7.0 mm. Gut very long (PAL 70–78%), straight and with striated hindgut from early flexion stage. Anus migrates anteriorly from myomere 36 to 33 between 4.7 and 30.7 mm. Gas bladder inflated only in larvae caught at night. Posterior end of dorsal fin 1–3 myomeres in front of origin of anal fin. Scales form by 30.7 mm.

Size at

Hatching [1]	2.6 mm
Notochord flexion	9.1–11.9 mm
Transformation	20.0–25.0 mm
Formation of fins:	
Dorsal 6.3–13.0 mm; Caudal 6.3–13.0 mm; Anal 6.3–13.0 mm; Pelvic 13.0–20.0 mm; Pectoral 20.0–25.8 mm	

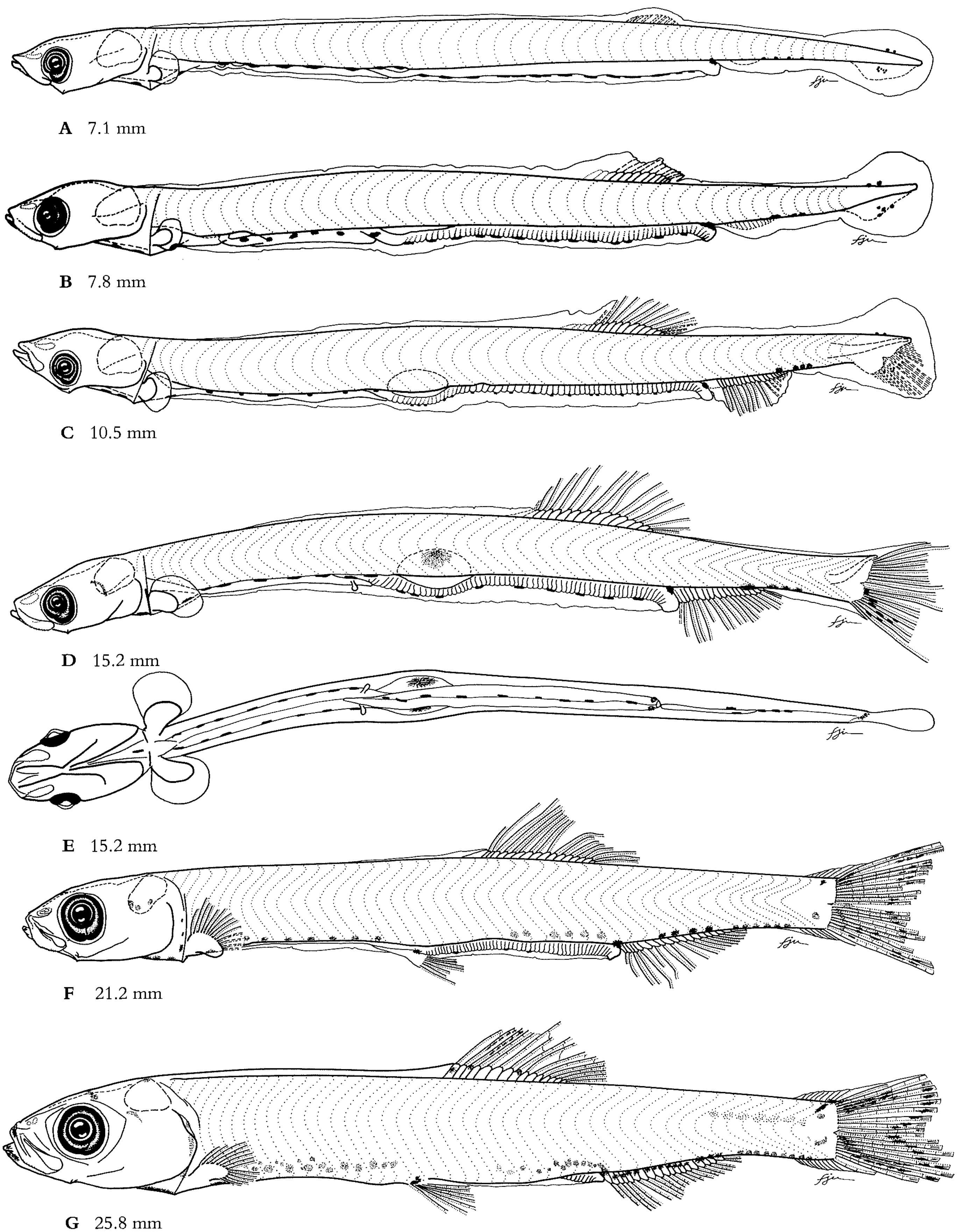
[1] Tregonning *et al.* (1996)

Pigmentation Larvae are lightly pigmented. *External*: 1–2 melanophores on isthmus in preflexion larvae, up to 4 in postflexion larvae. Paired series of 5–14 elongate melanophores dorsolaterally along foregut and a single series mid-ventrally along hindgut; mid-ventral series disappears during transformation. Two bilateral pairs of melanophores at pelvic-fin base following fin formation. Series along anal-fin base and ventral midline of caudal peduncle in postflexion larvae. Two to five melanophores dorsally and ventrally along notochord tip; dorsal melanophores disappear, ventral melanophores remain along base of lower caudal-fin rays in postflexion larvae. Melanophores on both jaws, over brain, along dorsal-fin rays and bases, and on upper caudal-fin rays in transforming larvae. *Internal*: Pigment in otic region from flexion stage. One to three melanophores on cleithrum and 1 melanophore over gas bladder in postflexion larvae. Melanophore series dorsally over hindgut from 16 mm, which develops from posterior to anterior. Pigment in hypural region and above posteriormost caudal vertebrae in postflexion larvae.

Material examined 27 larvae and juveniles, 4.7–30.7 mm BL, Lake Macquarie, Sydney Harbour and Botany Bay (NSW); 2 larvae, 15.2–21.2 mm BL, Swan and Peel–Harvey estuaries (WA).

Additional references Miskiewicz (1987).

Figure 11 Larvae and transforming stage of *Hyperlophus vittatus*. **A** Preflexion; note developing dorsal, caudal and anal fins. **B** Early flexion. **C** Flexion. **D** Early postflexion; note pelvic-fin bud. **E** Ventral view of larva in D. **F** Postflexion. **G** Transforming stage; scales omitted. A–C from Botany Bay (NSW); D from Swan Estuary (WA); F from Peel–Harvey Estuary (WA); G from Sydney Harbour (NSW). Illustrated by F. J. Neira.


A 7.1 mm
B 7.8 mm
C 10.5 mm
D 15.2 mm
E 15.2 mm
F 21.2 mm
G 25.8 mm

Clupeidae *Nematalosa vlaminghi* (Munro, 1956) Perth herring, bony bream

D 16–17 A 22–24 P_1 17–18 P_2 8 C 19 V 45–49

Adults Endemic to Western Australia from Broome to Bunbury. Occurs in estuarine and coastal waters. Adults are deep and laterally compressed, and have the ultimate dorsal-fin ray greatly elongate. Maximum size 36 cm (Chubb & Potter, 1984; Chubb *et al.*, 1984; Whitehead, 1985; Paxton & Hanley, 1989a).

Importance to fisheries Fished commercially in Western Australia and used mainly for bait in the western rock lobster fishery. About 80% of the catch from 1975 to 1983 was obtained between Perth and Bunbury (WA). Annual catch in the Swan Estuary ranges from 50 to 150 tonnes, about 35% of the Western Australian total (Chubb *et al.*, 1984; Chubb & Potter, 1984).

Spawning Late-stage eggs are pelagic and spherical, 1.2–1.5 mm in diameter, and have 1–3 oil globules. Mature individuals migrate from coastal marine waters to spawn in the upper reaches of estuaries between November and February (Chubb & Potter, 1984; Neira *et al.*, 1992). Larvae have been caught in the upper Swan Estuary (WA) in December and January (Neira *et al.*, 1992).

Diagnostic characters

- 36–40 + 6–13 = 46–49 myomeres
- Anus migrates anteriorly from myomere 40 to 36 between 4.0 and 16.8 mm
- Posterior end of dorsal fin 5–8 myomeres in front of origin of anal fin
- 5–8 internal melanophores dorsally along hindgut

Description of larvae

Morphology Body very elongate (BD 5–9%). Head small (HL 9–16%). Eyes pigmented by 3.7 mm. Minute villiform teeth from late preflexion stage. Gut very long (PAL 77–85%), straight and with striated hindgut from flexion stage. Anus migrates anteriorly from myomere 40 to 36 between 4.0 and 16.8 mm. Gas bladder inflated in postflexion larvae caught at night. Yolk sac is resorbed by 4.2 mm. Posterior end of dorsal fin 5–8 myomeres in front of origin of anal fin. Scales form after 30 mm (Neira, 1988).

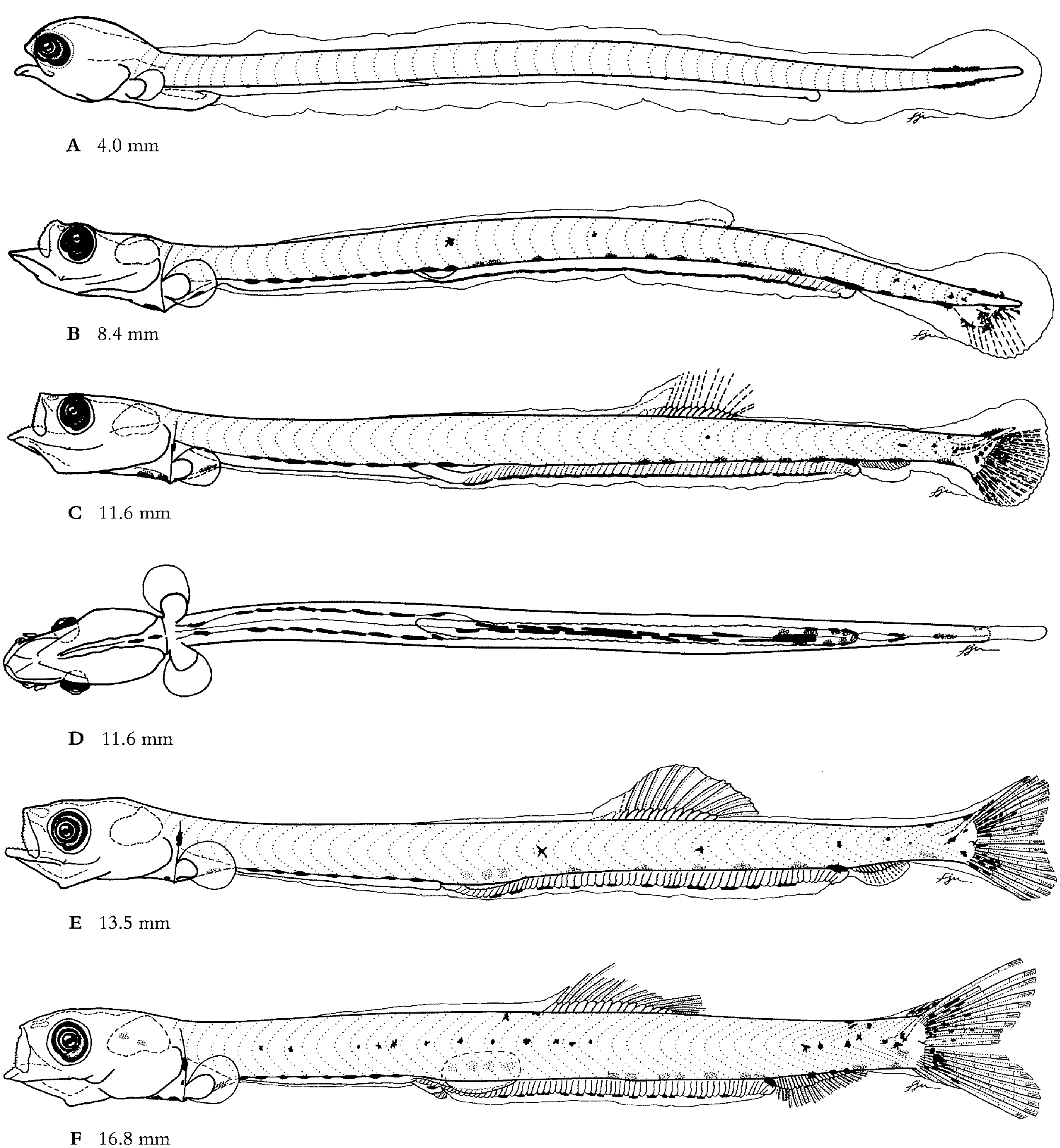
Size at	
Hatching	2.5–2.8 mm
Notochord flexion	9.7–12.7 mm
Transformation	>16.8 mm
Formation of fins:	
Dorsal 6.7–16.0 mm; Caudal 7.6–13.0 mm; Anal 10.0–16.0 mm; Pelvic 14.0–>16.8 mm; Pectoral >16.8 mm	

Pigmentation Larvae are lightly pigmented. *External*: 1–2 melanophores along isthmus, 1 pair posterior to cleithral symphysis, and a paired series of 7–11 elongate melanophores dorsolaterally along foregut. Continuous double stripe of pigment along ventral midline of hindgut, 1 large melanophore above anus, up to 3 along anal-fin base and ventral midline of caudal peduncle, and a few scattered melanophores along lateral midline of trunk and tail by late preflexion stage; mid-ventral pigment along hindgut becomes discontinuous during flexion stage. Series of small melanophores above and below notochord tip, the latter remaining along caudal-fin base and along caudal-fin rays in postflexion larvae. *Internal*: One or two melanophores along cleithrum from late flexion stage. A few melanophores in otic region from 14 mm, 3–4 large stellate melanophores on gas bladder in postflexion larvae; paired series of 5–9 melanophores dorsally along hindgut in late preflexion larvae.

Material examined 25 larvae, 2.5–16.8 mm BL, upper Swan Estuary (WA).

Additional references Neira (1988).

Figure 12 Larvae of *Nematalosa vlaminghi*. **A** Preflexion; note remnants of yolk sac. **B** Preflexion; note developing dorsal fin and hindgut striations. **C** Flexion; note most hindgut striations formed. **D** Ventral view of larva in C. **E** Postflexion. **F** Postflexion; note pelvic-fin bud. A–C, E, F from upper Swan Estuary (WA). Illustrated by F. J. Neira.


A 4.0 mm
B 8.4 mm
C 11.6 mm
D 11.6 mm
E 13.5 mm
F 16.8 mm

Clupeidae *Sardinops sagax* (Steindachner, 1879) Pilchard

D 17–20 A 16–21 P_1 16–19 P_2 8–9 C 19 V 47–53

Adults Distributed around southern Australia from Kalbarri (WA) to Rockhampton (Qld), including Tasmania; also around New Zealand to the Auckland Islands (57°S). Other sub-populations occur around southern Africa, the west coast of North and South America, and Japan. Found in estuarine and coastal waters. Adults have radiating bony striae on the opercle, and have a blue-green silvery body with a line of discrete dark spots along the lateral surface. Maximum size 30 cm, usually to 18 cm (Whitehead, 1985; Hutchins & Swainston, 1986; Parrish *et al.*, 1989; Paxton & Hanley, 1989a; Kuiter, 1993).

Importance to fisheries Small fisheries are restricted to Fremantle, Bunbury and Albany (WA), within Port Phillip Bay and coastal waters off the Gippsland Lakes (Vic), and Jervis Bay (NSW), with total annual catches of up to 10 000 tonnes. Fished with purse-seine nets and used mainly for pet food, feed for tuna farms, commercial and recreational bait, and a small proportion for human consumption (Fletcher, 1991; Kailola *et al.*, 1993; Neira *et al.*, 1997b).

Spawning Eggs are pelagic and spherical, 1.3–1.8 mm in diameter, and have a smooth chorion, a wide perivitelline space, a segmented yolk, and a single oil globule 0.15–0.17 mm (Dakin & Colefax, 1934; Baker, 1972; Robertson, 1975a). Spawns in coastal marine waters and in different seasons depending on geographical area (Blackburn, 1941, 1960; Whitehead, 1985; Fletcher, 1990). Eggs and larvae have been collected off southwestern Australia (Fletcher & Tregonning, 1992; Fletcher *et al.*, 1994), the Great Australian Bight (Blackburn, 1950b; Stevens *et al.*, 1984), and New South Wales (Dakin, 1937; Blackburn, 1941, 1949; Miskiewicz, 1987). Larvae have been caught in Western Australia in the lower Swan Estuary mostly in July and December (Gaughan *et al.*, 1990; Neira *et al.*, 1992), and coastal waters off Albany (Fletcher & Tregonning, 1992; Fletcher *et al.*, 1994); in Victoria outside Westernport Bay from November to April (Hoedt & Dimmlich, 1995); and in New South Wales entering Lake Macquarie throughout the year (Miskiewicz, 1987), and in coastal waters off Sydney from December to March (Gray *et al.*, 1992; Gray, 1993).

Diagnostic characters

- 36–42 + 10–13 = 48–53 myomeres
- Cross-hatched pattern of muscle fibres visible until 14 mm
- Anus migrates anteriorly from myomere 42 to 36 between 3.9 and 25.1 mm
- Posterior end of dorsal fin 4–6 myomeres in front of origin of anal fin
- Series of internal melanophores dorsally along hindgut in preflexion larvae

Description of larvae

Morphology Body very elongate (BD 5–8%), elongate after 20 mm (BD 9–12%). Head small, moderate after 25 mm (HL 10–22%). Minute villiform teeth by late preflexion stage. Gut very long (PAL 79–86%), straight and with striated hindgut. Anus migrates anteriorly from myomere 42 to 36 between 3.9 and 25.1 mm. Gas bladder inflated only in larvae caught at night. Posterior end of dorsal fin 4–6 myomeres in front of origin of anal fin. Scales form between 35 and 40 mm (Baker, 1972).

Size at

Hatching [1]	2.2–2.5 mm
Notochord flexion	9.8–12.2 mm
Transformation [1]	35.0–40.0 mm
Formation of fins:	
Caudal 7.5–12.2 mm; Dorsal 7.5–15.0 mm; Anal 9.3–15.0 mm; Pelvic 15.0–22.0 mm; Pectoral 21.7–25.1 mm	

[1] Baker (1972)

Pigmentation Larvae are lightly pigmented; pigment patterns may vary given the different breeding seasons and the geographical range of the species. *External*: 1–2 melanophores above hindbrain from late flexion stage; several along isthmus and posterior to cleithral symphysis from preflexion stage. Paired series of elongate melanophores dorsolaterally along foregut, a single series along ventral midline of hindgut, and 1 melanophore above anus. Two melanophores at pelvic-fin base by 21 mm. Melanophores along anal-fin base and ventral midline of caudal peduncle. Small melanophores under notochord tip in preflexion larvae, remaining along base of lower caudal-fin rays in postflexion larvae; additional melanophores along upper caudal-fin rays during flexion stage. Melanophores under orbit, along dentary, on snout, opercle, lateral midline of trunk and tail, dorsal-fin rays and bases, and dorsally along caudal peduncle by 24 mm. *Internal:* Melanophore series dorsally along hindgut in preflexion larvae; 2 melanophores in otic region, and pigment along cleithrum and above urostyle in postflexion larvae; pigment along posterior caudal vertebrae in late postflexion larvae.

Material examined 25 larvae, 3.9–25.1 mm BL, coastal waters of northern and central New South Wales, and Jervis Bay (NSW); 1 larva, 13.3 mm BL, off Albany (WA).

Additional references Dakin & Colefax (1934), Baker (1972), Miskiewicz (1987).

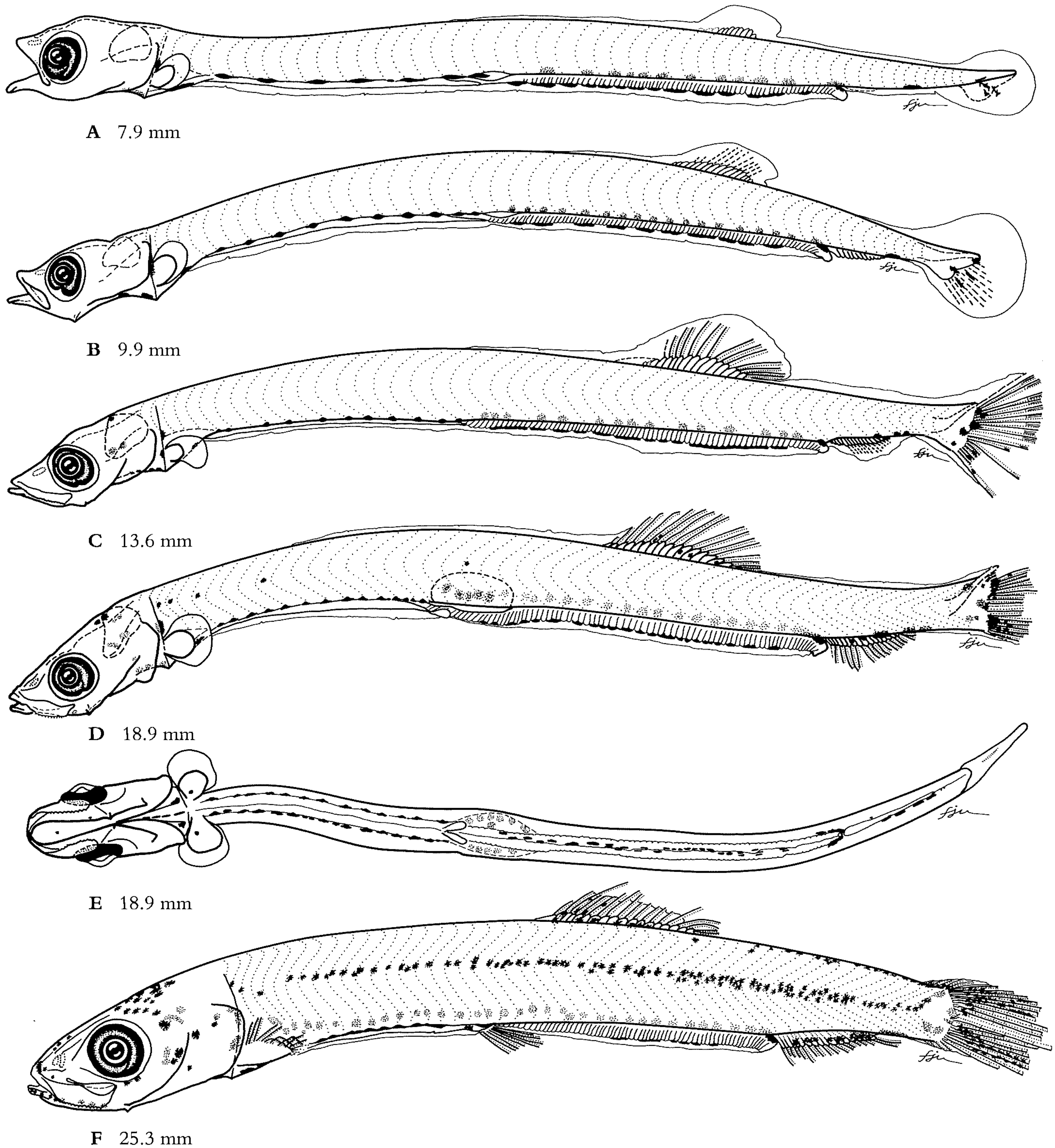


Figure 13 Larvae and transforming stage of *Sardinops sagax*. **A** Preflexion; note developing dorsal, caudal and anal fins. **B** Flexion. **C** Late flexion. **D** Postflexion; note pelvic-fin bud. **E** Ventral view of larva in D. **F** Transforming stage. A, B, D, F from Sydney coastal waters (NSW); C from Albany coastal waters (WA). Illustrated by F. J. Neira.

Clupeidae *Spratelloides robustus* Ogilby, 1897 Blue sprat, blue sardine

D 10–14 A 9–14 P_1 12–13 P_2 8 C 19 V 46–47

Adults Distributed around southern Australia from Dampier Archipelago (WA) to southern Queensland, including Tasmania. Found in the lower reaches of estuaries and coastal waters, often around shallow offshore reefs. Adults are dark blue and silvery, with a pair of longitudinal dark blue streaks near the centre of the caudal fin. Maximum size 12 cm (Wongratana, 1983; Whitehead, 1985; Hutchins & Swainston, 1986; Paxton & Hanley, 1989a; Kuiter, 1993; Gomon *et al.*, 1994).

Importance to fisheries Minor by-catch of other clupeoid fisheries and used mainly for bait (Kailola *et al.*, 1993).

Spawning Eggs undescribed. Eggs of the Japanese species *Spratelloides japonicus* are demersal and adhesive (Uchida *et al.*, 1958). Larvae have been caught entering Wilson Inlet (WA) in December and January (Neira & Potter, 1992a), entering Lake Macquarie (NSW) from September to April, with peak abundances between February and March (Miskiewicz, 1987), and in coastal waters off Sydney (NSW) from November to April (Gray, 1995).

Diagnostic characters

- 37–40 + 8–13 = 47–50 myomeres
- Muscle fibres without cross-hatched pattern
- Hindgut without striations
- Anus migrates anteriorly from myomere 40 to 37 between 3.7 and 18.1 mm
- Posterior end of dorsal fin 2–4 myomeres in front of origin of anal fin
- No pigment around tip of notochord in preflexion larvae
- 2–4 bilateral pairs of melanophores dorsally along posteriormost hindgut, above anus

Description of larvae

Morphology Body very elongate (BD 6–11%). Head small (HL 12–19%). Gut very long (PAL 76–89%), straight and with no striations on hindgut. Anus migrates anteriorly from myomere 40 to 37 between 3.7 and 18.1 mm. Gas bladder inflated only in larvae caught at night. Posterior end of dorsal fin 2–4 myomeres in front of origin of anal fin.

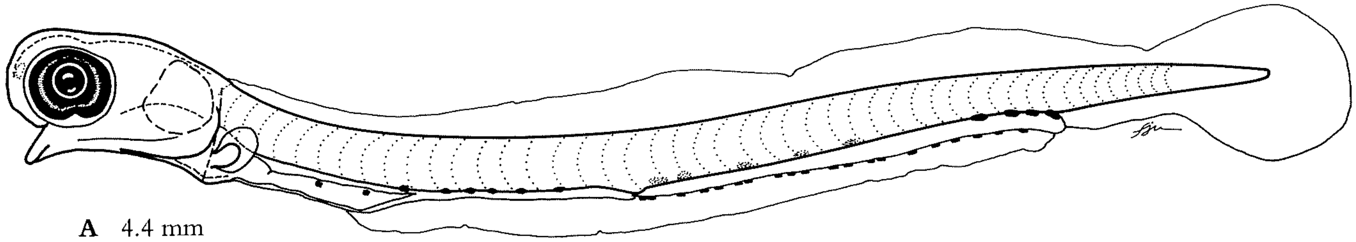
Size at	
Hatching	<4.3 mm
Notochord flexion	6.2–10.6 mm
Transformation	>18.1 mm
Formation of fins:	
Caudal 5.9–10.8 mm; Dorsal 5.9–13.7 mm; Anal 5.9–13.7 mm; Pelvic 12.4–14.6 mm; Pectoral >18.1 mm	

Pigmentation Larvae are lightly pigmented. *External:* Pair of melanophores above hindbrain by late flexion stage; additional melanophores on premaxilla and dentary in postflexion larvae. Paired series of 7–20 elongate melanophores dorsolaterally along foregut and a single series along ventral midline of hindgut, increasing in number with growth. Two to four pairs of melanophores dorsolaterally along posteriormost of hindgut, above anus. One or two melanophores along ventral midline of tail from flexion stage. Pigment along base of caudal-fin rays from late flexion stage. *Internal:* 1–2 melanophores in otic region and 2 under hindbrain from flexion stage. One melanophore along upper cleithrum in preflexion larvae, a second along lower cleithrum in postflexion larvae. One or two melanophores over gas bladder and 2–10 dorsolaterally over hindgut; 1–2 above urostyle in flexion larvae. Additional melanophores over gas bladder, a series dorsally along entire precaudal and caudal vertebrae, and around hypural region in postflexion larvae.

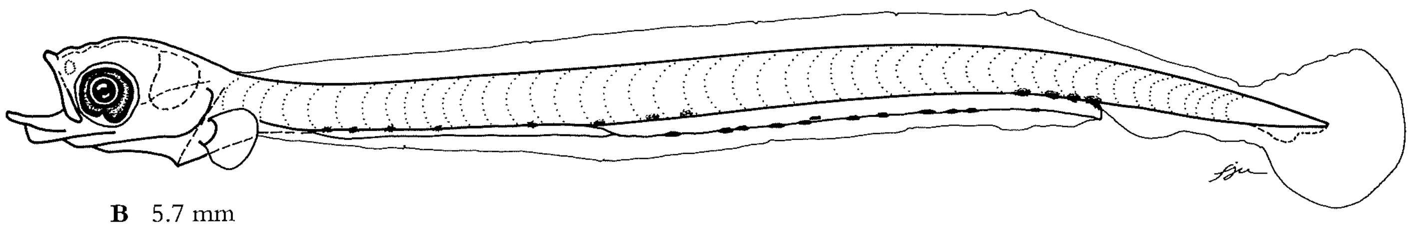
Material examined 22 larvae, 3.7–15.6 mm BL, Lake Macquarie and Botany Bay (NSW); 1 larva, 18.1 mm BL, Wilson Inlet (WA).

Additional references Miskiewicz (1987).

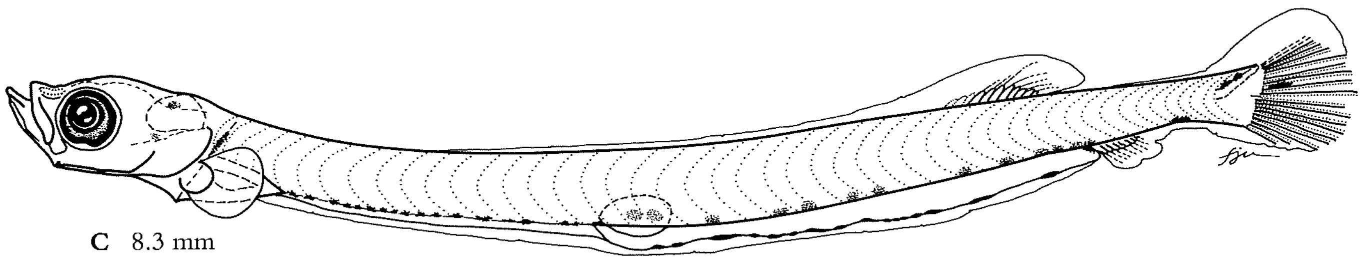
Figure 14 Larvae of *Spratelloides robustus*. **A** Preflexion. **B** Preflexion; note developing caudal fin. **C** Flexion; note developing dorsal and anal fins. **D** Postflexion. **E** Ventral view of larva in D; note developing pelvic fins. A from Botany Bay (NSW); B, C from Lake Macquarie (NSW); D from entrance channel of Wilson Inlet (WA). Illustrated by F. J. Neira.



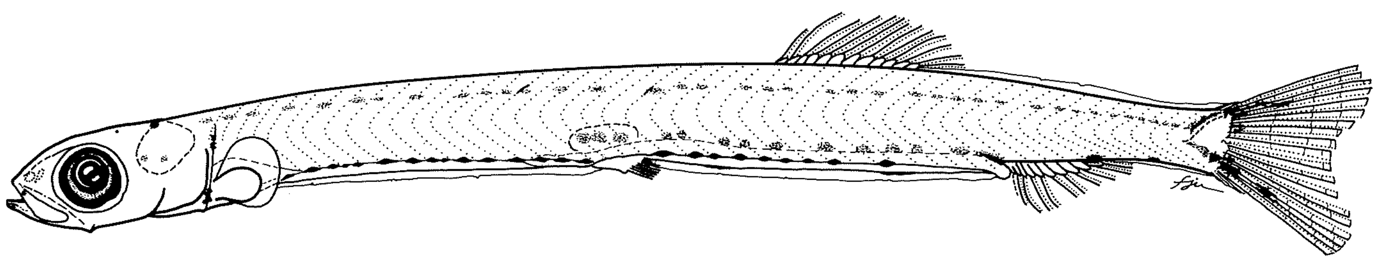
A 4.4 mm



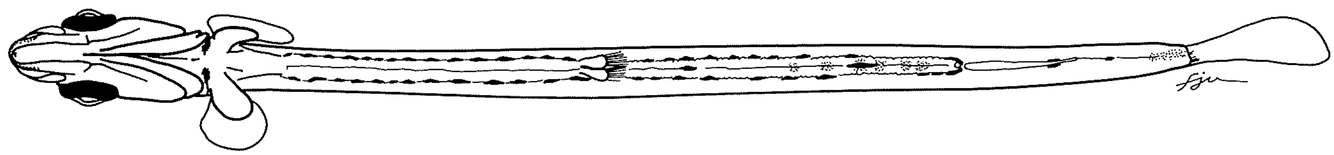
B 5.7 mm



C 8.3 mm



D 18.1 mm



E 18.1 mm

Engraulidae: Anchovies

A.G. Miskiewicz and F. J. Neira

Engraulids are found in estuaries and in shallow coastal waters of all seas between 60°N and 50°S, with a few species entirely in fresh water (Whitehead *et al.*, 1988). The family contains 16 genera and 139 species worldwide (Nelson, 1994). *Engraulis australis* is the only representative in temperate Australia and it is believed to comprise three subspecies on the basis of vertebral counts (Blackburn, 1950a; Paxton & Hanley, 1989b). Adults (most <20 cm, range 2–37 cm) are elongate, have a prominent snout projecting beyond the tip of the lower jaw, an underslung lower jaw, a long maxilla ending near the preopercular margin (except in the freshwater species *Amazonsprattus scintilla* in which the maxilla is very small), a short dorsal fin usually near midbody, and pelvic fins anterior, under or posterior to the dorsal fin. The anal fin varies in length and it is very long in *Coilia*, *Setipinna* and *Thryssa*. Dorsal and anal fins have no spines although some taxa have a small spine-like scute just anterior to the dorsal fin (Whitehead *et al.*, 1988). Eggs are pelagic and vary in shape from spherical (e.g. *Coilia*, *Setipinna*, *Thryssa*, 0.8–1.6 mm) to ovate (e.g. *Anchoa*, 0.8 × 0.7 mm) to extremely elliptical (e.g. *Engraulis* and some species of *Stolephorus*, 1.0–1.9 × 0.6–0.8 mm), have a segmented yolk and no oil globules except in *Coilia* and *Setipinna* (Robertson, 1975a; Zhang *et al.*, 1982; Zhang *et al.*, 1985; McGowan & Berry, 1984; Ikeda & Mito, 1988). Larvae have been described for representatives of most genera (see McGowan & Berry, 1984, and references therein; see also Zhang *et al.*, 1982; Zhang *et al.*, 1985; Fahay, 1983; Takita, 1988; Leis & Trnski, 1989; Watson & Sandknop, 1996b).

Meristic characters of the engraulid species of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Engraulis australis	(1)	13–18	17–19	15–17	7	19	40–48

Main characters of engraulid larvae

- 38–77 myomeres, typically 38–47; muscle fibres in a cross-hatched pattern, more evident in preflexion and flexion larvae
- Body very elongate to elongate (BD 7–19%), cylindrical to slightly compressed
- Head small to moderate (HL 11–28%), without spines
- Gut moderate to very long (PAL 48–81%), straight and with strongly striated hindgut
- Gut shortens with growth, anus migrates anteriorly by up to 7 myomeres
- Gas bladder over midgut, usually inflated
- Dorsal and anal fins posteriorly located, posterior end of dorsal fin overlaps origin of anal fin by 1–4 myomeres (except in *Thryssa* in which the dorsal fin is entirely anterior to anus); degree of overlap varies among taxa and developmental stage
- Body lightly pigmented, pattern along dorsal surface of gut species-specific
- No pigment dorsally along trunk and tail prior to transformation

References to engraulid larvae

Fahay (1983), McGowan & Berry (1984), Takita (1988), Leis & Trnski (1989), Watson & Sandknop (1996b).

Families with similar larvae

Ammodytidae – Myomeres without cross-hatched pattern; very small preopercular spines from 10 mm; long-based, continuous dorsal fin, 36–69 rays; gut without striations; continuous longitudinal series of melanophores or patches over gut and along ventral surface of trunk and tail.

Aulostomidae – 61–65 myomeres, without cross-hatched pattern; gut without striations; large size at notochord flexion (*ca* 20 mm).

Chanidae – Myomeres without cross-hatched pattern; gut without striations; melanophore series dorsally along trunk and tail.

Chirocentridae – 69–75 myomeres; no pigment ventrally along gut.

Clupeidae – 40–60 myomeres; posterior end of dorsal fin does not overlap anal-fin origin, or at most overlaps by up to 2 myomeres.

Creediidae – Myomeres without cross-hatched pattern; small posterior preopercular spines in 5–10 mm larvae; numerous small melanophores in series or in clusters along dorsal and ventral midlines of trunk and tail.

Galaxiidae (species with estuarine/marine phase) – Myomeres without cross-hatched pattern; dorsal and anal fins directly opposite; weakly striated gut; some pigment dorsally along trunk and tail.

Gonorhynchidae – 54–61 myomeres without cross-hatched pattern; gas bladder not apparent; heavy opposing pigment along dorsal and ventral surfaces of caudal peduncle.

Gonostomatidae (e.g. *Cyclothone*) – 29–33 myomeres, without cross-hatched pattern; gut moderate (PAL ~50%); dorsal and anal fins directly opposite.

Odacidae (early stages) – Myomeres without cross-hatched pattern; gut without striations.

Photichthyidae (some genera, e.g. *Vinciguerria*) – Myomeres without cross-hatched pattern; eyes oval and semi-stalked; no pigment ventrally along gut.

Protroctidae (one species with estuarine/marine phase) – Myomeres without cross-hatched pattern; adipose dorsal fin.

Schindleriidae – 31–44 myomeres, without cross-hatched pattern; gut without striations; small size at notochord flexion (2.5–3.5 mm).

Synodontidae – Myomeres without cross-hatched pattern; late forming dorsal fin (>10 mm); adipose fin from about 10 mm; prominent pigment blotches along dorsolateral surface of gut.

Engraulidae *Engraulis australis* (White, 1790) Anchovy

D 13–18 A 17–19 P_1 15–17 P_2 7 C 19 V 40–48

Adults Distributed around southern Australia from Point Quobba (WA) to Rockhampton (Qld), including Tasmania and Lord Howe Island; also around New Zealand. Found in estuaries, bays and coastal waters to a depth of 65 m. Adults have a rounded, long snout, a large inferior mouth with the maxilla extending beyond the eye, and are blue–green and silver–white. Maximum size 15 cm (Robertson, 1973; Hutchins & Swainston, 1986; Whitehead *et al.*, 1988; Paxton & Hanley, 1989b; Kuiter, 1993).

Importance to fisheries Fished commercially on a small scale in Fremantle and the Wilson Inlet (WA), Port Phillip Bay and the Gippsland Lakes (Vic), and Jervis Bay and Sydney Harbour (NSW). Caught mainly with purse-seine nets and used for pet food and bait (Blackburn 1941, 1950a; Winstanley, 1979; Whitehead *et al.*, 1988; Kailola *et al.*, 1993; Neira *et al.*, 1997a).

Spawning Eggs are pelagic and elliptical, 1.1–1.4 × 0.5–0.6 mm, and have a segmented yolk and no oil globule (Robertson, 1975a). Spawns in both estuarine and marine waters throughout the year, with peak spawning in spring through to autumn. Larvae have been caught in Western Australia in the Swan and Nornalup–Walpole estuaries, and in Wilson Inlet in most months, with peak abundances between October and December (Gaughan *et al.*, 1990; Neira & Potter, 1992b, 1994; Neira *et al.*, 1992); in Victoria in Port Phillip Bay and the Gippsland Lakes (Arnott & McKinnon, 1985; Jenkins, 1986b; Ramm, 1986); and in New South Wales in Lake Macquarie, Tuggerah Lakes, and in coastal waters of northern and central New South Wales, and off Sydney (Marsden, 1986; Miskiewicz, 1987; Gray, 1995).

Diagnostic characters

- 26–33 + 13–20 = 44–47 myomeres
- Cross-hatched pattern of muscle fibres visible until 12 mm
- Anus migrates anteriorly from myomere 33 to 26 between 2.9 and 32.2 mm
- Posterior end of dorsal fin overlaps anterior end of anal fin by up to 3 myomeres
- No melanophores along dorsal surface of hindgut prior to flexion stage

Description of larvae

Morphology Body very elongate through to postflexion stage, elongate in transforming stage (BD 7–15%). Head small through to postflexion stage, moderate by transforming stage (HL 14–24%). Snout round, lower jaw inferior from transforming stage. Minute teeth in both jaws by 8.5 mm. Gut initially very long (PAL 69–80%), long in transforming larvae (PAL to 66%), straight and with striated hindgut. Anus migrates anteriorly from myomere 33 to 26 between 2.9 and 32.2 mm. Gas bladder inflated only in larvae caught at night. Posterior end of dorsal fin overlaps anterior end of anal fin by up to 3 myomeres.

Size at

Hatching	<2.9 mm
Notochord flexion	7.6–11.1 mm
Transformation	>29 mm

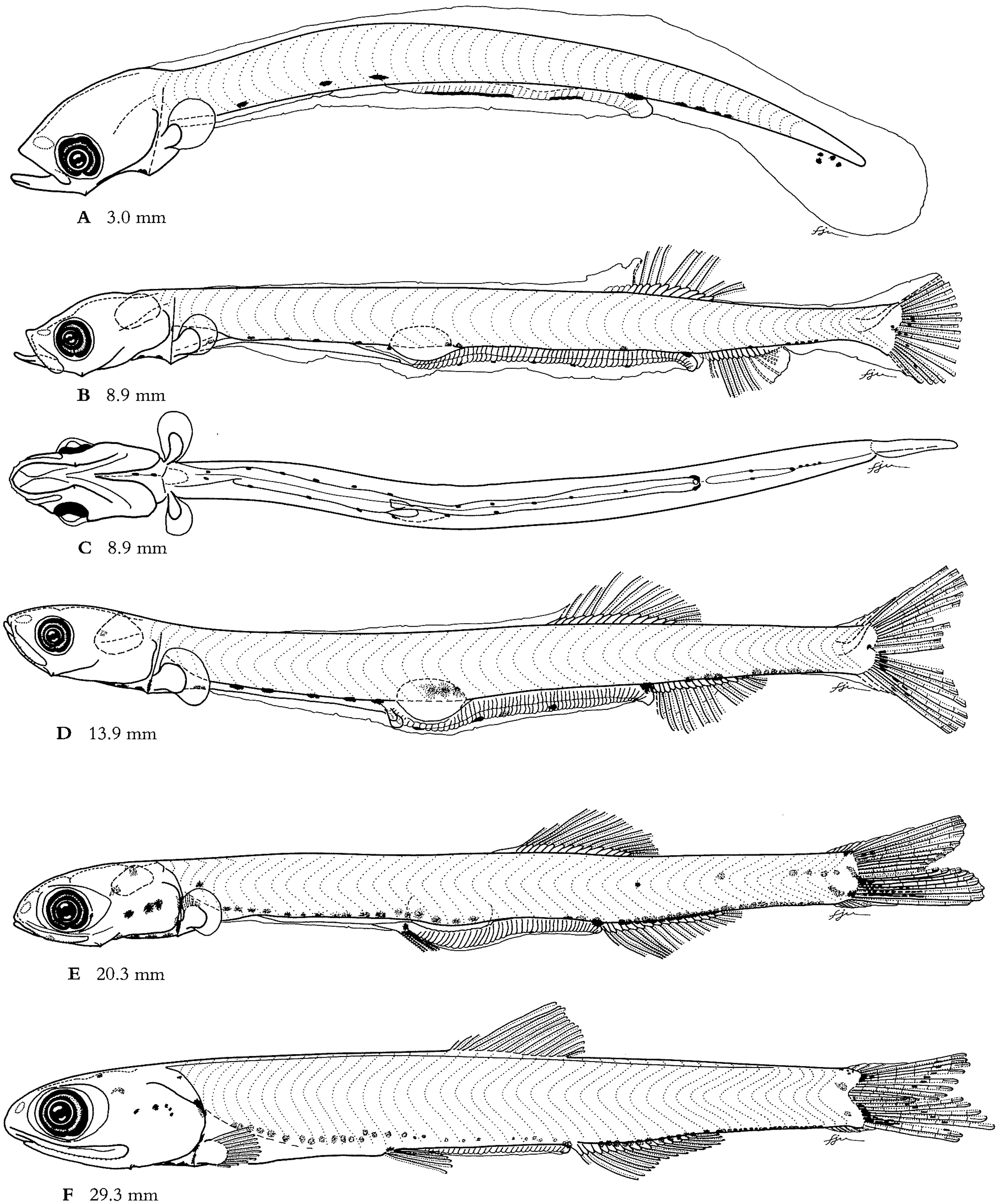
Formation of fins:
Dorsal 4.5–12.7 mm; Caudal 5.0–11.1 mm; Anal 5.0–13.3 mm; Pelvic 13.8–20.2 mm; Pectoral 20.2–>32.2 mm

Pigmentation Larvae are lightly pigmented. Pigment varies in intensity depending on locality; larvae caught in estuaries such as Wilson Inlet tend to be more heavily pigmented than those caught in marine waters. *External*: 1–2 melanophores along isthmus. Paired series of elongate melanophores along dorsolateral surface of foregut; single series along ventral midline of hindgut; bilateral pair of melanophores above anus. Three to five melanophores along ventral midline of tail, increasing in number along anal-fin base and caudal peduncle during postflexion stage. Small melanophores under notochord tip in preflexion larvae, remaining along base of lower caudal-fin rays in postflexion larvae. Additional melanophores on head, opercle, at pelvic-fin base, and caudal-fin rays in postflexion larvae, and along dorsal and lateral surfaces of trunk and tail in transforming larvae. Melanophores along foregut, hindgut and ventral surface of tail obscured by thickening of body wall in transforming larvae. *Internal:* Melanophores on gas bladder and a few dorsally along hindgut in flexion larvae. Pigment in otic region, along cleithrum, above urostyle and above posterior caudal vertebrae in postflexion larvae.

Material examined 29 larvae, 3.1–32.2 mm BL, Lake Macquarie and Botany Bay (NSW); 3 larvae, 2.9–20.2 mm BL, Swan Estuary (WA).

Additional references Blackburn (1941), Baker (1972), Robertson (1973), Miskiewicz (1987).

Figure 15 Larvae and transforming stage of *Engraulis australis*. **A** Preflexion. **B** Early postflexion. **C** Ventral view of larva in B. **D** Postflexion; note pelvic-fin bud. **E** Postflexion; note developing pectoral fin. **F** Transforming stage. A, D from Swan Estuary (WA); B, F from Botany Bay (NSW); E from Walpole Estuary (WA). Illustrated by F. J. Neira.


A 3.0 mm
B 8.9 mm
C 8.9 mm
D 13.9 mm
E 20.3 mm
F 29.3 mm

GONORHYNCHIFORMES

The Gonorhynchiformes is a very small order of primarily freshwater fishes found in tropical regions of Africa, with a few brackish and marine species in tropical to temperate regions of the Indian and Pacific oceans (Nelson, 1994). The order contains 4 families, 7 genera and 35 species (Nelson, 1994). Families comprise the Chanidae (milkfish), Gonorhynchidae (beaked sandfishes), Kneriidae and Phractolaemidae (snake mudhead). Gonorhynchiform fishes are elongate and have a small mouth with toothless jaws, and posteriorly located, spineless pelvic, dorsal and anal fins. Members of this order share several morphological affinities with clupeiforms, perhaps suggesting an evolutionary link between the two and the ostariophysan group that includes Characiformes, Cypriniformes and Siluriformes (Fink & Fink, 1981; Richards, 1984; Nelson, 1994). Larvae have been described for the single species of the Chanidae (*Chanos chanos*) and some representatives of the Gonorhynchidae, but are unknown for members of the other two families (see review of early life history stages by Richards, 1984; see also Olivar & John, 1987; Bruce, 1989a; Leis & Trnski, 1989).

Families and species included here

GONORHYNCHIDAE
Gonorhynchus greyi

Gonorhynchidae: Beaked salmons

B.D. Bruce

Gonorhynchids are marine fishes predominantly found in estuarine and shelf waters of the Indo-Pacific. The family contains 1 genus, *Gonorhynchus*, and at least 7 species although many authors believe the number to be less (Fink & Fink, 1981; Smith, 1986a; Nelson, 1994). The genus has an antitropical distribution, although it has been recorded from Hawaii to at least 18°S off the Great Barrier Reef (Bruce, 1989a). *Gonorhynchus greyi* is the only species in southern Australian waters (Last *et al.*, 1983; Paxton & Hanley, 1989d; Gomon *et al.*, 1994). Adults (to 60 cm) are elongate, have a protruding snout with a small barbel at the end, an inferior mouth without teeth, four or five branchiostegals, epibranchials behind the fourth gill arch, posteriorly-placed, spineless dorsal, anal and pelvic fins, ctenoid scales, and no gas bladder (Smith, 1986a). Eggs are unknown (Richards, 1984). Larvae have been described for *G. abbreviatus* (Furukawa, 1951; Hattori, 1964; Okiyama, 1988b), *G. gonorhynchus* (Olivar & John, 1987) and *G. greyi* (Bruce, 1989a). The large size reached prior to settlement (up to 90 mm) (Hattori, 1964) constitutes the only apparent specialisation of gonorhynchid larvae to pelagic life (Bruce, 1989a).

Meristic characters of the gonorhynchid genus of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Gonorhynchus	(1)	11–14	9–10	8–10	10	19	54–61

Main characters of gonorhynchid larvae

- 54–61 myomeres
- Body very elongate (BD 6–9%)
- Head small (HL 12–18%), without spines
- Mouth small, initially terminal but becoming subterminal in larger larvae
- Dorsal and anal fins posteriorly located; posterior end of dorsal fin separated by 6–9 myomeres from origin of anal fin
- Gut straight and very long (PAL 77–90%), with a strongly striated hindgut
- No apparent gas bladder
- No pigment ventrally along gut
- Heavy opposing pigment along dorsal and ventral surfaces of caudal peduncle

References to gonorhynchid larvae

Hattori (1964), Richards (1984), Olivar & John (1987), Okiyama (1988b), Bruce (1989a).

Families with similar larvae

Ammodytidae – Very small preopercular spines from 10 mm; long-based, continuous dorsal fin with 36–69 rays; gut long (PAL 59–70%), without striations; continuous longitudinal series of melanophores or patches over gut and along ventral surface of trunk and tail.

Aulostomidae – 61–65 myomeres; gut moderate to long (PAL 48–65%), without striations; large size at notochord flexion (*ca* 20 mm).

Chanidae – 44–47 myomeres; gut without striations; melanophore series dorsally along trunk and tail.

Chirocentridae – 69–75 myomeres; lack heavy opposing pigment along dorsal and ventral surfaces of caudal peduncle.

Clupeidae – Myomeres with muscle fibres in a cross-hatched pattern in most taxa; gas bladder present, prominent in larvae caught at night; lack heavy opposing pigment along dorsal and ventral surfaces of caudal peduncle.

Creediidae – Small posterior preopercular spines in larvae 5–10 mm; gut moderate to long (PAL 44–62%); pigment along dorsal midline of tail.

Engraulidae – Typically 38–47 myomeres, with muscle fibres in a cross-hatched pattern; gas bladder present and prominent in larvae caught at night; gut moderate to very long (PAL 48–81%); lack heavy opposing pigment along dorsal and ventral surfaces of caudal peduncle.

Galaxiidae (species with estuarine/marine phase) – Dorsal and anal fins directly opposite; gut long to very long (PAL 68–77%), weakly striated by postflexion stage; some pigment dorsally along trunk and tail.

Gonostomatidae (e.g. *Cyclothone*) – 29–33 myomeres; gut moderate (PAL ~50%); dorsal and anal fins directly opposite.

Photichthyidae (some genera, e.g. *Vinciguerria*) – Eyes oval and semi-stalked; gas bladder present; lack heavy opposing pigment along dorsal and ventral surfaces of caudal peduncle.

Protroctidae (one species with estuarine/marine phase) – Adipose dorsal fin.

Schindleriidae – 31–44 myomeres; gut long to very long (PAL 54–75%), without striations; small size at notochord flexion (2.5–3.5 mm).

Synodontidae – Anteriorly located pelvic and dorsal fins; adipose fin from about 10 mm; prominent pigment blotches along dorsolateral surface of gut; lack heavy opposing pigment along dorsal and ventral surfaces of caudal peduncle.

Gonorhynchidae *Gonorhynchus greyi* (Richardson, 1845) Beaked salmon

D 11–14 A 9–10 P_1 8–10 P_2 10 C 19 V 54–61

Adults Distributed around southern Australia from Shark Bay (WA) to Noosa Head (Qld), including Tasmania and Lord Howe Island. Occurs on shallow sandy bottoms of estuaries and in coastal waters to a depth of 160 m. Adults are elongate and have a pointed snout with a tube-like mouth, a small barbel on the lower jaw, a single, posteriorly-located dorsal fin, and a dark blotch on the dorsal, anal and caudal fins. They bury themselves head first when disturbed. Maximum size 50 cm (Last *et al.*, 1983; Hutchins & Swainston, 1986; Paxton & Hanley, 1989d; Gomon *et al.*, 1994).

Importance to fisheries Edible flesh although not highly esteemed (Gomon *et al.*, 1994).

Spawning Eggs undescribed. Larvae have been caught in coastal waters off southwestern Australia in December, coastal waters of eastern Tasmania from April to June, coastal waters off northern and central New South Wales from January to June (A.G. Miskiewicz, pers. comm.), and in coastal waters off Sydney (NSW) from October to July (Gray *et al.*, 1992; Gray, 1993).

Diagnostic characters

- 46–53 + 8–11 = 54–61 myomeres
- Prominent striations on hindgut in larvae >6.0 mm
- Gas bladder not apparent
- Posteriorly placed dorsal, anal and pelvic fins; dorsal and anal fins do not overlap
- Prominent pigment patch over dorsal and ventral midlines of caudal peduncle
- Small melanophores along lateral midline of trunk and tail in postflexion larvae
- 11–17 roughly alternating, evenly spaced internal melanophores dorsally along entire gut

Description of larvae

Morphology Body very elongate (BD 6–9%). Head small (HL 12–18%). Mouth small; snout overhangs lower jaw from 22 mm. Small fleshy papillae at corners of mouth by 30 mm. Single, medial barbel ventrally on snout in adults does not apparently form until after settlement. Gut very long (PAL 77–90%), straight and with strongly striated hindgut from late preflexion stage; striations obscured by overlying musculature from 20 mm. Dorsal, anal and pelvic fins all posteriorly placed, dorsal and anal fins short-based. Dorsal fin located entirely anterior to anal fin, does not migrate during development; posterior end of dorsal fin 6–9 myomeres in front of anus.

Size at

Hatching	<2.5 mm
Notochord flexion	7.6–12.0 mm
Settlement	>75.0 mm
Formation of fins:	

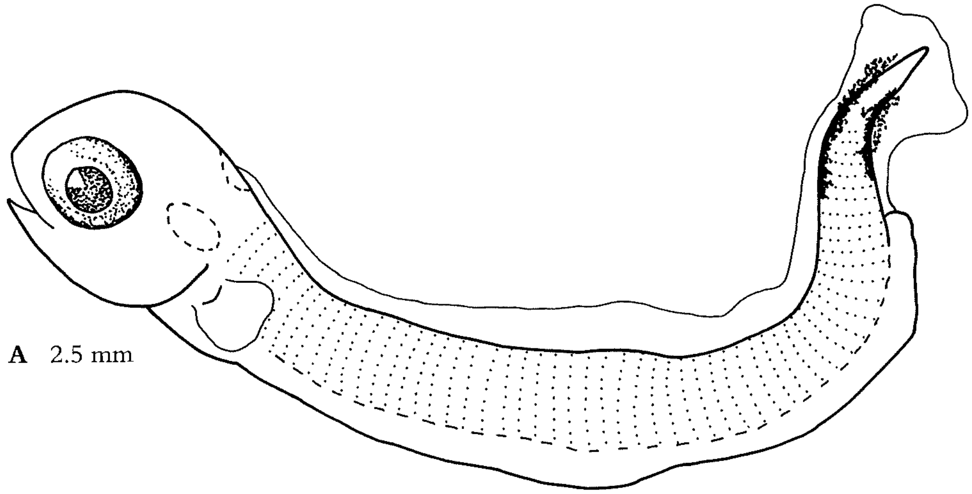
Dorsal 6.6–22.7 mm; Anal 6.6–22.7 mm; Caudal 10.1–13.2 mm; Pelvic 15.0–28.0 mm; Pectoral 20.5–40.2 mm

Pigmentation Larvae are lightly pigmented. *External*: 1–4 melanophores dorsally over head by late flexion stage. Scattered melanophores on snout in late postflexion larvae. One or two melanophores on opercle and 1–3 on ventral rim of orbit by 18.6 mm. Melanophore series along lateral midline of trunk and tail by postflexion stage. Prominent pigment patch along dorsal and ventral midlines of caudal peduncle. Scattered melanophores on caudal-fin rays in postflexion larvae. *Internal*: 1 melanophore near otic capsule. Series of 11–17 roughly alternating, evenly spaced melanophores dorsally along entire gut. One or two melanophores laterally near pelvic-fin base and just anterior to anus by 18.6–20.0 mm.

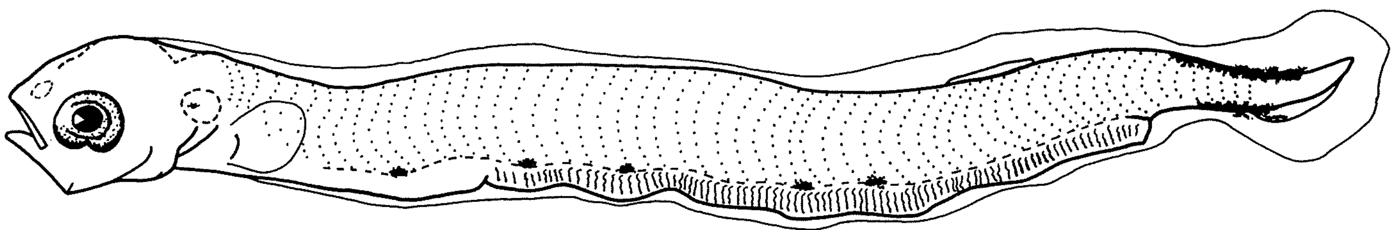
Material examined 30 larvae, 2.5–45.2 mm BL, coastal waters of central New South Wales; 5 larvae, 25.8–75.0 mm BL, coastal waters of eastern Tasmania; 5 larvae, 20.2–26.1 mm BL, Rottnest Island (WA).

Additional references Bruce (1989a).

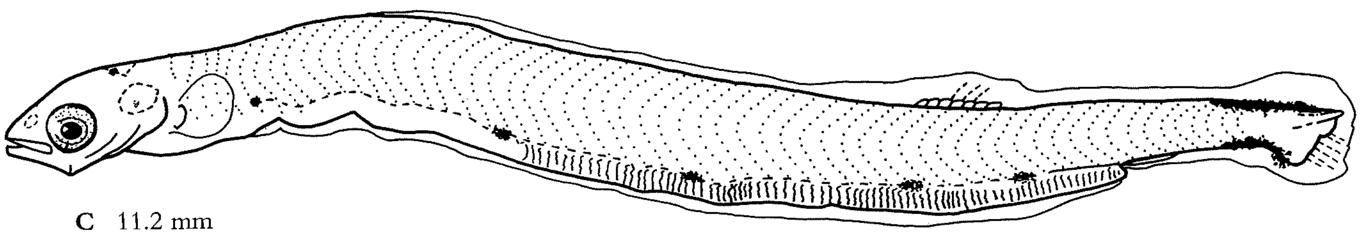
Figure 16 Larvae of *Gonorhynchus greyi*. **A** Preflexion. **B** Preflexion; note developing dorsal fin. **C** Late flexion; note developing anal fin. **D** Postflexion; note pelvic-fin bud. **E** Postflexion. **F** Postflexion; note small papillae at corners of mouth. A–F from central NSW coastal waters (from Bruce, 1989a). Illustrated by B.D. Bruce.



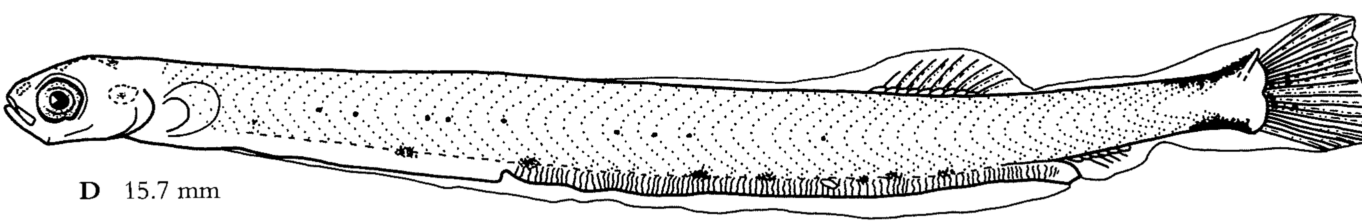
A 2.5 mm



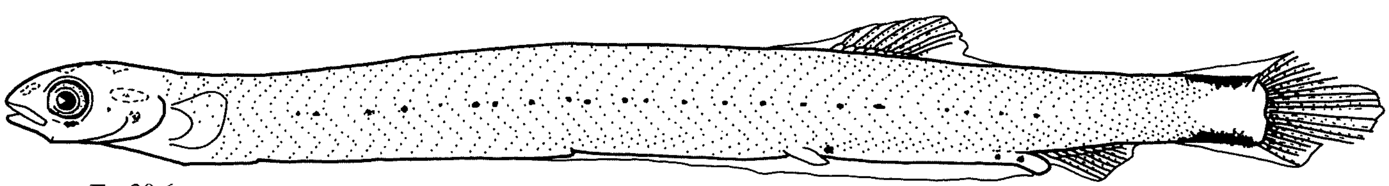
B 6.9 mm



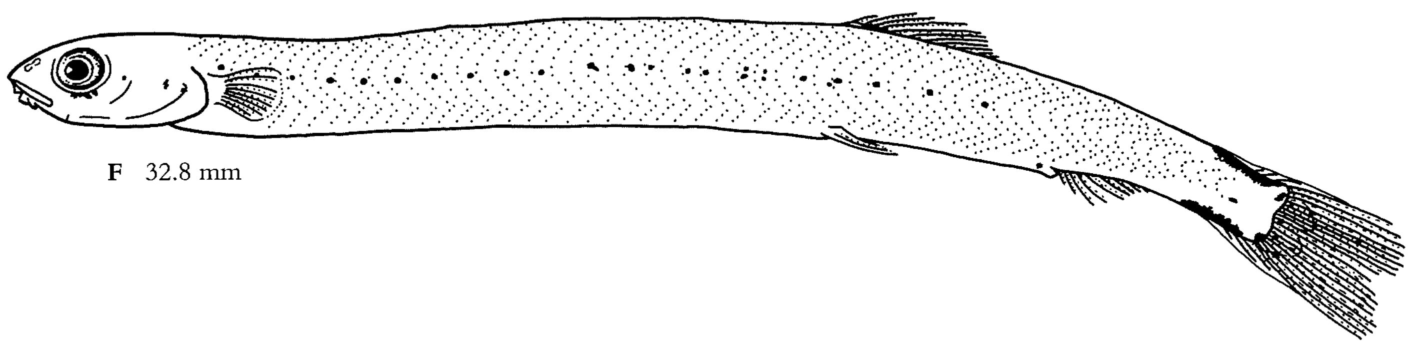
C 11.2 mm



D 15.7 mm



E 20.6 mm



F 32.8 mm

SILURIFORMES

The Siluriformes is a large order of predominantly freshwater fishes found in all continents except the polar regions. Almost 95% of the species are confined to fresh water while the remaining 5% occur in estuarine and coastal marine waters. The order comprises 34 families, approximately 416 genera and over 2500 species, with about 65% of the species occurring in the New World (Nelson, 1994; Teugels, 1996). The Ariidae and Plotosidae, which contain predominantly marine species, are the only families that occur naturally in Australian waters. Siluriform fishes belong to the series Otophysi (Superorder Ostariophysi), a large group of fishes with the anterior four or five vertebrae modified to form an otophysic connection. This modification, known as the Weberian apparatus, consists of a series of movable bony ossicles which connect the gas bladder to the inner ear for sound transmission (Fuiman, 1984; Nelson, 1994). Commonly known as 'catfishes' in reference to their mouth barbels, adults of many species reach a moderate to large size (up to 3 m, many <12 cm in length), and often have spinous rays (described as spines) in front of the dorsal and pectoral fins. Many species have a toxic venom produced by glandular cells contained in the epidermal tissue covering the spines, particularly those of the pectoral fins which can cause severe pain, and even death (Nelson, 1994). Larvae have been described for relatively few representatives of the Ariidae, Bagridae, Clariidae, Loricariidae, Plotosidae and Siluridae (see review of early life history stages by Fuiman, 1984; see also Hosoya, 1988a,b; Laurenson *et al.*, 1993). Siluriform larvae hatch in a poorly developed (altricial state) or in a well developed, nearly juvenile stage (precocial state), with a large yolk sac and the mouth barbels developing or formed (Fuiman, 1984).

Families and species included here

PLOTOSIDAE
Cnidoglanis macrocephalus

Plotosidae: Catfishes

F. J. Neira

Plotosids are found in fresh, estuarine and coastal marine waters of the Indian Ocean, and in the western Pacific region from Japan to Australia and Fiji. The family contains 9 genera and about 32 species, of which nearly half are freshwater (Nelson, 1994; Teugels, 1996). Four genera and 4 species have been recorded from temperate Australia. Of these, *Tandanus* is freshwater while *Paraplotosus* and *Plotosus* are primarily tropical marine but also occur in temperate waters (Allen, 1982, 1989; Hutchins & Swainston, 1986; Hoese & Hanley, 1989a; Pollard *et al.*, 1996). Adults (0.08–1.0 m) are elongate and eel-tailed, and have a broad, slightly depressed head with three to four pairs of barbels around the mouth, a tapering body with the second dorsal and anal fins confluent with the caudal fin, a stout serrated spine in the first dorsal fin, one smooth spine on each pectoral fin, and no scales. The spines in the dorsal and pectoral fins are highly venomous in some species. Marine species can be distinguished from freshwater species by the dendritic organ behind the anus in the former (Scott *et al.*, 1980). Some plotosids are known to spawn in nests built in flowing streams or soft sandy bottoms, where eggs and larvae are guarded and fanned by the male (Breder & Rosen, 1966; Laurenson *et al.*, 1993). Eggs are predominantly demersal, non-adhesive and spherical, and range in diameter from ~2.6 mm in *Neosilurus ater* to 7.4 mm in *Cnidoglanis macrocephalus* (Lake, 1967b; Orr & Milward, 1984; Laurenson *et al.*, 1993). Larvae are demersal and hatch with a large yolk sac. Depending on egg size, newly hatched larvae can be relatively small and poorly developed (e.g. 5.7–7.0 mm, *N. ater*, *Plotosus lineatus* and *T. tandanus*) or large and well developed (e.g. 27.0–28.5 mm, *C. macrocephalus*) (Lake, 1967b; Orr & Milward, 1984; Hosoya, 1988b; Laurenson *et al.*, 1993).

Meristic characters of plotosid genera of temperate Australia

	(n)	First Dorsal	Dorsal + Caudal + Anal	Pectoral	Pelvic	Vertebrae
Cnidoglanis	(1)	I, 3–5	222–234	I, 8–9	9–12	77–78
Paraplotosus	(1)	I, 4–5	100–110 + 10 + –	–	–	–
Plotosus	(1)	I, 4–5	160–187	–	–	–
Tandanus	(1)	I, 4–6	142–150	I, 10	–	–

Main characters of plotosid larvae
- >77 myomeres
- Body elongate (BD 14–18%)
- No head spines
- 3–4 pairs of mouth barbels, pair at mouth angle usually shorter
- Gut moderate (PAL 38–44%), loosely coiled
- Large yolk sac at hatching
- Dendritic organ protruding from anus in marine species
- Second dorsal and anal fins confluent with caudal fin

References to plotosid larvae
Hosoya (1988b), Laurenson *et al.* (1993).

Families with similar larvae

Ariidae – Males of most taxa are oral brooders; short-based dorsal and anal fins; adipose fin present; caudal fin deeply forked.

Plotosidae *Cnidoglanis macrocephalus* (Valenciennes, 1840)

Cobbler, estuary catfish

D I, 3–5 + 102–129 A 95–112 P_1 I, 8-9 P_2 9–12 C 6–9 V 77–78

Adults Endemic to southern Australia from Houtman Abrolhos Islands (WA) to southern Queensland, but apparently absent from most of Victoria and Tasmania. Occurs in estuarine and coastal marine waters. Adults have small eyes, four pairs of mouth barbels, a single serrate spine in the first dorsal and both pectoral fins, each of which is covered by a thin layer of tissue containing venom glands, and no scales. Maximum size 91 cm (Kowarsky, 1976; Hutchins, 1980; Scott *et al.*, 1980; Last *et al.*, 1983; Nel *et al.*, 1985; Hutchins & Swainston, 1986; Hoese & Hanley, 1989a).

Importance to fisheries Fished commercially with gill nets in several estuaries in southwestern Australia. Nearly half of the total commercial catch in Western Australia during recent years has been obtained from the seasonally closed Wilson Inlet (Lenanton & Potter, 1987; Anonymous, 1991).

Spawning Fully developed ovarian eggs average 7.4 mm in diameter. Breeds in burrows within Wilson Inlet (WA) between October and January. Newly-hatched larvae are guarded by adult males between their pelvic fins. This species produces the largest, most developed yolk-sac larvae so far recorded within the four plotosid species for which larvae are known (Nel *et al.*, 1985; Laurenson *et al.*, 1993).

Diagnostic characters

- First dorsal fin, and confluent second dorsal, caudal and anal fins nearly formed at hatching
- Large yolk sac at hatching
- Protruding dendritic organ just posterior to anus
- Four pairs of barbels around mouth

Description of larvae

Morphology Body elongate (BD 14–18%). Head small in newly hatched larvae (HL 16–20%), moderate in early juveniles (HL 20–25%). A series of conical teeth in both jaws. Eyes laterally positioned in yolk-sac larvae, dorsally positioned by settlement. Four pairs of mouth barbels at hatching. Gut moderate (PAL 38–44%), loosely coiled. Dendritic organ posterior to anus present at hatching. Large yolk sac at hatching resorbed by settlement. Pectoral- and pelvic-fin buds present, and medial fins nearly formed at hatching; anteriormost elements of second dorsal fin form last.

Size at

Hatching	27.0–28.5 mm
Notochord flexion	Prior to hatching
Settlement	34.0–38.0 mm

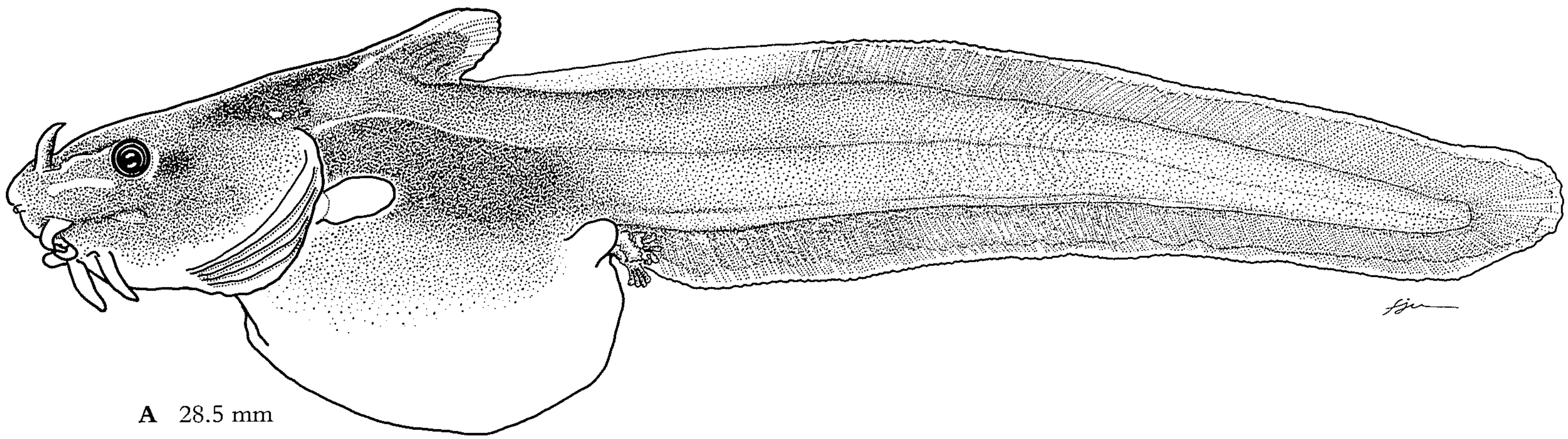
Formation of fins:
Caudal Prior to hatching; Anal Prior to hatching; First dorsal Prior to hatching; Second dorsal –34.0 mm; Pectoral 28.5–34.0 mm; Pelvic 28.5–34.0 mm

Pigmentation Larvae are moderately to heavily pigmented. *External:* Overall pale, yellowish coloration at hatching, with small stellate melanophores all over body except on ventral surface of head and yolk sac, maxillary and mental barbels, and pectoral- and pelvic-fin buds. Pigment heavier in juveniles, with dense pigment over entire body except ventral surface of head and gut. *Internal:* No pigment visible.

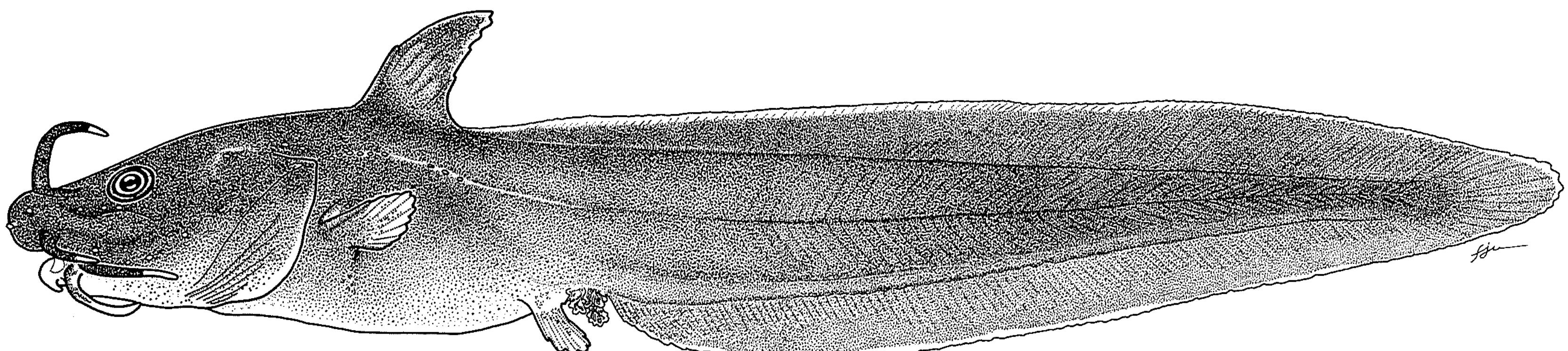
Material examined 16 larvae and juveniles, 27.0–38.0 mm BL, Wilson Inlet (WA).

Additional references Laurenson *et al.* (1993).

Figure 17 Larva and juvenile of *Cnidoglanis macrocephalus*. **A** Yolk-sac larva; note pectoral- and pelvic-fin buds. **B** Juvenile; note spines in first dorsal and pectoral fins. A, B from Wilson Inlet (WA) (from Laurenson *et al.*, 1993). Illustrated by F. J. Neira.



A 28.5 mm



B 35.5 mm

SALMONIFORMES

The Salmoniformes is a relatively large order of morphologically diverse freshwater, anadromous and diadromous, and marine fishes distributed worldwide. The taxonomic composition of the order is unclear and consequently the classification of the group varies between authors. The classification of Nelson (1994), which is based on the work of Begle (1991) and recognises the orders Osmeriformes and Salmoniformes, is not followed here as these groupings are highly contentious (G.D. Johnson, USNM, pers. comm.) and are based solely on reductive and homoplastic characters. Instead, we follow the earlier and more conservative classifications of Nelson (1984) and Eschmeyer & Bailey (1990), while accepting that the Galaxiidae is more closely related to the Northern Hemisphere Osmeriidae than to the Salmonidae. According to the latter authors, the order comprises 4 suborders, 15 families, about 90 genera and some 320 species (cf. Greenwood *et al.*, 1966; Weitzman, 1967; McDowall, 1969; see, however, Fink, 1984). Two suborders, Lepidogalaxioidei and Salmonoidei, are represented in southern Australia, the fomer containing the monotypic family Lepidogalaxiidae and the latter represented by the families Retropinnidae (smelts, graylings), Galaxiidae (whitebaits (Aplochitoninae) and southern minnows (Galaxiinae)), and Salmonidae (salmon, trout). Larvae have been described for representatives of most families in this order (see review of early life history stages by McDowall, 1984; see also Hearne, 1984; Kendall & Behnke, 1984; Martin, 1984; Haryu, 1988; Berra & Allen, 1991; Gill & Neira, 1994; Moser, 1996b; Gill, 1997).

Families and species included here

GALAXIIDAE
Galaxias occidentalis
Galaxiella munda
Galaxiella nigrostriata

Galaxiidae (Galaxiinae): Southern galaxias

H.S. Gill and F. J. Neira

Galaxiids are small (<25 cm), elongate fishes found exclusively in temperate regions of the Southern Hemisphere. They inhabit pools, creeks and rivers of temperate Australia, New Caledonia, New Zealand, South Africa and South America. Although most species are restricted to fresh water, several are diadromous and one species, *Galaxias maculatus*, is marginally catadromous (McDowall, 1968, 1984, 1988). Galaxiine galaxiids are represented in southern Australia by 4 genera and 21 species (McDowall & Frankenberg, 1981; Allen, 1989; Paxton & Hanley, 1989c; McDowall & Fulton, 1996; McDowall, 1997). Adult galaxiines are unique among Southern Hemisphere salmoniforms in that they lack an adipose fin. They have short, spineless, posteriorly placed dorsal and anal fins, pelvic fins placed at midbody, and no scales. Some species possess a finfold connecting both the dorsal and anal fins to the caudal fin. Little is known of the early life history of most galaxiines. Diadromous species, such as *G. fasciatus*, spawn in fresh water, whereas *G. maculatus* spawns in estuaries and deposits demersal and adhesive, spherical eggs, 1.0–2.0 mm in diameter (McDowall, 1984). Eggs of these species usually develop out of the water and hatch during subsequent floods or high tides; larvae migrate to sea and later return as elongate, transparent pelagic juveniles, the 'whitebait' stage, which in New Zealand support an important commercial fishery (McDowall, 1969, 1984, 1988; Andrews, 1976; McDowall & Frankenberg, 1981; Pen & Potter, 1991a). Known non-diadromous species spawn near the adult habitats and the pelagic 'whitebait' juvenile stage is absent (McDowall, 1984). Larvae have been described for representatives of *Galaxias* and *Galaxiella* (Benzie, 1968a,b; Llewellyn, 1971; Andrews, 1976; McDowall, 1984; Mitchell, 1989; Gill & Neira, 1994). The elongate, transparent body of juveniles of species with a marine or lacustrine phase is the only apparent specialisation to pelagic life. Following the marine phase, juveniles of these species often undergo changes in body morphology and pigmentation on entry to fresh water (McDowall, 1984).

Meristic characters of galaxiine galaxiid genera of temperate Australia

	(n)	Dorsal*	Anal*	Pectoral	Pelvic	Caudal	Vertebrae
Galaxias	(13)	7–12	9–19	10–18	5–9	14–17	44–64
Galaxiella	(3)	5–8	7–12	9–14	4–7	12–15	36–43
Neochanna	(1)	9–11	10–13	13–14	6–7	16–17	56–60
Paragalaxias	(4)	9–14	6–9	11–15	5–6	13–15	37–44

* Counts correspond to branched and unbranched, segmented rays (excluding procurrent rays) from McDowall & Frankenberg (1981).

Main characters of galaxiine galaxiid larvae

- 36–64 myomeres
- Body very elongate to elongate (BD 6–17%)
- No head spines
- Gut long to very long (PAL 58–77%), initially straight but becoming looped in some taxa (e.g. *Galaxiella*) prior to transformation; short to long preanal membrane
- Gut with weak striations in some taxa (e.g. *Galaxias*) by transforming stage
- Dorsal and anal fins posteriorly located and often connected to caudal fin by a persistent membrane; dorsal-fin origin directly opposite or slightly in front of anal-fin origin
- Body lightly to heavily pigmented; melanophores on fin membranes and along rays

References to galaxiine galaxiid larvae
McDowall (1984), Gill & Neira (1994).

Families with similar larvae (applies to species with estuarine/marine phase, e.g. *Galaxias*)

Ammodytidae – Very small preopercular spines from 10 mm; long-based, continuous dorsal fin, 36–69 rays; continuous longitudinal series of melanophores or patches over gut and along ventral surface of trunk and tail.
Aulostomidae – 61–65 myomeres; gut moderate to long (PAL 48–65%); large size at notochord flexion (*ca* 20 mm).
Chanidae – 44–47 myomeres; gut very long (PAL 78–83%).
Chirocentridae – 69–75 myomeres; no pigment along dorsal and ventral surfaces of caudal peduncle.
Clupeidae – Dorsal fin never completely opposite anal fin, posterior end of dorsal fin entirely in front of anal-fin origin or at the most overlapping by up to 2 myomeres; striated hindgut; myomeres with muscle fibres in a cross-hatched pattern in most taxa, more evident in preflexion and flexion stages.
Engraulidae – Dorsal fin never entirely opposite anal fin, posterior end of dorsal fin and anal-fin origin overlapping by 1–4 myomeres; striated hindgut; myomeres with muscle fibres in a cross-hatched pattern, more evident in preflexion and flexion stages.
Gonorhynchidae – 54–61 myomeres; dorsal fin entirely anterior to anal fin.
Synodontidae – Anteriorly located pelvic and dorsal fins; adipose fin from about 10 mm; prominent pigment blotches along dorsolateral surface of gut; lack pigment along dorsal and ventral surfaces of caudal peduncle.

Galaxiidae *Galaxias occidentalis* Ogilby, 1899 Western minnow

D 7–10 A 11–14 P_1 12–15 P_2 7 C 16 V 50–54

Adults Endemic to southwestern Western Australia, from approximately 250 km north of Perth to Waychinnicup Creek, 80 km east of Albany. Considered the most abundant freshwater fish species in southwestern Western Australia (McDowall & Frankenberg, 1981; Pen & Potter, 1991a). Adults have a flattened head and a slightly flattened snout, and are olive-green dorsally and silver–white ventrally, with dark bars laterally. Maximum size 16.3 cm (Allen, 1989; Paxton & Hanley, 1989c; Pen & Potter, 1991b).

Importance to fisheries –

Spawning Eggs undescribed. Mean diameter of preserved, mature ovarian oocytes is 1.3 mm. Mean fecundity is 905 eggs. Individuals reach sexual maturity after one year before moving into flooded creeks to spawn. Spawns in the Collie River (near Bunbury, WA) from early June to late September, with peak activity in August (Pen & Potter, 1991a).

Diagnostic characters

- 36–38 + 17–19 = 54–55 myomeres
- Gut very long (PAL 68–77%), straight and with weak striations in transforming larvae
- Body lightly pigmented
- 11–45 melanophores dorsally along gut
- Up to 29 melanophores along dorsal and ventral midlines of caudal peduncle, each merging into one solid pigmented stripe in postflexion larvae

Description of larvae

Morphology Body very elongate to elongate (BD 6–11%). Head small (HL 13–19%). Minute caniniform teeth in both jaws by late flexion stage. Gut very long (PAL 68–77%), straight and with weak striations prior to transforming stage. Long preanal membrane from late flexion stage, remaining through to transforming stage.

Size at

Hatching	<6.1 mm
Notochord flexion	9.3–13.1 mm
Transformation	>26.6 mm

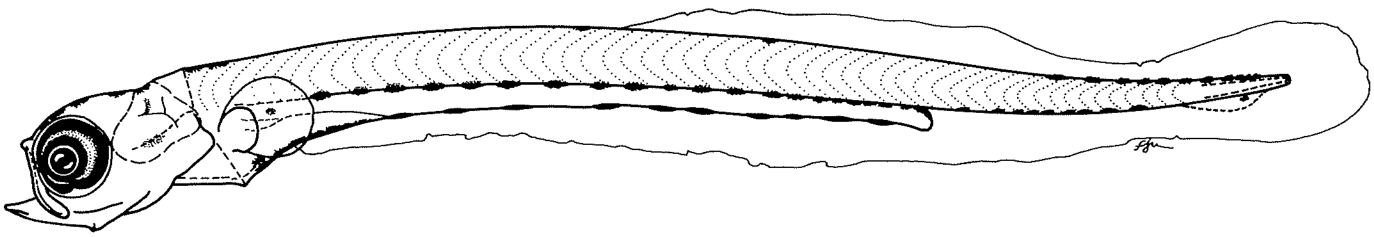
Formation of fins:
Caudal 6.1–17.7 mm; Dorsal 10.0–17.7 mm; Anal 10.0–17.7 mm; Pectoral 17.7–21.9 mm; Pelvic 17.7–>26.6 mm

Pigmentation Larvae are lightly pigmented. *External*: Melanophores scattered over dorsal surface of head and nape. Patch of melanophores along isthmus and around cleithral symphysis continuing as a series of 6–31 melanophores midventrally along gut in preflexion larvae. One to four melanophores on pectoral-fin base. Paired series of 11–45 melanophores dorsally along gut in preflexion larvae; series merges into one solid pigmented stripe by flexion stage and becomes internal by early postflexion stage. One melanophore above anus. Sparse series of 2–19 melanophores along dorsal midline of trunk. Series of up to 29 melanophores along dorsal and ventral midlines of caudal peduncle in preflexion and flexion larvae, both series merging into 1 solid pigmented stripe in postflexion larvae. *Internal*: Pigment on base of hindbrain. Pigment dorsally along gut by postflexion stage.

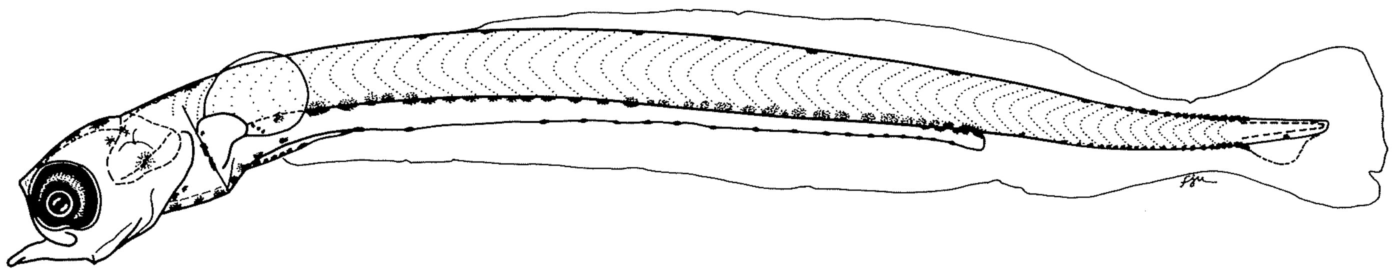
Material examined 21 larvae, 6.1–26.6 mm BL, Collie River (near Bunbury, WA).

Additional references Gill & Neira (1994).

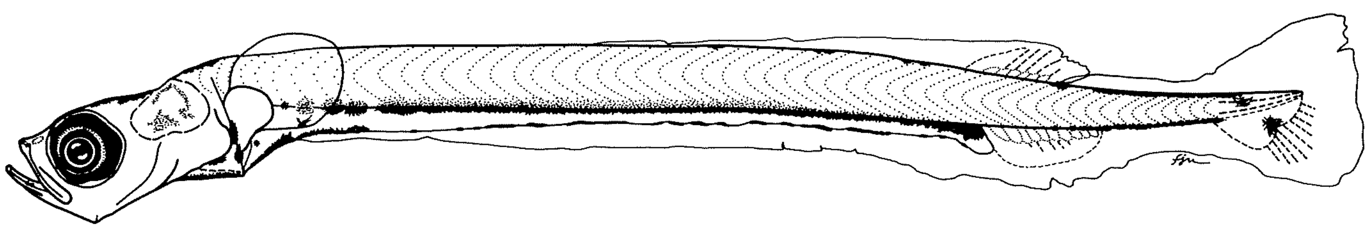
Figure 18 Larvae of *Galaxias occidentalis*. **A** Preflexion; note developing caudal fin. **B** Late preflexion. **C** Flexion; note developing dorsal and anal fins. **D** Late flexion. **E** Postflexion; note pelvic fin-bud; myomeres omitted. A–E from Collie River (WA) (from Gill & Neira, 1994). Illustrated by F. J. Neira.



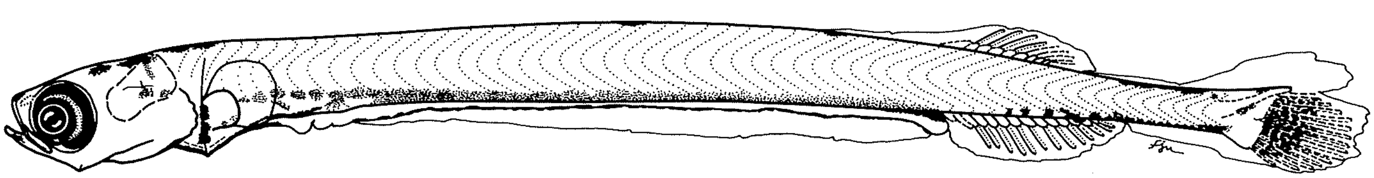
A 6.1 mm



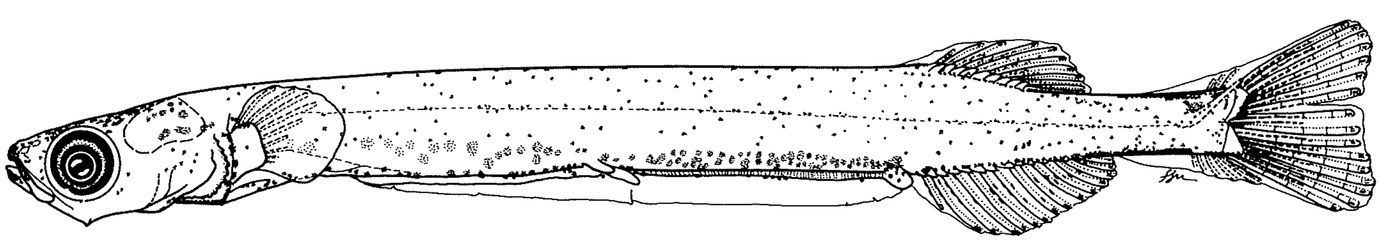
B 8.5 mm



C 10.9 mm



D 13.1 mm



E 17.7 mm

Galaxiidae *Galaxiella munda* McDowall, 1978 Mud minnow

D 6–8 A 9–12 P_1 9–12 P_2 5–7 C 13–15 V 38–43

Adults Endemic to southwestern Western Australia, from Ellen Brook (50 km north of Perth) to Albany, with an isolated population at Gingin. Restricted to streams, creeks and roadside drains. Adults are brown-grey dorsally and white ventrally with several whitish blotches near the dorsal midline, and a broad brown stripe just below midline from behind eye to caudal-fin base. Maximum size 5.8 cm (McDowall & Frankenberg, 1981; Allen, 1989; Paxton & Hanley, 1989c; Pen *et al.*, 1991).

Importance to fisheries –

Spawning Eggs undescribed. Mean diameter of preserved, mature ovarian oocytes is 1.1 mm. Mean fecundity is 65 eggs. Spawns from early July to October, with peak activity from mid-August to mid-September (Pen *et al.*, 1991).

Diagnostic characters

- 25–26 + 16–19 = 41–44 myomeres
- Gut long (PAL 64–69%)
- Body moderately pigmented dorsally and ventrally
- Internal pigment along base of hindbrain
- Melanophores scattered on isthmus, cleithral symphysis and ventral surface of gut
- Melanophores along edges of rays of all fins

Description of larvae

Morphology Body elongate (BD 11–17%). Head small to moderate (HL 19–23%). Minute villiform teeth along both jaws by early flexion stage, relatively large by early postflexion stage. Gut long (PAL 64–69%), initially straight and without a distinct stomach, looped by transforming stage; stomach is clearly formed by flexion stage and lies to the right of the intestine in ventral view. Small gas bladder over foregut. Yolk sac is resorbed by early flexion stage. Preanal membrane and remnants of dorsal finfold still present in transforming larvae.

Size at

Hatching	<5.0 mm
Notochord flexion	6.6–13.1 mm
Transformation	>16.3 mm
Formation of fins:	

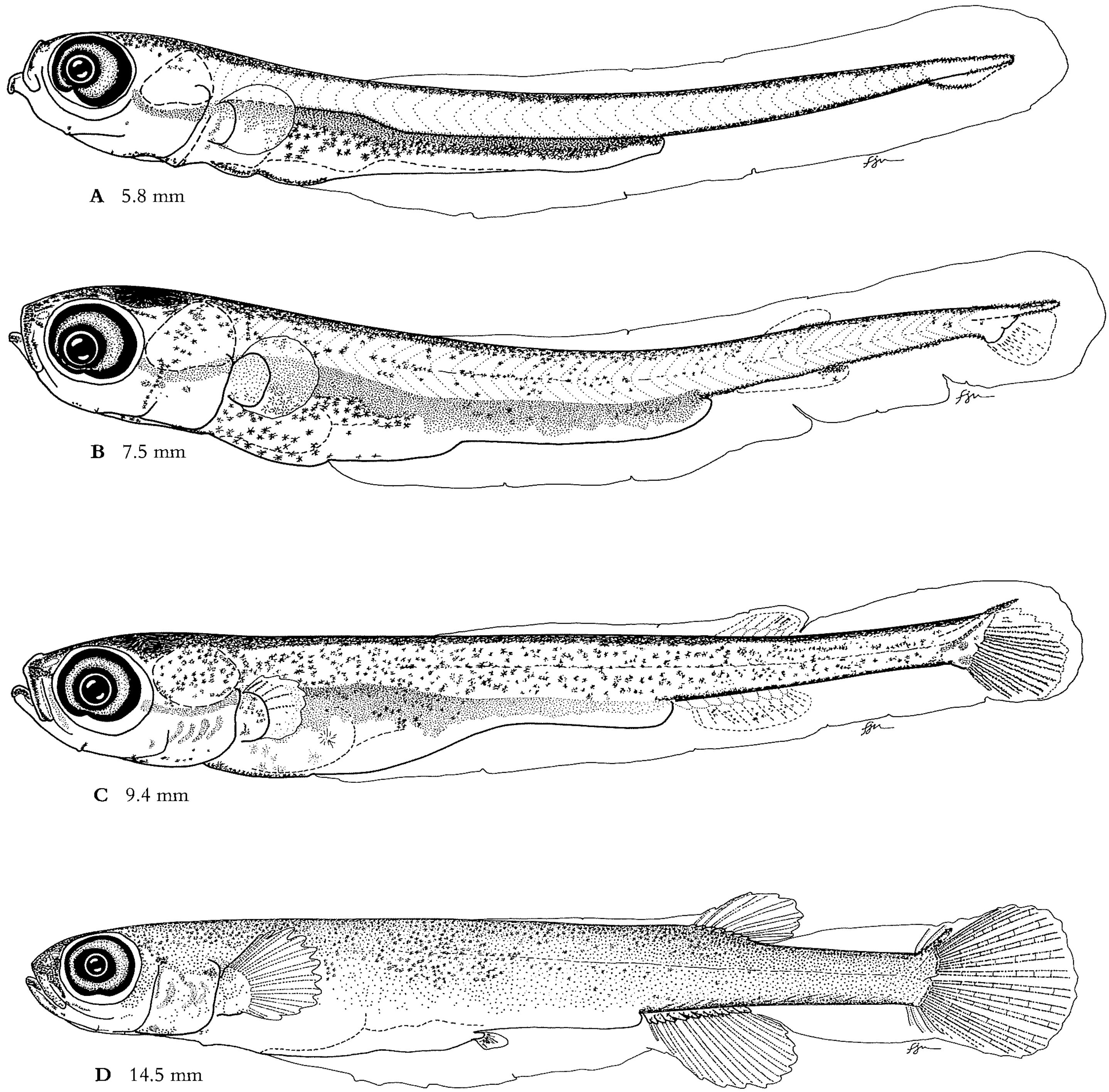
Caudal 5.8–13.6 mm; Dorsal 7.5–13.6 mm; Anal 7.5–13.6 mm; Pectoral 9.4–13.6 mm; Pelvic >12.0 mm

Pigmentation Larvae are moderately pigmented. *External*: Dense band of melanophores extending along dorsal and dorsolateral surfaces of head, trunk and tail, often with a distinct unpigmented gap between head and nape, and an unpigmented stripe along dorsal midline of trunk and tail in postflexion larvae. Patch of melanophores on snout, and along upper and lower jaws. Melanophores scattered ventrally along isthmus, cleithral symphysis and ventral surface of gut. Moderately dense band of melanophores along lateral surface of gut to anus, continuing along ventral midline of tail to end of caudal peduncle. No pigment along lateral surface of trunk and tail in preflexion and flexion larvae; pigment along dorsal and ventral surfaces of trunk and tail becomes diffuse during flexion stage. Melanophores over lateral surface of body from late flexion stage, with a discrete midlateral line. Melanophores along both edges of each ray of dorsal, caudal, anal and pectoral fins. *Internal*: Pigment along ventral surface of hindbrain, continuing dorsally over gut and gas bladder. Melanophores along cleithrum and on pterygiophores in transforming larvae.

Material examined 34 larvae, 5.0–16.3 mm BL, Big Brook (a tributary of the Donnelly River, near Pemberton, WA).

Additional references Gill & Neira (1994).

Figure 19 Larvae of *Galaxiella munda*. **A** Preflexion; note developing caudal fin. **B** Late preflexion; note developing dorsal and anal fins. **C** Flexion. D Postflexion; note developing pectoral-fin rays and pelvic-fin bud. Myomeres omitted in C, D. A–D from Big Brook (WA) (from Gill & Neira, 1994). Illustrated by F. J. Neira.


A 5.8 mm
B 7.5 mm
C 9.4 mm
D 14.5 mm

Galaxiidae *Galaxiella nigrostriata* (Shipway, 1953) Black-stripe minnow

D 6–8 A 8–11 P_1 11–14 P_2 5–6 C 12–15 V 38–43

Adults Endemic to southwestern Western Australia, from Northcliffe to Esperance. Restricted to slow-flowing streams, swamps and roadside drains. Aestivation is likely as many of the water bodies in which this species is found are ephemeral. Females and nonbreeding males are green-brown dorsally and white ventrally, with numerous pepper-like melanophores, while breeding males have 2 lateral black stripes separated by a bright yellow to red stripe. Life cycle is typically just over one year. Maximum size 4.8 cm (McDowall & Frankenberg, 1981; Allen, 1989; Paxton & Hanley, 1989c; Pen *et al.*, 1993).

Importance to fisheries –

Spawning Eggs undescribed. Mean diameter of preserved, mature ovarian oocytes is 0.9 mm. Mean fecundity is 62 eggs. Individuals reach sexual maturity at the end of their first year. Breeds from early June to September, with peak activity between late June and early July (Allen, 1989; Pen *et al.*, 1993).

Diagnostic characters

- 21–24 + 17–19 = 38–42 myomeres
- Gut long (PAL 58–65%)
- Body heavily pigmented dorsally and ventrally
- Dense patch of melanophores along isthmus, cleithral symphysis and anteroventral surface of gut
- Melanophores along edges of rays of dorsal, caudal, anal and pectoral fins

Description of larvae

Morphology Body very elongate to elongate (BD 8–15%). Head small to moderate (HL 15–24%). Gut long (PAL 58–65%), straight and with a distinct stomach anteriorly by early flexion stage; stomach lies to the right of the intestine in ventral view. Small gas bladder above foregut. Yolk sac is resorbed by early flexion stage. Preanal membrane and remnants of dorsal finfold still present in transforming larvae.

Size at

Hatching	<4.1 mm
Notochord flexion	7.6–10.3 mm
Transformation	13.2–>16.2 mm
Formation of fins:	

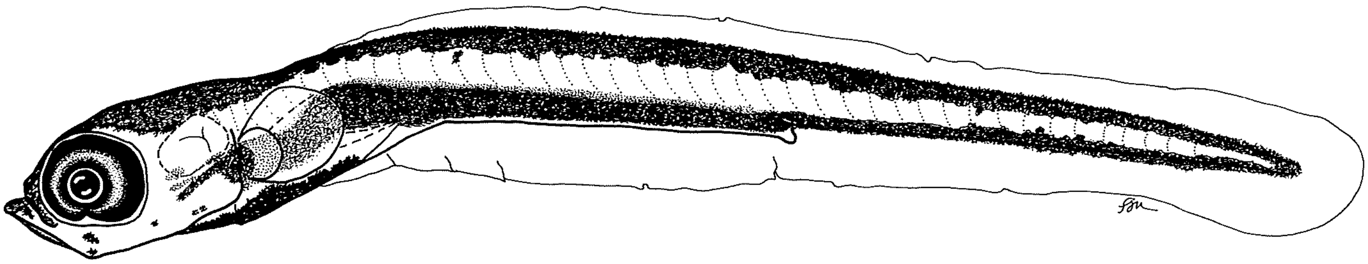
Caudal 6.1–12.3 mm; Dorsal 8.8–12.3 mm; Anal 8.8–12.3 mm; Pectoral 9.5–12.3 mm; Pelvic 12.3–>16.2 mm

Pigmentation Larvae are heavily pigmented. *External*: Melanophores at tip of upper and lower jaws. Dense band of melanophores along entire dorsolateral surface of head, trunk and tail. Dense patch of melanophores along isthmus, cleithral symphysis and anteroventral surface of gut. Dense pigmented band along lateral surface of gut extending to anus and continuing along ventral midline of tail to notochord tip. No pigment along lateral area between dorsolateral and ventrolateral dark bands in preserved preflexion and early flexion larvae (bright yellow to red in live larvae); pigment along dorsal and ventral surfaces of trunk and tail becomes diffuse during flexion stage. Heavy pigment over lateral surface of head, trunk and tail by late flexion stage. Melanophores along both edges of each ray of dorsal, caudal, anal and pectoral fins. Prominent series of melanophores along lateral midline of trunk and tail in postflexion larvae. *Internal*: Pigment dorsally over gut and gas bladder.

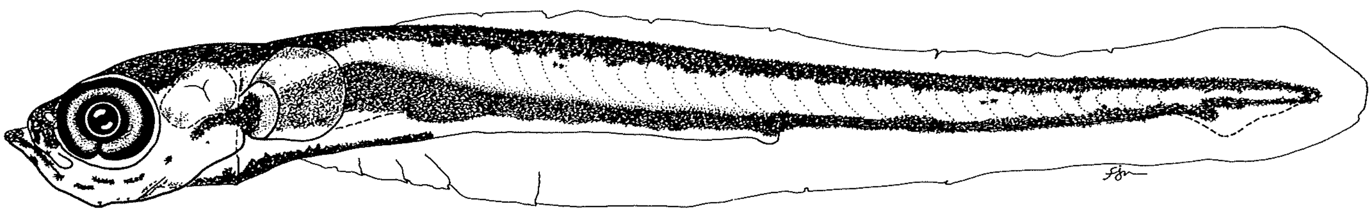
Material examined 27 larvae, 4.1–16.2 mm BL, roadside pools, d'Entrecasteaux National Park (WA).

Additional references Gill & Neira (1994).

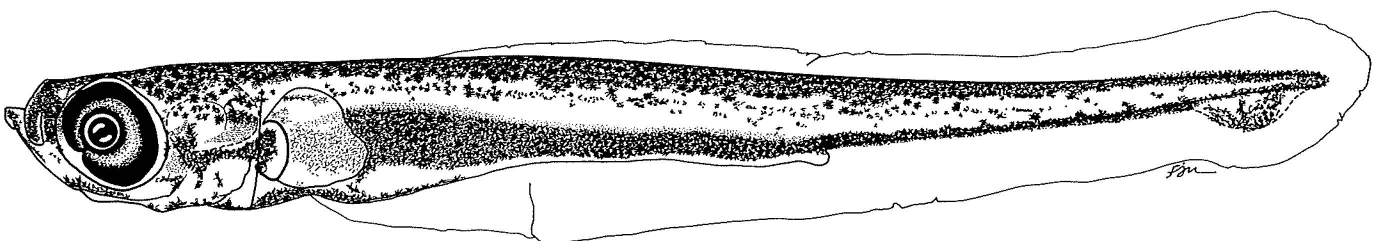
Figure 20 Larvae of *Galaxiella nigrostriata*. **A** Preflexion. **B** Preflexion; note developing caudal fin. **C** Preflexion. **D** Flexion. **E** Postflexion; note pelvic-fin bud. Myomeres omitted in C, D, E. A–E from Collie River (WA) (from Gill & Neira, 1994). Illustrated by F. J. Neira.



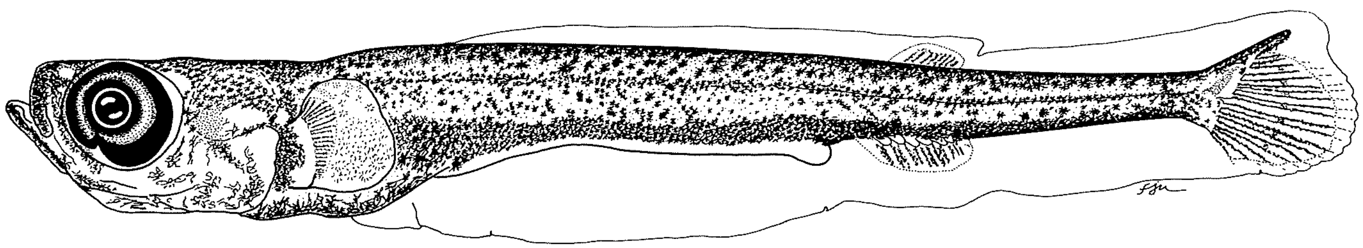
A 4.8 mm



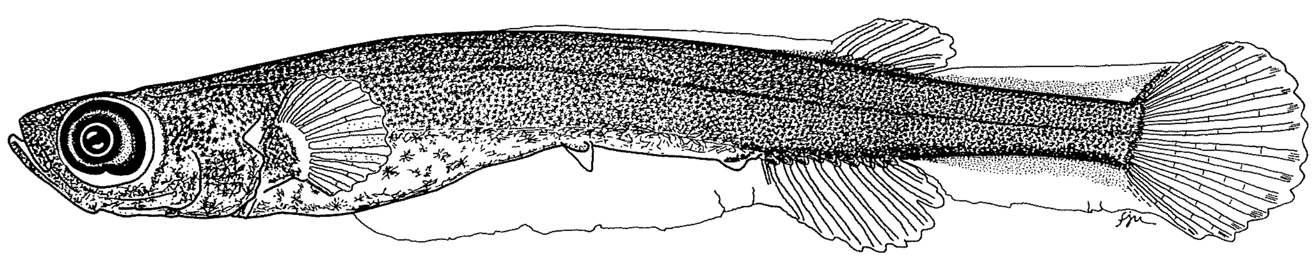
B 6.1 mm



C 7.6 mm



D 9.5 mm



E 12.3 mm

OPHIDIIFORMES

The Ophidiiformes is a small order of mostly marine, benthic fishes common in tropical to polar areas of the Atlantic, Indian and Pacific oceans. Representatives inhabit a wide range of habitats, including estuarine, shelf, slope and abyssal waters. About 5 species, all from the family Bythitidae, are confined to fresh and brackish waters (Gordon *et al.*, 1984; Nelson, 1994). The order contains the suborders Ophidioidei (oviparous species) and Bythitoidei (viviparous species), 5 families, about 92 genera and over 355 species (Nelson, 1994). Families comprise the Carapidae (pearlfishes) and Ophidiidae (cusk eels) in the Ophidioidei, and Bythitidae (viviparous brotulas), Aphyonidae and Parabrotulidae (false brotulas) in the Bythitoidei (Cohen & Nielsen, 1978; Nelson, 1994). The position of the Parabrotulidae is uncertain, as the family has been aligned with both the Zoarcidae (Nielsen *et al.*, 1990) and Aphyonidae (Anderson, 1986; Nelson, 1994). Almost 60% of the species belong to the Ophidiidae. Larvae have been described for representatives of the Bythitidae, Carapidae and Ophidiidae (see review of early life history stages by Gordon *et al.*, 1984; see also Leis & Rennis, 1983; Okiyama, 1988d,e; Matarese *et al.*, 1989; Ambrose, 1996d,e,f).

Families and species included here

OPHIDIIDAE
Genypterus blacodes
Genypterus tigerinus

Ophidiidae: Cusk eels, lings

D.M. Furlani

Ophidiids are almost exclusively marine fishes found in tropical to polar areas in the Atlantic, Indian and Pacific oceans. Most species are benthic and occur in shelf, slope and abyssal waters, with a few inhabiting shallow rocky areas and coral reefs. The family contains about 46 genera and 209 species worldwide (Nelson, 1994). Sixteen genera and at least 25 species have been recorded from Australia, 3 genera and 4 species in temperate waters (Last *et al.*, 1983; May & Maxwell, 1986; Paxton & Hanley, 1989e; Gomon *et al.*, 1994). Adults (0.1-2.0 m) have a long, posteriorly tapering body with cod-like gill openings, long, spineless dorsal and anal fins confluent with the caudal fin and, when present, jugular pelvic fins with one or two elements. Head spines are mostly absent although some taxa may have one or two opercular spines (e.g. *Brotula*, *Dannevigia*), while others have a rostral spine (e.g. *Lepophidium*, some *Ophidion*). The length of the pectoral fins varies among genera (May & Maxwell, 1986). Eggs of *Brotula*, *Genypterus* and *Ophidion* are pelagic and spherical to slightly ellipsoidal, 1.1–1.3 mm in diameter (Mito, 1962; Brownell, 1979; Fahay, 1992). Larvae have been described for representatives of more than half of the genera (see Gordon *et al.*, 1984, and references therein; see also Brownell, 1979; Ambrose *et al.*, 1983; Leis & Rennis, 1983; Okiyama, 1988e; Matarese *et al.*, 1989; Olivar & Sabates, 1989; Fahay, 1992; Ambrose, 1996d). The elongate, early forming pectoral fins in larvae of some taxa (e.g. *B. multibarbata*) constitute a specialisation to pelagic life (Leis & Rennis, 1983).

Meristic characters of ophidiid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Brotulotaenia	(1)	119–134	98–108	22–26	absent	9	69–73
Dannevigia	(1)	96–103	76–80	24–27	2	8	–
Genypterus	(2)	140–178*	104–126*	19–24	2	9	68–70

* CSIRO (Tas) radiographic counts give D 140–162 and A 105–118.

Main characters of ophidiid larvae

- 48–87 myomeres
- Body very elongate to moderate (BD 7–24%), with a tapered tail
- Angle of lower jaw typically ventrally directed and pronounced
- Head spines limited to 1–2 opercular spines in some taxa
- Barbels on lower jaw present (Brotulinae) or absent (Ophidiinae)
- Gut moderate to long (PAL 25–56%), loosely coiled
- Dorsal and anal fins spineless, and confluent with caudal fin
- Early forming, elongate pectoral fins in some taxa (e.g. *Brotula*)
- Pelvic fins jugular, inserted immediately posterior to cleithral symphysis, spineless
- Early forming pigment on branchiostegal membrane in many taxa
- Pigment blotches along dorsal and ventral surfaces of tail in many taxa, number and position species-specific; continuous ventral pigment along tail in other taxa
- Pigment along dorsal and ventral finfolds, and around caudal finfold in some taxa

References to ophidiid larvae

Brownell (1979), Leis & Rennis (1983), Gordon *et al.* (1984), Okiyama (1988e), Matarese *et al.* (1989), Olivar & Sabates (1989), Fahay (1992), Ambrose (1996d).

Families with similar larvae

Ammodytidae –Very small preopercular spines from 10 mm; gut long to very long (PAL 59–70%); 36–69 soft dorsal-fin rays; posteriorly-located anal fin, 14–36 rays; dorsal and anal fins not confluent with caudal fin.

Bregmacerotidae – 43–59 vertebrae; 2 dorsal fins, first consisting of an elongate occipital ray on nape which forms early in some taxa (2.0–2.5 mm); second dorsal and anal fins strongly lobed and not confluent with caudal fin; early forming pelvic fins, initially with 3–4 rays (5–7 in adults).

Bythitidae (live bearers) – 40–65 myomeres; opercular spine in larvae of some taxa >13 mm; gut coils shortly after parturition; dorsal and anal fins not confluent with caudal fin.

Carapidae – >82 myomeres; vexillum present; gut short (PAL 6–33%) and compact; pelvic fins absent; body lightly pigmented, melanophores around notochord tip in early stages of some taxa.

Macrouridae – >100 vertebrae; elongate tail, second dorsal and anal fins tapering to a sharp point; caudal fin usually absent; pectoral-fin base moderately to markedly stalked; early forming pelvic fins, often develop simultaneously with dorsal and anal fins; barbels often on lower jaw.

Macruronidae – 78–81 myomeres; 2 dorsal fins, first high and spinous; second dorsal and anal fins confluent with caudal fin; pelvic fins thoracic; late forming pectoral-fin rays, pectoral-fin base moderately stalked; prominent gap between anus and origin of anal fin; no barbels on lower jaw.

Moridae – 41–63 vertebrae; one or two dorsal and anal fins, neither confluent with caudal fin; narrow caudal peduncle, caudal fin small; pectoral-fin base slightly to moderately stalked; early forming, jugular pelvic fins; barbels on lower jaw in some taxa.

Odacidae – 30–54 myomeres, 32–42 in most taxa; dorsal fin not confluent with caudal fin; short-based, posteriorly located anal fin; very little or no pigment in most taxa.

Phycidae – 38–55 myomeres; elongate, early forming pelvic fins, initially with 3–4 rays (2–9 in adults), and moderately to heavily pigmented early in development; pterotic spines in several taxa; 2–3 dorsal fins, not confluent with caudal fin; barbels on lower jaw and snout in a few taxa.

Sillaginidae (early stages) – 32–45 myomeres; angle of lower jaw not ventrally directed; dorsal and anal fins not confluent with caudal fin; melanophore series ventrally along gut.

Ophidiidae *Genypterus blacodes* (Forster, 1801) Pink ling

D* 140–154 A* 105–114 P_1 19–24 P_2 2 C 9 V* 68–70

* Meristic values supplemented by CSIRO (Tas) radiographic records.

Adults Distributed around southern Australia from Cape Naturaliste (WA) to Newcastle (NSW), including Tasmania; also in New Zealand and Chile. Based on colour patterns, Gomon *et al.* (1994) suggest *G. blacodes* may include two discrete species. However, preliminary genetic analysis has not yet revealed any diagnostic allozyme markers for separation of the two colour morphs (R. Ward, CSIRO Hobart, pers. comm.). Found burrowed in soft sand and mud, or in reef caves, at depths of 40–1000 m (Williams *et al.*, 1996). Juveniles are common on the continental shelf, adults in deeper waters. Adults are very elongate and compressed with a tapering tail, dorsal and anal fins confluent with the caudal fin, jugular pelvic fins, and pinkish with lateral mottled brown markings. Differs from *G. tigerinus* in having the upper jaw extending only a short distance past the eye. Maximum size 1.6 m (Last *et al.*, 1983; Gomon *et al.*, 1994; Tilzey, 1994a).

Importance to fisheries Fished commercially by trawlers and dropliners in temperate Australia and also in New Zealand. Largest commercial catches are obtained over the continental slope at depths of 300–600 m. Catches in Australia reached 1440 tonnes in 1993 (Kailola *et al.*, 1993; Staples & Tilzey, 1994).

Spawning Eggs undescribed. Eggs of *G. capensis* are pelagic and spherical, 1.18–1.30 mm in diameter, and have a single oil globule 0.09–0.11 mm (Brownell, 1979). Spawning seems to occur in winter to spring (Tilzey, 1994a). Larvae have been caught in shelf and slope waters of New South Wales from July to September (A.G. Miskiewicz, pers. comm.), and in coastal waters off Sydney from April to August (Gray, 1995).

Diagnostic characters

- 12–19 + 43–53 = 60–68 myomeres
- Body elongate in postflexion larvae (BD 11–12%)
- Snout length typically < eye diameter
- Series of melanophores along ventral midline of trunk and tail, single from isthmus to midbody, paired from midbody to caudal peduncle
- No melanophores along dorsal midline of trunk and tail
- Lateral midline pigment on posterior half of tail from 8 mm

Description of larvae

Morphology Body very elongate to elongate (BD 9–12%). Head small (HL 14–20%). Angle of lower jaw ventrally pronounced in preflexion larvae. Snout length typically < eye diameter (63% of larvae examined). Small teeth along both jaws in preflexion larvae >4.5 mm. Gut moderate (PAL 32–49%), initially straight and with a single coil at midgut from late preflexion stage. Gas bladder over midgut between myomeres 3–7, inflated only in some larvae. Dorsal- and anal-fin rays develop from posterior to anterior.

Size at

Hatching	<2.5 mm
Notochord flexion	8.2–11.8 mm
Settlement	>24.1 mm

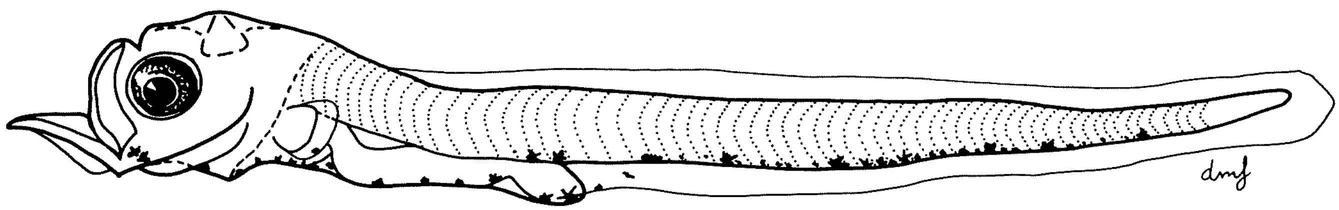
Formation of fins:
Caudal 7.8–9.4 mm; Anal 7.8–9.9 mm; Dorsal 7.8–13.4 mm; Pelvic 8.1–11.8 mm; Pectoral 10.3–13.4 mm

Pigmentation Larvae are lightly pigmented. *External*: 1–2 melanophores at angle of lower jaw; melanophores on snout and scattered on branchiostegal membrane from 5.4 mm. Two to three pairs of melanophores dorsally on head from 10 mm, about 6 pairs from 15 mm. Series of melanophores ventrally along body, single from isthmus to midbody, paired along anal fin from midbody to caudal peduncle; pigment along tail more prominent from 15 mm. Pigment along lateral midline of tail anteriorly and posteriorly from 8 mm. Melanophores along lateral and ventral midlines obscured by musculature by 24.1 mm. *Internal:* 2–3 pairs of melanophores on forebrain from 9.4 mm. Sparse pigment over fore- and hindgut from 6.5 mm. Pigment dorsally along posterior caudal vertebrae from 13.4 mm.

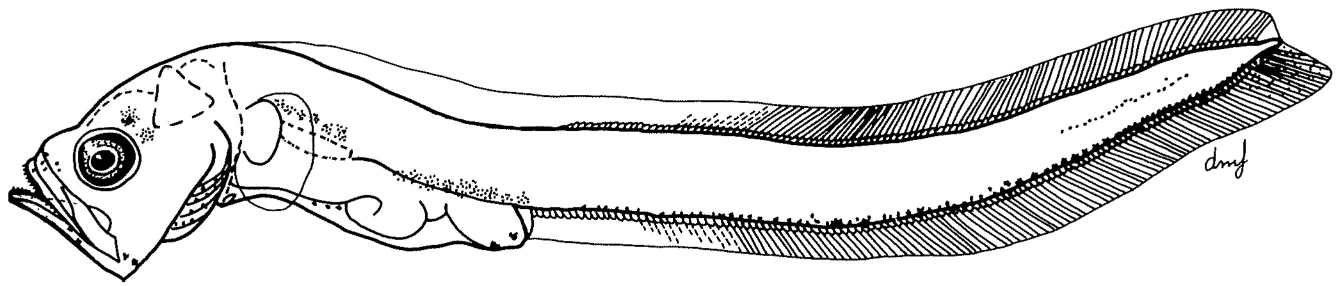
Material examined 20 larvae, 2.5–24.1 mm BL, coastal waters of northern and central New South Wales.

Additional references –

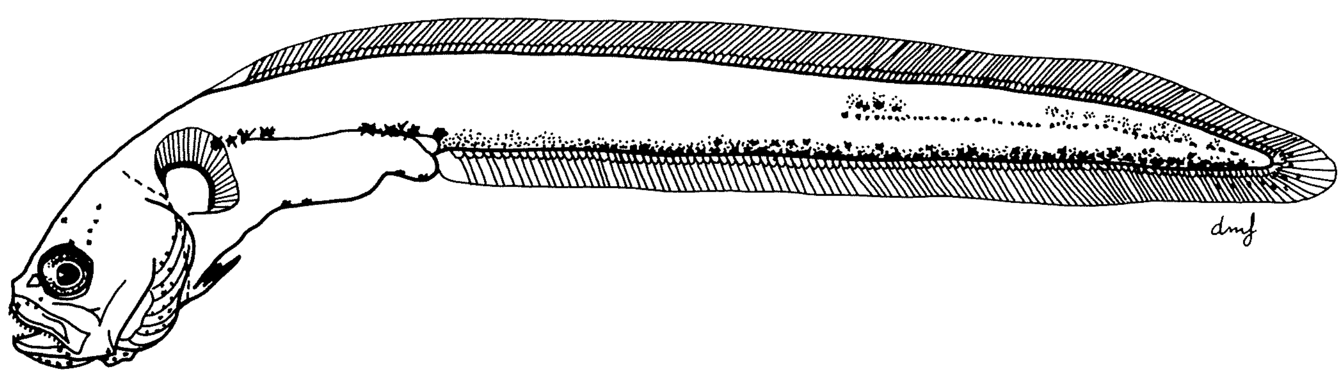
Figure 21 Larvae of *Genypterus blacodes*. **A** Preflexion. **B** Flexion; note pelvic-fin bud; myomeres omitted. **C** Postflexion; myomeres omitted. A–C from NSW coastal waters. Illustrated by D.M. Furlani.



A 4.1 mm



B 9.4 mm



C 15.6 mm

Ophidiidae *Genypterus tigerinus* Klunzinger, 1872 Rock ling

D* 144–162 A* 107–118 P_1 19–24 P_2 2 C 9 V* 68–70
*Meristic values supplemented by CSIRO (Tas) radiographic records.

Adults Distributed around southern Australia from Fremantle (WA) to Newcastle (NSW), including Tasmania; also in New Zealand. Restricted to estuaries, shallow bays and coastal reefs to a depth of 60 m. Juveniles are found in seagrass beds in estuaries while adults inhabit caves and rocky recesses. Adults are very elongate and compressed with a tapering tail, dorsal and anal fins confluent with the caudal fin, and jugular pelvic fins. Juveniles are pale with blackish irregular markings, adults pinkish silver to uniformly black with darker mottled pattern. Differs from *G. blacodes* in having the upper jaw extending well past the eye. Maximum size 1.2 m (Last *et al.*, 1983; May & Maxwell, 1986; Kuiter, 1993, 1996; Gomon *et al.*, 1994).

Importance to fisheries Targeted by recreational fishers mainly with gill nets and spears (Gomon *et al.*, 1994).

Spawning Eggs undescribed. Eggs of *G. capensis* are pelagic and spherical, 1.18–1.30 mm in diameter, and have a single oil globule 0.09–0.11 mm in diameter (Brownell, 1979). Larvae have been caught in coastal waters around Tasmania during spring and summer months.

Diagnostic characters

- 15–20 + 42–52 = 60–70 myomeres
- Body elongate in postflexion larvae (BD 15–18%)
- Snout length ≥ eye diameter
- Melanophores on ligament joining dentary and maxilla from 15 mm
- Pelvic fin pigmented from 12.3 mm
- Large melanophores scattered along dorsal and ventral midlines of tail

Description of larvae

Morphology Body very elongate to elongate (BD 8–18%). Head small to moderate (HL 16–27%). Angle of lower jaw ventrally pronounced in preflexion larvae. Snout length ≥ eye diameter (94% of larvae examined). Small, fine teeth along both jaws from 6.4 mm. Gut moderate to long (PAL 30–56%), initially straight, and with a single coil from 6.8 mm. Gas bladder above midgut between myomeres 3–8, inflated in some larvae. Dorsal- and anal-fin rays develop from posterior to anterior.

Size at

Hatching	<5.9 mm
Notochord flexion	7.8–14.5 mm
Settlement	~21.0–25.0 mm
Formation of fins:	

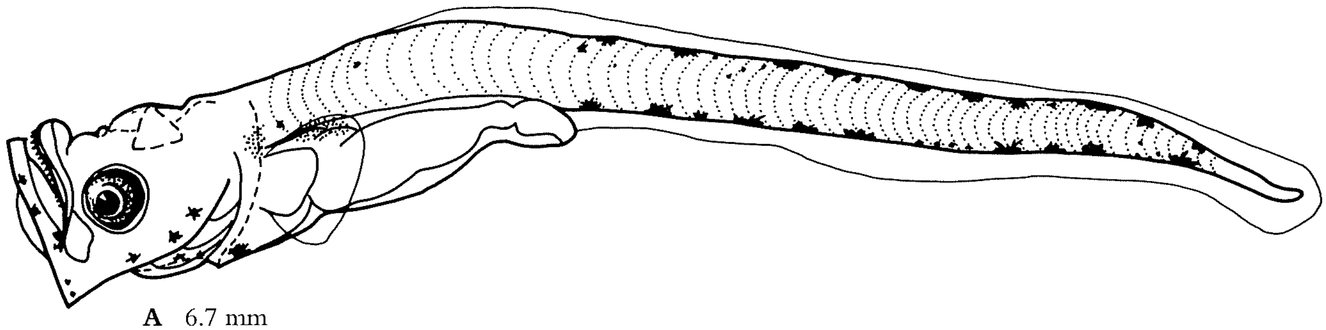
Pelvic 7.4–11.1 mm; Anal 8.1–11.1 mm; Dorsal 8.1–11.1 mm; Caudal 8.1–13.8 mm; Pectoral 8.1–12.3 mm

Pigmentation Larvae are lightly pigmented. *External*: 3–4 melanophores along ventral surface of dentary, several on opercle, and 2–3 on branchiostegal membrane, increasing in number with growth. Six to nine melanophores on ligament joining dentary and maxilla from 15 mm. One to several prominent melanophores along ventral midline of trunk below pectoral-fin base. Large melanophores dorsally along trunk and tail and ventrally along tail, with 1 melanophore approximately every 2–3 myomeres roughly alternating between dorsal and ventral surfaces. Paired series of smaller melanophores along ventral midline of tail from 8.1 mm, on either side of anal fin, extending onto anal-fin base with development. Scattered light pigment over trunk and tail, and on medial fins from 11 mm; 10–12 melanophores on each pelvic-fin element from 12.3 mm. *Internal:* Pigment over foregut.

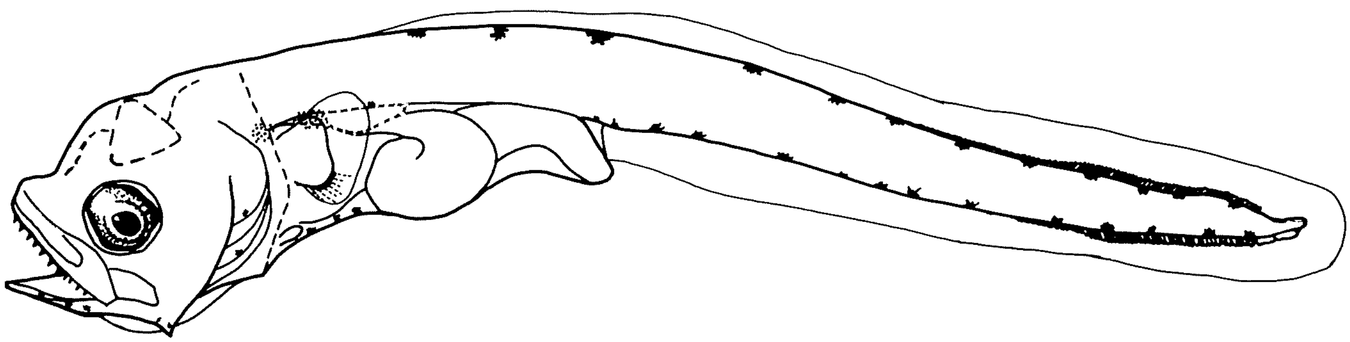
Material examined 23 larvae, 5.9–24.6 mm BL, coastal waters of Tasmania.

Additional references –

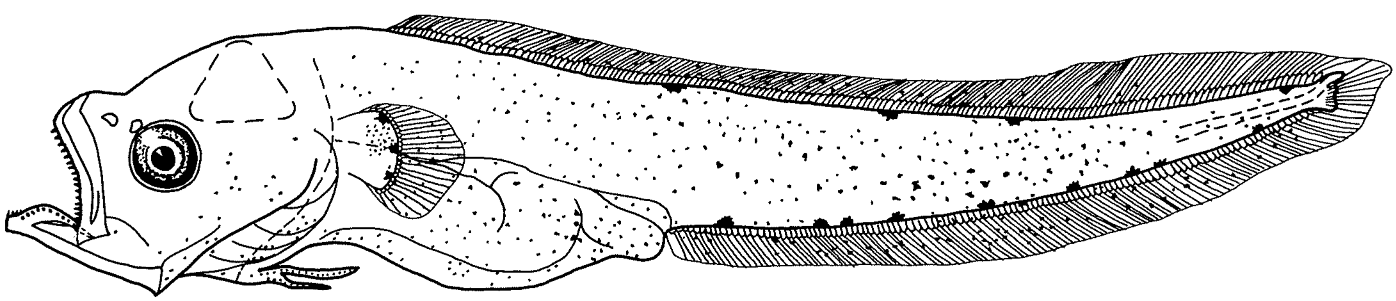
Figure 22 Larvae and settlement stage of *Genypterus tigerinus*. **A** Preflexion. **B** Flexion; note pelvic-fin bud. **C** Postflexion; internal pigment over foregut partly obscured by pectoral-fin base. **D** Settlement stage; note all fin rays formed. Myomeres omitted in B, C, D. A–D from Tas coastal waters. Illustrated by D.M. Furlani.



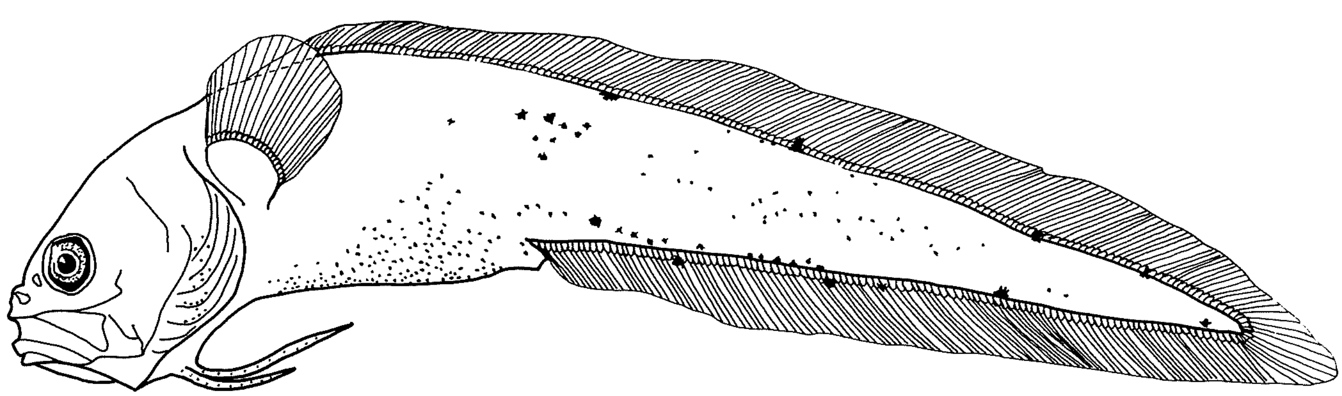
A 6.7 mm



B 9.5 mm



C 15.2 mm



D 24.6 mm

GADIFORMES

The Gadiformes is a small order of marine, bathypelagic and benthopelagic fishes represented in all seas from Arctic to Antarctic regions, with one species (a gadid) confined to fresh water. Many species have considerable commercial importance. Taxonomic relationships of the various representatives are uncertain as conflicting views are still held by those working on the group (e.g. Cohen, 1984, 1989; Howes, 1989, 1991a,b; Markle, 1989). According to Nelson (1994), the order comprises 12 families, 85 genera and 482 species. Families include the Bregmacerotidae (codlets), Gadidae (cods), Macrouridae (grenadiers), Macruronidae (southern hakes), Merluccidae (merluccid hakes), Moridae (morid cods) and Phycidae (phycid hakes). Over half of the species are macrourids, with most representatives occurring in tropical to subtropical regions at depths between 200 and 2000 m (Nelson, 1994). Gadiform fishes are moderate to very elongate, have a premaxilla forming the entire margin of the upper jaw, long-based dorsal and anal fins without true spines, and pelvic fins that, when present, have up to 11 rays, and which are either thoracic or jugular (Nelson, 1994). The caudal fin is incomplete or absent in over one-third of all gadiforms, including macrourids and macruronids. Larvae have been described for representatives of most families (see review of early life history stages by Fahay & Markle, 1984; see also Ahlstrom & Counts, 1955; de Ciechomski & Weiss, 1974; Markle, 1982; Fahay, 1983; Dunn & Matarese, 1984, 1987; Houde, 1984; Minami, 1988d; Matarese *et al.*, 1989; Ambrose, 1996a,b,c; Stevens & Moser, 1996).

Families and species included here

MACRURONIDAE
Macruronus novaezelandiae

PHYCIDAE
Gaidropsarus sp.

Macruronidae: Southern hakes

B.D. Bruce

Macruronids are marine fishes found predominantly in the Southern Hemisphere, with one species in the North Atlantic (Nelson, 1994). They occur in shelf (as juveniles) to slope waters, to a depth of about 1000 m. The traditional placement of members of this family in the Merluccidae (e.g. Norman, 1937; Marshall, 1966; Inada, 1981; Okamura, 1989) was challenged by Markle (1989) and Howes (1991a). The latter argued that *Merluccius* was the sole member of Merluccidae, regarded *Lyconus* as a subgenus of *Macruronus*, and considered *Macruronus* and (possibly) *Lyconodes* to form a monophyletic group within Macruronidae. Following Howes (1991a) and Nelson (1994), the family contains the genus *Macruronus* and the monotypic *Lyconodes*. *Macruronus* (including *Lyconus*) has seven nominal species (Howes, 1991a) although some authors consider the actual number to be less (e.g. Cohen, 1986; Gomon *et al.*, 1994). Two species of *Macruronus*, *M. novaezelandiae* and *M. pinnatus*, have been recorded from temperate Australia. Adults (to 1.1 m) have a long tapering body, a large terminal mouth with two rows of teeth, long-based dorsal and anal fins that are confluent with the caudal fin, and pectoral fins placed high on the body. Eggs and larvae have been described for *M. novaezelandiae* (Patchell *et al.*, 1987; Bruce, 1988). Eggs are pelagic and spherical, 1.01–1.18 mm in diameter, and have a single, large oil globule. Macruronid larvae have no apparent specialisations to pelagic life.

Meristic characters of macruronid genus of temperate Australia*

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Macruronus	(2)	XII–XIII + 96–106	89–93	13–20	7–10	12–13	19–21 + 58–60 = 78–81

* Damage to the tail in all Australian collected material of *M. pinnatus* prevents a complete assessment of meristic charcters (R. Daley, CSIRO, Tas, pers. comm.).

Main characters of macruronid larvae

- 78–81 myomeres
- Body elongate to moderate (BD 14–24%), with tapered tail
- Single opercular spine in postflexion larvae
- Gut moderate (PAL 31–44%), initially straight but coiled by late preflexion stage
- Anus opens laterally on finfold in early larvae
- Prominent gap between anus and origin of anal fin, persisting after anal fin is formed
- 2 dorsal fins, first high and spinous; second dorsal and anal fins confluent with caudal fin
- Pelvic fins thoracic
- Late forming pectoral-fin rays, pectoral-fin base moderately stalked
- Body initially moderately pigmented, becoming heavily pigmented with growth

References to macruronid larvae

Patchell *et al.* (1987), Bruce (1988).

Families with similar larvae

Bregmacerotidae – 43–59 vertebrae; two dorsal fins, first consisting of an elongate occipital ray on nape which forms early in some taxa (2.0–2.5 mm); second dorsal and anal fins strongly lobed and not confluent with caudal fin; early forming, jugular pelvic fins, initially with 3–4 rays (5–7 in adults).

Macrouridae – >100 vertebrae; elongate tail, second dorsal and anal fins tapering to a sharp point; caudal fin usually absent; pectoral-fin base moderately to markedly stalked; early forming pelvic fins; barbels often on lower jaw.

Moridae – 41–63 vertebrae; 1–2 dorsal and anal fins, neither confluent with caudal fin; narrow caudal peduncle, caudal fin small; early forming, jugular pelvic fins; barbels on lower jaw in some taxa.

Ophidiidae – 48–87 myomeres; dorsal and anal fins spineless, confluent with caudal fin; pelvic fins jugular, inserted immediately posterior to cleithral symphysis; pigment blotches often along tail.

Phycidae – 38–55 myomeres; elongate, early forming pelvic fins, initially with 3–4 rays (2–9 in adults), and moderately to heavily pigmented early in development; pterotic spines in several taxa; 2–3 dorsal fins, not confluent with caudal fin; barbels on lower jaw and snout in a few taxa.

Macruronidae *Macruronus novaezelandiae* (Hector, 1871) Blue grenadier

D XII–XIII + 96–106 A 89–93 P_1 17–20 P_2 7–8 C 12–13 V 78–81

Adults Distributed around southern Australia from west of the Great Australian Bight to Broken Bay (NSW), including Tasmania; also in New Zealand. Juveniles are found in estuaries and bays in southern Tasmania, sometimes in deep shelf waters, while adults occur on slope waters to depths over 1000 m. Adults are very elongate and compressed with a tapering tail, dorsal and anal fins confluent with the caudal fin, and blue–green dorsally and silver ventrally. Maximum size 1.1 m (Paul, 1986; Kenchington & Augustine, 1987; Kailola *et al.*, 1993; Gomon *et al.*, 1994; Smith, 1994).

Importance to fisheries Fished commercially mainly by trawling on the west coast of Tasmania during the spawning season. Total annual catch up to 4400 tonnes in southern Australia (Kailola *et al.*, 1993; Smith, 1994; Staples & Tilzey, 1994).

Spawning Eggs are pelagic and spherical, 1.1–1.2 mm in diameter, and have a smooth chorion, an unsegmented yolk and a single oil globule 0.36–0.42 mm (Bruce, 1988). Spawning has been reported off western Tasmania between mid May and September, although its onset may vary between years (Gunn *et al.*, 1989; Smith, 1994). Larvae have been caught in coastal waters of Tasmania from June to September (Thresher *et al.*, 1988), and as far north as Bermagui (NSW) (Bruce *et al.*, 1996).

Diagnostic characters

- 78–81 myomeres
- No head spines except for a single opercular spine by 22 mm
- Persistent gap between anus and origin of anal fin
- Large size at notochord flexion (≥20 mm)
- Paired melanophore series dorsally on tail along either side of developing dorsal fin
- Usually 2 prominent melanophores ventrally along midtail until 15 mm

Description of larvae

Morphology Body elongate to moderate (BD 14–24%). Head small to moderate (HL 19–25%). Mouth functional and eyes pigmented in reared larvae by 3.5–3.7 mm. Small villiform teeth along premaxilla by 7.2 mm. One opercular spine by 22 mm. Gut moderate (PAL 31–44%), straight in yolk-sac larvae and coiled in preflexion larvae by 3.6 mm. Anus opens laterally to the right in larvae until 5.1 mm, becoming symmetrical about the ventral midline thereafter. Gas bladder over foregut by 3.5 mm, inflated and prominent. Prominent gap between anus and origin of anal fin, persisting after anal fin is formed.

Size at

Hatching	2.2–2.3 mm
Notochord flexion	20.0–28.0 mm
Settlement	>34.2 mm

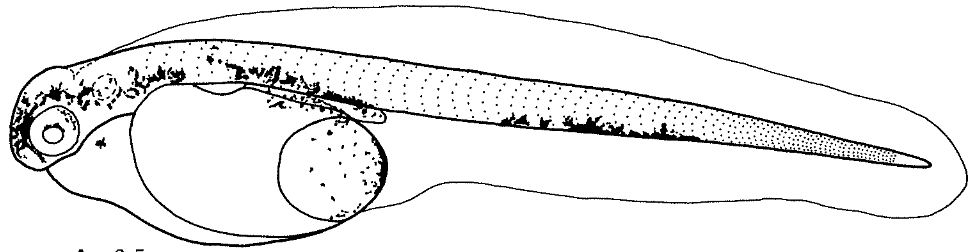
Formation of fins:
Pelvic 5.7–16.3 mm; Dorsal 5.7–23.2 mm; Anal 6.9–21.0 mm; Caudal 10.4–>34.2 mm; Pectoral 22.0–>34.2 mm

Pigmentation Larvae are lightly to moderately pigmented. *External*: Scattered melanophores over head in preflexion larvae, increasing in number with growth; 3–5 melanophores along gular membrane by 4.2 mm, 10–12 by 12 mm; 5–6 melanophores along lower jaw by 7.1 mm and pigment over mid- and hindbrain by 16 mm. Pigment over entire gut except ventral surface by 24.2 mm. Paired melanophore series dorsally on midtail along developing dorsal fin by 5 mm, extending anteriorly and posteriorly during development; melanophore series from head develops concurrently, and extends posteriorly to join tail series by 10.5 mm. One to three, usually 2, prominent melanophores ventrally along midtail in larvae until 15 mm. Melanophores scattered laterally over tail in larvae from 11.5 mm. Some melanophores on dorsal-fin bases by 14 mm, with 1 on each base by 29 mm. *Internal:* Melanophores over otic capsule and dorsally over gas bladder. Some melanophores over vertebrae by 9.5 mm, extending anteriorly to midbody and posteriorly to last vertebrae by 34.2 mm.

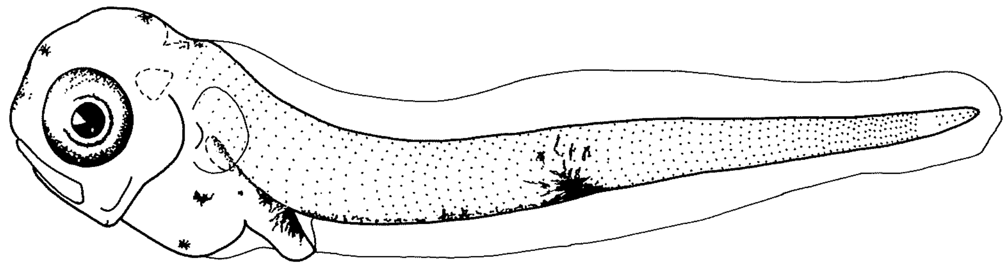
Material examined 74 larvae, 2.2–34.2 mm BL, coastal waters of Tasmania.

Additional references Patchell *et al.* (1987), Bruce (1988).

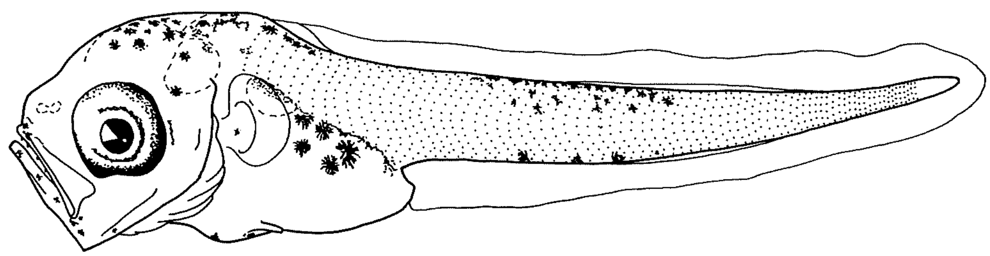
Figure 23 Larvae of *Macruronus novaezelandiae*. **A** Preflexion, yolk-sac. **B** Preflexion. **C** Preflexion; note developing dorsal and anal fins, and pelvic-fin bud. **D** Dorsal view of larva in C. **E** Preflexion. **F** Flexion; postanal myomeres omitted. A reared at CSIRO (Tas); B, C, E, F from Tas coastal waters (from Bruce, 1988). Illustrated by B.D. Bruce.



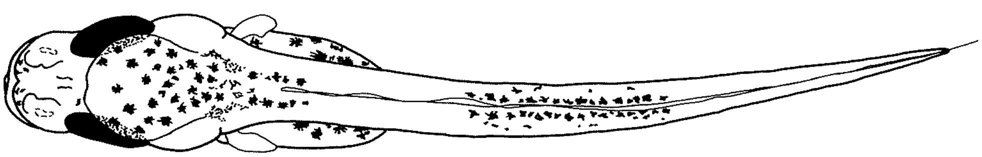
A 3.5 mm



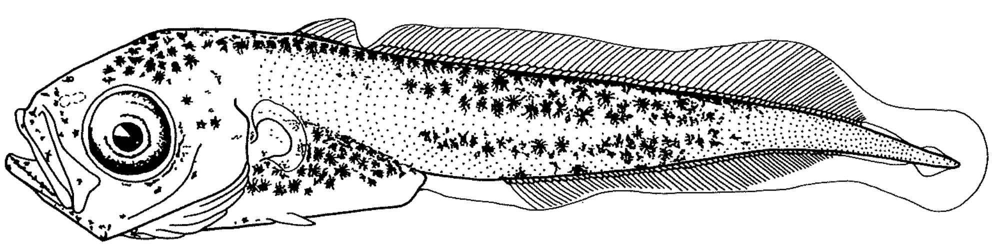
B 3.6 mm



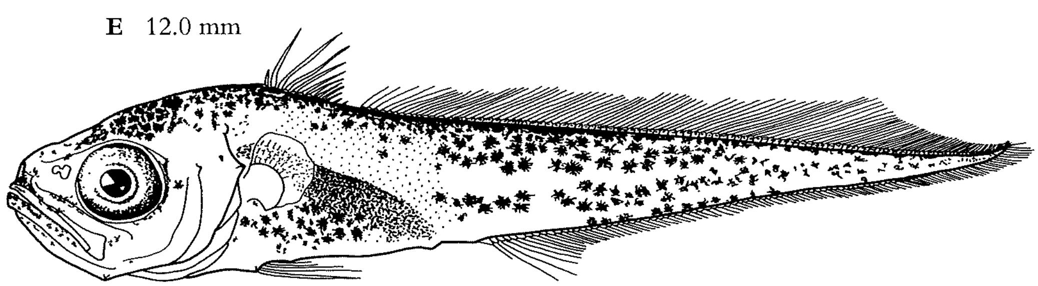
C 7.2 mm



D 7.2 mm



E 12.0 mm



F 24.2 mm

Phycidae: Phycid hakes

B.D. Bruce

Phycids are marine fishes found in shelf and slope waters in temperate regions of the North Atlantic and in Japan, with a small number of species occurring at similar latitudes off Australia, New Zealand and South Africa (Svetovidov, 1948; Nelson, 1994). The current taxonomic composition of the family is unclear and most species are still placed in the Gadidae (e.g. Dunn & Matarese, 1984; Fahay & Markle, 1984). Following Markle (1989) and Nelson (1994), the family comprises 5 genera (*Ciliata*, *Enchelyops*, *Gaidropsarus*, *Phycis* and *Urophycis*) and 27 species. *Gaidropsarus* is the most widespread genus, with approximately 12 species worldwide, including at least 4 species in the Southern Hemisphere (Svetovidov, 1986). One species, *G. novaezelandiae*, has been recorded from temperate Australia, though only from a small number of specimens (Norman, 1937; Ayling & Cox, 1982; Last *et al.*, 1983; Svetovidov, 1986). A second, and possibly undescribed *Gaidropsarus* species may also occur in the region based on larvae described herein. Adults (to 30 cm) are elongate, have two or three dorsal fins and a single anal fin with no spines, snout and/or chin barbels, and highly specialised otoliths (Nelson, 1994). Eggs are pelagic and spherical, 0.6–1.0 mm in diameter, and have multiple oil globules that coalesce into one during development (Brownell, 1979; Dunn & Matarese, 1984). Larvae have been described for representatives of all genera (see Dunn & Matarese, 1984, and references therein; see also Russell, 1976; Brownell, 1979; Robertson & Mito, 1979; Markle, 1982; Fahay, 1983; Fahay & Markle, 1984; Dunn & Matarese, 1987). The pterotic spines and the extended larval stage in some taxa are the only apparent specialisations of phycid larvae to pelagic life (Markle, 1982; Dunn & Matarese, 1984, 1987).

Meristic characters of the phycid genus of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal*	Vertebrae
Gaidropsarus	1–2	1 + 44–59, 50–69	44–59	20–22	6–8	32–34	46–49

* Total caudal fin elements

Main characters of phycid larvae

- 38–55 myomeres
- Body moderate (BD 20–35%), stocky and rounded in cross-section
- Head spination limited to moderate pterotic spines in *Ciliata*, *Gaidropsarus* and *Phycis*
- Barbels on snout and tip of lower jaw in Gaidropsarinae, absent in Phycinae
- Gut moderate to long (PAL 47–63%)
- Elongate, early forming pelvic-fin rays, initially with 3–4 elements (2–9 in adults), full pelvic-fin complement is attained during late postflexion stage in most taxa; pelvic-fin bases initially inserted high and laterally on body
- 2–3 dorsal fins depending on subfamily
- Body lightly to moderately pigmented in most taxa, heavily pigmented by postflexion stage in some (e.g. *Gaidropsarus*)
- Gut heavily pigmented in some taxa (e.g. *Gaidropsarus*)
- Pelvic fins moderately to heavily pigmented in early stages
- Usually 1–2 pigmented bands along tail

References to phycid larvae

Brownell (1979), Robertson & Mito (1979), Demir (1982), Markle (1982), Fahay (1983), Dunn & Matarese (1984, 1987), Fahay & Markle (1984).

Families with similar larvae

Blenniidae – Body elongate to moderate in most taxa (BD 15–27%); no pterotic spines; preopercular spines in most tribes; moderate to large pectoral fins with pigment usually over membrane and underside of fin base; 0–4 pelvic-fin rays; melanophore series usually along ventral midline of tail.

Bregmacerotidae – 43–59 vertebrae; 2 dorsal fins, first consisting of an elongate occipital ray on nape which forms early in some taxa (2.0–2.5 mm); second dorsal and anal fins strongly lobed; early forming, jugular pelvic fins, initially with 3–4 rays (5–7 in adults).

Exocoetidae (early stages) – No head spines; lower jaw considerably produced in some taxa; short-based, posteriorly located dorsal and anal fins; pectoral fins very large; pelvic fins very large and abdominal, inserted posteriorly on body.

Macruronidae – 78–81 myomeres; second dorsal and anal fins confluent with caudal fin; pectoral-fin base moderately stalked; prominent gap between anus and origin of anal fin; no barbels on lower jaw; pigment blotches along tail.

Monodactylidae (*Monodactylus* early stages) – 24–25 myomeres; moderate to deep body; moderate head spination, including a serrate supraocular ridge and prominent preopercular spines; early forming, thoracic pelvic fins; no lower jaw barbels; distinct band of heavy pigment across head and trunk in preflexion larvae.

Moridae – 41–63 vertebrae; 1–2 dorsal and anal fins; no pterotic spines; narrow caudal peduncle, caudal fin small; early forming, jugular pelvic fins; pectoral-fin base slightly to moderately stalked; barbels on lower jaw in some taxa.

Ophidiidae – 48–87 myomeres; no pterotic spines; dorsal and anal fins confluent with caudal fin; pelvic fins jugular, inserted immediately posterior to cleithral symphysis; pigment blotches often along tail.

Trachichthyidae – 26–30 myomeres; usually prominent preopercular and opercular spines; short-based dorsal and anal fins, III–X, 8–18 and II–III, 8–11 respectively; pelvic fin I, 6; body moderately to heavily pigmented.

Phycidae *Gaidropsarus* sp. — Rock ling

D 1 + 46–50, 50–52 A 44–46 P_1 20–22 P_2 6–8 C^* 32–34 V 46–49
* Total caudal fin elements (4 + 2 primary elements)

Adults Known from only a small number of specimens from coastal waters of southern Tasmania. Appears to be an undescribed species which may have been misidentified as *G. novaezelandiae* (e.g. Norman, 1937; Last *et al.*, 1983; Svetovidov, 1986). Based on fin meristics of larvae, the illustrated species is not *G. novaezelandiae* and it is unclear whether the latter occurs in Tasmania or if previous records refer to the illustrated species. In New Zealand, *G. novaezelandiae* occurs in intertidal rock pools and coastal marine waters to a depth of 446 m. Large postflexion larvae of this species are found in surface waters, sometimes at considerable distances from shore (Robertson & Mito, 1979). Adult *G. novaezelandiae* are elongate, and have three barbels and a series of prominent pores on the head, and a modified first dorsal fin comprising one elongate ray followed by a variable number of short, closely spaced filiform rays along a longitudinal groove (Ayling & Cox, 1982; Last *et al.*, 1983; Svetovidov, 1986).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in coastal and oceanic waters of southern and western Tasmania from September to November.

Diagnostic characters

- 21–23 + 24–25 = 45–47 myomeres
- Gut large and loosely coiled
- 2 prominent pterotic spines
- Early forming pelvic fins, high on trunk and heavily pigmented from preflexion stage; pectoral-fin rays elongate, extending past anus from late flexion stage
- Broad vertical band of pigment above anus in preflexion larvae

Description of larvae

Morphology Body moderate (BD 20–35%), deepest during late flexion stage. Head moderate to large (HL 25–34%). Small villiform teeth along both jaws by flexion stage. Snout protrudes slightly beyond lower jaw from 13.6 mm. Snout and chin barbels by 10.8 mm. Prominent pores around orbit and over opercle by 25.6 mm. Two prominent pterotic spines from preflexion stage, gradually decreasing in prominence with development. Gut moderate to long (PAL 47–63%), large and loosely coiled; anus exits through left of anal finfold in preflexion larvae. Early forming pelvic fins, high on trunk, initially with 3–4 elements; pectoral-fin rays elongate, reaching past anus from late flexion stage. Pectoral fin high on trunk, above lateral midline. Anteriormost element of first dorsal fin by 13.6 mm; remaining filiform rays of modified first dorsal fin develop along midline groove by 20 mm, difficult to see in larvae viewed laterally.

Size at

Hatching	<2.1 mm
Notochord flexion	3.8–4.5 mm
Settlement	>25.6 mm

Formation of fins:
Pelvic <2.1–13.6 mm; Anal 3.7–25.6 mm; Dorsal 3.7–25.6 mm; Caudal 3.7–10.9 mm; Pectoral 4.8–13.6 mm

Pigmentation Larvae are moderately to heavily pigmented. *External*: Scattered melanophores over tip of both jaws and opercle, increasing in number with growth. Melanophores scattered dorsally on head and nape; saddle of pigment extending over entire dorsal surface of head and gut by flexion stage; melanophores laterally over entire gut by 10.9 mm. Broad vertical band of pigment above region of anus in preflexion larvae; band broadens anteriorly and posteriorly covering entire trunk and tail, except caudal peduncle, by 10.9 mm; no pigment on caudal peduncle until about 20 mm. Pelvic fins heavily pigmented. *Internal:* Patch of pigment below nostrils by late flexion stage. Pigment over forebrain, below otic capsule and dorsally over gas bladder and gut; pigment laterally over gut with growth.

Material examined 15 larvae, 2.1–25.6 mm BL, coastal waters of western and southeastern Tasmania.

Additional references –

Figure 24 Larvae of *Gaidropsarus* sp. **A** Preflexion; note heavily pigmented, developing pelvic fins. **B** Late flexion. **C** Postflexion; note developing barbels and first dorsal-fin ray. Myomeres omitted in B, C. A–C from western Tas coastal waters. Illustrated by B.D. Bruce.

Phycidae *Gaidropsarus* sp. Rock ling

D 1 + 46–50, 50–52 A 44–46 P_1 20–22 P_2 6–8 C* 32–34 V 46–49
*Total caudal fin elements (4 + 2 primary elements)

Adults Known from only a small number of specimens from coastal waters of southern Tasmania. Appears to be an undescribed species which may have been misidentified as *G. novaezelandiae* (e.g. Norman, 1937; Last *et al.*, 1983; Svetovidov, 1986). Based on fin meristics of larvae, the illustrated species is not *G. novaezelandiae* and it is unclear whether the latter occurs in Tasmania or if previous records refer to the illustrated species. In New Zealand, *G. novaezelandiae* occurs in intertidal rock pools and coastal marine waters to a depth of 446 m. Large postflexion larvae of this species are found in surface waters, sometimes at considerable distances from shore (Robertson & Mito, 1979). Adult *G. novaezelandiae* are elongate, and have three barbels and a series of prominent pores on the head, and a modified first dorsal fin comprising one elongate ray followed by a variable number of short, closely spaced filiform rays along a longitudinal groove (Ayling & Cox, 1982; Last *et al.*, 1983; Svetovidov, 1986).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in coastal and oceanic waters of southern and western Tasmania from September to November.

Diagnostic characters

- 21–23 + 24–25 = 45–47 myomeres
- Gut large and loosely coiled
- 2 prominent pterotic spines
- Early forming pelvic fins, high on trunk and heavily pigmented from preflexion stage; pectoral-fin rays elongate, extending past anus from late flexion stage
- Broad vertical band of pigment above anus in preflexion larvae

Description of larvae

Morphology Body moderate (BD 20–35%), deepest during late flexion stage. Head moderate to large (HL 25–34%). Small villiform teeth along both jaws by flexion stage. Snout protrudes slightly beyond lower jaw from 13.6 mm. Snout and chin barbels by 10.8 mm. Prominent pores around orbit and over opercle by 25.6 mm. Two prominent pterotic spines from preflexion stage, gradually decreasing in prominence with development. Gut moderate to long (PAL 47–63%), large and loosely coiled; anus exits through left of anal finfold in preflexion larvae. Early forming pelvic fins, high on trunk, initially with 3–4 elements; pectoral-fin rays elongate, reaching past anus from late flexion stage. Pectoral fin high on trunk, above lateral midline. Anteriormost element of first dorsal fin by 13.6 mm; remaining filiform rays of modified first dorsal fin develop along midline groove by 20 mm, difficult to see in larvae viewed laterally.

Size at

Hatching	<2.1 mm
Notochord flexion	3.8–4.5 mm
Settlement	>25.6 mm

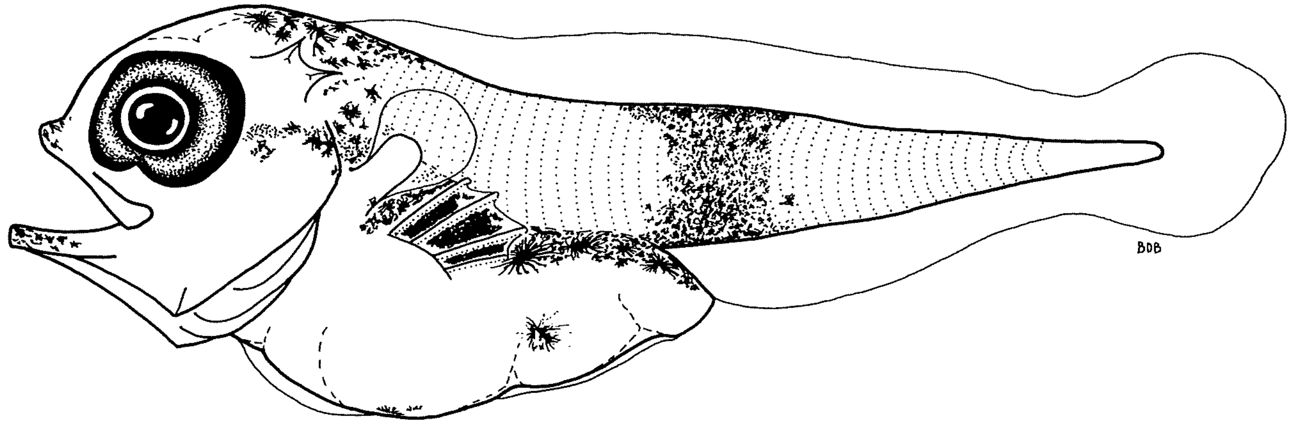
Formation of fins:
Pelvic <2.1–13.6 mm; Anal 3.7–25.6 mm; Dorsal 3.7–25.6 mm; Caudal 3.7–10.9 mm; Pectoral 4.8–13.6 mm

Pigmentation Larvae are moderately to heavily pigmented. *External*: Scattered melanophores over tip of both jaws and opercle, increasing in number with growth. Melanophores scattered dorsally on head and nape; saddle of pigment extending over entire dorsal surface of head and gut by flexion stage; melanophores laterally over entire gut by 10.9 mm. Broad vertical band of pigment above region of anus in preflexion larvae; band broadens anteriorly and posteriorly covering entire trunk and tail, except caudal peduncle, by 10.9 mm; no pigment on caudal peduncle until about 20 mm. Pelvic fins heavily pigmented. *Internal:* Patch of pigment below nostrils by late flexion stage. Pigment over forebrain, below otic capsule and dorsally over gas bladder and gut; pigment laterally over gut with growth.

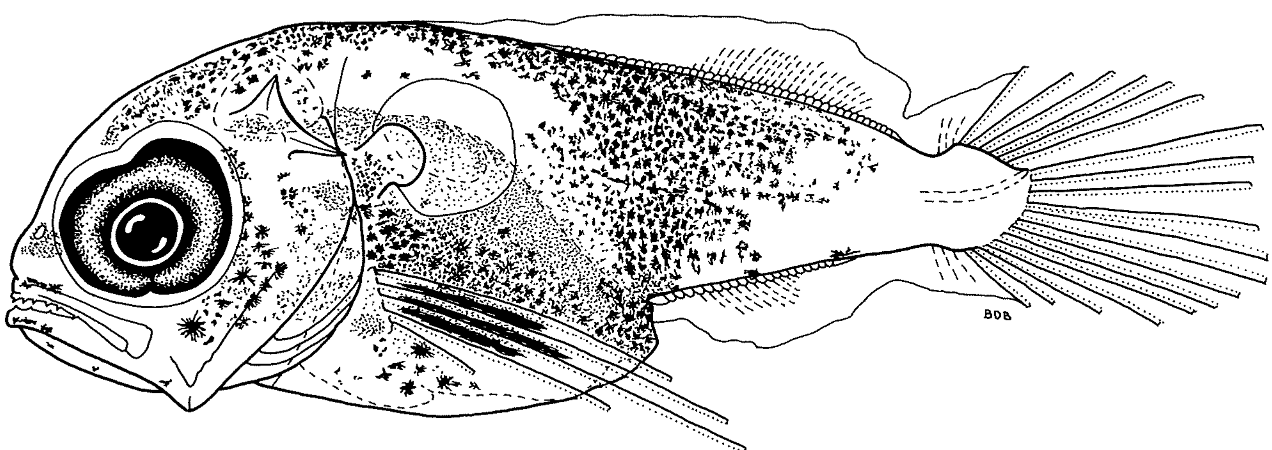
Material examined 15 larvae, 2.1–25.6 mm BL, coastal waters of western and southeastern Tasmania.

Additional references –

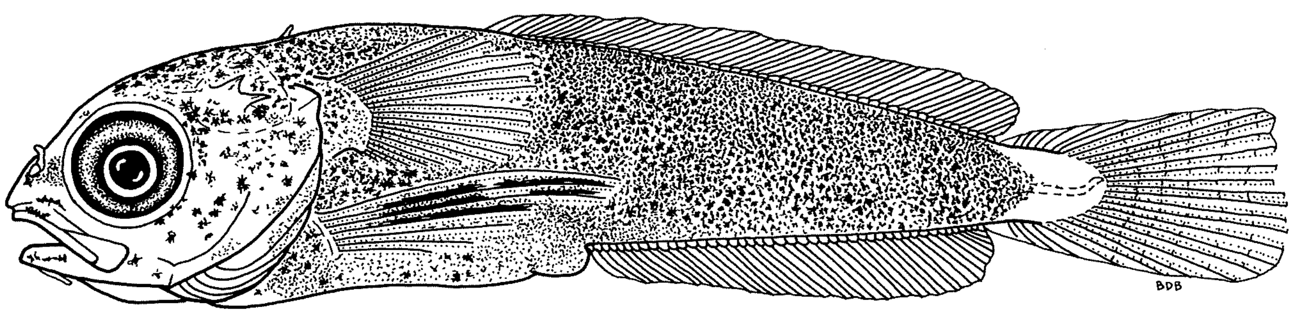
Figure 24 Larvae of *Gaidropsarus* sp. **A** Preflexion; note heavily pigmented, developing pelvic fins. **B** Late flexion. **C** Postflexion; note developing barbels and first dorsal-fin ray. Myomeres omitted in B, C. A–C from western Tas coastal waters. Illustrated by B.D. Bruce.



A 2.2 mm



B 4.5 mm



C 13.7 mm

BELONIFORMES

The Beloniformes is a small order of atherinomorph fishes found in freshwater, estuarine and marine habitats in tropical to temperate regions worldwide. About 27% of the species are confined to fresh water and/or brackish waters while the remaining 73% are marine, primarily in surface oceanic waters. The order contains 5 families, 38 genera and about 190 species (Collette *et al.*, 1984a; Nelson, 1994). Families comprise the Adrianichthyidae, Belonidae (needlefishes), Exocoetidae (flyingfishes), Hemiramphidae (halfbeaks) and Scomberesocidae (sauries). Beloniform fishes are moderately to very elongate, have a fixed or non-protrusible upper jaw, and opposing, spineless dorsal and anal fins that are situated posteriorly on the body. Larvae are primarily neustonic and have been described for many representatives of all five families (see review of early life history stages by Collette *et al.*, 1984a; see also Fahay, 1983; Chen, 1988a,b,c,d; Leis & Trnski, 1989; Watson, 1996a,b,c,d).

Families and species included here

SCOMBERESOCIDAE
Scomberesox saurus scomberoides

Scomberesocidae: Sauries

B.D. Bruce and C.A. Sutton

Scomberesocids are primarily oceanic, epipelagic fishes found in tropical to temperate waters worldwide (Hubbs & Wisner, 1980). We follow Nelson (1994) in regarding the family as comprising four monotypic genera (see however Collette *et al.*, 1984a). One genus, *Scomberesox*, contains a North Atlantic and a Southern Hemisphere subspecies, the latter occurring in southern Australian waters (Hubbs & Wisner, 1980; Paxton & Hanley, 1989f; Gomon *et al.*, 1994). Sauries support a major commercial fishery in the northwest Pacific (400 000 tonnes in 1993; Sommer, 1995) and are considered to be a potential fishery resource in other regions (Smith *et al.*, 1970; Watanabe *et al.*, 1988). Adults (to 46 cm) are elongate and laterally compressed, have either a long, slender beak with both jaws produced, or a short beak with only the lower jaw slightly produced. The dorsal and anal fins are short-based, spineless, and posteriorly located, and are followed by a series of finlets. Eggs are slightly elliptical (longest axis 1.6–2.8 mm), have no oil globules, and are pelagic in all genera except in *Cololabis* which typically attach to floating objects by a cluster of long filaments arising from one pole (Nakamura, 1937; Orton, 1964; Collette *et al.*, 1984a). Larvae have been described for representatives of *Cololabis* and *Scomberesox* (see Collette *et al.*, 1984a and references therein; see also Hardy, 1978a; Hubbs & Wisner, 1980; Fahay, 1983; Chen, 1988b; Watson, 1996a). Larvae hatch at the postflexion stage (6–7 mm) with a small to moderate yolk sac, functional mouth and eyes, developing caudal-fin rays, and usually a heavily pigmented body (Uchida *et al.*, 1958; Hardy, 1978a; Collette *et al.*, 1984a; Watson, 1996a). The jaws of long-beaked species start to elongate at about 40–60 mm (Hubbs & Wisner, 1980). The moderately advanced state of development at hatching, as with belonid and hemiramphid larvae (Leis & Trnski, 1989), appears to be the only specialisation of scomberesocid larvae to pelagic life.

Meristic characters of the scomberesocid genus of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Scomberesox	(1)	10–12 + 5–6 finlets	12–14 + 5–7 finlets	12–14	6	16–17	39–42 + 26–27 = 64–68

Main characters of scomberesocid larvae

- 62–70 myomeres
- Body elongate (BD 10–12%), becoming laterally compressed in older larvae
- Moderately large size at hatching (6–7 mm); notochord flexion is completed during embryonic stage
- No head spines
- Gut long to very long (PAL 65–71%), straight
- Long, persistent preanal membrane
- Short-based, posteriorly located dorsal and anal fins, both followed by finlets
- Late forming, posteriorly located pelvic fins
- Body heavily pigmented at hatching

References to scomberesocid larvae

Hardy (1978a), Hubbs & Wisner (1980), Fahay (1983), Collette *et al.* (1984a), Chen (1988b), Watson (1996a).

Families with similar larvae

Belonidae – 53–97 myomeres; greatly produced lower jaw in older larvae ('halfbeak' stage); large size at hatching (4–15 mm); lack dorsal and anal finlets.

Bovichtidae (*Bovichtus* early stages) – 37–38 myomeres; lack dorsal and anal finlets; stout opercular spine.

Echeneidae (early stages) – 26–41 myomeres; preflexion stage at hatching; sucking disc on head or nape from flexion stage in some taxa; gill arches and filaments exposed posteriorly until end of flexion stage.

Exocoetidae – 39–52 myomeres; body deep anteriorly; jaws relatively short, lower jaw produced in juveniles of a few taxa; barbels on lower jaw in juveniles of many taxa; pectoral and pelvic fins very large; lack dorsal and anal finlets; body usually moderately pigmented, discrete melanophores over trunk and tail.

Hemiramphidae – 37–63 myomeres; lack dorsal and anal finlets; body lightly to heavily pigmented, distinct melanophore series dorsally and ventrally along trunk and tail.

Sphyraenidae (later stages) – 24 myomeres; small preopercular spines; 2 separate dorsal fins; lack dorsal and anal finlets.

Scomberesocidae *Scomberesox saurus scomberoides* (Richardson, 1843) Saury

D 10–12 + 5–6 A 12–14 + 5–7 P_1 12–14 P_2 6 C 16–17 V 64–68

Adults Distributed around southern Australia from Geraldton (WA) to Port Macquarie (NSW), including Tasmania; also throughout temperate waters elsewhere in the Southern Hemisphere. Juveniles and adults are most common seaward of the continental shelf break, although they occasionally enter bays and estuaries. Adults have elongate, toothless bill-like jaws, and finlets posterior to the dorsal and anal fins. Maximum size 45 cm (Hubbs & Wisner, 1980; Hutchins & Swainston, 1986; Paxton & Hanley, 1989f; Gomon *et al.*, 1994).

Importance to fisheries Not fished commercially in southern Australia. Prey item of many large oceanic predators such as marlin and tuna (Hutchins & Swainston, 1986; Gomon *et al.*, 1994).

Spawning Eggs are pelagic and spherical, 2.5–2.6 mm in diameter, and have numerous short, rigid chorionic filaments, and no oil globule. Eggs have been collected off southern New South Wales in May. Larvae have been caught in coastal waters of northern and central New South Wales from January to May (A.G. Miskiewicz, pers. comm.), Tasmania from February to May, and South Australia from January to April.

Diagnostic characters

- 64–68 myomeres (obscured by pigment)
- Lower jaw slightly projected beyond upper jaw
- Dorsal fin directly opposite anal fin
- Body heavily pigmented
- Expanded melanophore at base of caudal-fin rays

Description of larvae

Morphology Body elongate (BD 10–12%), initially cylindrical, laterally compressed with development. Head moderate (HL 20–24%). Lower jaw robust, projecting slightly beyond upper jaw; elongation of jaws to form characteristic adult beak had not commenced by 55 mm in series examined. Gut long to very long (PAL 65–71%), straight. Prominent preanal membrane extending from about midgut to anus until 22.0 mm. Scales form between 17.8 and 25.2 mm.

Size at

Hatching	6.4–6.6 mm
Notochord flexion	Prior to hatching
Transformation	*ca.* 25 mm

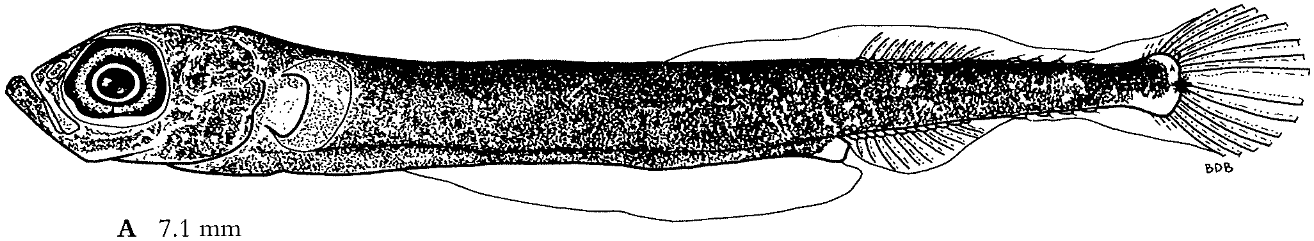
Formation of fins:
Caudal Prior to hatching; Anal <6.4–11.2 mm; Dorsal <6.4–11.2 mm; Pelvic 18.5–23.1 mm; Pectoral 12.0–17.8 mm

Pigmentation Larvae are heavily pigmented. *External*: Melanophores densely and evenly spread over entire body except ventrolateral surface of caudal peduncle until 8.5 mm. Pigment reduced to scattered discrete melanophores covering lateral surface of body from 8.5 mm, remaining dense and coalesced dorsally and dorsolaterally. Prominent expanded melanophore medially at base of caudal-fin rays; 1–5 smaller melanophores scattered over upper caudal-fin ray bases which merge to cover all bases by 25 mm. *Internal*: Melanophores densely and evenly spread over entire gut except around anus.

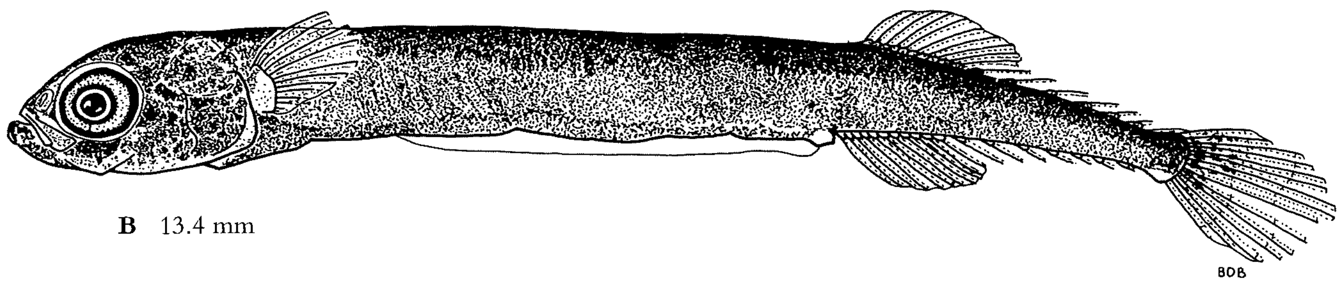
Material examined 30 larvae and juveniles, 6.4–55.0 mm BL, coastal waters of eastern Tasmania.

Additional references (including for *S. s. saurus*) Gilchrist (1904), Roule & Angel (1930), Sanzo (1940), Brownell (1979), Nesterov & Shiganova (1976).

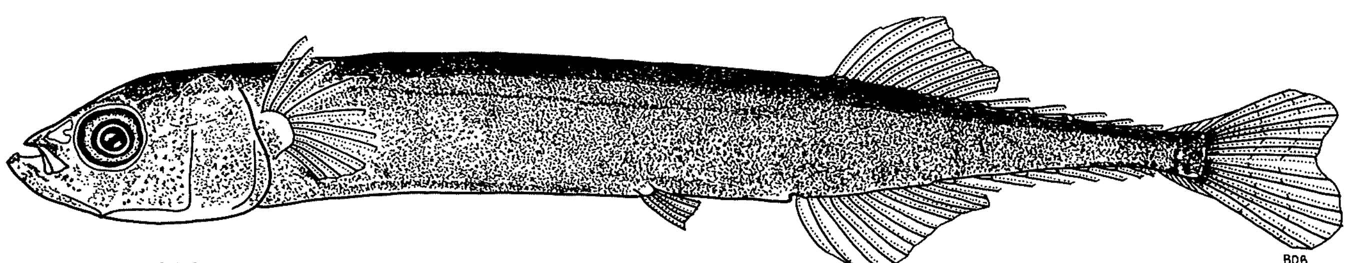
Figure 25 Postflexion larvae of *Scomberesox saurus scomberoides*. **A** Larva with elongate preanal finfold. **B** Larva with developing pectoral-fin rays. **C** Larva approaching transformation. A–C from eastern Tas coastal waters. Illustrated by B.D. Bruce.



A 7.1 mm



B 13.4 mm



C 24.3 mm

BERYCIFORMES

The Beryciformes is a small order of exclusively marine fishes found in coastal and oceanic waters worldwide, to a depth of about 5000 m. This morphologically diverse order of fishes includes rocky and coral-reef dwellers, as well as epipelagic, mesopelagic, bathypelagic and bathybenthic species (Keene & Tighe, 1984; Kotlyar, 1986; Nelson, 1994). Taxonomic relationships of the various representatives are uncertain as conflicting views are still held by those working on the order (e.g. Johnson & Patterson, 1993; Moore, 1993). According to Nelson (1994), the order comprises 3 suborders, 7 families, 28 genera and 123 species. Of the 3 suborders, we treat a single family in each of the Berycoidei and Trachichthyoidei. The Berycoidei comprises the single family Berycidae (alfonsinos), with 2 genera and 9 species. The Trachichthyoidei comprises the families Anomalopidae (flashlight fishes), Anoplogastridae (fangtooths), Diretmidae (spinyfins), Monocentridae (pinecone fishes) and Trachichthyidae (roughies), with a total of 18 genera and 54 species (Nelson, 1994). Larvae have been described for several members of the Berycidae and for representatives of the five trachichthyoid families (see review of early life history stages by Keene & Tighe, 1984; see also Post, 1976; Crossland, 1981a; Post & Quero, 1981; Konishi *et al.*, 1988; Okiyama, 1988f,g,h; Colin, 1989; Matarese *et al.*, 1989; Mundy, 1990; Jordan & Bruce, 1993; Baldwin & Johnson, 1995; Watson, 1996e,f,g; Konishi & Okiyama, 1997).

Families and species included here

BERYCIDAE
Centroberyx affinis

TRACHICHTHYIDAE
Aulotrachichthys sp.
Optivus sp. 1
Paratrachichthys sp.

Berycidae: Redfishes, nannygais, alfonsinos

A.G. Miskiewicz, B.D. Bruce and T. Trnski

Berycids are demersal marine fishes found in tropical to temperate waters of the Atlantic, Indian, and the western and central Pacific oceans. They occur on rocky reefs in shelf and slope waters to a depth of about 1250 m, with most species at depths between 200 and 600 m (Busakhin, 1982). The family contains two genera and 9 species (Woods & Sonoda, 1973; Busakhin, 1982; Nelson, 1994). Both genera and 6 species have been recorded from temperate Australia (Last *et al.*, 1983; Hutchins & Swainston, 1986; Paxton & Hanley, 1989h; Gomon *et al.*, 1994). Several species are commercially important (Kailola *et al.*, 1993). Adults (to 60 cm) are bright red, have a large mouth, strong ctenoid scales, pelvic fins with one spine and 7–13 soft rays, usually four anal-fin spines, and a deeply forked caudal fin (Paxton & Hanley, 1989h; Gomon *et al.*, 1994). Eggs of *Beryx splendens* are pelagic and spherical, 1.09–1.25 mm in diameter (Onishi, 1966, 1968; Ikeda & Mito, 1988). Larvae have been described for *B. decadactylus* and *B. splendens* (Onishi, 1966, 1968; Okiyama, 1988g; Mundy, 1990). The moderate head spination, and the early forming, elongate dorsal- and pelvic-fin elements constitute the only apparent specialisations of berycid larvae to pelagic life (Mundy, 1990).

Meristic characters of berycid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Beryx	(2)	IV, 13–20	III–IV, 25–30	15–18	I, 10–13	19	10 + 14 = 24
Centroberyx	(4)	VI–VII, 11–14	IV, 12–14	12–14	I, 7	19	10 + 14 = 24

Main characters of berycid larvae

- 23–24 myomeres
- Body elongate to moderate (BD 16–33%)
- Head rounded and moderately deep in postflexion larvae
- Weak to moderate head spination from late flexion stage
- Gut moderate to long (PAL 45–60%), initially straight but becoming coiled after flexion stage
- Elongate, early forming pelvic-fin elements
- Body lightly pigmented, pigment limited to dorsal surface of head and ventral surface of posterior portion of tail

References to berycid larvae

Onishi (1966, 1968), Keene & Tighe (1984), Okiyama (1988g), Mundy (1990).

Families with similar larvae

Apogonidae – 2 separate dorsal fins; lack elongate, early forming pelvic-fin elements; body lightly to heavily pigmented; pelvic fins I, 5.

Bramidae – 36–54 myomeres; elongate dorsal-fin base, with ≥ 30 elements; head heavily pigmented from preflexion stage, head and trunk heavily pigmented in postflexion stage.

Callanthiidae – Early forming head spines in most taxa; gut moderate to long (PAL 43–51%); dorsal fin XI, 10–12; short-based anal fin, III, 10–11; pelvic fins I, 5.

Gobiidae (early stages) – Typically 25–27 myomeres; no head spines; 2 separate dorsal fins; lack early forming pelvic fins; pelvic fins I, 5.

Lutjanidae (early stages of some Etelinae) – Preopercular spines in early preflexion larvae; usually more than 1 melanophore ventrally along tail; IX–XIII dorsal-fin spines; pelvic fins I, 5.

Melamphaidae (early stages) – 25–31 myomeres; large head often with large eyes; weak to well developed head spination depending on taxa; pigment dorsally along tail, on pelvic fins, and internally at mid- or hindbrain in some taxa; anal fin typically I, 7–11.

Pempheridae (early stages) – 24–26 myomeres; melanophores often along dorsal and lateral surfaces of trunk and tail; pelvic fins I, 5.

Serranidae (Anthiinae) – 26–28 myomeres; early forming head spines; gut usually long and coiled early in development; pelvic fins I, 5, first ray produced in some taxa.

Trachichthyidae – 26–30 myomeres; early forming head spines; heavily pigmented pelvic fins, I, 6, not elongate; body moderately to heavily pigmented.

Berycidae *Centroberyx affinis* (Günther, 1859) Redfish, eastern nannygai

D VI–VII, 11–13 A IV, 12 P_1 13–14 P_2 I, 7 C 19 V 24

Adults Distributed along southeastern Australia from Newcastle (NSW) to Bass Strait and northeastern Tasmania; also in New Zealand. Form large demersal schools in shelf and slope waters to a depth of 500 m, and apparently move up into the water column at night to feed. Juveniles also aggregate in schools and often enter estuaries. Adults have a deeply forked tail and are bright red. Maximum size 51 cm (Hutchins & Swainston, 1986; Paxton & Hanley, 1989h; Gomon *et al.*, 1994; Rowling, 1994b; Kuiter, 1996; Edgar, 1997).

Importance to fisheries Fished commercially in Victoria and New South Wales where it forms an important part of the South East Trawl fishery. Total catch in 1993 reached 2100 tonnes (Kailola *et al.*, 1993; Gomon *et al.*, 1994; Rowling, 1994b; Staples & Tilzey, 1994).

Spawning Eggs undescribed. Spawning has been reported off New South Wales between late summer and autumn (Rowling, 1994b). Larvae have been caught in coastal waters off Sydney (NSW) from November to May (Gray *et al.*, 1992; Gray, 1993).

Diagnostic characters

- 10–13 + 11–14 = 24–25 myomeres
- Head spination from late flexion stage
- Large, inflated gas bladder
- Elongate, early forming pelvic-fin rays
- Melanophores dorsally on head from late preflexion stage
- 5 melanophores on ventral midline of posterior of tail in preflexion larvae, decreasing to 1 expanded melanophore in postflexion larvae

Description of larvae

Morphology Body elongate to moderate in preflexion larvae (BD 16–33%), moderate to deep in flexion larvae (BD 33–44%), deep in postflexion larvae (BD 41–44%). Head moderate in preflexion larvae, large in flexion and postflexion larvae (HL 25–40%). Small teeth in jaws by late preflexion stage. A few small posterior preopercular spines, 1 opercular spine, and a supracleithral and supraocular ridge by late flexion stage; a few lachrymal spines, a second opercular spine, 2 supracleithral spines, 1 interopercular and several subopercular spines, anterior preopercular and posterior preopercular spines, and infraorbital, pterotic, frontal and posttemporal ridges by postflexion stage. An additional frontal ridge, all ridges spinous, a third opercular spine, 1 cleithral spine, several supramaxillary spines, and 1 small lateral spine on cheek in front of anterior preopercular series by settlement. Gut long (PAL 50–59%), initially straight, coiled by late preflexion stage. Large, inflated gas bladder over foregut. First dorsal- and anal-fin spines form directly; remaining spines transform sequentially from soft rays, with last two dorsal- and last anal-fin elements becoming spines by 35 mm. Elongate, early forming pelvic fins, pelvic-fin rays reach beyond anus from late preflexion stage. Procurrent caudal rays are spinous.

Size at

Hatching	<2.6 mm
Notochord flexion	4.6–6.0 mm
Settlement	9.6–12.0 mm
Formation of fins:	
Pelvic 3.2–9.4 mm; Caudal 3.3–5.7 mm; Dorsal [1] 3.4–5.7 mm; Anal [1] 3.5–5.7 mm; Pectoral 5.2– ~ 7.7 mm	

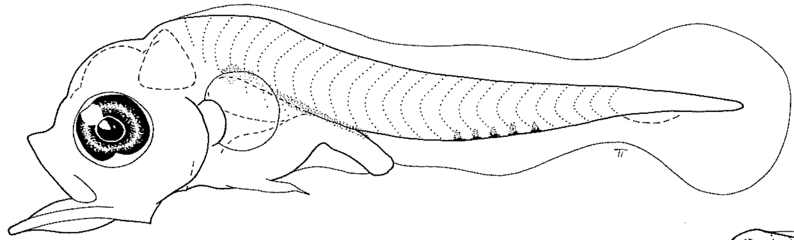
[1] All elements present, but spines continue to transform from soft rays until 35 mm.

Pigmentation Larvae are lightly pigmented. *External*: 1 small melanophore above midbrain from late preflexion stage, number increasing with development. Series of 5 stellate melanophores along ventral midline of posterior of tail in preflexion larvae, reduced to 1 expanded melanophore on caudal peduncle from late preflexion stage. Series of melanophores along dorsal midline of caudal peduncle from late flexion stage; 1–2 melanophores along lateral midline of caudal peduncle from mid-flexion stage until 8.5 mm. *Internal*: Pigment over hindbrain and under otic capsule in postflexion larvae. Pigment dorsally over gas bladder and gut in preflexion larvae, extending laterally and posteriorly from end of flexion stage.

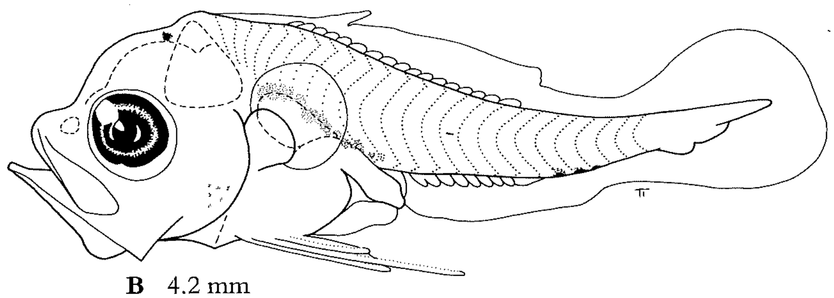
Material examined 22 larvae, 2.6–9.6 mm BL, coastal waters of Sydney (NSW); 34 juveniles, 12.0–36.0 mm BL, Australian Museum collection.

Additional references –

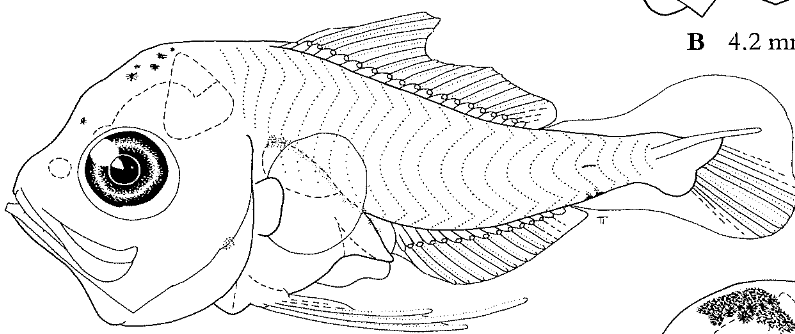
Figure 26 Larvae of *Centroberyx affinis*. **A** Preflexion; note pelvic-fin bud. **B** Preflexion; note developing dorsal and anal fins. **C** Flexion. **D** Early postflexion. **E** Postflexion. **F** Postflexion; note lachrymal and supramaxillary spines; myomeres omitted. A–F from central NSW coastal waters. Illustrated by T. Trnski.



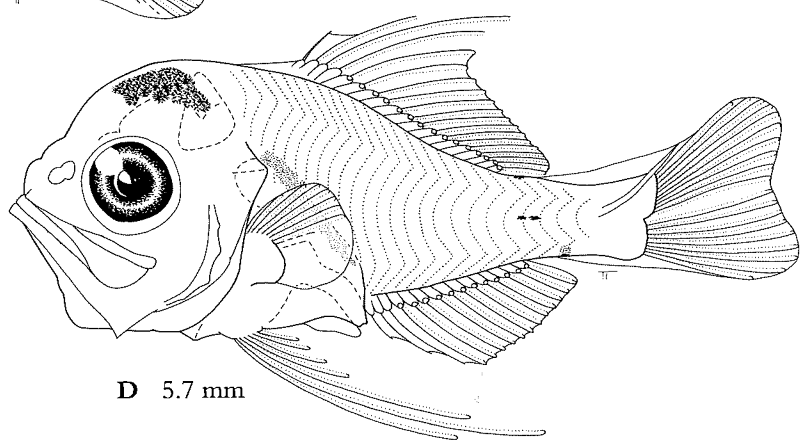
A 3.3 mm



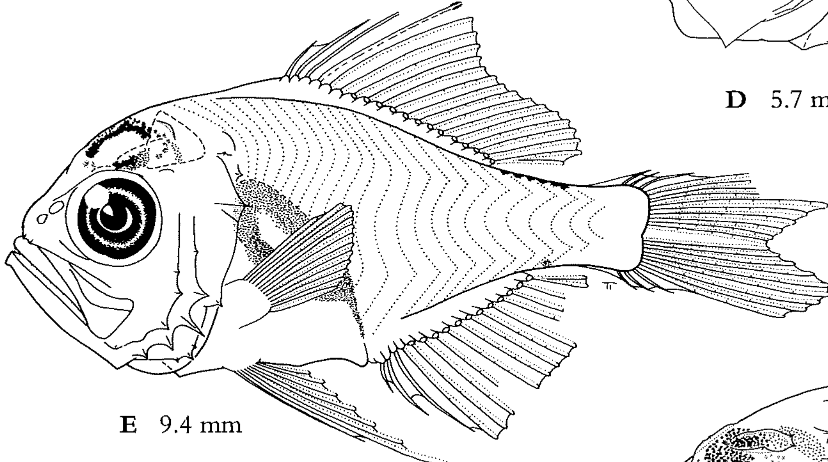
B 4.2 mm



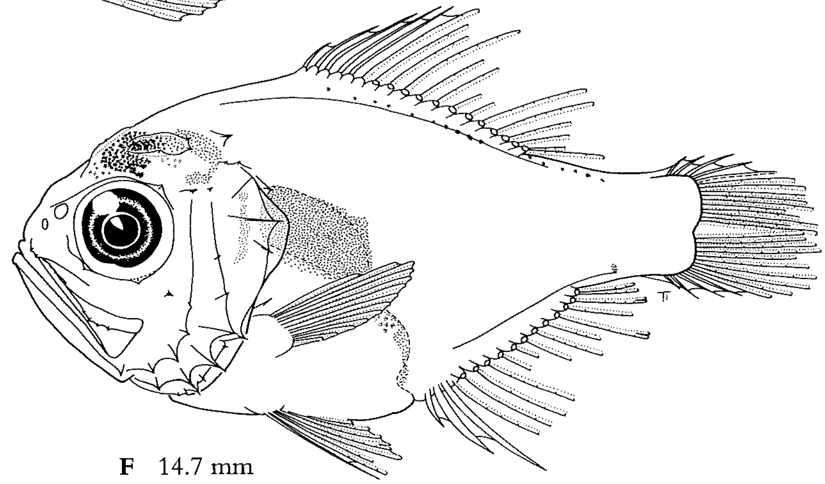
C 5.3 mm



D 5.7 mm



E 9.4 mm



F 14.7 mm

Trachichthyidae: Roughies, sawbellies

A.R. Jordan and B.D. Bruce

Trachichthyids are demersal marine fishes found in the Atlantic, Indian and Pacific oceans. They occur in estuarine, shelf and slope waters to a depth of about 1500 m, with most species in deep water. The family comprises 7 genera and about 33 species (Nelson, 1994). The group has not been well studied and several species in Australian waters are still undescribed. A current revision of the Australian species by M.F. Gomon (NMV, pers. comm.) recognises 7 genera and 15 species, with all 7 genera and 12 species in temperate waters (Paxton & Hanley, 1989g; Kotlyar, 1992; Gomon *et al.*, 1994). Adults (to 55 cm) are deep bodied, have a large and deep head with bony ridges and mucus-filled cavities, a distinct spine at the angle of the preopercle, scute-like scales ventrally on the body, pelvic fins with I, 6–7 elements, and a deeply forked caudal fin (Nelson, 1994). One species, the orange roughy, *Hoplostethus atlanticus*, forms the basis of an important fishery off mainland southern Australia and around southern Tasmania, and off New Zealand (Last *et al.*, 1983). Eggs of *Hoplostethus* and *Paratrachichthys* are pelagic and spherical, 1.8–2.3 mm in diameter, and have none or a single oil globule (Robertson, 1975a; Bulman & Koslow, 1995). Larvae have been described for representatives of *Aulotrachichthys*, *Gephyroberyx*, *Hoplostethus*, *Optivus* and *Paratrachichthys* (Crossland, 1981a; Konishi *et al.*, 1988; Jordan & Bruce, 1993; Konishi & Okiyama, 1997). The weak to well developed and extensive head spination, and the early forming pelvic fins constitute the only apparent specialisations of trachichthyid larvae to pelagic life (Jordan & Bruce, 1993).

Meristic characters of trachichthyid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Aulotrachichthys	(2)	V, 13	II–III, 8–9	12–14	I, 6	17	27–29
Gephyroberyx	(1)	VIII, 13–14	III, 11	14	I, 6	17	26–27
Hoplostethus	(4)	V–VIII, 12–18	III, 9–11	12–20	I, 6	17	24–30
Optivus	(2)	IV, 11	III, 9	10–12	I, 6	17	27
Paratrachichthys	(1)	V, 13	III, 10	12–14	I, 6	17	26–27
Sorosichthys	(1)	IX–X, 8–9	II, 8–9	13	I, 6	17	27
Trachichthys	(1)	III–IV, 11–12	III, 9–10	13–14	I, 6	17	27

Main characters of trachichthyid larvae

- 26–30 myomeres
- Body moderate prior to flexion stage, deep after flexion stage (BD 40–50%)
- Head deep, with a moderate to large mouth
- Weak to well developed head spination, including prominent bony cranial ridges, and preopercular and opercular spines; preopercular spine at angle posteriorly directed and prominent in some taxa; angular, articular and supramaxillary spines in some taxa
- Gut long to very long (PAL 54–71%), initially straight but becoming coiled and compact (triangular-shaped) prior to flexion stage
- Prominent gas bladder, visible in all stages
- Early forming, heavily pigmented pelvic fins
- Moderately to heavily pigmented body

References to trachichthyid larvae

Keene & Tighe (1984), Konishi *et al.* (1988), Jordan & Bruce (1993).

Families with similar larvae

Anomalopidae – 30–31 myomeres; light organ beneath eye; lack posteriorly directed preopercular spine at angle; dorsal fin II–VI, 14–19; pigment on caudal fin; scales with dermal spines.

Anoplogastridae – Posteriorly directed, serrate parietal spine and posterior preopercular spine at angle, both very prominent in flexion and postflexion larvae; pelvic fins not precocious; dorsal and anal fins spineless, 17–20 and 7–10 respectively.

Berycidae – 24–25 myomeres; weak to moderate head spination from late flexion stage; anal fin III–IV, 12–30; early forming, elongate pelvic fins, I, 7–13; gut long (PAL 45–60%); body lightly pigmented, pigment restricted to head and ventrally on tail.

Bramidae – 36–54 myomeres; long-based, spineless dorsal and anal fins, both fins with high number of rays (21–50); early forming, elongate pectoral-fin rays; pelvic fins I, 5, not pigmented.

Diretmidae – Posteriorly directed, serrate parietal spine and posterior preopercular spine at angle, both very prominent in postflexion larvae; pelvic fins not precocious; dorsal and anal fins I, 24–30 and I, 18–24 respectively.

Monocentridae – Wide basal, bony projections on cranium; lack posteriorly directed preopercular spine at angle; 2 dorsal fins; pigment over spinous portion of dorsal fin; small number of 'barnacle-shaped' scales.

Monodactylidae (*Monodactylus*) – 24–25 myomeres; moderate head spination; long-based dorsal and anal fins, V–VIII, 27–31 and III, 27–32 respectively; pelvic fins I, 5; body moderately to heavily pigmented.

Nomeidae (some taxa, e.g. *Nomeus*, *Psenes*) – 30–42 myomeres; long-based dorsal fin with > VIII spines and >20 rays; long-based anal fin with II–III spines and >20 rays.

Phycidae - 38-55 myomeres; pelvic fins initially with 3–4 rays (2–9 in adults); lack preopercular spines; pterotic spines in several taxa; 2–3 dorsal fins; spineless, long-based anal fin, 44–59 rays; barbels on lower jaw and snout in a few taxa.

Zeidae – 29–42 myomeres; body rhomboid and laterally compressed in late larvae; gut tightly coiled; long-based dorsal and anal fins, often with elongate anterior rays; dorsal fin VII–X, 24–36; anal fin II–V, 23–38; body evenly pigmented in early larvae, pigment extending to finfold.

Trachichthyidae *Aulotrachichthys* sp. Roughy

D V, 13 A III, 8–9 P_1 12–14 P_2 I, 6 C 17 V 27–29

Adults Undescribed species distributed along southeastern Australia from Brisbane (Qld) to Green Cape (NSW). Occurs on rocky reefs in coastal waters. Adults have a striated silvery tissue extending ventrally from the pelvic-fin base to just past the anal-fin base (May & Maxwell, 1986; Paxton & Hanley 1989g; Gomon *et al.*, 1994).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in coastal waters of northern and central New South Wales during winter (Jordan & Bruce, 1993).

Diagnostic characters

- 15–18 + 9–12 = 27–29 myomeres
- Extensive, well developed head spination
- Anus migrates forward in late preflexion and early flexion larvae
- Ventral striated tissue from end of flexion stage
- Dermal spines on body from late flexion stage
- Pigmented light organ around anus from late preflexion stage
- Large, early forming pelvic fins, heavily pigmented
- Body heavily pigmented except for last 5–6 postanal myomeres

Description of larvae

Morphology Body moderate in preflexion larvae (BD 25–39%), deep in flexion and postflexion larvae (BD ~50%). Head moderate in preflexion larvae (HL 24–34%), large in flexion and postflexion larvae (HL ~43%). Minute teeth on lower jaw by late flexion stage. Low supraocular ridge with 1 spine by 2.8 mm, and up to 9 spines from flexion stage. Anterior and posterior preopercular spines from early flexion stage. Spines on dentary, at angle of lower jaw, supramaxilla and infraorbital, and several cranial and opercular ridges during flexion stage. Parietal, supracleithral and posttemporal spines, and nasal and frontal ridges by mid-flexion stage. Gut long in preflexion larvae (PAL 54–69%), reaching adult location by early flexion stage (PAL 38–54%), large and coiled from late preflexion stage. A light organ surrounds anus by 3.6 mm and becomes heavily pigmented and rugose by 4.4 mm. Ventral striated tissue visible in postflexion larvae. Dermal spines at pelvic-fin base by 5.7 mm; cluster of spines anterior to anus by early postflexion stage. Series of strong spines extending posteriorly along ventral midline between pelvic-fin base and anus by early postflexion stage; these later presumably become scutes. Dermal spines in longitudinal rows over entire body surface and along base of dorsal and anal fins by 7.9 mm; these later develop into ctenoid scales.

Size at

Hatching	<2.8 mm
Notochord flexion	4.9–7.9 mm
Settlement	>7.9 mm
Formation of fins:	

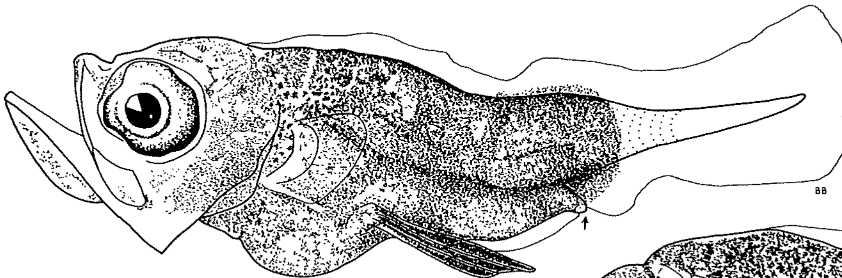
Pelvic <2.8 mm; Dorsal 3.9–7.9 mm; Anal 3.9–7.9 mm; Pectoral 4.9–7.9 mm; Caudal 4.9–5.7 mm

Pigmentation Larvae are heavily pigmented. *External*: Extensive pigment over entire head and body, except for region around mouth and last 5–6 postanal myomeres. Pelvic fins heavily pigmented. *Internal*: Light pigment dorsally over gas bladder in some larvae.

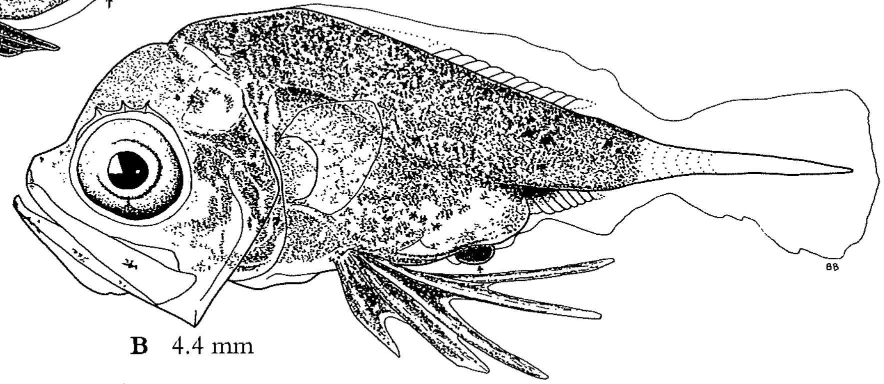
Material examined 24 larvae, 2.8–5.7 mm BL, coastal waters of northern and central New South Wales; 1 larva, 7.9 mm BL, coastal waters of northeastern Tasmania.

Additional references Jordan & Bruce (1993).

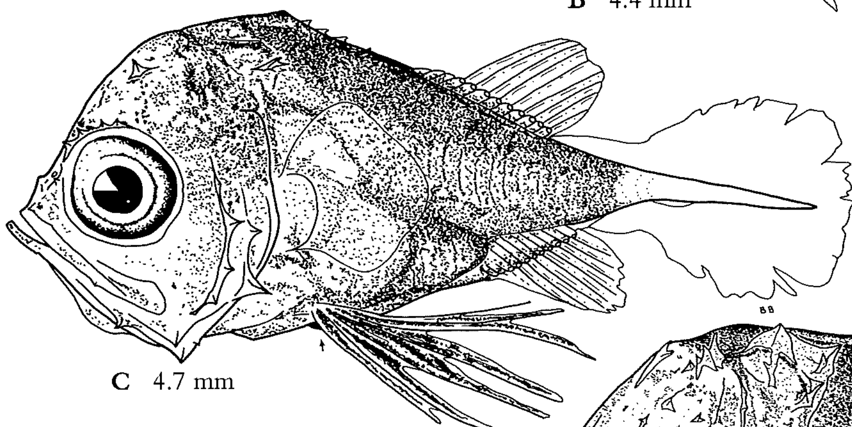
Figure 27 Larvae of *Aulotrachichthys* sp. **A** Preflexion; note heavily pigmented pelvic fin. **B** Preflexion; note developing dorsal and anal fins. **C** Late preflexion. **D** Flexion; pectoral fin is missing. **E** Postflexion. Arrows indicate position of anus. A–E from northern and central NSW coastal waters (from Jordan & Bruce, 1993). Illustrated by B.D. Bruce.



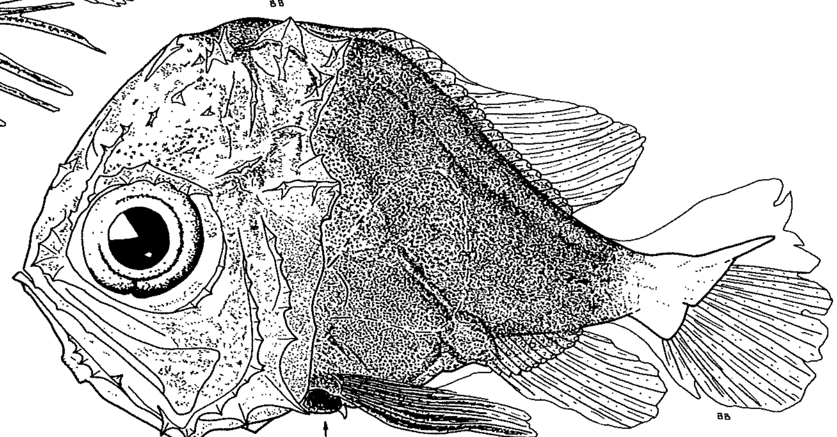
A 2.9 mm



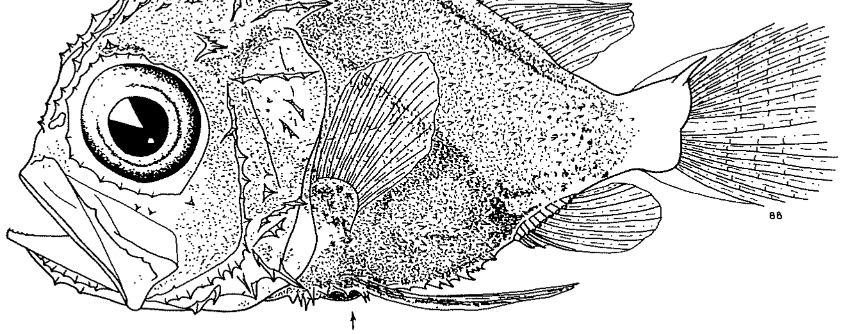
B 4.4 mm



C 4.7 mm



D 5.7 mm



E 7.9 mm

Trachichthyidae *Optivus* sp. 1 Violet roughy

D IV, 11 A III, 9 P_1 10–12 P_2 I, 6 C 17 V 27

Adults Undescribed species distributed along southeastern Australia from Moreton Bay (Qld) to Port Phillip Bay (Vic), and northern Tasmania. Occurs around coastal reefs to a depth of 50 m. Adults are dark dorsally and silvery violet ventrally, with a longitudinal brown stripe on each caudal-fin lobe. Maximum size 12 cm (Gomon *et al.*, 1994; Edgar, 1997).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in coastal waters between Cape Byron (NSW) and Flinders Island (Bass Strait) during winter (Jordan & Bruce, 1993).

Diagnostic characters

- 15–18 + 9–12 = 27–29 myomeres
- Extensive but relatively weak head spination
- Anus does not migrate
- Dermal spines on body during flexion stage
- No light organ
- Early forming pelvic fins, small and moderately pigmented
- Body moderately pigmented

Description of larvae

Morphology Body moderate in preflexion larvae (BD 34–40%), deep in flexion and postflexion larvae (BD 44–49%). Head large (HL 36–46%). Minute teeth in both jaws from 15 mm. Low supraocular ridge with 4–5 small spines from 3.4 mm. Cranial ridges and posterior preopercular spines by early flexion stage; articular, maxillary, anterior preopercular, opercular, frontal, parietal, posttemporal and supracleithral spines, and spines over cranial ridges by late flexion stage. Gut long (PAL 65–71%), large, initially straight but coiled by 3.5 mm. Row of large spines mid-ventrally between pelvic-fin base and anus by early postflexion stage; these become ventral scutes by 15 mm. Small dermal spines in longitudinal rows over entire body and along dorsal- and anal-fin bases during flexion stage. Base of each dermal spine transforms into a small ctenoid scale by 8 mm; spines increase to a maximum of 3 per scale by 10 mm.

Size at

Hatching	<2.5 mm
Notochord flexion	4.0–7.1 mm
Settlement	10.6–15.0 mm
Formation of fins:	

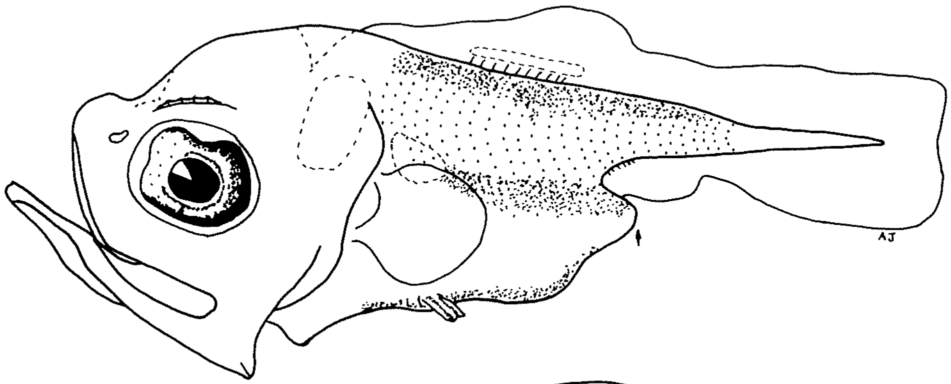
Dorsal 2.7–7.1 mm; Anal 2.7–7.1 mm; Pelvic 3.2–8.0 mm; Pectoral 4.5–7.1 mm; Caudal 4.2–7.1 mm

Pigmentation Larvae are moderately pigmented. *External*: Broad horizontal bands of scattered melanophores dorsally over trunk and tail, and dorsally and ventrally along gut in preflexion larvae. Pigment dorsally over head, opercular region, and entire trunk and tail, except posterior of caudal peduncle, by end of flexion stage. Pelvic fins moderately pigmented by early flexion stage; pigment contracts towards base during flexion stage and disappears by 23 mm. *Internal*: Light pigment dorsally over brain and gas bladder in some larvae.

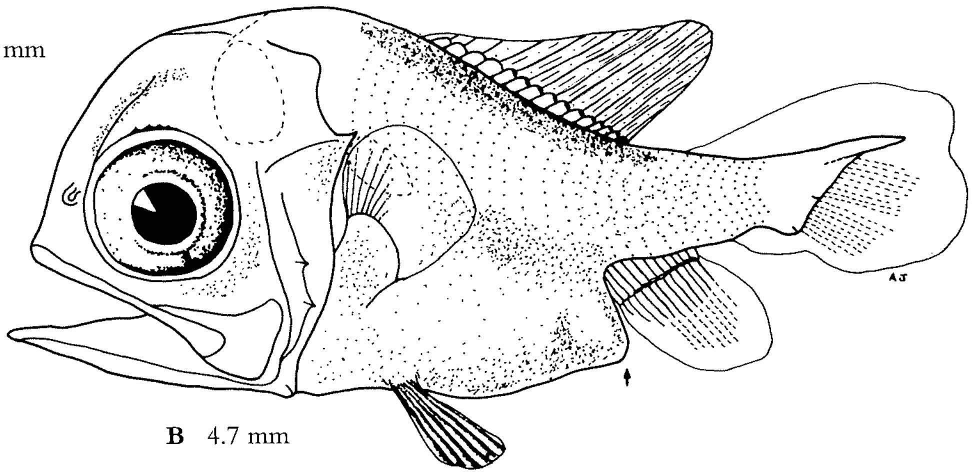
Material examined 145 larvae, 2.5–10.6 mm BL, coastal waters of northern and central New South Wales; 2 larvae, 4.4–4.7 mm BL, coastal waters of northeastern Tasmania; 6 juveniles, 15.0–23.0 mm BL, Botany Bay (NSW).

Additional references Jordan & Bruce (1993).

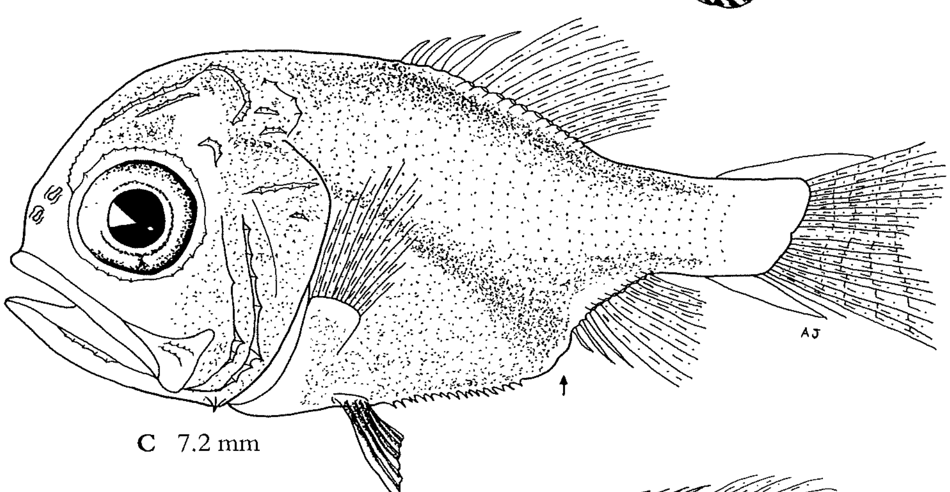
Figure 28 Larvae and juvenile of *Optivus* sp. 1. **A** Preflexion; note pelvic-fin bud and developing dorsal and anal fins. **B** Flexion. **C** Postflexion. **D** Juvenile; scale spination omitted. Arrows indicate position of anus. A–C from northern and central NSW coastal waters; D from Botany Bay (NSW) (from Jordan & Bruce, 1993). Illustrated by A.R. Jordan.



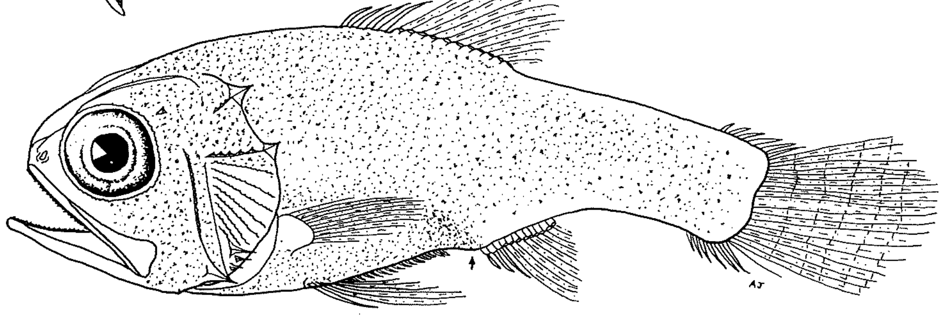
A 3.4 mm



B 4.7 mm



C 7.2 mm



D 23.0 mm

Trachichthyidae *Paratrachichthys* sp. Sandpaper fish

D V, 13 A III, 10 P_1 12–14 P_2 I, 6 C 17 V 26–27

Adults Undescribed species distributed around southern Australia from Perth (WA) to Port Stephens (NSW), including northern Tasmania. Occurs in coastal waters to depths of 220 m, usually on rocky reefs. This species has only recently been distinguished from *P. trailli*, a closely related species endemic to New Zealand. Adults have a light-producing organ adjacent to the anus between the pelvic fins, and are reddish purple to crimson with silvery sides. Maximum size 25 cm (Hutchins & Swainston, 1986; Kuiter, 1993, 1996; Gomon *et al.*, 1994; Edgar, 1997).

Importance to fisheries –

Spawning Eggs undescribed. Eggs of *P. trailli* from New Zealand are pelagic and spherical, 1.8–1.9 mm in diameter, and have a segmented yolk and no oil globule (Robertson, 1975a). Larvae have been caught in coastal waters of northern and central New South Wales in July and August, and around the entire coast of Tasmania from September to April (Jordan & Bruce, 1993).

Diagnostic characters

- 14–18 + 9–13 = 27–29 myomeres
- Extensive but relatively weak head spination
- Anus migrates anteriorly during flexion stage
- No dermal spines in flexion larvae
- Light organ around anus from late preflexion stage, pigmented during flexion stage
- Large, early forming pelvic fin, heavily pigmented
- Body moderately to heavily pigmented except for last 2–8 postanal myomeres

Description of larvae

Morphology Body moderate in preflexion larvae (BD 20–35%), deep in postflexion larvae (BD 40–50%). Head moderate to large (HL 22–41%), deep by postflexion stage. No teeth apparent. Low supraocular ridge with 1–2 spines by 3.9 mm, up to 6 spines in flexion larvae; supraocular finely serrate in postflexion larvae. One opercular spine by late flexion stage, and 2 posterior preopercular spines and 1 posttemporal spine by 8.7 mm, all remain in adults. Cranial ridges from late preflexion stage, without spines. Gut long (PAL 57–68%), large, initially straight but coiled in late preflexion larvae. Anus migrates anteriorly during flexion stage and remains between pelvic fins from early postflexion stage. Light organ around anus visible as an unpigmented, thickened ring in late preflexion larvae, becoming heavily pigmented and rugose in late flexion larvae. Dermal spines and scales not developed by 10 mm.

Size at

Hatching	<3.3 mm
Notochord flexion	5.9–7.6 mm
Settlement	>10.0 mm
Formation of fins:	

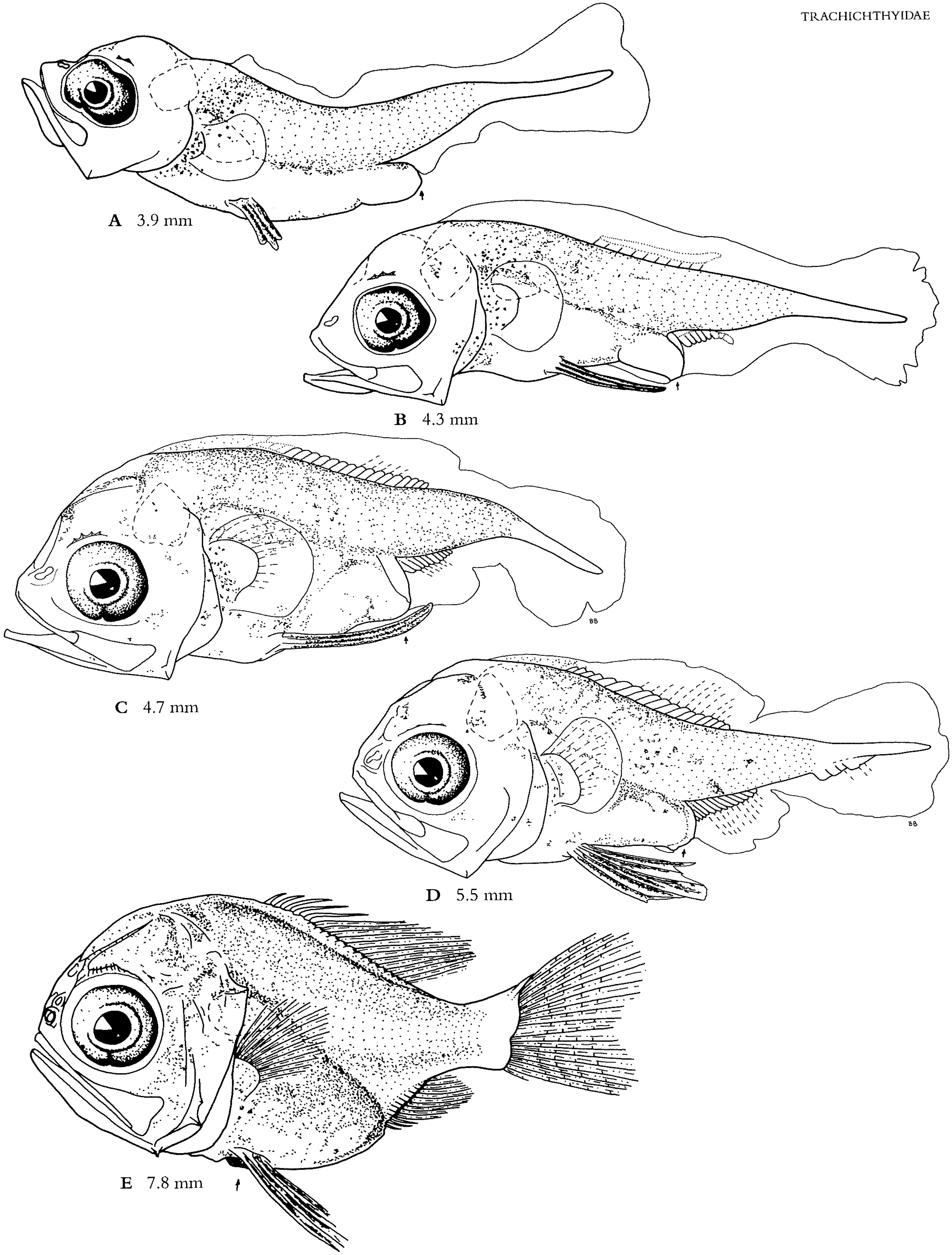
Pelvic 3.3–5.6 mm; Dorsal 4.3–7.8 mm; Anal 4.3–7.8 mm; Pectoral 4.7–7.8 mm; Caudal 5.5–7.8 mm

Pigmentation Larvae are moderately to heavily pigmented. *External:* Pigment over dorsal and ventral surfaces of body except for last 2–8 postanal myomeres; pigment dorsally over head, on opercle, laterally on gut and most of trunk and tail by postflexion stage. Pelvic fins heavily pigmented from 3.3 mm. *Internal:* Light pigment dorsally over gas bladder in some larvae.

Material examined 84 larvae, 3.3–10.0 mm BL, coastal waters of Tasmania; 35 larvae, 3.4–6.5 mm BL, coastal waters of northern and central New South Wales.

Additional references Jordan & Bruce (1993).

Figure 29 Larvae of *Paratrachichthys* sp. **A** Preflexion; note developing pelvic fins. **B** Preflexion; note developing dorsal and anal fins. **C** Preflexion. **D** Late preflexion. **E** Postflexion. Arrows indicate position of anus. A–D from northern and central NSW coastal waters; E from off Maria Island (Tas) (from Jordan & Bruce, 1993). Illustrated by B.D. Bruce.



A 3.9 mm

B 4.3 mm

C 4.7 mm

D 5.5 mm

E 7.8 mm

GASTEROSTEIFORMES

The Gasterosteiformes is a small order of morphologically diverse, specialised fishes well represented in tropical to temperate regions worldwide, with about 95% of the species occurring in estuarine and marine waters. The order comprises 11 families, 71 genera and 257 species (Nelson, 1994). Families include the Aulostomidae (trumpetfishes), Centriscidae (shrimpfishes), Fistulariidae (cornetfishes), Gasterosteidae (sticklebacks), Macroramphosidae (bellowsfishes), Pegasidae (seamoths) and Syngnathidae (seahorses, pipefishes). Gasterosteiform fishes are often relatively small and cryptic, have a rather small mouth at the end of a usually tubular snout, a body often covered with an armour of dermal plates, and a pelvic girdle which is never attached directly to the cleithra (Fritzsche, 1984). Larvae have been described for representatives of all families except the Indostomidae, a monotypic family confined to fresh waters in southeast Asia (see review of early life history stages by Fritzsche, 1984; see also Leis & Rennis, 1983; Zhang *et al.*, 1985; Iwata & Minami, 1988; Kimura, 1988a,b; Minami, 1988a,b,c; Minami & Kimura, 1988; Okiyama, 1988c; Leis & Trnski, 1989; Walker, 1989; Watson & Sandknop, 1996c,d,e).

Families and species included here

PEGASIDAE
Eurypegasus draconis
Pegasus volitans

SYNGNATHIDAE
Hippocampus abdominalis
Phycodurus eques
Stigmatopora nigra
Urocampus carinirostris

Pegasidae: Seamoths

S.E. Reader and F. J. Neira

Pegasids are benthic, predominantly marine fishes found in tropical to temperate waters of the Indo-West Pacific (Palsson & Pietsch, 1989; Nelson, 1994). They are commonly found in shallow coastal waters to a depth of 150 m, generally over sand and mud substrates although some species prefer coarse substrates or seagrass. The seasonal presence of adults near surface waters suggests some type of migration (Kuiter, 1985, 1993). The family contains the genera *Eurypegasus* and *Pegasus*, and five species (Nelson, 1994). Both genera and three species have been recorded from temperate Australia (Paxton & Hanley, 1989i; Gomon *et al.*, 1994). Adults (8–18 cm) have a broad, depressed body completely encased in an armour of fused, dermal plates, a mouth beneath a long, flattened rostrum, large, horizontal fan-shaped pectoral fins, and no gas bladder. The tail is encircled by laterally articulated or fused bony rings (Palsson & Pietsch, 1989). They are well camouflaged and can adapt their external appearance to that of their surroundings. *Eurypegasus* differ from *Pegasus* in having three, instead of four, pairs of dorsolateral body plates, and four, instead of five, pairs of ventrolateral body plates. Eggs of *Eurypegasus* are pelagic and spherical, and about 1.0 mm in diameter (Herold & Clark, 1993). Larvae have been described for *P. volitans* (as *P. natans*) (Jones & Kumaran, 1967; Kimura, 1988b), and *E. papilio* (Leis & Rennis, 1983). The dermal sac is the only apparent specialisation of pegasid larvae to pelagic life (Leis & Rennis, 1983). Juveniles are pelagic before becoming demersal (Palsson & Pietsch, 1989; Gomon *et al.*, 1994).

Meristic characters of pegasid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Eurypegasus	(1)	5	5	9–12	I, 2	8	7 + 12–15 = 19–22
Pegasus	(2)	5	5	9–18	I, 2–3	8	7 + 12–15 = 19–22

Main characters of pegasid larvae
- Body dorsoventrally compressed; tail laterally compressed
- Body enclosed by a dermal sac in small larvae; head and trunk encased by ossified, rigid dermal plates and tail encircled by distinct bony rings in postflexion larvae
- Mouth small and protractile
- Large, fan-shaped pectoral fins, horizontally oriented
- Spineless, posteriorly located dorsal and anal fins, each with 5 rays
- Body moderately to heavily pigmented

References to pegasid larvae
Jones & Kumaran (1967), Leis & Rennis (1983).

Families with similar larvae

None

Pegasidae *Eurypegasus draconis* (Linnaeus, 1766) Dwarf seamoth

D 5 A 5 P_1 9–12 P_2 I, 2 C 8 V 19–22

Adults Distributed around northeastern Australia from the Dampier Archipelago (WA) to Botany Bay (NSW). Also widespread in tropical and subtropical coastal waters of the Indian, and the western and central Pacific oceans. A small benthic species found in estuaries and sheltered coastal bays, usually between 35 and 90 m, but also in shallower waters. Adults have a broad rostrum with lateral hook-like serrations and 8–9 tail rings. Males have a broad bluish white margin on the pectoral fins. Maximum size 8 cm (Palsson & Pietsch, 1989; Paxton & Hanley, 1989i; Kuiter, 1996).

Importance to fisheries –

Spawning Eggs are pelagic and spherical, and about 1.0 mm in diameter. Spawning in aquaria occurs at dusk and eggs hatch in 24–29 hours at 27°C (Herold & Clark, 1993). Larvae have been caught in surface coastal waters of northern and central New South Wales from January to April (A.G. Miskiewicz, pers. comm.).

Diagnostic characters

- 7–8 + 10–12 = 19–20 myomeres
- Body width between pectoral-fin bases >50%
- 8 tail rings by 4.2 mm
- Pectoral fin with concentric bands of pigment

Description of larvae

Morphology Body moderate to deep (BD 37–41%). Body wider than deep, width between pectoral-fin bases >50%. Head moderate to large (HL 34–45%). Mouth small, subterminal by late flexion stage. Gill opening extends along pectoral-fin base. Gut long to very long (PAL 64–76%). Pectoral fin large and fan-shaped in postflexion larvae. One pelvic-fin ray forms early and becomes very elongate. Head and trunk encased in a bony armour in smallest larva. Three tail rings by early postflexion stage, all 8 rings ossified by late postflexion stage.

Size at

Hatching [1]	2.2 mm
Notochord flexion	<3.7–4.8 mm
Settlement	>8.8 mm
Formation of fins:	
Pectoral <3.7 mm; Dorsal <3.7 mm; Anal <3.7 mm; Caudal <3.7–4.8 mm; Pelvic 3.7–>8.8 mm	

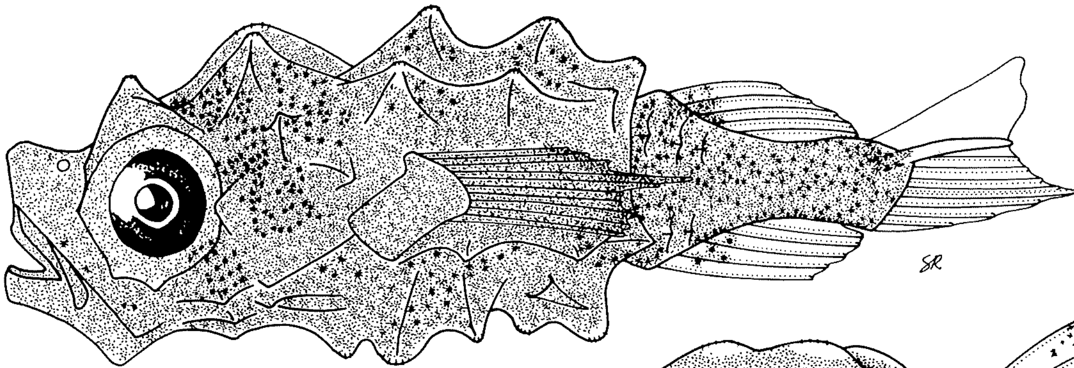
[1] Herold & Clark (1993)

Pigmentation Larvae are moderately to heavily pigmented. *External*: Fine melanophores scattered over entire body. Sparse dark spots and blotches over body, and no pigment around anus in postflexion larvae. Pectoral fin lightly pigmented, with concentric dark and light rings by postflexion stage. One melanophore distally on uppermost caudal-fin ray by 8.8 mm. *Internal*: Pigment over entire gut.

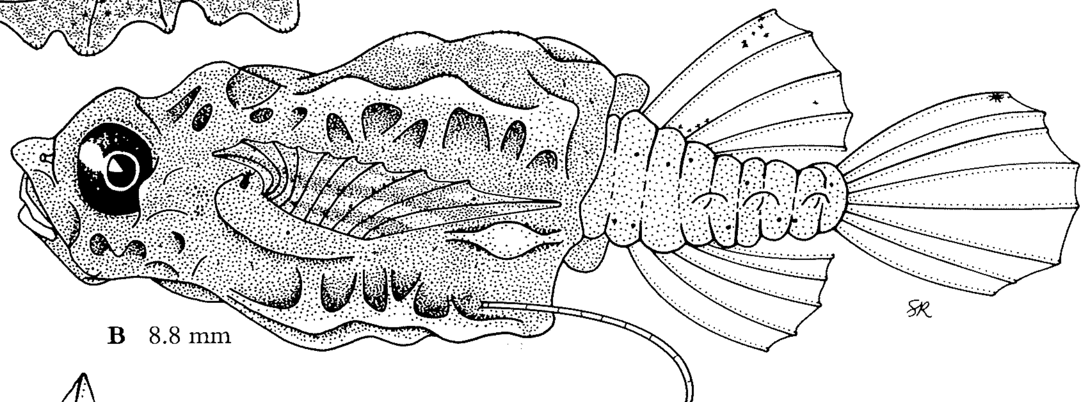
Material examined 4 larvae, 3.7–4.8 mm BL, and 1 larva, 8.8 mm BL, coastal waters of northern and central New South Wales.

Additional references –

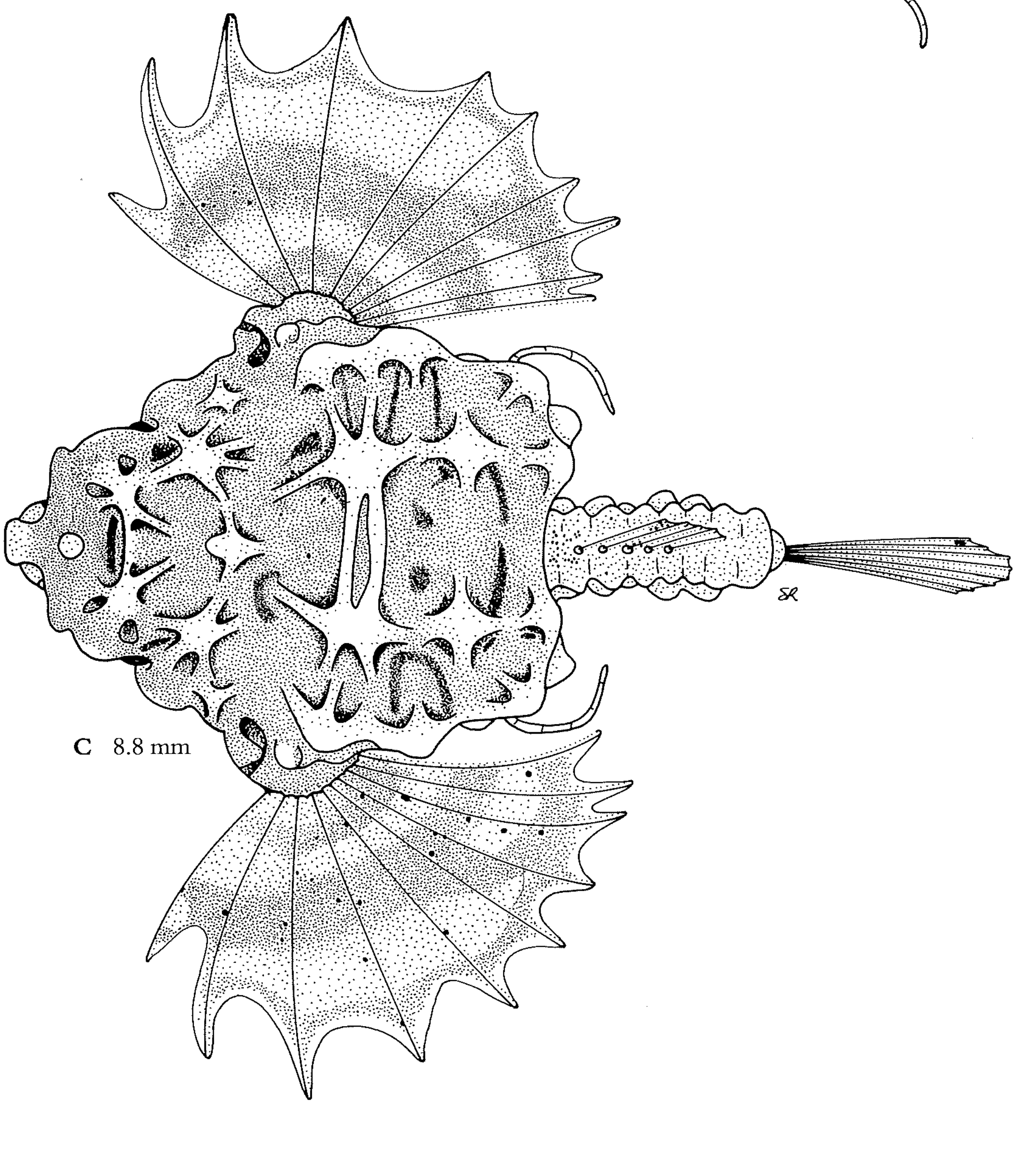
Figure 30 Larvae of *Eurypegasus draconis*. **A** Flexion. **B** Postflexion. **C** Dorsal view of larva in B showing fan-shaped pectoral fins. A from South West Rocks (NSW); B from Port Hacking (NSW). Illustrated by S.E. Reader.



A 3.8 mm



B 8.8 mm



C 8.8 mm

Pegasidae *Pegasus volitans* Linnaeus, 1758 Slender seamoth

D 5 A 5 P_1 9–12 P_2 I,2 C 8 V 21

Adults Distributed around northern Australia from Mandurah (WA) to Bermagui (NSW). Also widespread in tropical and subtropical coastal waters of the Indo-West Pacific. Found in estuaries and bays on shallow sand and mud bottoms, and amongst seagrass beds, mostly at depths between 9 and 27 m. Adults have a long and slender rostrum with lateral hook-like serrations, and 12 tail rings, the posteriormost 3 fused. Maximum size 18 cm (Palsson & Pietsch, 1989; Paxton & Hanley, 1989i; Kuiter, 1993).

Importance to fisheries Sold dried for medicinal purposes and as souvenirs in Philippine markets (R. Fritzsche, HSU, pers. comm.).

Spawning Eggs undescribed although probably pelagic (Kuiter, 1993). Larvae have been caught in the lower Swan Estuary and Cockburn Sound (WA) from November to April (Neira *et al.*, 1992; Jonker, 1993), in offshore waters of northern and central New South Wales in May (A.G. Miskiewicz, pers. comm.), and in coastal waters off Sydney (NSW) from August to October (Gray, 1995).

Diagnostic characters

- 7–8 + 10–12 = 19–20 myomeres
- Body width between pectoral-fin bases 25–40%
- 12 tail rings

Description of larvae

Morphology Body elongate to moderate (BD 14–26%), initially round in cross-section, much wider than deep by postflexion stage. Body width between pectoral-fin bases 25–40%. Head moderate to large (HL 23–44%), initially round, dorsoventrally flattened by flexion stage. Mouth small, terminal in preflexion larvae, subterminal in postflexion larvae. Gill opening small and located at dorsal margin of pectoral-fin base in preflexion and flexion larvae, extending along entire pectoral-fin base in postflexion larvae. Gut moderate to long (PAL 36–69%), coiled. Pectoral fin large and fan-shaped in postflexion larvae. One pelvic-fin ray during flexion stage, elongate and segmented; second ray from 6.7 mm, shorter than first and unsegmented. Dermal bony plates present by 2 mm, with a single, median dorsal ridge and pointed ridges above and below eye; sharp bony ridges over head, trunk and tail during flexion stage, fully ossified by early postflexion stage.

Size at

Hatching	<1.4 mm
Notochord flexion	3.4–4.2 mm
Settlement	>6.7 mm
Formation of fins:	

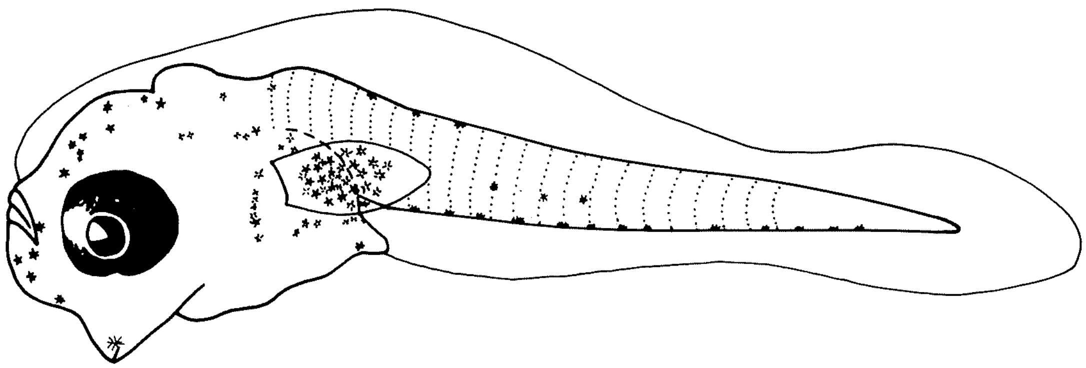
Pectoral 1.4–3.8 mm; Dorsal 2.8–3.8 mm; Anal 2.8–3.8 mm; Pelvic 2.8–>6.7 mm; Caudal 3.4–4.2 mm

Pigmentation Larvae are initially moderately pigmented, becoming heavily pigmented with growth. *External*: Melanophores on snout, lower jaw and angle of lower jaw in preflexion larvae. Light to moderate pigment dorsally and laterally on head, lighter ventrally. Series of melanophores ventrally from anus to notochord tip; several melanophores may be present along dorsal midline of trunk and tail, and laterally on tail. One melanophore may be present above and below notochord tip, and on caudal-fin membrane. Ring of pigment on anterior half of tail by 2 mm, absent from early flexion stage. Scattered melanophores on pectoral-fin membrane except on distal margin; heavy pigment with lighter patches on pectoral fin during flexion stage. Stellate melanophores on posterior of head, trunk and tail in postflexion larvae; light pigment ventrally on trunk and no pigment around anus. Small stellate melanophores anteriorly on head, on caudal-fin base, and along dorsal-fin base between rays 2 and 5, extending along second ray and membrane. *Internal*: Melanophores dorsally and laterally on gut in preflexion larvae.

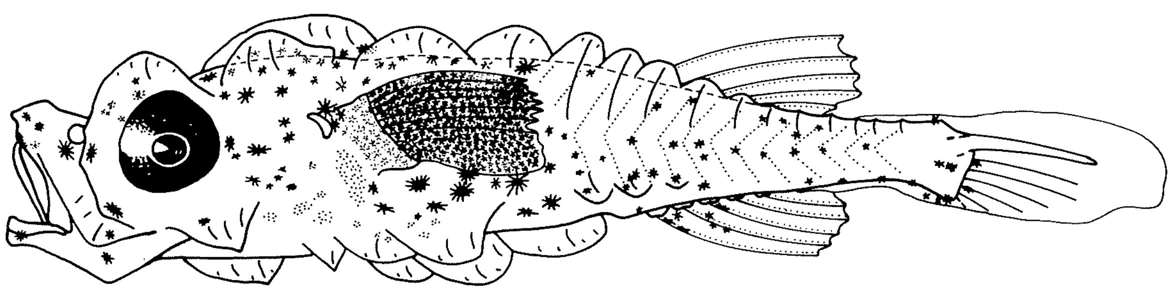
Material examined 9 larvae, 1.4–3.8 mm BL, Swan Estuary and Cockburn Sound (WA); 9 larvae, 3.4–6.7 mm BL, coastal waters off Sydney (NSW).

Additional references Jones & Kumaran (1967), Kimura (1988b).

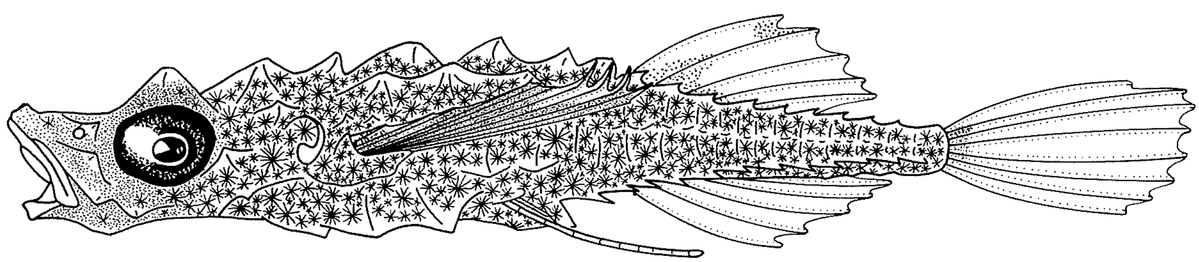
Figure 31 Larvae of *Pegasus volitans*. **A** Preflexion, note dermal sac enclosing most of body. **B** Flexion. **C** Postflexion. **D** Dorsal view of larva in C showing fan-shaped pectoral fins. A from lower Swan Estuary (WA); B from Rockingham (WA); C from Lake Macquarie (NSW). Illustrated by S.E. Reader.



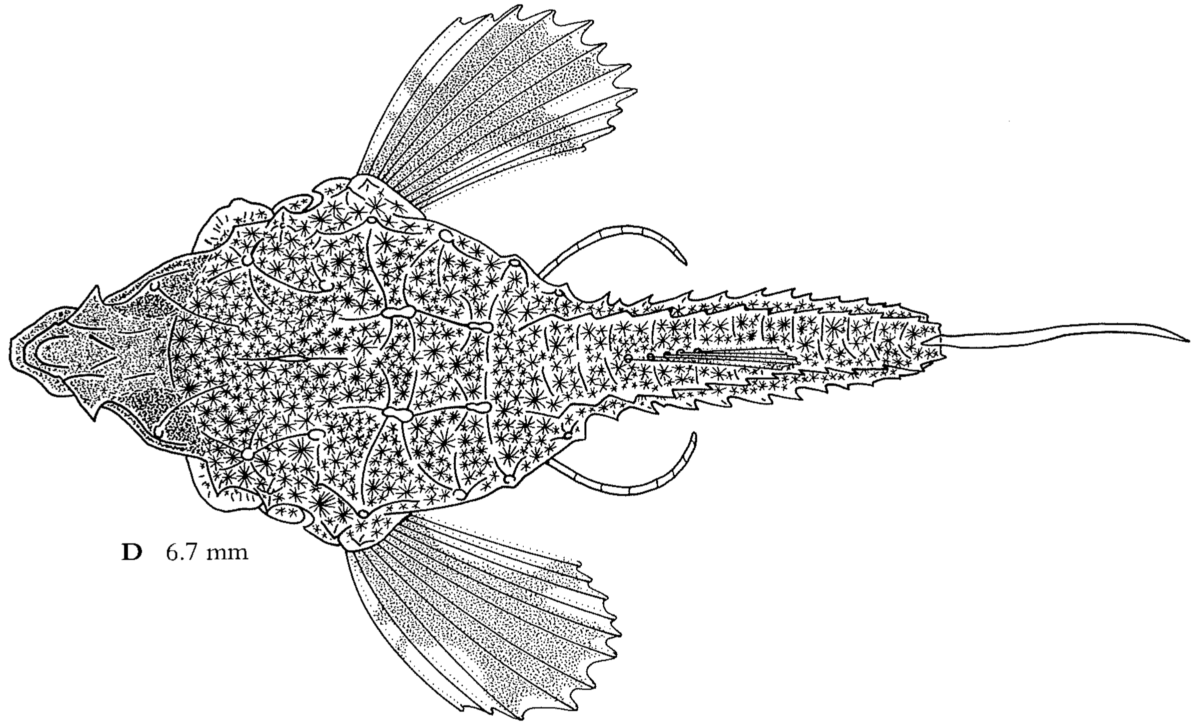
A 1.4 mm



B 3.4 mm



C 6.7 mm



D 6.7 mm

Syngnathidae: Pipefishes and seahorses

M.F. Gomon and F.J. Neira

Syngnathids are mostly slender, elongate fishes found in freshwater, estuarine and marine habitats in tropical to temperate regions worldwide. About 47 genera and 175 species of pipefishes, including the seahorse-like seadragons, and 19 species of seahorses (*Hippocampus*), occur in the Indo-Pacific region (Dawson, 1985). This is the most diverse family of coastal fishes in southern Australia, represented there by 23 of the 38 genera and 40 of the 98 species recorded from Australia. Most Australian species occur in estuaries and coastal waters, where they are frequently associated with seagrass and rocky bottoms, and are absent from fully fresh water. Some, notably seahorses, occasionally occur in drifts of macrophytic algae. Adults (5–65 cm) have a body armour composed of bony plates arranged in the form of rings, with several series of longitudinal ridges extending along the entire body. The number of trunk (7–28) and tail (14–91) rings, dorsal fin-ray counts and the continuity of trunk ridges with tail ridges are used to identify genera and species. The body surface in some species has a fleshy integument which is variously produced into filaments or flaps, assisting the bearer to escape detection. Their small flap-like mouth is usually positioned at the end of an elongate tubular snout, and the gill opening is reduced to a pore at the upper end of the opercle. A single, spineless dorsal fin and the lack of pelvic fins are consistent features, with other fins being present or absent depending on the taxa. In species which have lost the caudal fin, the tail has developed into a prehensile structure that is used to hold onto objects such as seagrass blades. All species are sexually dimorphic and males incubate the eggs on the underside of their trunk or tail. Eggs are fully exposed to the water in some genera, partially hidden by spongy tissue in others and completely concealed within a well defined brood pouch in the rest. Eggs have been described for *Hippocampus erectus* (Hudson & Hardy, 1975). Larvae have been described for representatives of *Cosmocampus*, *Doryrhamphus*, *Hippocampus* and *Syngnathus* (see Fritzsche, 1984, and references therein; see also Minami & Kimura, 1988; Watson & Sandknop, 1996e). Young from pouch brooding species are released 1–2 weeks after spawning. Most genera release well developed young that often resemble miniature versions of the adults, while some genera (e.g. *Doryrhamphus*) release less developed young (Watson & Sandknop, 1996e). Newly emerged young of *Hippocampus* are virtually as straight as juvenile pipefishes, and bending of the body occurs within a day or two after birth.

Meristic characters of syngnathid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Caudal	Body rings
Acentronura	(1)	15–16	3–4	14–15	0	12 + 37
Campichthys	(1)	16–19	3–4	7–9	8–10	16–17 + 32–36
Filicampus	(1)	24–27	4	14–16	8	17–19 + 34–38
Heraldia	(1)	23–27	4	18–22	11	16–19 + 14–16
Hippocampus	(5)	7–31	0–4	10–17	0	8–13 + 31–49
Histiogamphelus	(2)	23–28	3–4	11–14	10	18–22 + 28–37
Hypselognathus	(2)	29–35	3–4	10–14	10	24–28 + 41–45
Kaupus	(1)	30–36	3–4	9–11	7–10	16–18 + 35–38
Kimblaeus	(1)	25–27	0	9–10	8	17–18 + 44–46
Leptoichthys	(1)	33–41	5	20–23	11	22–28 + 18–24
Lissocampus	(3)	13–15	3–4	5–8	10	12–14 + 44–62
Maroubra	(1)	23–27	4	16–20	10	15–17 + 26–29
Mitotichthys	(4)	23–40	2–4	10–18	10	19–23 + 34–50
Nannacampus	(1)	14–18	0	0	10	15 + 34–36

	(n)	Dorsal	Anal	Pectoral	Caudal	Body rings
Notiocampus	(1)	11–13	0	0	6–7	18–19 + 42–48
Phycodurus	(1)	34–38	4	19–21	0	18 + 41–44
Phyllopteryx	(1)	27–34	4–5	20–23	0	17–18 + 31–37
Pugnaso	(1)	21–25	2–3	8–11	10	17–19 + 41–44
Solegnathus	(3)	34–49	4	22–26	0	21–27 + 47–59
Stigmatopora	(2)	35–64	4	11–18	0	16–23 + 67–91
Stipecampus	(1)	26–29	3–4	12–13	8	19–20 + 39–42
Urocampus	(1)	13–15	2	7–10	10	7–10 + 49–59
Vanacampus	(4)	19–31	3–4	8–14	10	16–20 + 34–51

Main characters of syngnathid larvae

- Morphologically similar to adults at birth, apart from paler pigmentation and, in some taxa, the presence or absence of some fins (anal or caudal fins) that are subsequently lost or gained prior to maturation
- Tubular, short to elongate snout in many taxa, tipped with a tiny, flap-like mouth
- Full complement of rays in dorsal and caudal fins (taxa with caudal fin) typically present in newly released young of most taxa
- Pelvic fins absent
- Trunk and tail ridges poorly developed in early stages of some taxa

References to syngnathid larvae

Fritzsche (1984), Minami & Kimura (1988), Watson & Sandknop (1996e).

Families with similar larvae

Aulostomidae – 61–65 myomeres; gut moderate to long (PAL 48–65%), straight; 2 continuous parallel stripes of tiny melanophores ventrally along tail; small melanophores on caudal finfold and around notochord tip.

Fistulariidae – 74–89 myomeres; body very elongate; snout elongate; gut very long (PAL 68–82%), extending well past midbody; numerous small, hooked retrose spinules over trunk and tail from early preflexion stage.

Solenostomidae – 29–33 myomeres; pelvic fins present, I, 6; 2 separate dorsal fins, first with V elongate spines; anal fin posteriorly located and directly opposite second dorsal fin, 17–22 rays; gut long to very long (PAL 67–79%), straight.

Syngnathidae *Hippocampus abdominalis* Lesson, 1827 Bigbelly seahorse

D 23–31 A 4 P_1 14–17 C 0 Body rings 11–13 + 44–49

Adults Distributed along southern Australia from Investigator Strait (SA) to Sydney Harbour (NSW), including Tasmania; also in New Zealand. Occurs in estuarine and shallow coastal marine waters, especially among kelp and sponges, and in the vicinity of rocky reefs to a depth of 12 m. Juveniles may be found attached to drifting seaweed. This is the largest seahorse species in southeastern Australia, and has more dorsal-fin rays and tail rings than any other seahorse. Maximum size 30 cm (Last *et al.*, 1983; Kuiter, 1993, 1996; Gomon *et al.*, 1994; Edgar, 1997).

Importance to fisheries Actively sought by marine aquarium collectors. Small numbers of wild-caught and aquarium-reared individuals are sold locally and internationally for the aquarium trade. Its sedentary habits make it a relatively easy species to culture. Dried and sold to the oriental medicine trade as a tonic and aphrodisiac (Dawson, 1985; Edgar, 1997).

Spawning Eggs undescribed. Fertilised eggs deposited by females in the abdominal pouch of males are incubated for about four weeks before hatching. Hatching occurs at night, coinciding with full moon periods during summer months. Young emerge from the pouch and immediately rise to the surface where they grasp floating debris with their tail (R. H. Kuiter, AP, pers. comm.).

Diagnostic characters

- Head slightly angled to body axis at birth, angle rapidly becoming very pronounced
- Head with an elongate, tubular snout, and a small, flap-like mouth
- Anus below posterior third of dorsal fin
- No caudal fin
- 8–12 narrow, pale pigment bands on tail

Description of larvae

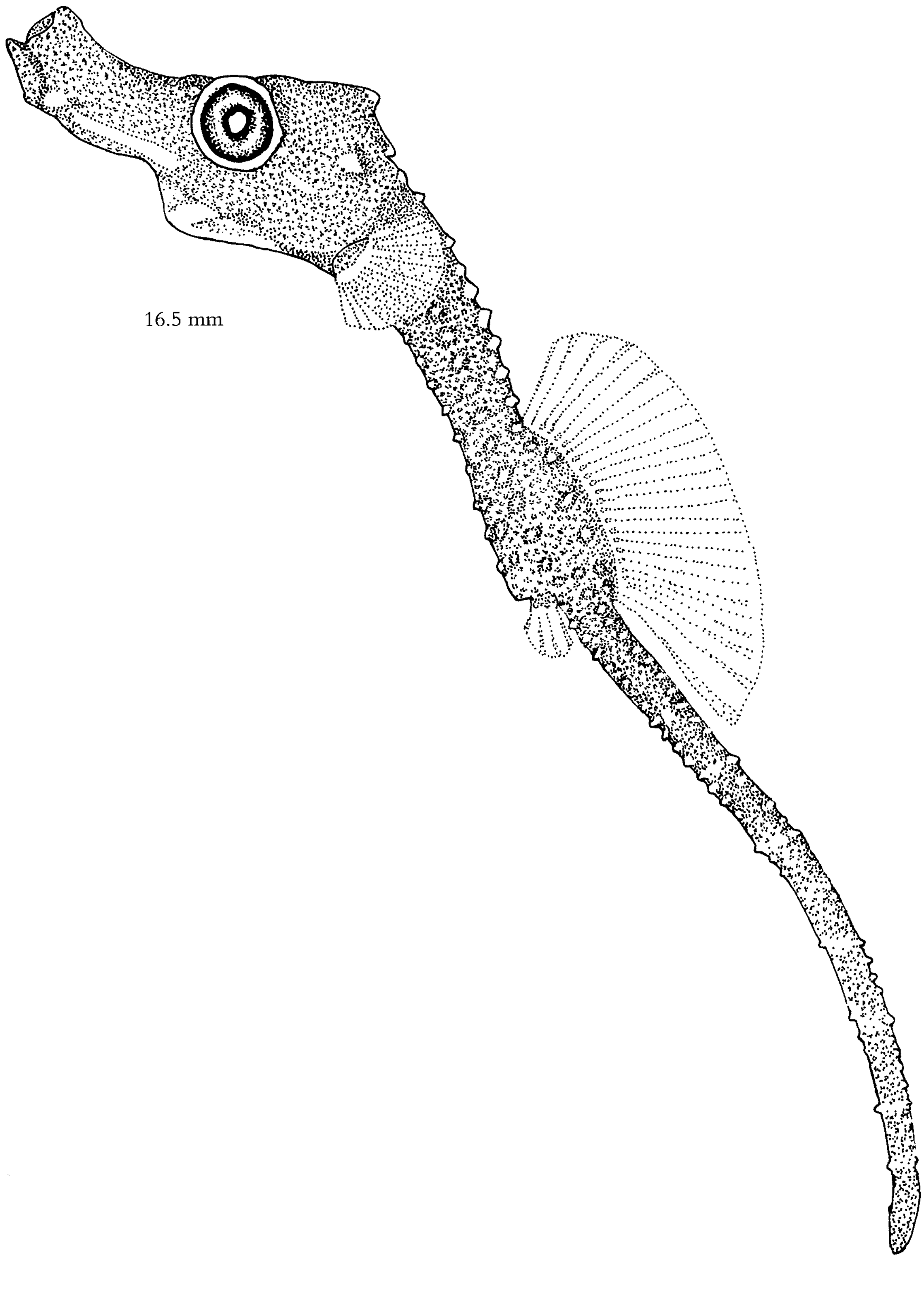
Morphology Newly emerged larvae (16 mm) have an extremely slender body that is relatively straight at birth but which bends to the adult form within 1–2 days. Head moderate (HL 23–25%), snout elongate (SnL 43–48%). Gut long (PAL 50–52%), completely hidden by trunk rings. All fin elements (caudal fin absent) formed at birth. Body ridges clearly visible at birth; body spines small but prominent, all of similar size.

Pigmentation *External:* Body mostly dusky, uniformly covered with small melanophores; slightly paler areas of less dense melanophores on opercle and in 8–12 narrow bands on tail. *Internal:* No pigment visible.

Material examined 12 larvae, 16.0–17.0 mm BL, Port Phillip Bay (Vic).

Additional references Gomon (1997).

Figure 32 Newly emerged larva of *Hippocampus abdominalis*. From Port Phillip Bay (Vic) (from Gomon, 1997). Illustrated by R. Campbell.



16.5 mm

Syngnathidae *Phycodurus eques* (Günther, 1865) Leafy seadragon

D 34–38 A 4 P_1 19–21 C 0 Body rings 18 + 41–44

Adults Endemic to southern Australia from Lancelin (WA) to Apollo Bay (Vic). Occurs on algal beds and rocky reefs in coastal waters at depths of 4–30 m. Adults have an S-shaped body, a very elongate snout, and numerous prominent leaf-like appendages on the head and snout, underside of thorax, and dorsally along the body nearly to the tip of the tail. Maximum size 35 cm (Dawson, 1985; Kuiter, 1993, 1996; Gomon *et al.*, 1994).

Importance to fisheries Protected species in South Australia. Taken in small numbers by aquarium collectors for the domestic and international marine aquarium trade, although food requirements make it difficult to maintain. Aquarium-reared individuals have proven to be more suitable for this industry (Gomon *et al.*, 1994).

Spawning Eggs pear-shaped, about 4 × 7 mm. Approximately 250 eggs are incubated by males on the underside of the tail, where they are embedded in spongy tissue. They hatch after about six weeks. Spawning occurs during summer months (Kuiter, 1988; R.H. Kuiter, AP, pers. comm.).

Diagnostic characters

- Body very slender, cylindrical and somewhat S-shaped
- Head distinctly angled to body axis at birth
- Anus below dorsal-fin origin
- Numerous large, leaf-like skin flaps on body
- No caudal fin
- Body lightly pigmented, with narrow dark bands encircling tail and dorsal third of thorax

Description of larvae

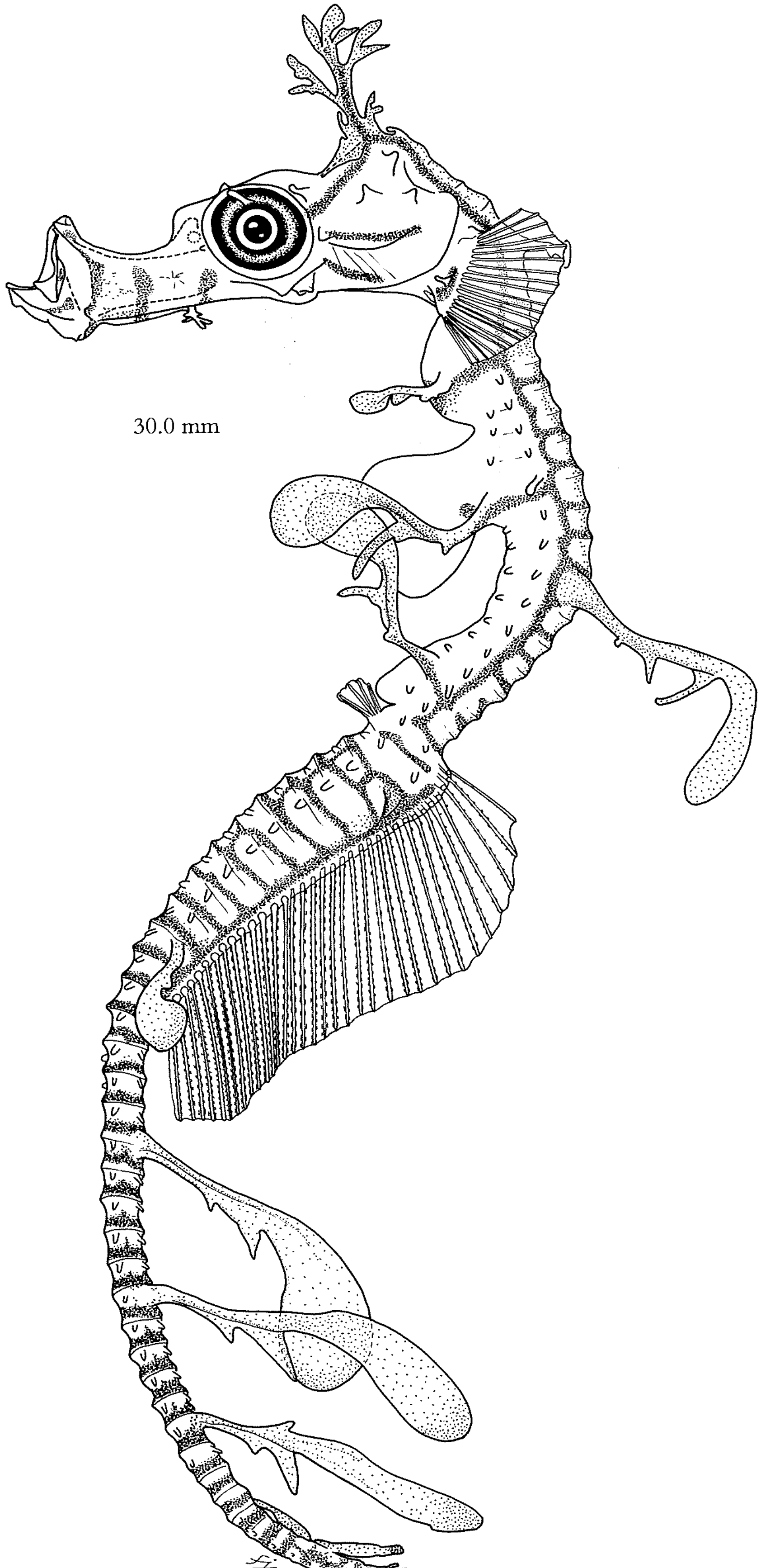
Morphology Newly emerged larvae (30 mm) are very slender and have a small yolk sac. Head small (HL 19–20%); snout much shorter than in adults (SnL 38–46%). Gut moderate (PAL 43–48%). All fin elements (caudal fin absent) formed by birth. Body rings and ridges initially indistinct, but distinguishable by the short body spines. Dermal appendages become more palmate with growth.

Pigmentation *External:* Body mostly translucent, with narrow black bands, 1 per body ring, encircling dorsal third of trunk and tail; ventral edge of trunk bands connected by a narrow longitudinal black stripe, continuing anteriorly onto neck and head with perpendicular branches extending onto base of dermal flaps. Additional stripes or bands on snout, above eye and on opercle. Another longitudinal black stripe outlines base of dorsal fin. *Internal:* No pigment visible.

Material examined 5 larvae, 30.0 mm BL, Victor Harbour (SA).

Additional references –

Figure 33 Larva of *Phycodurus eques*; note small yolk sac. From Victor Harbour (SA). Illustrated by F. J. Neira.



30.0 mm

Syngnathidae *Stigmatopora nigra* Kaup, 1856 Wide-bodied pipefish

D 35–47 A 4 P_1 11–16 C 0 Body rings 16–19 + 67–79

Adults Distributed around southern Australia from Rottnest Island (WA) to Moreton Bay (Qld), including Tasmania; also in New Zealand. The most common pipefish in southern Australia, it is found in protected estuarine areas, bays and coastal marine waters. Occurs among seagrass and algae, at depths of a few metres or less, but recorded to 35 m. Occasionally found in floating seaweed. Adults are slender and have an elongate snout, continuous superior and inferior trunk and tail ridges, a dorsal fin which originates on trunk rings 5–9, and an extremely slender tail without a caudal fin. The trunk is broad in females and the brood pouch in males is on the underside of the tail immediately behind the anal fin. Maximum size 16 cm (Dawson, 1982, 1985; Last *et al.*, 1983; Kuiter, 1993; Gomon *et al.*, 1994).

Importance to fisheries –

Spawning Eggs undescribed. Up to 41 eggs are incubated by the male in a brood pouch formed from laterally expanded flaps of skin on the underside of the tail. Newly emerged larvae may remain in the pouch. Brooding occurs during the months of February, April to June and August to October (Dawson, 1982). Larvae have been caught in the Swan Estuary (WA) in spring and summer (Neira *et al.*, 1992), and in Lake Macquarie (NSW) in all months except July (Miskiewicz, 1987).

Diagnostic characters

- Body extremely slender and cylindrical
- Head with an elongate, tubular snout, and a small, flap-like mouth
- Long-based dorsal fin, positioned between trunk rings 5–9 and tail rings 5–7
- No caudal fin

Description of larvae

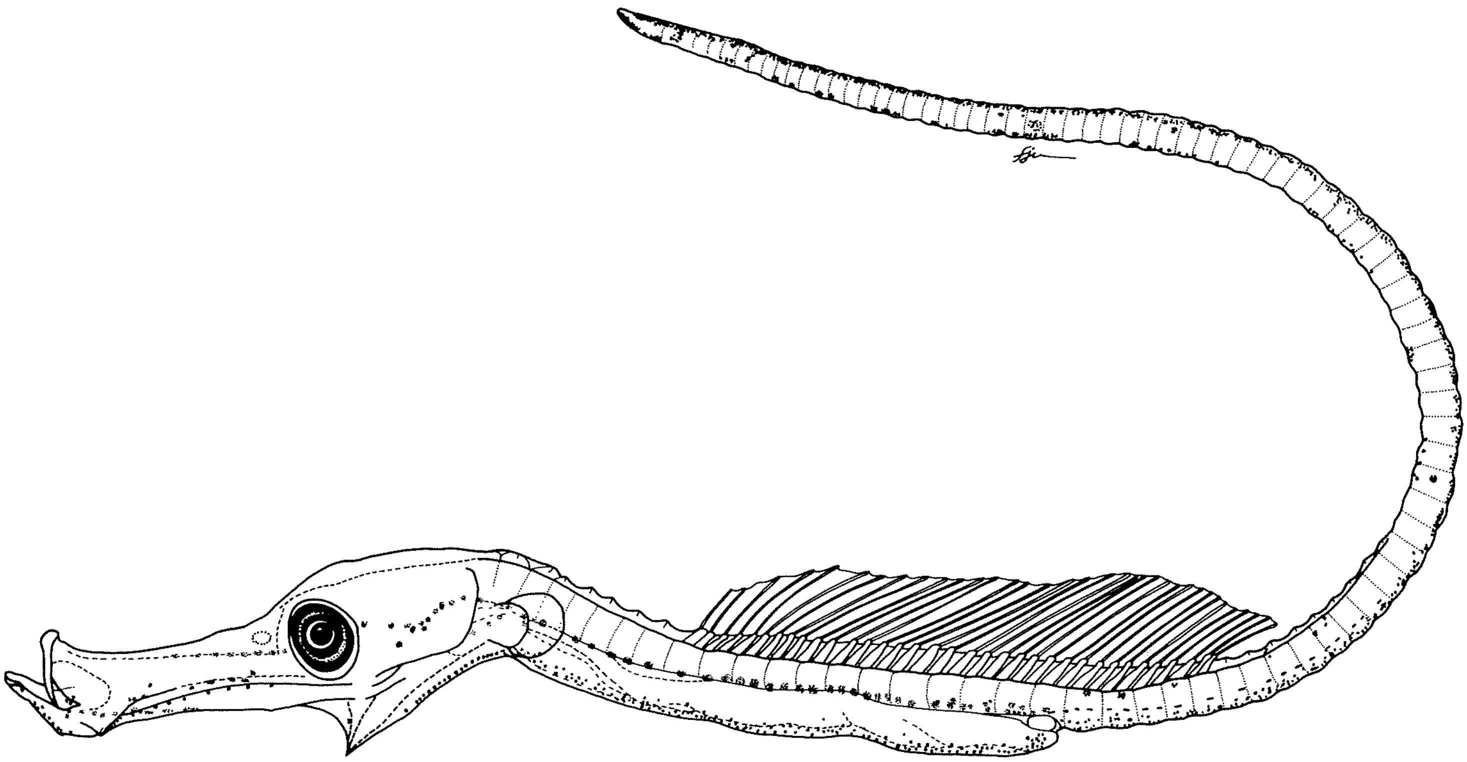
Morphology Newly emerged larvae (9.3 mm) are extremely slender. Head small (HL 13–17%), snout very elongate (SnL 52–62%). Supraoccipital and otic crests, and median dorsal snout ridge absent in newly emerged larvae. Gut moderate (PAL 30–44%), straight. Small gas bladder over foregut. Newly emerged larvae have a fully-formed dorsal fin. Pectoral-fin rays first appear by 17 mm. Body ridges not apparent at birth, but tiny body spines are developed.

Pigmentation Larvae are lightly to moderately pigmented. *External*: Body translucent to pale; series of melanophores along ventral surface of snout and gular region, extending posteriorly along gut to tip of tail. Two anteriorly diverging rows of markings along snout, and several very faint broad bands of melanophores along tail. *Internal*: Continuous series of melanophores along snout and under brain, and dorsally along gut to anus.

Material examined 6 larvae, 9.3–21.6 mm BL, Swan Estuary (WA).

Additional references –

Figure 34 Larva of *Stigmatopora nigra*; note anal fin still not developed. From Swan Estuary (WA). Illustrated by F. J. Neira.



11.4 mm

Syngnathidae *Urocampus carinirostris* Castelnau, 1872 Hairy pipefish

D 13–15 A 2 P_1 7–10 C 10 Body rings 7–10 + 49–59

Adults Distributed around southern Australia from Mandurah (WA) to Bowen (Qld), including Tasmania. Common in lower reaches of rivers, sheltered estuarine areas and shallow coastal reefs. Adults are usually found among fine-leaf seagrass or slender algae, rarely at depths of more than a few metres. Adults are small and slender, and have a short, thick snout, continuous superior trunk and tail ridges and discontinuous inferior trunk and tail ridges, small pectoral fins, and a dorsal fin that originates on tail rings 5–9. Its body usually has numerous hair-like appendages which provide camouflage. Maximum size 10 cm (Dawson, 1985; Kuiter, 1993; Gomon *et al.*, 1994).

Importance to fisheries –

Spawning Eggs undescribed. Up to 20 eggs are incubated by the male in a brood pouch formed from laterally expanded flaps of skin on the underside of the tail. Newly emerged larvae may remain in the pouch. Spawning in Queensland takes place during July (Dawson, 1980). In Western Australia larvae have been caught in the Swan and Nornalup–Walpole estuaries, and the Wilson Inlet during most months, with peak abundances between October and April (Neira *et al.*, 1992; Neira & Potter, 1992b, 1994), and in New South Wales entering and within Lake Macquarie in all months except August (Miskiewicz, 1987).

Diagnostic characters

- Body extremely slender and cylindrical
- Head with a short, tubular snout, and a small, flap-like mouth
- Short-based dorsal fin, originating on tail rings 5–9, well posterior to anus
- Caudal fin present
- Body lightly pigmented, with a pale vertical band on each body ring

Description of larvae

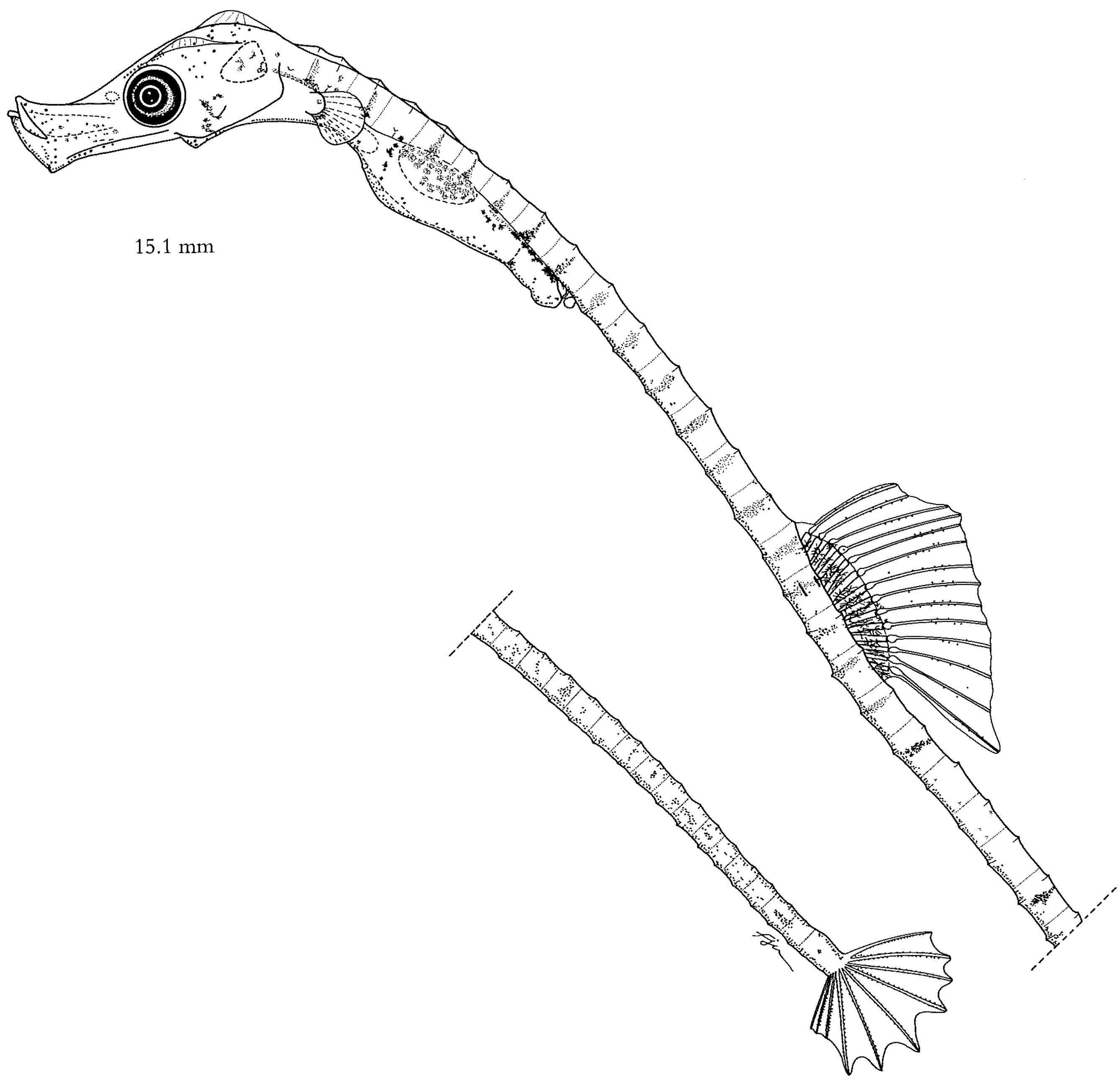
Morphology Newly emerged larvae (9.5 mm) are very elongate and slender. Head small (HL 9–14%), snout elongate (SnL 33–46%). Smallest larva has a low supraoccipital and otic crest, but no median dorsal snout ridge. Gut short to moderate (PAL 21–31%), straight. Gas bladder conspicuous and inflated. Dorsal and caudal fins are complete at birth; anal-fin bud first noticeable by 15 mm, fully formed after 22 mm; pectoral-fin rays start to develop by 13 mm. Body rings not present in newly emerged larvae; spines weakly developed dorsally.

Pigmentation Larvae are lightly pigmented. *External:* Body translucent to pale, with fine melanophores on ventral surface of trunk and tail. Faint pigment bands on each ring, those on every 5th–7th ring more distinct. Other melanophores concentrated on dorsal-fin base and along dorsal- and caudal-fin rays. Melanophores evenly scattered over body by 22 mm, with bands still visible. *Internal:* Melanophores on snout, below hindbrain, dorsally over foregut, and dorsally and around gas bladder.

Material examined 8 larvae, 9.5–22.0 mm BL, Swan Estuary (WA).

Additional references –

Figure 35 Larva of *Urocampus carinirostris*; note small anal-fin anlage. From Swan Estuary (WA). Illustrated by F. J. Neira.


15.1 mm

SCORPAENIFORMES

The Scorpaeniformes is a large order of morphologically diverse, mostly demersal fishes well represented worldwide in tropical to polar regions, in habitats ranging from fresh water to deep slope marine waters (Washington *et al.*, 1984b). About 96% of the species are marine (Nelson, 1994). Scorpaeniform fishes are characterised by the presence of a suborbital stay – a posterior extension of the third infraorbital bone which is usually firmly attached to the preoperculum. This structure provides the basis for the vernacular name 'mail-cheeked' fishes to denote the entire group (Washington *et al.*, 1984a,b). It is uncertain whether this character indeed defines the group as monophyletic, so the classification and placement of the order, as well as the family arrangements within the order, remain provisional (see Washington *et al.*, 1984a; see also Johnson & Patterson, 1993; Ishida, 1994). According to Nelson (1994), the order comprises 7 sub-orders, 25 families, 266 genera and over 1270 species. Families of the suborders Platycephaloidei and Scorpaenoidei are treated here. The Platycephaloidei comprises the families Bembridae (deep-water flatheads), Hoplichthyidae (ghost flatheads) and Platycephalidae (flatheads), with a total of 23 genera and about 75 species (Nelson, 1994). The Scorpaenoidei includes the largest number of species within the order and the worlds most venomous fishes, with 7 families, 96 genera and 544 species. Scorpaenoid families include the Aploactinidae (velvetfishes), Caracanthidae (coral crouchers), Congiopodidae (horsefishes), Gnathanacanthidae (red velvetfishes), Pataecidae (prowfishes), Scorpaenidae (scorpionfishes, stonefishes) and Triglidae (searobins, gurnards). Larvae have been described for one species of the Hoplichthyidae, several members of the Platycephalidae, and representatives of all scorpaenoid families except the Gnathanacanthidae and Pataecidae (see review of early life history stages by Washington *et al.*, 1984b; see also Moser *et al.*, 1977; Brownell, 1979; Fahay, 1983; Leis & Rennis, 1983; Zhang *et al.*, 1985; Houde *et al.*, 1986; Kojima, 1988f,g,h; Kojima *et al.*, 1988; Kojima & Nakamura, 1988; Leis & Trnski, 1989; Matarese *et al.*, 1989; Moser, 1996c; Richards, 1996).

Families and species included here

PLATYCEPHALIDAE
Platycephalus fuscus
Platycephalus speculator

SCORPAENIDAE
Centropogon australis
Gymnapistes marmoratus
Helicolenus percoides
Neosebastes scorpaenoides

TRIGLIDAE
Chelidonichthys kumu
Lepidotrigla modesta
Lepidotrigla mulhalli
Lepidotrigla papilio
Lepidotrigla vanessa
Pterygotrigla polyommata

Platycephalidae: Flatheads

F. J. Neira and A.G. Miskiewicz

Platycephalids are benthic fishes found in estuarine and coastal marine waters of the Indo-Pacific (one east Atlantic species), with a few species occurring among coral reefs. The family contains 18 genera and about 60 species (Nelson, 1994). Twelve genera and about 41 species, 17 of which are endemic, have been recorded from Australia, 5 genera and 13 species in temperate waters (Knapp, 1984; Hutchins & Swainston, 1986; Paxton & Hanley, 1989k; Keenan, 1991; Gomon *et al.*, 1994). Several species have commercial and recreational importance (Kailola *et al.*, 1993). Adults (0.4–1.5 m) are elongate, have a markedly depressed head with bony ridges usually bearing spines or serrations, two separate but adjacent dorsal fins, thoracic pelvic fins set apart away from the body, and a short-based, spineless anal fin. The first spine of the spinous dorsal fin is small and partially embedded in the flesh, and detached from, although adjacent to, the second spine (Gomon *et al.*, 1994). Eggs are pelagic and spherical, 0.8–1.2 mm in diameter (Uchida *et al.*, 1958; Ueno & Fujita, 1958; Chang *et al.*, 1980; Ikeda & Mito, 1988; Hyndes *et al.*, 1992). Larvae have been described for representatives of a few genera (e.g. Fujita & Ueno, 1956; Ueno & Fujita, 1958; Chang *et al.*, 1980; Leis & Rennis, 1983; Zhang *et al.*, 1985; Kojima, 1988g; Hyndes *et al.*, 1992). The large, wing-shaped pectoral fins, and the gas bladder which is lost in the adults of some species, are specialisations of platycephalid larvae to pelagic life (Leis & Rennis, 1983).

Meristic characters of platycephalid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Leviprora	(1)	I,VII + 12	11–12	17–19	I, 5	15	–
Neoplatycephalus	(3)	VIII–IX + 14	13–15	16–22	I, 5	15	–
Platycephalus	(7)	VII–IX + 13–15	12–15	18–21	I, 5	15	11–12 + 15–16 = 27
Suggrundus	(1)	VII–XII + 10–12	10–13	18–25	I, 5	15	27
Thysanophrys	(1)	VIII–IX + 11–12	11	19–21	I, 5	15	27

Main characters of platycephalid larvae

- 25–28 myomeres, typically 27
- Body elongate to moderate (BD 14–26%), becoming dorsally compressed at settlement
- Head initially round and compressed, becoming greatly depressed, with an elongate, flattened snout by settlement stage
- Eyes are round and laterally positioned in all larval stages, but become slightly ovoid and migrate to a dorsal position after settlement
- Well developed and extensive head spination, including preopercular (preflexion stage), supraocular, pterotic, small parietal, posttemporal, cleithral and supracleithral spines; these are retained after settlement
- Gut moderate to long (PAL 50–70%), coiled and compact
- Gas bladder inconspicuous, visible above foregut in preflexion and flexion larvae
- 2 separate dorsal fins; dorsal-fin spines form earlier than soft dorsal-fin rays
- Pectoral fins large and wing-shaped from early stages; rays start to form during preflexion stage
- Moderate to extensive pigment on pectoral-fin base; melanophores along pectoral-fin rays and scattered over connecting membranes
- Melanophores usually along ventral midline of tail and scattered laterally over trunk and tail

References to platycephalid larvae

Leis & Rennis (1983), Washington *et al.* (1984b), Kojima (1988g).

Families with similar larvae

Hoplichthyidae – First dorsal fin short, with V spines; anal fin 16–17; body mostly without pigment except dorsally on gut.

Opistognathidae (early stages) – 26–35 myomeres; poorly developed head spination, small, weak preopercular spines; body lightly pigmented; no pigment dorsally on head, lower jaw and dorsally or laterally on tail.

Serranidae (Anthiinae) – Snout short and rounded; 1 dorsal fin, X–XIII, 13–22; early forming, elongate second or third dorsal-fin spine, and produced pelvic-fin ray in some taxa.

Percophidae – 32–34 myomeres; no head spines; early forming, elongate pelvic-fin rays in some taxa; pelvic fins jugular; long-based anal fin.

Scorpaenidae – Single, continuous dorsal fin; head large and round, without flattened, elongate snout; parietal spines often prominent; body typically lightly pigmented prior to settlement.

Triglidae – 25–39 myomeres, typically 27–35; head large to very large, with deeply concave snout profile (duckbill-shaped snout); late forming (flexion stage) preopercular spines; posttemporal spines often prominent and serrate along anterior edge; pectoral fin 13–16, lower 2–3 pectoral-fin rays elongate and detached from rest of fin from late postflexion stage; body usually lightly pigmented.

Platycephalidae *Platycephalus fuscus* Cuvier, 1829 Dusky flathead

D VIII–IX + 13–14 A 13–14 P_1 19–20 P_2 I, 5 C 15 V 27

Adults Endemic to northeastern and southeastern Australia from Mackay (Qld) to Wilsons Promontory (Vic). Occurs over sand and mud bottoms of estuaries, and in coastal marine embayments, to a depth of 25 m. Adults have a large dark blotch on the caudal fin. Maximum size 1.5 m (Hutchins & Swainston, 1986; Paxton & Hanley, 1989k; Kuiter, 1993, 1996).

Importance to fisheries Fished commercially and recreationally in estuaries in southern Queensland and New South Wales. Total commercial catch in 1989-90 was about 250 tonnes (Roughley, 1964; State Pollution Control Commission, 1981; Kailola *et al.*, 1993).

Spawning Eggs undescribed. Spawns in coastal waters near mouths of estuaries between late summer and early autumn (Roughley, 1964; Lewis, 1971; Dredge, 1976). Larvae have been caught entering Lake Macquarie (NSW) from November to May, with peak abundances between January and March (Miskiewicz, 1987), and in coastal waters off Sydney (NSW) from October to May (Gray, 1995).

Diagnostic characters

- 10–11 + 16–17 = 27–28 myomeres
- Light pigment dorsally on head and anterior of trunk
- Broad band of melanophores scattered over trunk and tail above anus
- Single series of 18–20 melanophores along ventral midline of tail
- Pigmented stripe from snout to posterior margin of opercle

Description of larvae

Morphology Body moderate (BD 23–26%), compressed. Head moderate in preflexion larvae (HL 29–33%), large in flexion and postflexion larvae (HL 32–40%). Teeth along both jaws by late preflexion stage. Two moderate posterior preopercular spines in early preflexion larvae, up to 5 in postflexion larvae. Two or three anterior preopercular spines and 1 large parietal spine in preflexion larvae; infraorbital, supraocular, supracleithral and cleithral spines in flexion larvae, and 1 posttemporal, 1–2 pterotic and 1 nasal spine in early postflexion larvae. Gut moderate to long (PAL 48–63%), coiled. Gas bladder above foregut. Large, wing-shaped pectoral fins, extending beyond anus from flexion stage. Lateral-line scales begin to form at settlement.

Size at

Hatching	<2.6 mm
Notochord flexion	4.4–6.2 mm
Settlement	9.9–12.8 mm

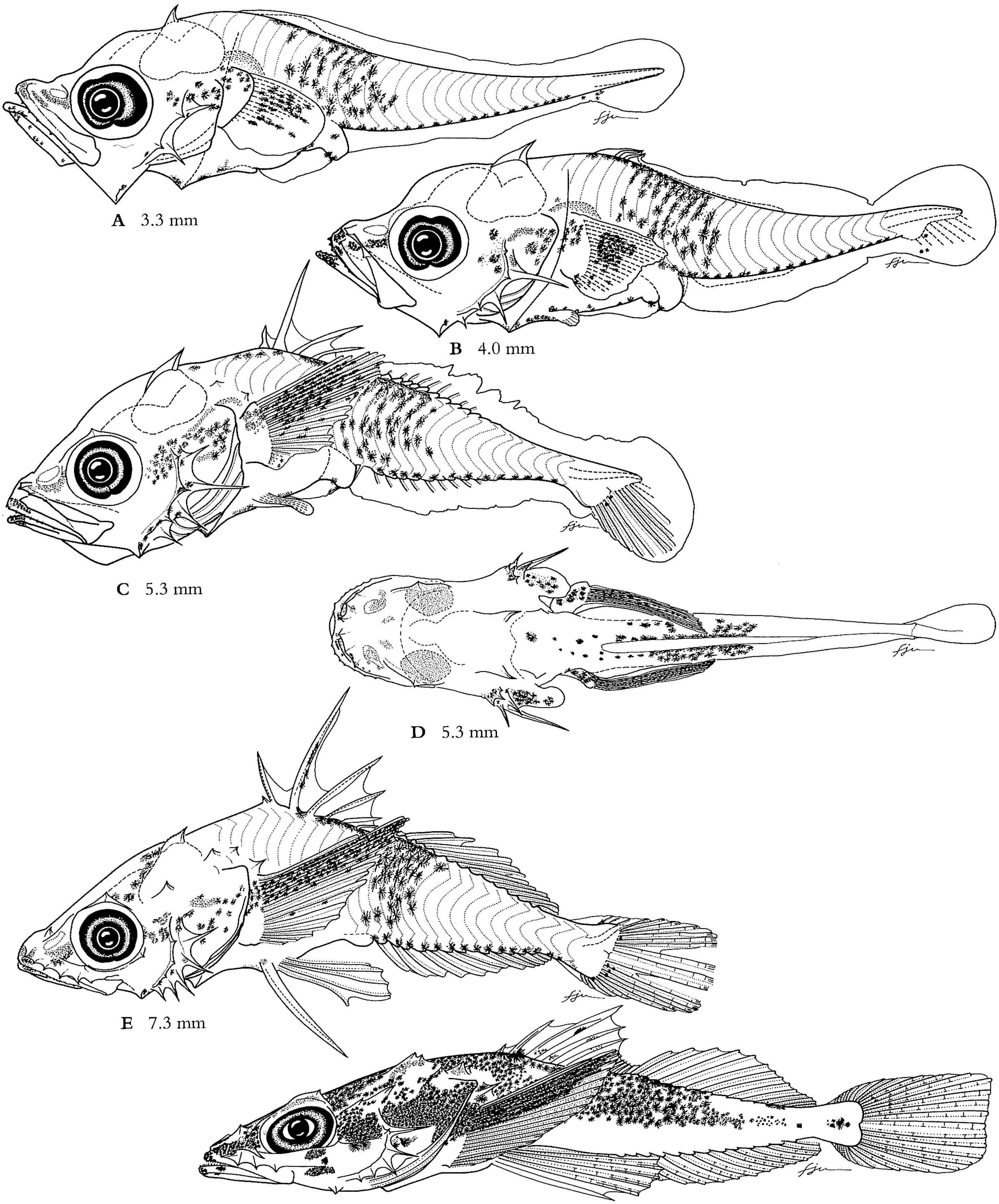
Formation of fins:
Pectoral 2.6–6.4 mm; Pelvic 3.3–6.4 mm; Dorsal 3.3–7.3 mm; Caudal 3.9–7.0 mm; Anal 4.0–7.3 mm

Pigmentation Larvae are moderately pigmented. *External*: Pigment on tip of upper and lower jaws; 1 melanophore at angle of lower jaw; melanophores on opercle; pigment over midbrain in postflexion larvae. Numerous small melanophores ventrally along trunk from cleithral symphysis to gut, decreasing in number with growth and absent by settlement. Broad band of melanophores scattered over trunk and tail, between dorsal-fin base and anus. Series of 18–20 melanophores along ventral midline of tail which disappear prior to settlement. A few small melanophores under notochord tip in preflexion larvae, remaining along base of lower caudal-fin rays in postflexion larvae. Pigment on upper portion of pectoral-fin base and along upper pectoral-fin rays. A few melanophores along dorsal-fin spines III and IV in postflexion larvae, spreading to spines V to VII prior to settlement. Lower pectoral-fin rays and rays of second dorsal, anal and pelvic fins remain unpigmented. *Internal*: Pigment on snout, base of otic capsule, and dorsally over gut and gas bladder.

Material examined 25 larvae, 2.6–8.4 mm BL, and 1 juvenile, 12.8 mm BL, Lake Macquarie, Botany Bay and Green Cape (NSW); 1 settlement larva, 9.9 mm BL, Moreton Bay (Qld).

Additional references Miskiewicz (1987).

Figure 36 Larvae and settlement stage of *Platycephalus fuscus*. **A** Preflexion; note pelvic-fin bud. **B** Late preflexion. **C** Flexion. **D** Dorsal view of larva in C. **E** Postflexion. **F** Settlement stage; myomeres omitted. A–C, E from Botany Bay (NSW); F from Moreton Bay (Qld). Illustrated by F. J. Neira.



F 9.9 mm

Platycephalidae *Platycephalus speculator* Klunzinger, 1872 Southern flathead

D VIII–IX + 13–14 A 13–14 P_1 18–21 P_2 I, 5 C 15 V 27

Adults Endemic to southern Australia from Kalbarri (WA) to eastern Victoria, including northern Tasmania. Found in shallow areas of estuaries and inshore marine embayments, to a depth of 30 m. Adults have 3–5 large round black spots with white margins on the lower-half of the caudal fin. Maximum size 90 cm (Last *et al.*, 1983; Hutchins & Swainston, 1986; Edgar, 1997).

Importance to fisheries Fished commercially with gill nets in Wilson Inlet (WA). Also targeted by recreational fishers along the southern coast of Western Australia (Lenanton & Potter, 1987; Hyndes *et al.*, 1992).

Spawning Late-stage eggs are pelagic and spherical, average 0.8 mm in diameter, and have a smooth chorion, an unsegmented yolk, and a single, pigmented oil globule. Spawning in Wilson Inlet (WA) occurs predominantly between December and March (Hyndes *et al.*, 1992). Larvae have been caught in Wilson Inlet in December (Neira & Potter, 1992b).

Diagnostic characters

- 10–11 + 15–16 = 26–27 myomeres
- Heavy pigment dorsally over head and trunk
- Pigment laterally along entire trunk to anterior half of tail
- Single series of 13–16 melanophores along ventral midline of tail

Description of larvae

Morphology Body initially elongate to moderate (BD 14–25%), elongate in juveniles (BD 13–18%). Head moderate to large (HL 20–41%), initially slightly compressed, depressed in postflexion larvae. Eyes initially round and laterally positioned, slightly ovoid and dorsally positioned after settlement. Small teeth on premaxilla and dentary by flexion stage. One anterior preopercular and 2 posterior preopercular spines, and a large parietal spine in smallest larva; 5 posterior preopercular spines in postflexion larvae, all retained after settlement. Three anterior preopercular spines in flexion larvae, merging with posterior preopercular spines before settlement. One supraocular spine prior to flexion stage; 1 cleithral spine and infraorbital spines from flexion stage; nasal, pterotic, posttemporal and supracleithral spines by postflexion stage. Gut moderate to long (PAL 48–62%), coiled. Small gas bladder over foregut. Large, wing-shaped pectoral fins, extending beyond anus from flexion stage. Scales form after 30 mm BL (Hyndes *et al.*, 1992).

Size at

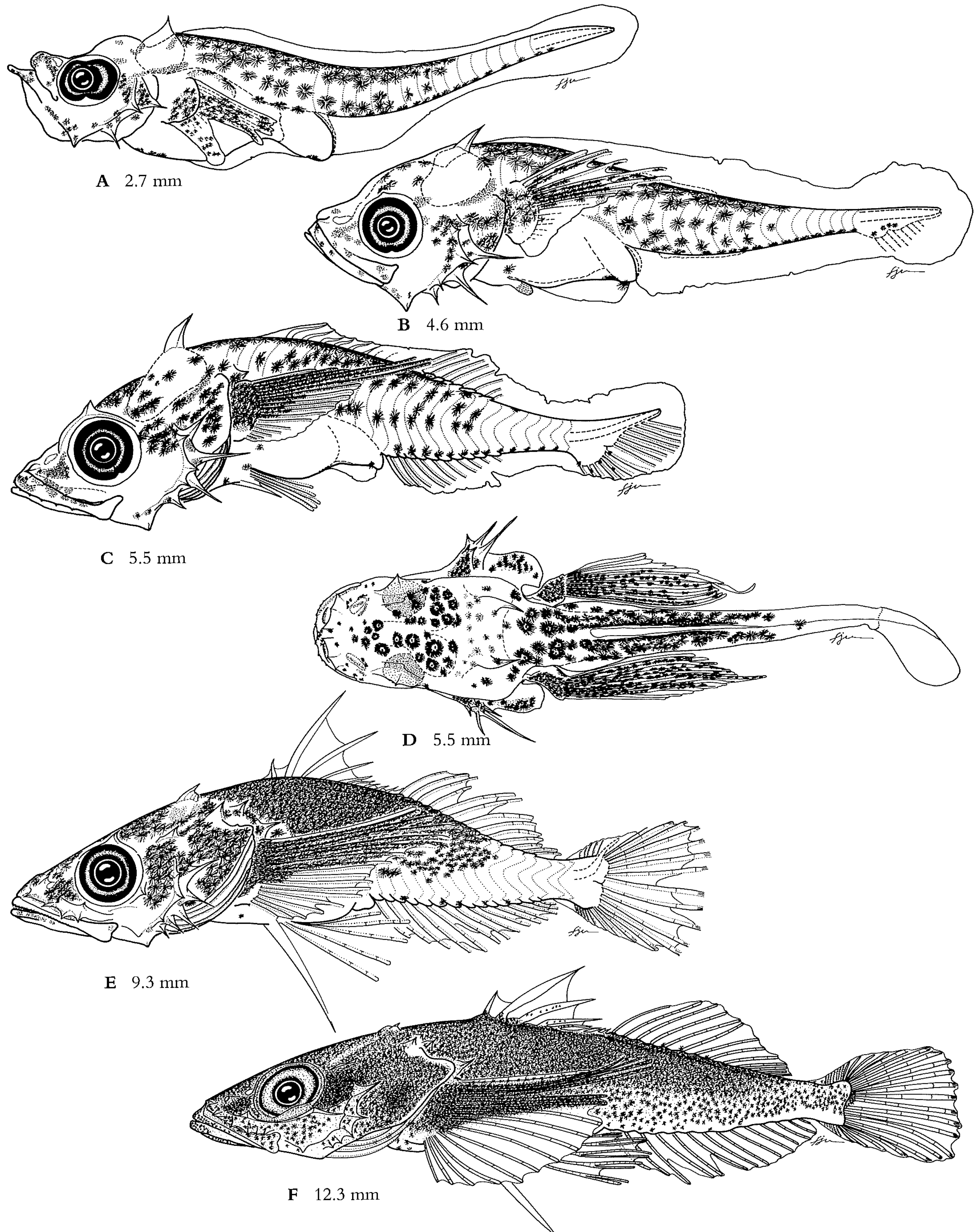
Hatching	<1.6 mm
Notochord flexion	5.0–7.0 mm
Settlement	12.8–15.5 mm
Formation of fins:	
Pectoral 2.5–6.0 mm; Pelvic 4.5–5.5 mm; Caudal 4.5–7.5 mm; Dorsal 4.5–8.0 mm; Anal 4.5–8.0 mm	

Pigmentation Larvae are moderately to heavily pigmented. *External*: Melanophores scattered over snout, lower jaw and opercle. Stellate melanophores on dorsal surface of head in late preflexion larvae. A few melanophores along ventral midline of trunk. Pigment on dorsal and lateral surfaces of trunk, and anterior of tail, heavier by postflexion stage. Single series of 13–16 melanophores along ventral midline of tail, reducing in number with growth and disappearing at settlement. No pigment on dorsal and lateral surfaces of caudal peduncle until settlement stage. Several small melanophores under notochord tip in preflexion larvae, remaining along base of lower caudal-fin rays until flexion stage. Melanophores on pectoral-fin base and along edges of upper 6–7 pectoral-fin rays. A few melanophores on dorsal-fin spines III–V in late postflexion larvae. Lower 9–10 pectoral-fin rays, and rays of second dorsal, anal and pelvic fin unpigmented. *Internal*: Pigment on snout and base of otic capsule. Pigment dorsally over gas bladder and hindgut, only visible in preflexion and flexion larvae.

Material examined 21 larvae, 1.6–12.8 mm BL, and 9 juveniles, 15.5–25.5 mm BL, Wilson Inlet (WA).

Additional references Hyndes *et al.* (1992).

Figure 37 Larvae and settlement stage of *Platycephalus speculator*. **A** Preflexion. **B** Late preflexion; note developing pelvic fin. **C** Flexion. **D** Dorsal view of larva in C. **E** Postflexion. **F** Settlement stage; myomeres omitted. A–C, E, F from Wilson Inlet (WA) (from Hyndes *et al.*, 1992). Illustrated by F. J. Neira.


A 2.7 mm
B 4.6 mm
C 5.5 mm
D 5.5 mm
E 9.3 mm
F 12.3 mm

Scorpaenidae: Scorpionfishes

F. J. Neira and D.M. Furlani

Scorpaenids are primarily marine (rarely in fresh water) cryptic, demersal fishes found in tropical to sub-polar waters worldwide, with most species in the Indian and Pacific oceans. The family comprises 56 genera and about 388 species (Nelson, 1994). About 33 genera and 80 species have been recorded from Australia, 10 genera and 20 species in temperate waters (Scott *et al.*, 1980; Last *et al.*, 1983; Poss & Rama-Rao, 1984; Hutchins & Swainston, 1986; May & Maxwell, 1986; Allen & Cross, 1989a; Kuiter, 1993, 1996; Gomon *et al.*, 1994; Pollard & Parker, 1996). Adults (9–90 cm) have a large head, large fan-shaped pectoral fins, thoracic pelvic fins, and a continuous, notched dorsal fin. The head typically bears two opercular spines, three to five preopercular spines and prominent, spiny bony ridges. The spines of the dorsal, anal and pelvic fins are strong and venomous. Reproductive modes include internal fertilisation, and viviparity and ovoviviparity, as in members of the Sebastinae, spawning of spherical to ovoid eggs (0.7 × 1.2 mm) embedded in a large pelagic gelatinous matrix as in most reef scorpaenids, and individual pelagic eggs (0.8–1.4 mm in diameter) in other species (Orton, 1955; Mito & Uchida, 1958; Moser *et al.*, 1977; Washington *et al.*, 1984b; Moser, 1996a). Larvae have been described for representatives of many genera (see Washington *et al.*, 1984b and references therein; see also Moser *et al.*, 1977; Leis & Rennis, 1983; Kojima *et al.*, 1988; Moser, 1996c). Many taxa have extended pelagic juvenile stages, notably representatives of the Sebastinae (Leis & Rennis, 1983; Washington *et al.*, 1984b). The well developed and complex head spination, the large fan-shaped pectoral fins, and the gas bladder which is lost in the adults of some species (e.g. scorpaenines), constitute specialisations of scorpaenid larvae to pelagic life (Leis & Rennis, 1983).

Meristic characters of scorpaenid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal (branched)	Vertebrae
NEOSEBASTINAE							
Maxillicosta	(2)	XIII, 6–8	III, 5	20–24	I, 5	10–12	26
Neosebastes	(5)	XIII, 7–9	III, 5–6	18–22	I, 5	13–15	25–26
SCORPAENINAE							
Scorpaena	(4)	XII–XIII, 9–10	III, 5	15–18	I, 5	15	24–25
Scorpaenodes	(1)	XII–XIV, 7–10	III, 4–6	15–20	I, 5	15	24
SEBASTINAE							
Helicolenus	(2)	XII, 11–12	III, 5	18–20	I, 5	15	25
SEBASTOLOBINAE							
Trachyscorpia	(1)	XIII, 8–9	III, 5	20–23	I, 5	13	25–26
TETRAROGINAE							
Centropogon	(2)	XV–XVI, 7–9	III, 5	12–15	I, 5	12	26–27
Glyptauchen	(1)	XVI–XVIII, 6–7	III, 5–6	13–15	I, 5	12	26–28
Gymnapistes	(1)	XII–XIII, 7–10	III, 4–6	10–12	I, 5	14*	27–29
Notesthes	(1)	XIV–XVI, 8–10	III, 5	11–14	I, 5	–	27–28

* Segmented rays

Main characters of scorpaenid larvae

- 24–31 myomeres, typically 24–27
- Body initially elongate, becoming moderate to deep with development (BD 12–51%)
- Head initially small to moderate, becoming moderate to large with development (HL 13–46%), laterally compressed
- Well developed and extensive head spination, including large preopercular and parietal spines which may be serrate, and also supraocular, infraorbital, opercular, pterotic, posttemporal and cleithral spines
- Gut moderate to very long (PAL 35–73%), coiled and compact soon after hatching
- Small gas bladder above gut, lost in the adults of some taxa
- Small to no gap between anus and origin of anal fin
- Single, continuous dorsal fin
- Pectoral fins often wide-based, large and fan-shaped from early stages; rays start to form during preflexion stage and may become long and reach caudal peduncle in some taxa
- Body lightly to moderately pigmented prior to transformation
- Melanophores along pectoral-fin rays and scattered over connecting membranes

References to scorpeanid larvae

Moser *et al.* (1977), Leis & Rennis (1983), Washington *et al.* (1984b), Kojima *et al.* (1988), Moser (1996c).

Families with similar larvae

Aploactinidae – Dorsal fin originates from top of head in most taxa; anterior 3–5 dorsal-fin spines usually elevated and separated from remaining spines; pelvic fins I, 2–3.

Caracanthidae – 23–24 myomeres; very large, serrate posterior preopercular and parietal spines in postflexion larvae; body almost totally unpigmented in postflexion larvae; pelvic fins I, 2–3.

Congiopodidae – 28–39 vertebrae; 36 myomeres (*Congiopodus spinifer*); dorsal fin originates from top of head, long-based; pectoral fin 8–12; gut long and straight; gill opening reduced to a small slit above pectoral-fin base.

Hoplichthyidae – First dorsal fin short, with V spines; anal fin 16–17; body mostly without pigment except dorsally on gut.

Opistognathidae (early stages) – 26–35 myomeres; weak head spination, including small preopercular spines; body lightly pigmented, no melanophores over head, dorsally and laterally over trunk and tail.

Platycephalidae – 2 dorsal fins; head greatly depressed, with a flattened, elongate snout in postflexion larvae; early forming (preflexion stage) preopercular spines; parietal spines often small; body moderately pigmented.

Serranidae (Anthiinae) – Early forming, elongate second or third dorsal-fin spine, and produced pelvic-fin ray in some taxa; head large and deep, with short, rounded snout.

Triglidae – 25–39 myomeres, typically 27–35; head moderate to large (HL 22–56%), with deeply concave snout profile (duckbill-shaped snout); late forming (flexion stage) preopercular spines; posttemporal spines often prominent and serrate along anterior edge; lower 2–3 pectoral-fin rays elongate and detached from rest of fin from late postflexion stage; body lightly pigmented in most taxa.

Scorpaenidae *Centropogon australis* (White, 1790) Fortescue

D XV–XVI, 7–9 A III, 5 P_1 14 P_2 I, 5 C 12 V 26–27

Adults Endemic to southeastern Australia from Bundaberg (Qld) to the Gippsland Lakes (Vic). Found in seagrass beds in estuaries and coastal bays, and sponge gardens on inshore reefs, to a depth of 30 m. Adults have a large horizontal spine below the eye, a dorsal fin which originates just behind the posterior edge of the eye, and venomous dorsal spines. Maximum size 14 cm (Hutchins & Swainston, 1986; Allen & Cross, 1989a; Kuiter, 1993, 1996; Gomon *et al.*, 1994).

Importance to fisheries Often caught in prawn nets and may inflict a painful sting to fishers (Edgar, 1997).

Spawning Eggs undescribed. Larvae have been caught throughout the year entering Lake Macquarie (NSW), with a peak abundance in September (Miskiewicz, 1987), and in coastal waters off Sydney (NSW) from October to July (Gray, 1995).

Diagnostic characters

- 10–11 + 16–17 = 26–27 myomeres
- Dermal sac around most of body until flexion stage, with melanophores along dorsal and ventral edges
- Pectoral fin typically with 14 rays
- Paired row of small melanophores along ventral midline of trunk and tail
- Internal melanophores dorsally along vertebrae in postflexion larvae

Description of larvae

Morphology Body moderate (BD 20–33%). Dermal sac encloses most of body in preflexion larvae, disappearing with formation of dorsal and anal fins. Head moderate in preflexion and flexion larvae (HL 20–31%), moderate to large in postflexion larvae (HL 30–35%). One supraocular, 1 parietal, 1 pterotic, and 1 anterior preopercular and 2 posterior preopercular spines by flexion stage. Up to 5 posterior preopercular spines in postflexion larvae; anterior preopercular spines merge with posterior preopercular spines by settlement. Infraorbital, opercular, posttemporal and supracleithral spines by late flexion stage. Nasal and cleithral spines in late postflexion larvae. Gut moderate in preflexion larvae (PAL 38–50%), moderate to long in flexion and postflexion larvae (PAL 44–63%), coiled and compact. Gas bladder present. Moderate gap between anus and origin of anal fin, reduced in postflexion larvae after anal fin is formed. Large, fan-shaped pectoral fins, extending beyond anus (P_1L 28–50%). Last dorsal- and anal-fin spines transform from soft rays by end of flexion stage.

Size at

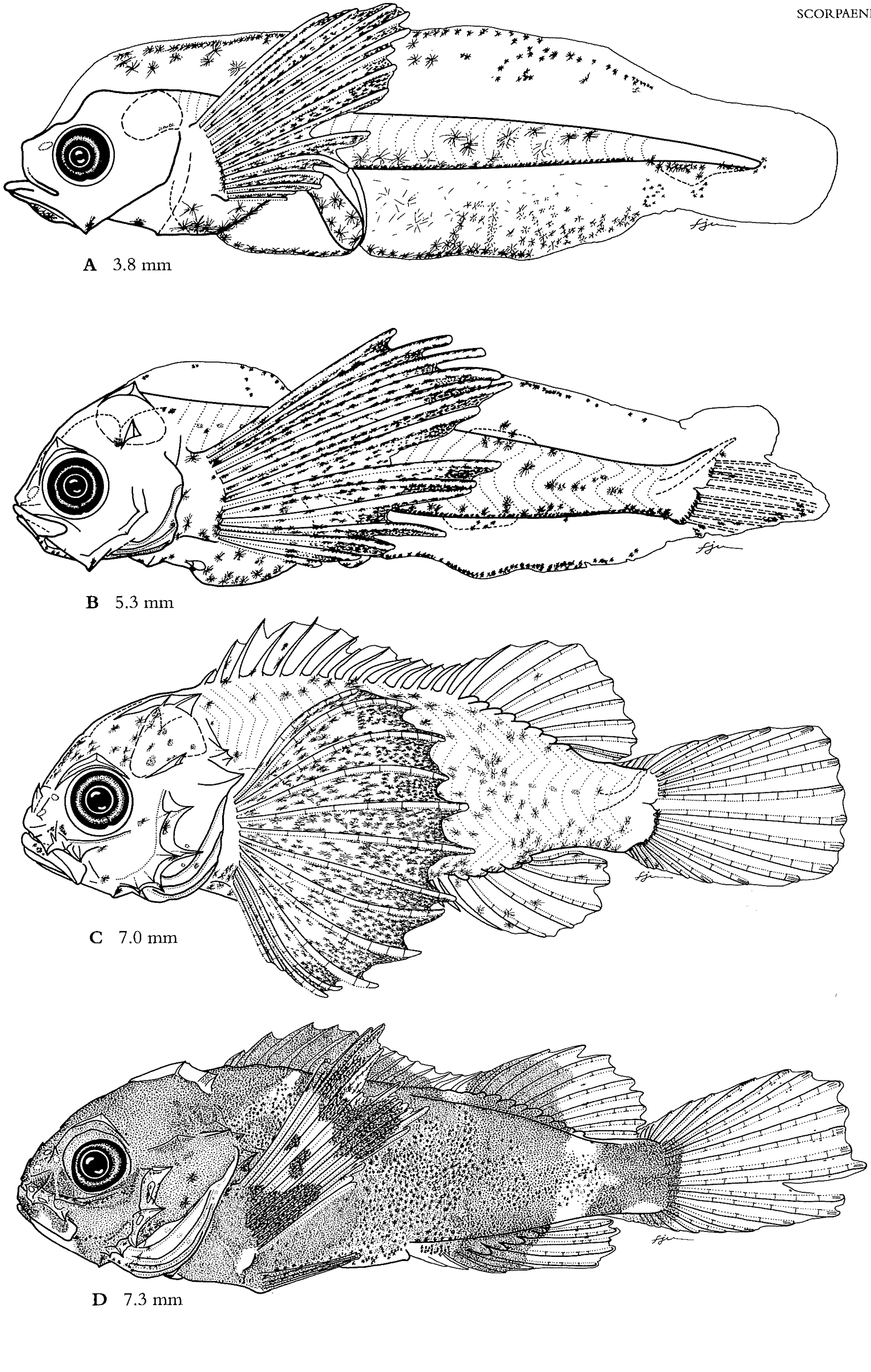
Hatching	<3.0 mm
Notochord flexion	3.9–6.4 mm
Settlement	7.2–9.3 mm
Formation of fins:	
Pectoral <3.0 mm; Caudal 3.6–5.6 mm; Pelvic 5.3–6.4 mm; Dorsal 5.3–7.0 mm; Anal 5.3–7.0 mm	

Pigmentation Larvae are moderately pigmented. *External*: A few melanophores on ventral surface of lower jaw, 1 at angle of lower jaw and 1 on isthmus. Several melanophores dorsally on head, and on suborbital and preopercular areas in postflexion larvae. Melanophores on dermal sac, particularly along dorsal and ventral edges. Some melanophores scattered on lateral and ventral surfaces of gut, and lateral surface of trunk and tail in postflexion larvae. Continuous paired series of small melanophores along ventral midline of trunk and tail. Melanophores below notochord tip in preflexion larvae, remaining along caudal-fin base in postflexion larvae. Melanophores along margins of each pectoral-fin ray and on pectoral-fin membrane, concentrated distally. Pigment over most of head, trunk and tail, and over membranes of all fins except caudal fin in late postflexion larvae before settlement. *Internal*: Pigment dorsally over gas bladder; 10–12 discrete melanophores dorsally over gut in postflexion larvae, extending to above anus. Series of melanophores dorsally along vertebrae in postflexion larvae.

Material examined 24 larvae, 3.0–7.3 mm BL, and 3 juveniles, 7.2–9.3 mm BL, Lake Macquarie, Coffs Harbour and coastal waters off Sydney (NSW).

Additional references –

Figure 38 Larvae of *Centropogon australis*. **A** Preflexion; note dermal sac enclosing most of body. **B** Flexion; note pelvic-fin bud and developing dorsal and anal fins. **C** Early postflexion; pelvic-fin obscured by pectoral fin. **D** Postflexion, near settlement. A, B from Sydney coastal waters (NSW); C, D from Lake Macquarie (NSW). Illustrated by F. J. Neira.


A 3.8 mm
B 5.3 mm
C 7.0 mm
D 7.3 mm

Scorpaenidae *Gymnapistes marmoratus* (Cuvier, 1829) Cobbler, devilfish

D XII–XIII, 7–10 A III, 4–6 P_1 10–12 P_2 I, 5 C 14 (branched) V 28

Adults Monotypic genus endemic to southern Australia from Fremantle (WA) to Sydney (NSW), including Tasmania. Occurs in shallow seagrass beds in estuaries and sheltered bays at depths between 2 and 26 m. Adults possess venomous infraorbital, preopercular and dorsal-fin spines, and lack scales. Maximum size 23 cm (Scott *et al.*, 1980; Last *et al.*, 1983; Hutchins & Swainston, 1986; Kuiter, 1996).

Importance to fisheries Often entangled in beach seine nets, making hauling dangerous due to venomous head and dorsal-fin spines (Hutchins, 1980).

Spawning Eggs undescribed. Spawns between late winter and early spring (Grant, 1972). Larvae have been caught in the lower Swan Estuary (WA) from July to October, with peak abundances in July and August (Neira, 1989; Neira *et al.*, 1992), in Port Phillip Bay (Vic) from July to October (Jenkins, 1986b), and in the Gippsland Lakes (Vic) (Ramm, 1986).

Diagnostic characters

- 9–11 + 17–20 = 28–29 myomeres
- Pectoral fins typically with 11 rays, pigmented distally
- Single row of 16–22 small melanophores along ventral midline of tail
- No pigment laterally along tail until postflexion stage

Description of larvae

Morphology Body elongate in preflexion larvae (BD 12–18%), moderate in flexion and postflexion larvae (BD 21–37%). Dermal sac encloses most of body in preflexion larvae, and disappears with formation of dorsal and anal fins. Head small to moderate in preflexion and flexion larvae (HL 13–32%), moderate to large in postflexion larvae (HL 30–39%). Two posterior preopercular spines in preflexion larvae, 2 anterior preopercular spines in flexion larvae; 4 posterior preopercular and 3 anterior preopercular spines in early postflexion larvae. Supraocular, infraorbital, parietal, pterotic and posttemporal spines in flexion larvae; cleithral, supracleithral and opercular spines in postflexion larvae. Posterior infraorbital spine (suborbital stay) and uppermost posterior preopercular spine prominent in juveniles. Gut moderate in preflexion and flexion larvae (PAL 35–51%), long in postflexion larvae (PAL 55–63%), coiled and compact. Small gas bladder visible until about 10 mm. Small gap between anus and origin of anal fin, reduced once anal fin is formed. Large, fan-shaped pectoral fins, extending beyond anus (P_1L 20–44%).

Size at

Hatching	<2.6 mm
Notochord flexion	4.8–6.0 mm
Settlement	~9.0–11.0 mm
Formation of fins:	

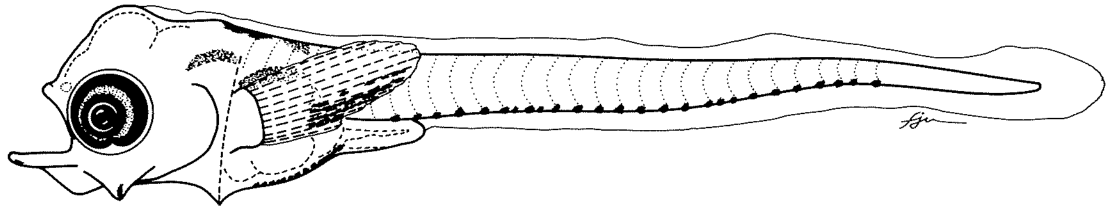
Pectoral 3.3–4.7 mm; Caudal 4.6–6.0 mm; Pelvic 4.8–9.3 mm; Dorsal 5.0–9.0 mm; Anal 5.0–9.0 mm

Pigmentation Larvae are lightly pigmented prior to settlement. *External*: 1 melanophore on gular membrane and 1 at angle of lower jaw; pigment along isthmus by late preflexion stage. Scattered melanophores over dorsal and lateral surfaces of head by end of flexion stage. Series of melanophores along ventral surface of gut and 1 melanophore at anus. Single series of 16–22 melanophores along ventral midline of tail in preflexion larvae, about 1 per myomere, paired along anal-fin base in postflexion larvae. No melanophores along lateral surface of trunk and tail in preflexion and flexion larvae, several in early postflexion larvae. Melanophores along margins of each pectoral-fin ray and a few on fin membrane, concentrated distally. Melanophores scattered over all fins except caudal fin by settlement stage. Blotches of pigment on body and on dorsal-, anal- and pectoral-fin membranes in newly settled juveniles. *Internal*: Melanophores at base of hindbrain and dorsally over gas bladder and gut.

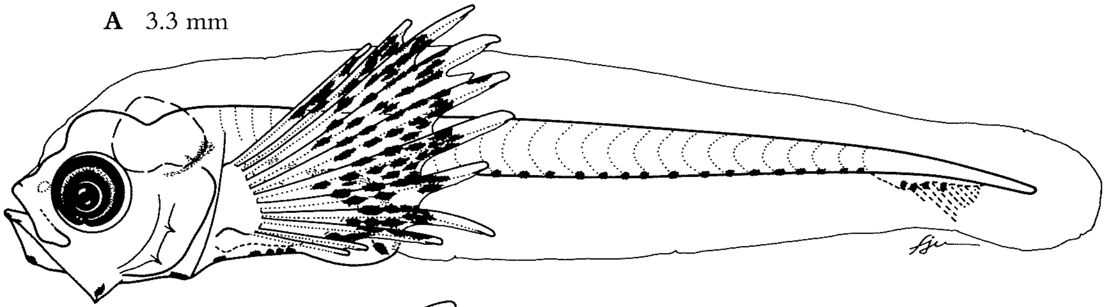
Material examined 23 larvae, 2.6–9.3 mm BL, and 7 juveniles, 10.9–16.8 mm BL, lower Swan Estuary (WA).

Additional references Neira (1989).

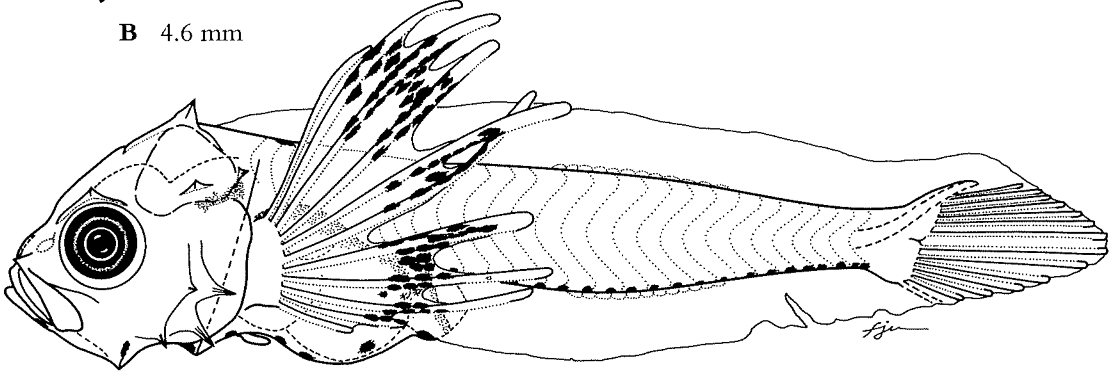
Figure 39 Larvae and newly-settled juvenile of *Gymnapistes marmoratus*. **A** Preflexion. **B** Preflexion; note large, fan-shaped pectoral fin. **C** Flexion; note pelvic-fin bud. **D** Postflexion. **E** Newly-settled juvenile; myomeres omitted. A–D from lower Swan Estuary (WA); E from Peel–Harvey Estuary (WA) (from Neira, 1989). Illustrated by F. J. Neira.



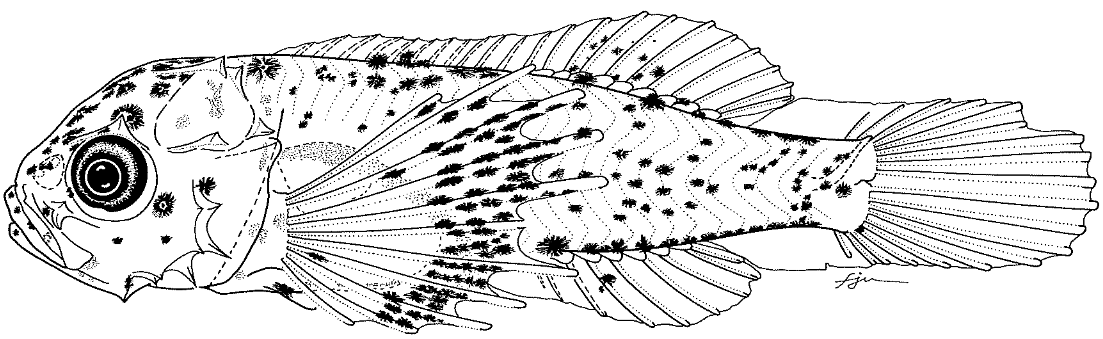
A 3.3 mm



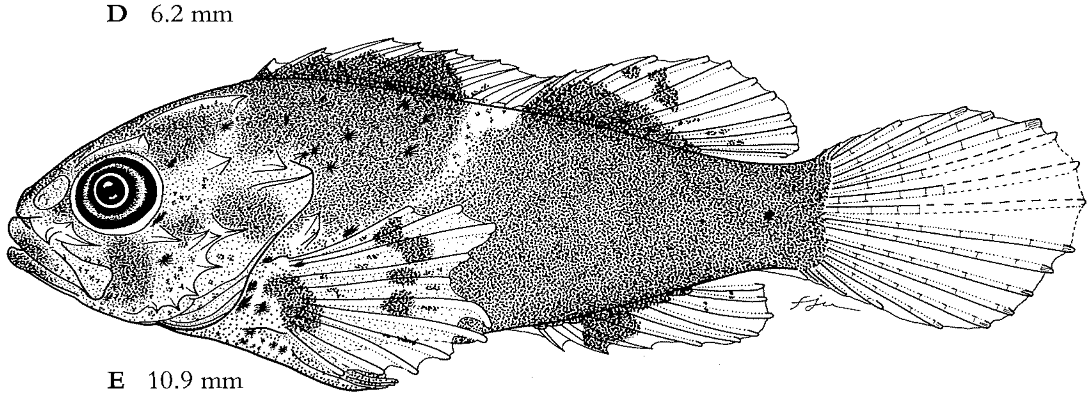
B 4.6 mm



C 5.1 mm



D 6.2 mm



E 10.9 mm

Scorpaenidae *Helicolenus percoides* (Richardson, 1842) Ocean perch

D XII, 11–12 A III, 5 P_1 18–20 P_2 I, 5 C 15 V 25

Adults Distributed around southern Australia from Fremantle (WA) to Coffs Harbour (NSW), including Tasmania; also in New Zealand. Several morphs, possibly representing several species, have been included under *H. percoides* in Australia; all have different depth distributions and are distinguishable by morphological, reproductive, size and colour differences. Adult *Helicolenus* spp. are demersal, common in shelf and slope waters to a depth of 750 m; juveniles are abundant on the continental shelf. Head and dorsal-fin spines are venomous. Maximum size 43 cm (Last *et al.*, 1983; Hutchins & Swainston, 1986; May & Maxwell, 1986; Gomon *et al.*, 1994; Park, 1994; Williams *et al.*, 1996).

Importance to fisheries Fished commercially by trawling in southeastern Australia. Over 300 tonnes of *Helicolenus* spp. were caught in 1993 by the South East Trawl fishery (Klaer, 1990; Park, 1994; Staples & Tilzey, 1994).

Spawning Eggs undescribed. Fertilisation is internal, with developed larvae recorded in females of one morph. Gonad development indicates mating occurs during winter (Park, 1994). Larvae have been caught in coastal waters off Sydney (NSW) from May to December (Gray, 1995), and in coastal waters of Tasmania from October to February (Marshall & Jordan, 1992; Furlani, 1997).

Diagnostic characters

- 8–10 + 15–17 = 24–25 myomeres
- Dermal sac encloses most of body
- Mass of spongy tissue above trunk from late preflexion stage
- Supraocular, parietal and posterior preopercular spines finely serrate by late flexion stage
- 6–8 melanophores along ventral midline of tail, between myomeres 7–15

Description of larvae

Morphology Body moderate (BD 21–37%). Dermal sac encloses most of body in preflexion larvae, disappearing with formation of dorsal and anal fins. Mass of spongy tissue on dermal sac above trunk from late preflexion stage. Head moderate to large (HL 23–44%). Anterior and posterior preopercular, parietal and pterotic spines in late preflexion larvae; 2 anterior preopercular and 3 posterior preopercular spines in early postflexion larvae; posterior preopercular spine at angle elongate and serrate by postflexion stage. One supraocular, 1 pterotic and 1 posttemporal spine by late flexion stage; supraocular and parietal spines finely serrate by end of flexion stage. Supracleithral spines in late postflexion larvae. Gut moderate to long (PAL 40–60%), coiled and compact by 3 mm. Moderate gas bladder over foregut. Moderate gap between anus and origin of anal fin, reduced after anal fin is formed.

Size at

Hatching	<1.9 mm
Notochord flexion	4.8–7.5 mm
Settlement	>12.3 mm
Formation of fins:	

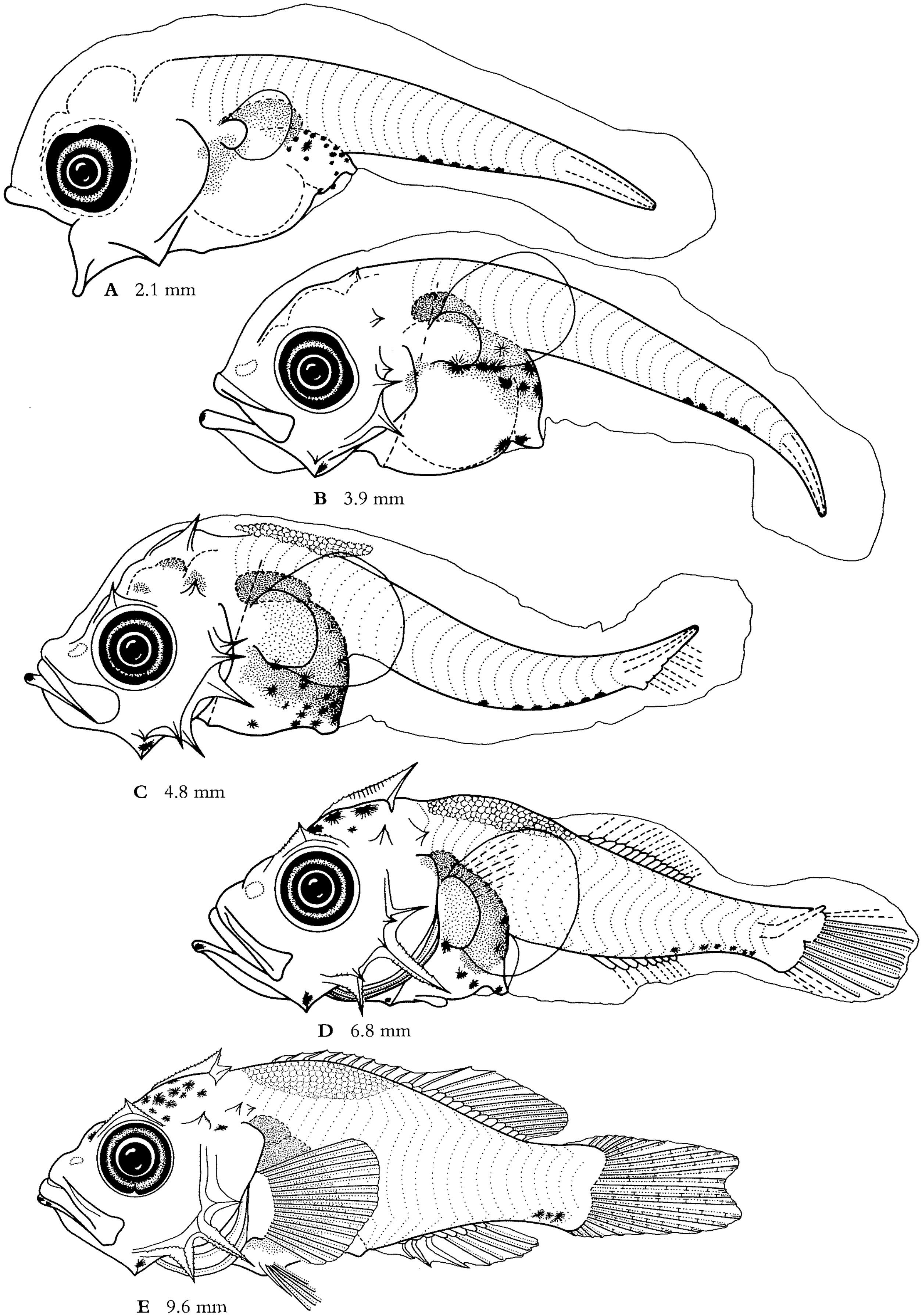
Caudal 4.8–7.7 mm; Pectoral 5.4–8.5 mm; Dorsal 5.5–9.0 mm; Anal 5.5–9.0 mm; Pelvic 7.7–8.2 mm

Pigmentation Larvae are lightly pigmented. *External*: 1 melanophore on tip of lower jaw and 1 at angle of lower jaw; 2–3 melanophores over midbrain in mid-flexion larvae, heavy pigment in postflexion larvae. Scattered melanophores laterally on gut from preflexion stage. Series of 6–8 expanded melanophores along ventral midline of tail, between myomeres 7 and 15. Light pigment on pectoral-fin base and fin membrane from flexion stage. *Internal*: Pigment on the mid- and hindbrain by late preflexion stage. A few melanophores scattered dorsally over gut and gas bladder, extending over most of gut in postflexion larvae.

Material examined 60 larvae, 1.9–12.3 mm BL, Bass Strait and coastal waters of Tasmania.

Additional references Furlani (1997).

Figure 40 Larvae of *Helicolenus percoides*. **A** Preflexion. **B** Preflexion; note developing preopercular spines. **C** Flexion; note mass of spongy tissue dorsally on trunk. **D** Late flexion; note pelvic-fin bud. **E** Postflexion. A–E from Tas coastal waters (modified from Furlani, 1997). Redrawn by F. J. Neira.



A 2.1 mm

B 3.9 mm

C 4.8 mm

D 6.8 mm

E 9.6 mm

Scorpaenidae *Neosebastes scorpaenoides* Guichenot, 1867

Common gurnard perch

D XIII, 7–9   A III, 5–6 P_1 20–22 P_2 I, 5   C 13–15   V 25–26

Adults Endemic to southern Australia from Ceduna (SA) to Sydney (NSW), including Tasmania. Found on rocky reefs in coastal waters to a depth of 140 m. Adults have a curved lateral line near the dorsal-fin base and long, venomous dorsal-fin spines. Maximum size 40 cm (Last *et al.*, 1983; Hutchins & Swainston, 1986; Allen & Cross, 1989a).

Importance to fisheries Caught by commercial trawlers and occasionally by recreational fishers with handlines (Last *et al.*, 1983; Gomon *et al.*, 1994).

Spawning Eggs undescribed. Larvae have been caught in coastal waters off Sydney (NSW) in all months except March, June and August (Gray, 1995).

Diagnostic characters

- 10–12 + 14–16 = 26 myomeres
- Pectoral fin typically with 20 rays
- Melanophore series along dorsal, lateral and ventral midlines of tail
- No pigment dorsally or laterally on caudal peduncle
- Internal melanophores dorsally along notochord from flexion stage

Description of larvae

Morphology Body moderate to deep (BD 29–44%). Head moderate to large (HL 28–45%). One parietal and 3 posterior preopercular spines in early preflexion larvae; up to 5 small to moderate posterior preopercular spines in postflexion larvae. One supraocular, 1 opercular, 1 posttemporal and 1 supracleithral spine in flexion larvae; nasal, infraorbital, pterotic and cleithral spines in postflexion larvae. Gut long (PAL 52–73%), coiled and large. Gas bladder over foregut, inflated. No gap between anus and origin of anal fin. Large, fan-shaped pectoral fins, extending to level of anus in postflexion larvae. Last dorsal- and anal-fin spines transform from soft rays in late postflexion larvae. Small preanal membrane, persisting until late flexion stage.

Size at

Hatching	<1.8 mm
Notochord flexion	4.1–5.5 mm
Settlement	>7.3 mm

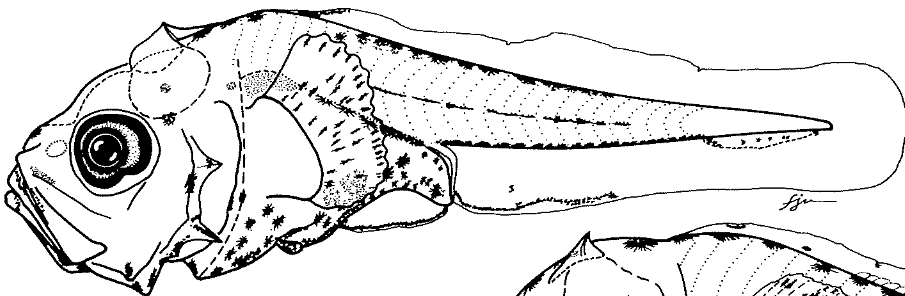
Formation of fins:
Pelvic 3.4–5.3 mm; Dorsal 3.6–6.3 mm; Anal 3.6–7.3 mm; Pectoral 4.1–5.3 mm; Caudal 4.1–6.1 mm

Pigmentation Larvae are moderately pigmented prior to settlement. *External*: 1 melanophore on snout, a few on upper jaw and ventral surface of lower jaw, and 1 at angle of lower jaw. A few melanophores on preopercle, 2 each dorsally over head and on nape. Melanophores over lateral and ventral surfaces of gut, including 4–5 along hindgut. Melanophore series along lateral midline of trunk and tail, between myomeres 9–10 and 20–22. Paired series of melanophores along dorsal midline of trunk and tail, extending to myomeres 19–20 (to last dorsal-fin ray); paired series along ventral midline of tail extending from above anus to caudal peduncle. No pigment on dorsal and lateral surfaces of caudal peduncle during development. Melanophores along margin of anterior portion of dorsal and anal finfolds, and along ventral edge of preanal membrane until flexion stage. Melanophores on membrane and along margins of pectoral- and pelvic-fin rays; other fins unpigmented. Additional pigment on head, pectoral-fin base and laterally on trunk and tail after flexion stage. *Internal*: Melanophores on midbrain, base of brain and dorsally over gas bladder and gut. Melanophore series dorsally along notochord from flexion stage.

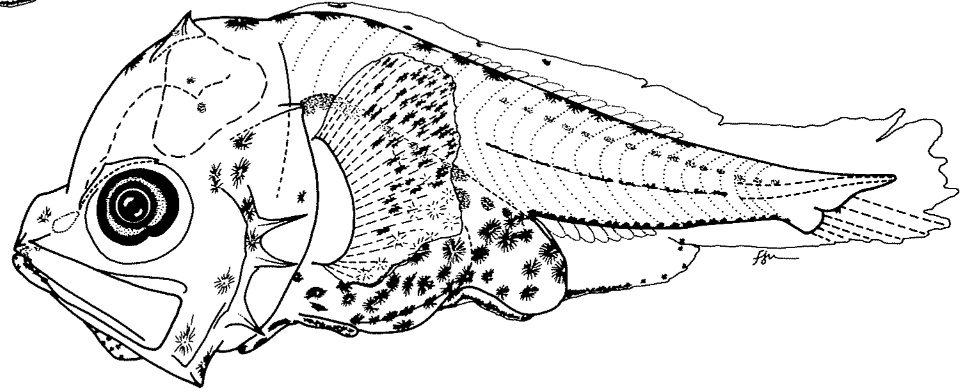
Material examined 22 larvae, 1.8–7.3 mm BL, coastal waters off Sydney (NSW).

Additional references –

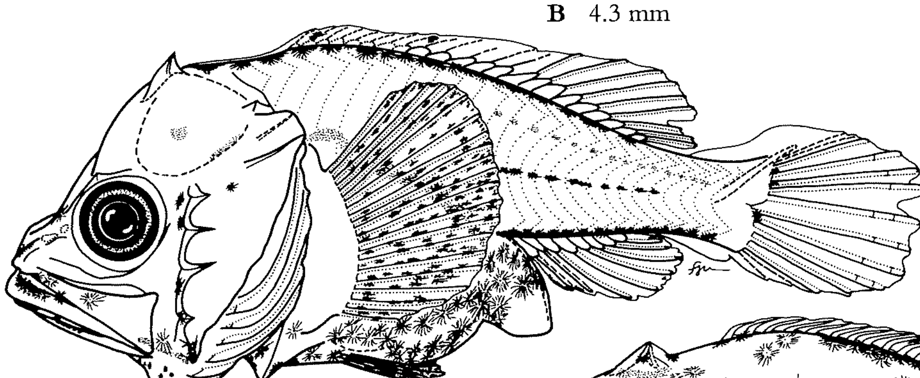
Figure 41 Larvae of *Neosebastes scorpaenoides*. **A** Preflexion; note pelvic-fin bud. **B** Flexion; note developing dorsal and anal fins. **C** Late flexion. **D** Postflexion. **E** Postflexion, near settlement; note lower pectoral-fin rays are bent forward. A–E from Sydney coastal waters (NSW). Illustrated by F. J. Neira.



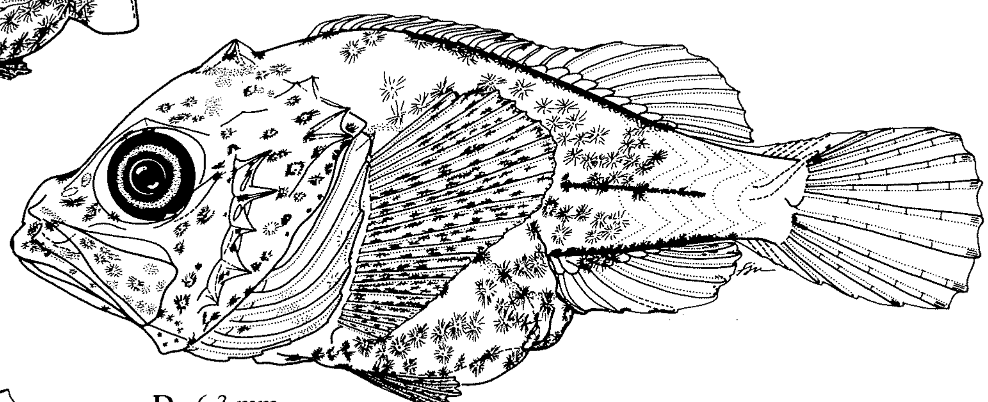
A 3.5 mm



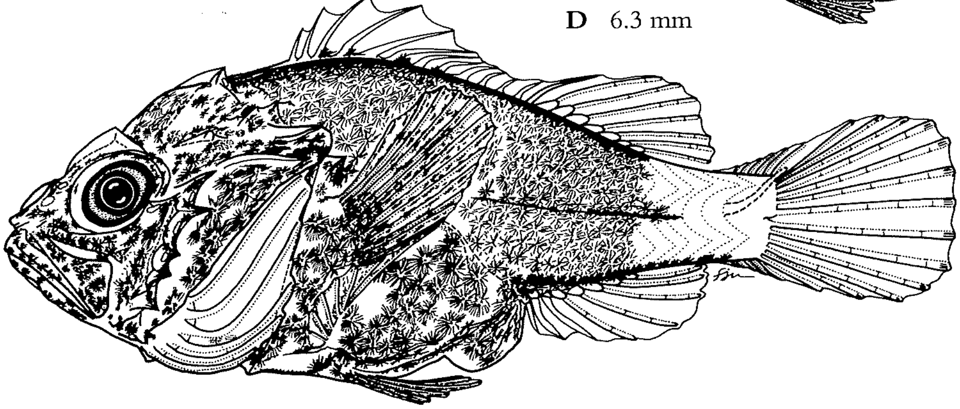
B 4.3 mm



C 5.3 mm



D 6.3 mm



E 7.3 mm

Triglidae: Searobins, gurnards

A.R. Jordan, W.J. Richards and F. J. Neira

Triglids are benthic marine fishes found in tropical to temperate waters worldwide, with most species in tropical regions of the Indo-Pacific. They occur in shelf and slope waters to a depth of 500 m. The family contains 14 genera and 100 species (Nelson, 1994). Five genera and about 12 species, 7 of which are endemic, have been recorded from temperate Australia (Paxton & Hanley, 1989j; Gomon *et al.*, 1994). Adults (0.12–1.0 m) have a large head with several weak to strong spines, prominent, fan-shaped pectoral fins with the lower two or three rays enlarged and detached (free) from the rest of the fin, squamation varying from heavy, armored plate-like scales to moderate or very small scales, and a short-based, spineless anal fin. Rostral (preorbital) projections often bearing spines are very pronounced in adults of some taxa (e.g. *Peristedion*) but may be weak or absent in others; nuchal spines (posttemporal in larvae) are usually large, often reaching the base of the first dorsal fin. Eggs are pelagic and spherical, 0.9–1.7 mm in diameter, and typically have a single oil globule although eggs of some taxa have multiple oil globules (Padoa, 1956e,f; Mito, 1963; Robertson, 1975a; Brownell, 1979; Fahay, 1983; Washington *et al.*, 1984b; Zhang *et al.*, 1985; Ikeda & Mito, 1988; Richards, 1996). Larvae have been described for representatives of *Bellator*, *Chelidonichthys*, *Lepidotrigla*, *Peristedion*, *Prionotus* and *Pterygotrigla* (see Washington *et al.*, 1984b, and references therein; see also Fahay, 1983; Kojima, 1988h; Leis & Trnski, 1989; Richards, 1990, 1996). The large head with relatively large spines, the large, fan-shaped pectoral fins, and the gas bladder which is apparently lost before settlement, constitute specialisations of triglid larvae to pelagic life (Leis & Trnski, 1989).

Meristic characters of triglid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Chelidonichthys	(1)	VIII–IX + 15–16	14–15	10–11 + 3	I, 5	13	12–13 + 21–22 = 33–35
Lepidotrigla	(6)	VIII–XI + 13–17	14–17	10–12 + 3	I, 5	13	9–11 + 21–23 = 30–34
Peristedion	(1)	VIII + 21–22	20	11–14 + 2	I, 5	13	37
Pterygotrigla	(3)	VII–IX + 11–13	12–13	11–13 + 3	I, 5	13	9–11 + 14–18 = 25–28
Satyrichthys	(1)	VII + 18	17	11–14 + 2	I, 5	12*	30

* Branched rays

Main characters of triglid larvae

- 25–39 myomeres, typically 27–35
- Body elongate to moderate (BD 16–38%)
- Head moderate to large (HL 22–56%), slightly compressed, and with deeply concave snout profile; snout wider than deep, duckbill-shaped
- Mouth large and somewhat horizontal, often reaching below mideye
- Weak to well developed and extensive head spination, including:
  - 2 posttemporal spines, usually serrate, either one or both of which may become very long and prominent depending on taxon (regarded by some authors as the nuchal spine in adults, e.g. *Peristedion*), and often reaching beyond caudal peduncle;
  - series of infraorbital spines connected by ridges, sometimes projecting anteriorly beyond the snout and forming a rostral projection (rostral spine) which may become long and prominent in postflexion larvae of some taxa (e.g. *Peristedion*, *Pterygotrigla*) or remain short and weak in others (e.g. *Lepidotrigla*);
  - weak to very strong anterior and posterior preopercular spines, forming during flexion stage;
  - vertically directed spine at angle of lower jaw from flexion stage in some taxa;
  - supraocular, either as a spine or as a serrate or smooth ridge, and cleithral, pterotic and nasal spines

- Gut moderate to long (PAL 38–69%), coiled and compact
- Small gap between anus and origin of anal fin until fin is completely formed
- 2 separate dorsal fins
- Pelvic fins thoracic
- Pectoral fins large, wide-based and fan-shaped from preflexion stage; rays start to form during preflexion stage; lower 2–3 rays stout and detached (but not completely free) from rest of fin from late postflexion stage
- Body lightly pigmented in larvae of most taxa except *Chelidonichthys* which become heavily pigmented early in development; pectoral fins heavily pigmented in some taxa

References to triglid larvae
Padoa (1956e,f), Uchida *et al.* (1958), Mito (1966), Fahay (1983), Washington *et al.* (1984b), Kojima (1988h), Leis & Trnski (1989), Richards (1990, 1996).

Families with similar larvae

Aploactinidae – Dorsal fin originates from top of head in most taxa; anterior 3–5 dorsal-fin spines usually elevated and separated from remaining spines; pelvic fin I, 2–3.
Congiopodidae – Dorsal fin originates from top of head, long-based; pectoral fin 8–12; gut long and straight; gill opening reduced to a small slit above pectoral-fin base.
Hoplichthyidae – 26 vertebrae; short-based first dorsal fin with V spines; body mostly without pigment except dorsally over gut.
Opistognathidae (early stages) – Weak head spination, including small preopercular spines; body lightly pigmented, no melanophores over head, dorsally and laterally on trunk and tail.
Percophidae – No head spines; early forming, elongate pelvic-fin rays in some taxa; pelvic fins jugular.
Platycephalidae – Head and body depressed from late postflexion stage; pectoral fin 16–25, lower pectoral-fin rays not detached; early forming (preflexion stage) preopercular spines; small posttemporal spines; body moderately pigmented.
Scorpaenidae – 24–31 myomeres, typically 24–27; single, continuous dorsal fin; head large, without broad, duckbill-shaped snout; preopercular spines usually large; lower pectoral-fin rays not detached; body typically lightly pigmented prior to settlement.

Triglidae *Chelidonichthys kumu* (Cuvier, 1829) Red gurnard

D VIII–IX + 15–16 A 14–15 P_1 10–11 + 3 P_2 I, 5 C 13 V 33–35

Adults Distributed around southern Australia from Shark Bay (WA) to southern Queensland, including Tasmania and Lord Howe Island; also in New Zealand, Japan, China and Korea, and South Africa. Demersal species found on sandy bottoms in coastal marine waters, occasionally in estuaries, to a depth of 200 m, but more frequently between 75 and 150 m; juveniles may occur in bays. Adults possess a smooth snout without prominent spines, and blue spots on the pectoral fins. Maximum size 60 cm (Hutchins & Swainston, 1986; Paxton & Hanley, 1989j; Gomon *et al.*, 1994; Kuiter, 1996).

Importance to fisheries Not fished commercially although excellent quality fish caught in bottom trawls and sometimes with hook and line (Gomon *et al.*, 1994).

Spawning Eggs are pelagic and spherical, 1.3–1.5 mm in diameter, and have a smooth chorion, an unsegmented yolk and a single oil globule 0.28 mm; embryo and yolk in late-stage eggs have regularly spaced melanophores (Robertson, 1975a). Larvae have been caught in coastal waters off Sydney in August (Gray, 1995).

Diagnostic characters

- 14–15 + 19–20 = 33–35 myomeres
- Supraocular ridge, parietal, pterotic, posttemporal and lower opercular spines serrate from 10 mm
- Heavily pigmented pectoral fins, rays unpigmented distally
- Large pigment patch over caudal peduncle and base of caudal-fin rays in postflexion larvae

Description of larvae

Morphology Body moderate in postflexion larvae (BD 29–36%). Head large in postflexion larvae (HL 37–42%), with a concave snout. Small teeth on dentary by 14.6 mm. Anterior preopercular, posterior preopercular and infraorbital spines, 2 posttemporal and opercular spines, 1 prominent parietal and 1 cleithral, 1 pterotic, 1 nasal and 1 supraocular spine in postflexion larvae; posttemporal, lower opercular, parietal, pterotic, and supraocular spines finely serrate. Preopercular margin serrate in late postflexion larvae. Gut moderate in postflexion larvae (PAL 48–50%), coiled and compact. Gas bladder visible in all postflexion larvae examined. Large, fan-shaped pectoral fin, reaching beyond anus in postflexion larvae (P_1L 30–32%).

Size at

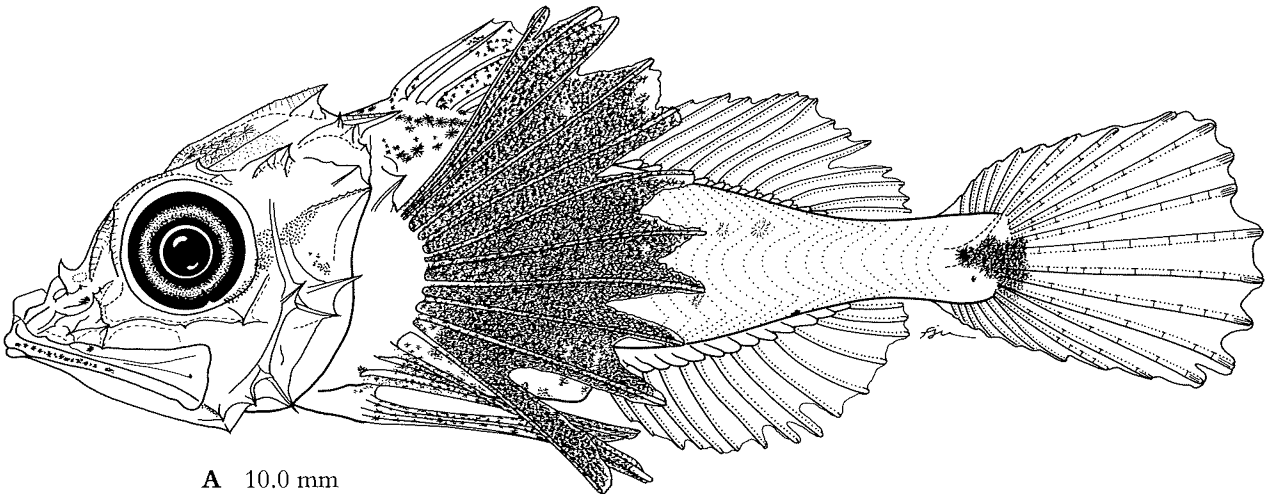
Hatching	–
Notochord flexion	<10.0 mm
Settlement	>15.0 mm
Formation of fins:	
Pectoral <10.0 mm; Caudal <10.0 mm; Dorsal <10.0 mm; Anal <10.0 mm; Pelvic <10.0 mm	

Pigmentation Postflexion larvae become heavily pigmented with development. *External*: Light pigment on head, trunk and tail in smallest postflexion larva examined (10.0 mm); larvae are heavily pigmented by 15 mm. Large melanophore patch over caudal peduncle in a 10.0 mm larva, extending to base of caudal-fin rays; patch merges with lateral tail pigment by 14 mm. Pectoral fins heavily pigmented, with rays unpigmented distally. Series of melanophores vertically along pectoral-fin base from 11 mm. Melanophores scattered over membranes of first dorsal and pelvic fins. Second dorsal and anal fins, and most of caudal fin unpigmented. *Internal*: Heavy pigment dorsally over gut and gas bladder.

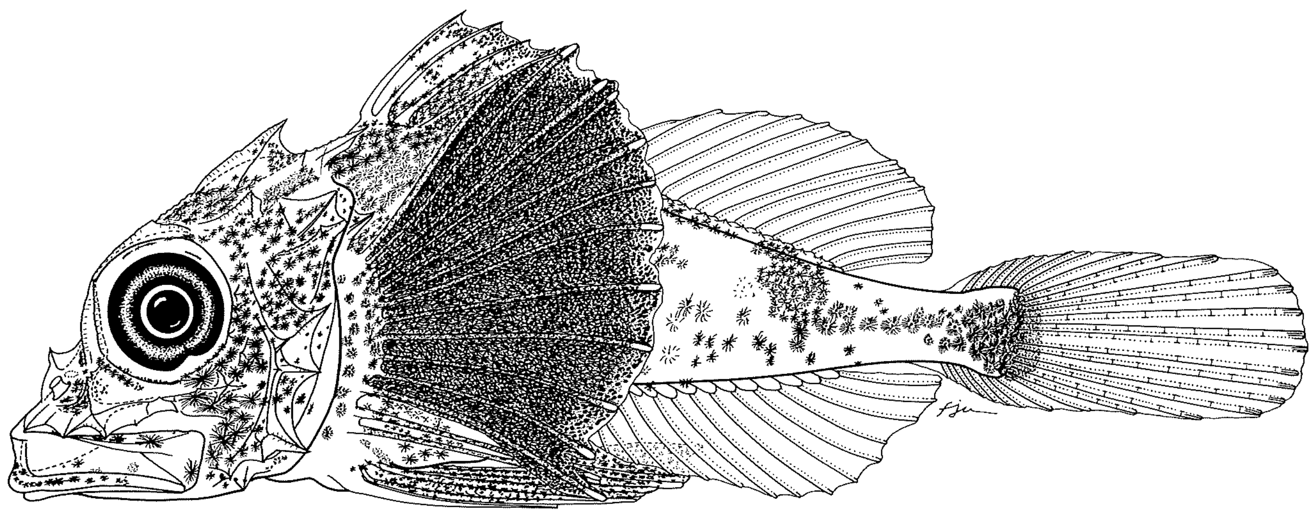
Material examined 7 larvae, 10.0–14.6 mm BL, coastal waters off Sydney (NSW); 2 larvae, 14.0–15.0 mm BL, coastal waters off Great Barrier Island (New Zealand).

Additional references –

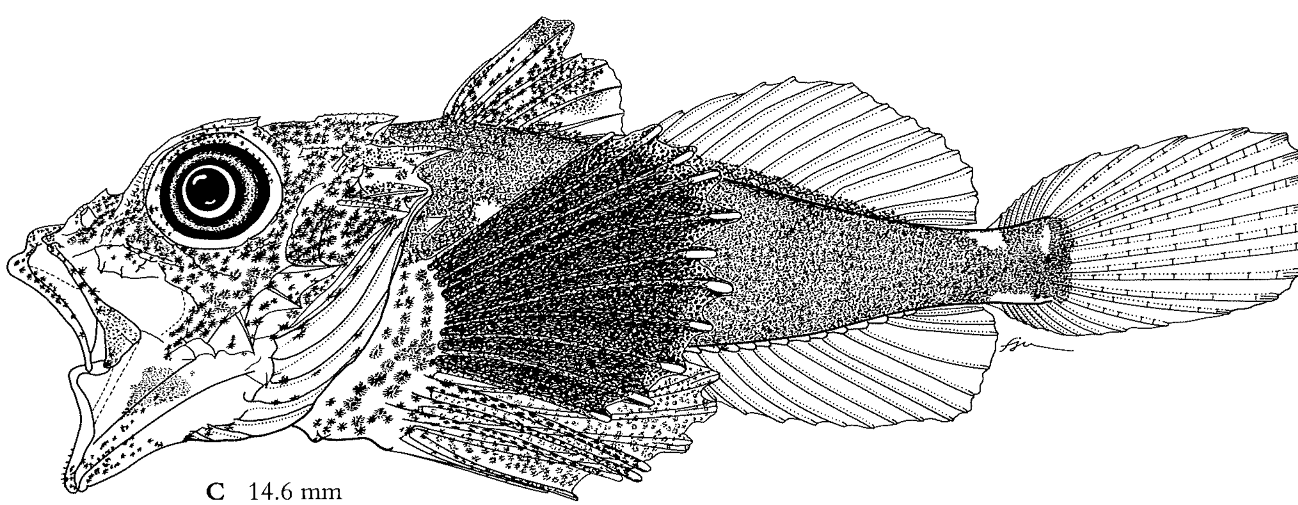
Figure 42 Larvae of *Chelidonichthys kumu*. **A** Postflexion; only posterior myomeres drawn. **B** Postflexion; note 12th pectoral-fin ray still attached to membrane; myomeres omitted. **C** Postflexion, near settlement. A–C from Sydney coastal waters, (NSW). Illustrated by F. J. Neira.



A 10.0 mm



B 11.7 mm



C 14.6 mm

Triglidae *Lepidotrigla modesta* Waite, 1899 Minor gurnard

D IX + 15–16 A 16–17 P_1 10–12 + 3 P_2 1, 5 C 13 V 32–34

Adults Endemic to southern Australia from Shark Bay (WA) to Port Stephens (NSW), including Tasmania. Most widespread species in the genus, occurring in coastal marine waters at depths of about 10–300 m. Adults possess a distinctly concave snout profile and interorbit, and a body bright red above and whitish below. Maximum size 22 cm (Gomon *et al.*, 1994; Williams *et al.*, 1996).

Importance to fisheries Occasionally caught as by-catch in bottom trawls but of no commercial importance (Last *et al.*, 1983).

Spawning Eggs undescribed. Eggs of *Lepidotrigla* spp. are pelagic and spherical, 1.2–1.4 mm in diameter, and have a single oil globule (Washington *et al.*, 1984b). Larvae have been caught in coastal waters of eastern Tasmania from December to April (Marshall & Jordan, 1992).

Diagnostic characters

- 6–11 + 21–26 = 31–32 myomeres
- Opposing series of 2–6 small melanophores along dorsal and ventral midlines of caudal peduncle
- Internal melanophores over midbrain in preflexion larvae
- Sparse pigment concentrated proximally on pectoral- and pelvic-fin membranes in postflexion larvae

Description of larvae

Morphology Body moderate (BD 21–28%). Head moderate (HL 23–29%), with a concave snout. Parietal spines from preflexion stage; 1 supraocular, and infraorbital, anterior preopercular and posterior preopercular, pterotic, and posttemporal spines, and 1 small spine at angle of lower jaw from flexion stage. Parietal spine prominent and serrate along anterior edge from early postflexion stage. Second posttemporal spine in postflexion larvae by 8.6 mm, and nasal spine by 11.4 mm. Gut moderate (PAL 41–50%), coiled and compact. Small to moderate gas bladder over foregut. Large pectoral fin, reaching past anus by 12.8 mm (P_1L 23–40%).

Size at

Hatching	<4.5 mm
Notochord flexion	6.9–8.8 mm
Settlement	>13.8 mm

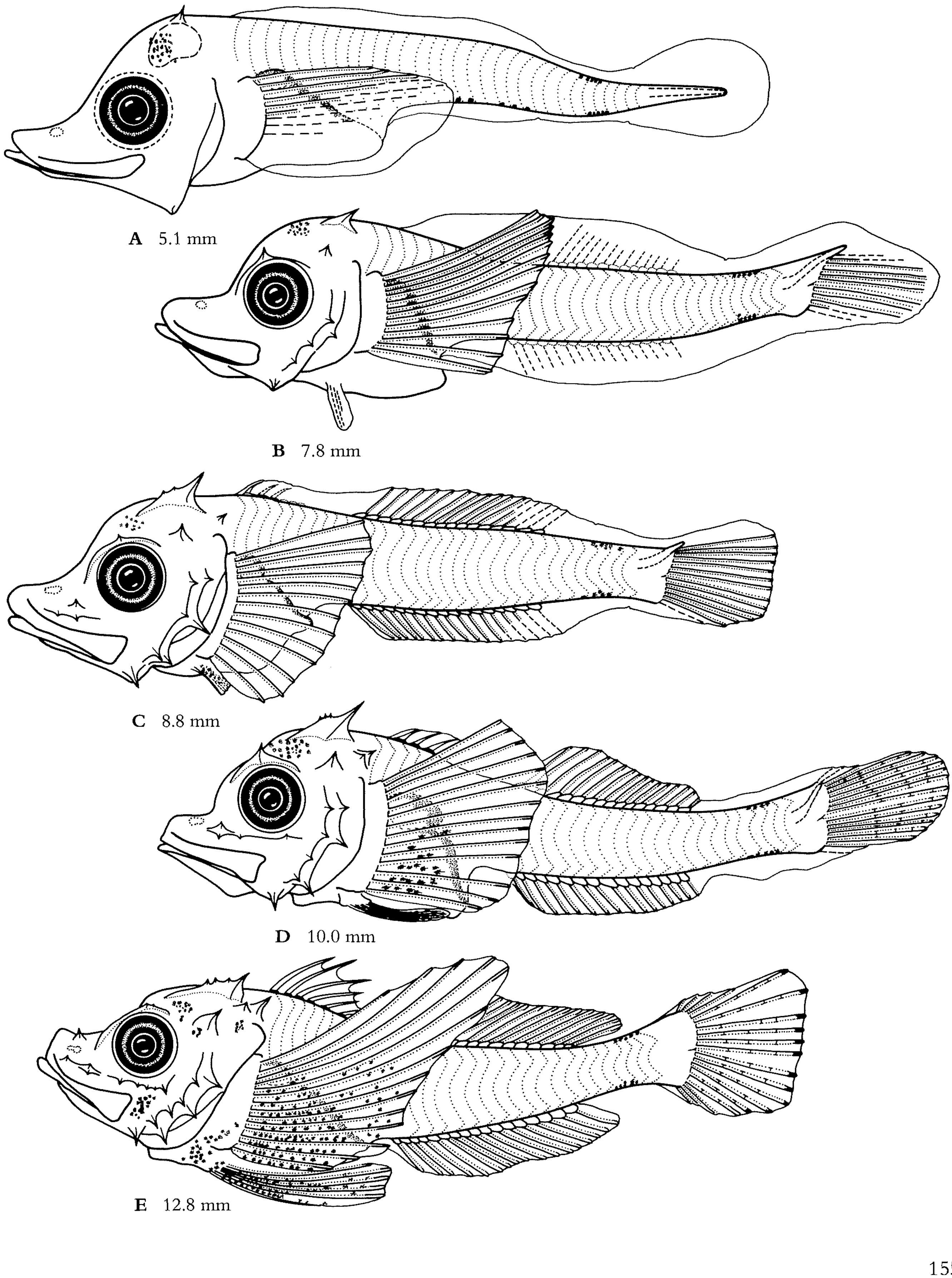
Formation of fins:
Pectoral 4.5–7.0 mm; Caudal 6.8–8.9 mm; Dorsal 7.0–9.8 mm; Anal 7.0–9.8 mm; Pelvic 7.0–9.8 mm

Pigmentation Larvae are lightly pigmented. *External:* A few melanophores along ventral midline at midtail in preflexion larvae, disappearing in flexion larvae. Opposing series of 2–6 melanophores along dorsal and ventral midlines of caudal peduncle. Sparse pigment concentrated proximally over membranes of pectoral and pelvic fins in postflexion larvae. Additional melanophores scattered dorsally on head, below eye, and on pectoral- and pelvic-fin bases by 12 mm. *Internal:* Light pigment over midbrain and dorsally over gas bladder and gut.

Material examined 23 larvae, 4.5–13.8 mm BL, coastal waters of eastern Tasmania.

Additional references –

Figure 43 Larvae of *Lepidotrigla modesta*. **A** Preflexion; note developing pectoral-fin rays. **B** Flexion; note developing dorsal, anal and pelvic fins. **C** Early postflexion. **D** Postflexion. **E** Postflexion; note serrate parietal spine. A–E from eastern Tas coastal waters. Redrawn by F. J. Neira.


A 5.1 mm
B 7.8 mm
C 8.8 mm
D 10.0 mm
E 12.8 mm

Triglidae *Lepidotrigla mulhalli* Macleay, 1884 Deepwater gurnard

D IX, 14–15 A 15 P_1 11 + 3 P_2 I, 5 C 13 V 31

Adults Endemic to southeastern Australia from western Bass Strait (Vic) to Port Stephens (NSW), including Tasmania. Demersal species found on sandy bottoms in coastal marine waters at depths of 10–200 m. Adults have a straight to convex snout profile and interorbit, and a mottled pink body, dark red above and whitish below. Maximum size at least 20 cm (Gomon *et al.*, 1994; Kuiter, 1996).

Importance to fisheries Occasionally caught as by-catch in bottom trawls but of no commercial importance (Last *et al.*, 1983).

Spawning Eggs undescribed. Eggs of *Lepidotrigla* spp. are pelagic and spherical, 1.2–1.4 mm in diameter, and have a single oil globule (Washington *et al.*, 1984b). Larvae have been caught in coastal waters of eastern Tasmania from December to March (Marshall & Jordan, 1992).

Diagnostic characters

- 8–11 + 19–23 = 30–32 myomeres
- Parietal spine with a second smaller spine anteriorly
- Lightly pigmented pectoral fins from early flexion stage, with melanophores evenly distributed
- 5–15 small melanophores along ventral midline of tail

Description of larvae

Morphology Body moderate (BD 20–29%). Head moderate (HL 22–32%), with a concave snout. One large parietal spine with a second smaller spine anteriorly, and 1 supraocular, 1 pterotic, 1 posterior preopercular and 1 spine at angle of lower jaw by early flexion stage. Anterior preopercular spines by end of flexion stage. Infraorbital and 2 posttemporal spines, and 1 nasal spine by 9.8 mm. Gut moderate (PAL 41–50%), coiled and compact. Moderate gas bladder over foregut, visible through to postflexion larvae. Large pectoral fin, reaching beyond anus from early preflexion stage (P_1L 18–34%).

Size at

Hatching	<4.2 mm
Notochord flexion	5.1–8.5 mm
Settlement	>11.1 mm
Formation of fins:	

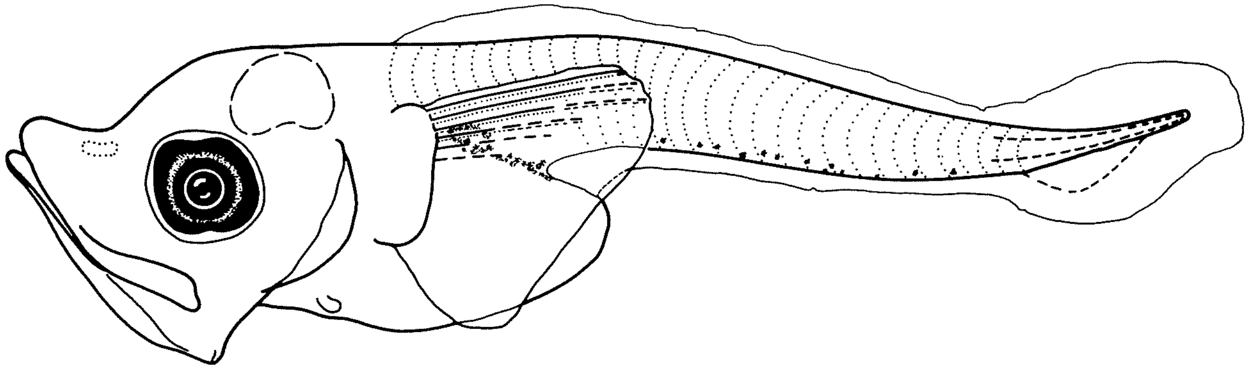
Pectoral <4.2–6.3 mm; Pelvic 5.0–9.0 mm; Caudal <6.2–7.8 mm; Dorsal 6.3–9.0 mm; Anal 6.3–9.0 mm

Pigmentation Larvae are lightly pigmented. *External*: Pigment on ventral surface of gut by flexion stage. Series of 5–15 small melanophores along ventral midline of tail; sparse pigment ventrolaterally on tail from flexion stage. Sparse, evenly scattered melanophores on pectoral- and pelvic-fin membranes from flexion stage. *Internal*: Light pigment over brain and nape from flexion stage, and dorsally over gas bladder and gut in all stages.

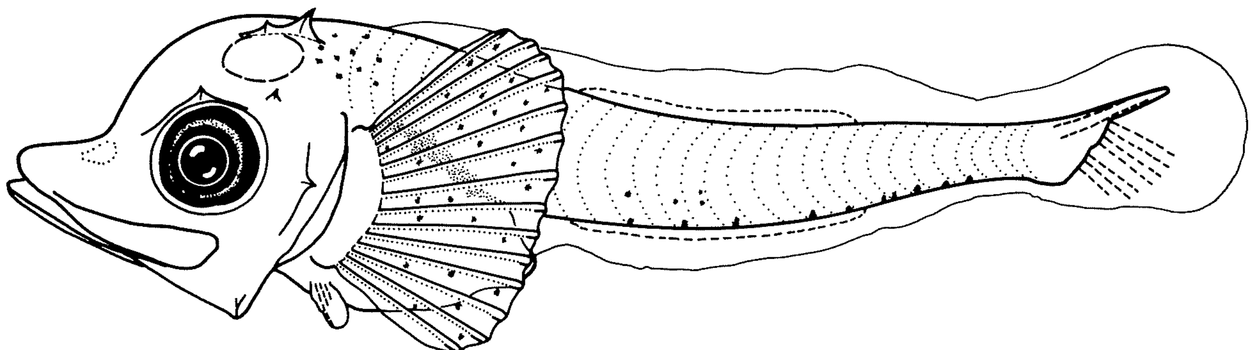
Material examined 41 larvae, 4.2–11.1 mm BL, coastal waters of eastern Tasmania.

Additional references -

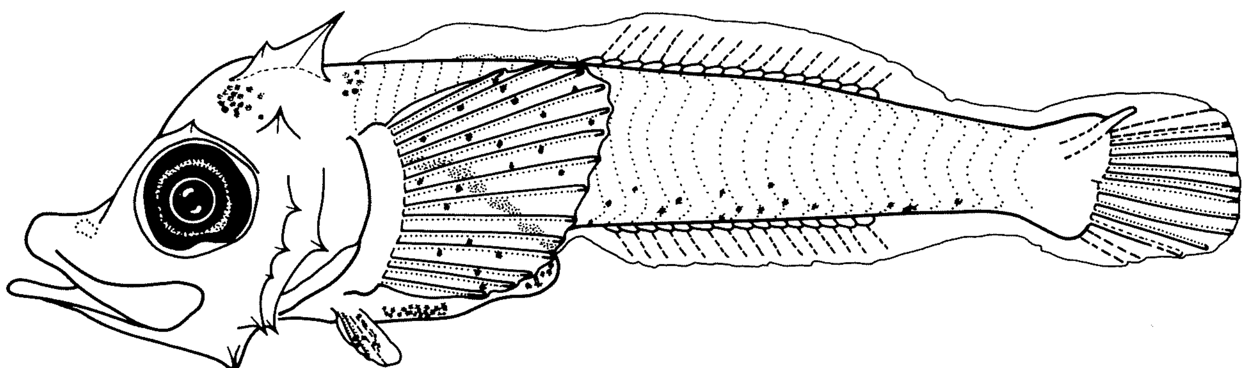
Figure 44 Larvae of *Lepidotrigla mulhalli*. **A** Preflexion; note developing pectoral-fin rays and pelvic-fin bud. **B** Flexion; note developing dorsal and anal fins. **C** Early postflexion. **D** Postflexion. A–D from eastern Tas coastal waters. Redrawn by F. J. Neira.



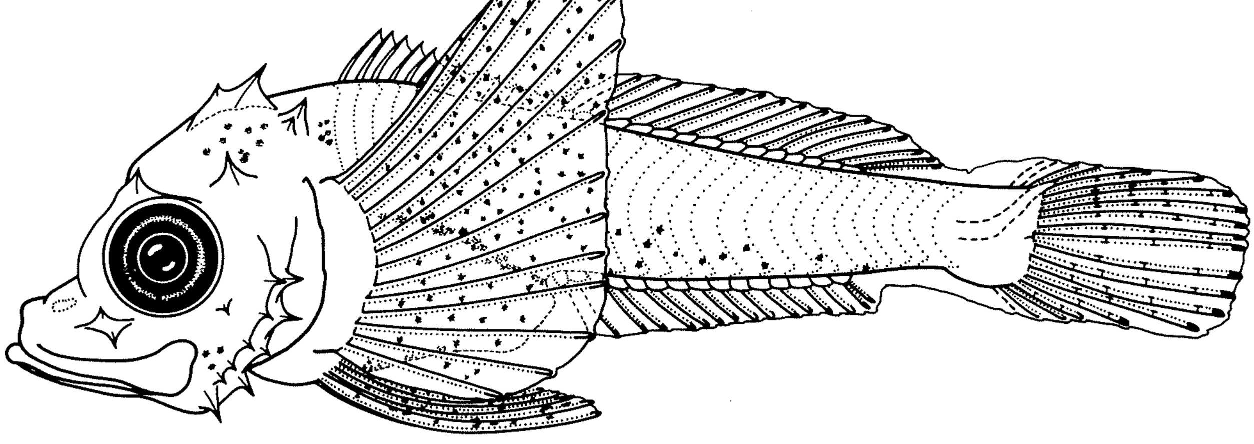
A 5.0 mm



B 6.3 mm



C 7.6 mm



D 9.6 mm

Triglidae *Lepidotrigla papilio* (Cuvier, 1829) Southern spiny gurnard

D VIII–IX + 13–15 A 13–15 P_1 11 + 3 P_2 I, 5 C 13 V 30–31

Adults Endemic to southern Australia from Perth (WA) to Ballina (NSW), including Tasmania. Demersal species found in bays and coastal marine waters to a depth of about 60 m. Adults have scute-like lateral-line scales, a prominent white-edged dark blotch on the first dorsal fin, a broad pale band on the caudal fin, and blackish green colour on the inner surface of the large pectoral fins. Maximum size 20 cm (Hutchins & Swainston, 1986; Gomon *et al.*, 1994).

Importance to fisheries Occasionally caught as by-catch in bottom trawls but of no commercial importance (Last *et al.*, 1983).

Spawning Eggs undescribed. Eggs of *Lepidotrigla* spp. are pelagic and spherical, 1.2–1.4 mm in diameter, and have a single oil globule (Washington *et al.*, 1984b). Larvae have been caught in coastal waters of eastern Tasmania from November to February and in April (Marshall & Jordan, 1992).

Diagnostic characters

- 8–13 + 18–22 = 30–31 myomeres
- Melanophores evenly scattered on pectoral-fin membrane
- Moderate pigment on gut
- Pigment on inner and outer surfaces of pectoral-fin base from early flexion stage
- Pigment on pelvic-fin membrane
- Melanophore series along ventral midline of tail disappears prior to flexion stage

Description of larvae

Morphology Body elongate in preflexion larvae (BD 18%), moderate in flexion and postflexion larvae (BD 23–26%). Head moderate (HL 23–28%), with a concave snout. Supraocular, parietal and pterotic spines by early flexion stage. Small spine at angle of lower jaw, and anterior preopercular and posterior preopercular spines by late flexion stage. Infraorbital spines and 1 posttemporal spine in postflexion larvae (not illustrated in series). Gut moderate (PAL 43–50%), coiled and compact. Small gas bladder over foregut. Large pectoral fin, reaching beyond anus by flexion stage (P_1L 20–22%).

Size at

Hatching	<5.1 mm
Notochord flexion	6.0–8.1 mm
Settlement	>9.6 mm
Formation of fins:	

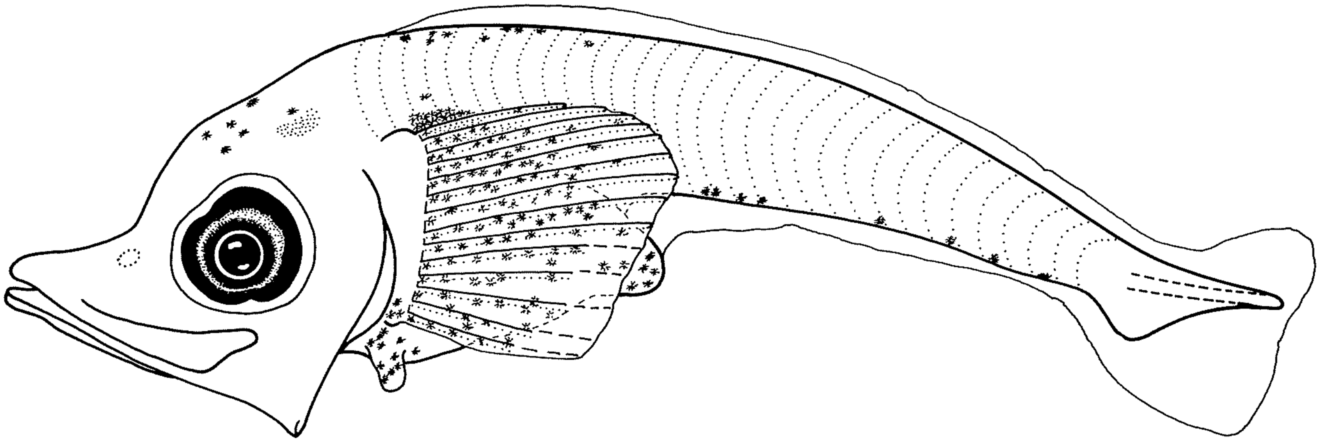
Pectoral <5.1–6.2 mm; Caudal <5.1–8.1 mm; Pelvic <5.1–9.1 mm; Dorsal 5.4–9.1 mm; Anal 5.4–9.1 mm

Pigmentation Larvae are moderately pigmented. *External*: Scattered melanophores dorsally on head and trunk, laterally on gut, and on ventral surface of gut; additional melanophores on gut during flexion stage. Series of 10–20 melanophores along ventral midline of tail in preflexion larvae, disappearing in mid-flexion larvae. Melanophores on pelvic-fin buds from late preflexion stage, and on inner and outer surfaces of pectoral-fin base during flexion stage. Evenly scattered melanophores on pectoral-fin membrane. *Internal*: Pigment on base of hindbrain and dorsally over gas bladder and gut.

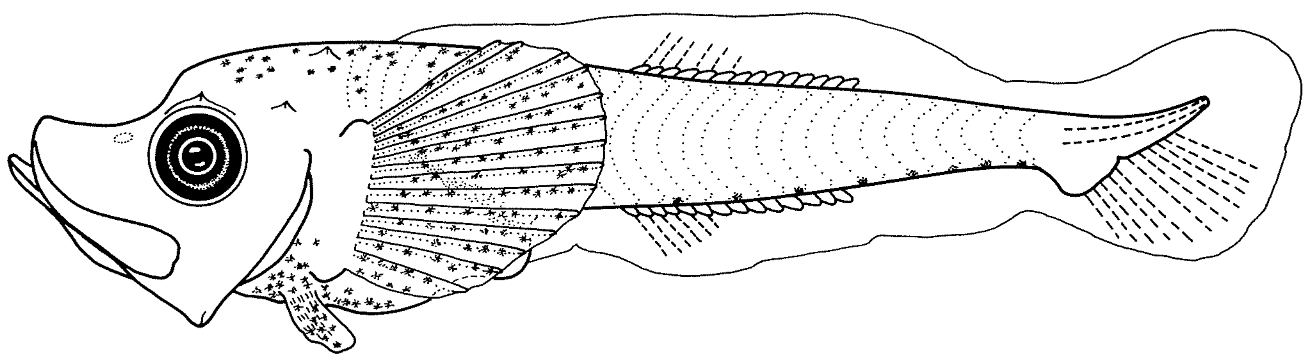
Material examined 9 larvae, 5.1–9.6 mm BL, coastal waters of eastern Tasmania.

Additional references –

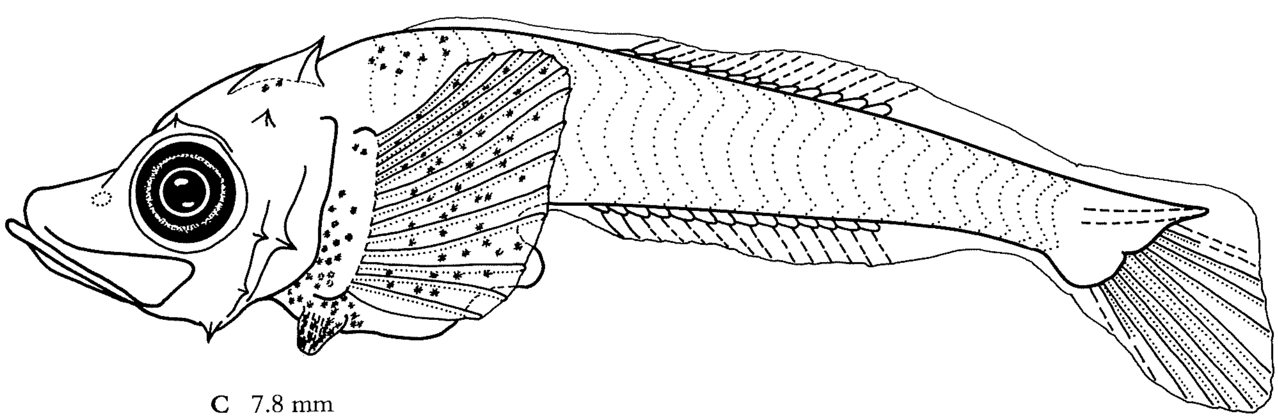
Figure 45 Larvae of *Lepidotrigla papilio*. **A** Preflexion; note pigmented pelvic-fin bud. **B** Flexion; note developing dorsal and anal fins. **C** Late flexion. A–C from eastern Tas coastal waters. Redrawn by F. J. Neira.



A 5.1 mm



B 6.2 mm



C 7.8 mm

Triglidae *Lepidotrigla vanessa* (Richardson, 1839) Butterfly gurnard

D X–XI + 16–17 A 16–17 P_1 11 + 3 P_2 I, 5 C 13 V –

Adults Endemic to southern Australia from Esperance (WA) to Newcastle (NSW), including Tasmania. Demersal species found in coastal marine waters at depths of 10–100 m. Adults have large pectoral fins that reach well beyond the tips of the pelvic fins, and a prominent black spot on the first dorsal fin between spines V–VIII. Maximum size 28 cm, the largest member of the genus (Gomon *et al.*, 1994).

Importance to fisheries One of the most common by-catch species in trawl catches, especially in Bass Strait, but of no commercial importance (Gomon *et al.*, 1994).

Spawning Eggs undescribed. Eggs of *Lepidotrigla* spp. are pelagic and spherical, 1.2–1.4 mm in diameter, and have a single oil globule (Washington *et al.*, 1984b). Larvae have been caught in coastal waters of eastern Tasmania from January to March (Marshall & Jordan, 1992).

Diagnostic characters

- 6–10 + 22–26 = 31–32 myomeres
- Body elongate in preflexion and flexion larvae (BD <20%)
- Large size at notochord flexion (8.0–11.0 mm)
- Very large pectoral fins, reaching to middle of anal fin (P_1L 35–50%)
- Body pigment confined to a series of small melanophores along base of second dorsal-fin base

Description of larvae

Morphology Body elongate in preflexion and flexion larvae (BD 16–19%), moderate in postflexion larvae (BD 22–24%). Head moderate (HL 25–31%), with a concave snout. Supraocular, pterotic, parietal and posterior preopercular spines from flexion stage; parietal spine prominent and serrate by postflexion stage. Spine at angle of lower jaw, anterior preopercular spines, and 2 small posttemporal spines in early postflexion larvae; infraorbital spines by 12.2 mm. Gut moderate (PAL 38–49%), coiled and compact. Small gas bladder over foregut, absent from late flexion stage. Very long pectoral fin, reaching to at least middle of anal fin (P_1L 35–50%).

Size at

Hatching	<7.8 mm
Notochord flexion	8.0–11.0 mm
Settlement	>16.6 mm

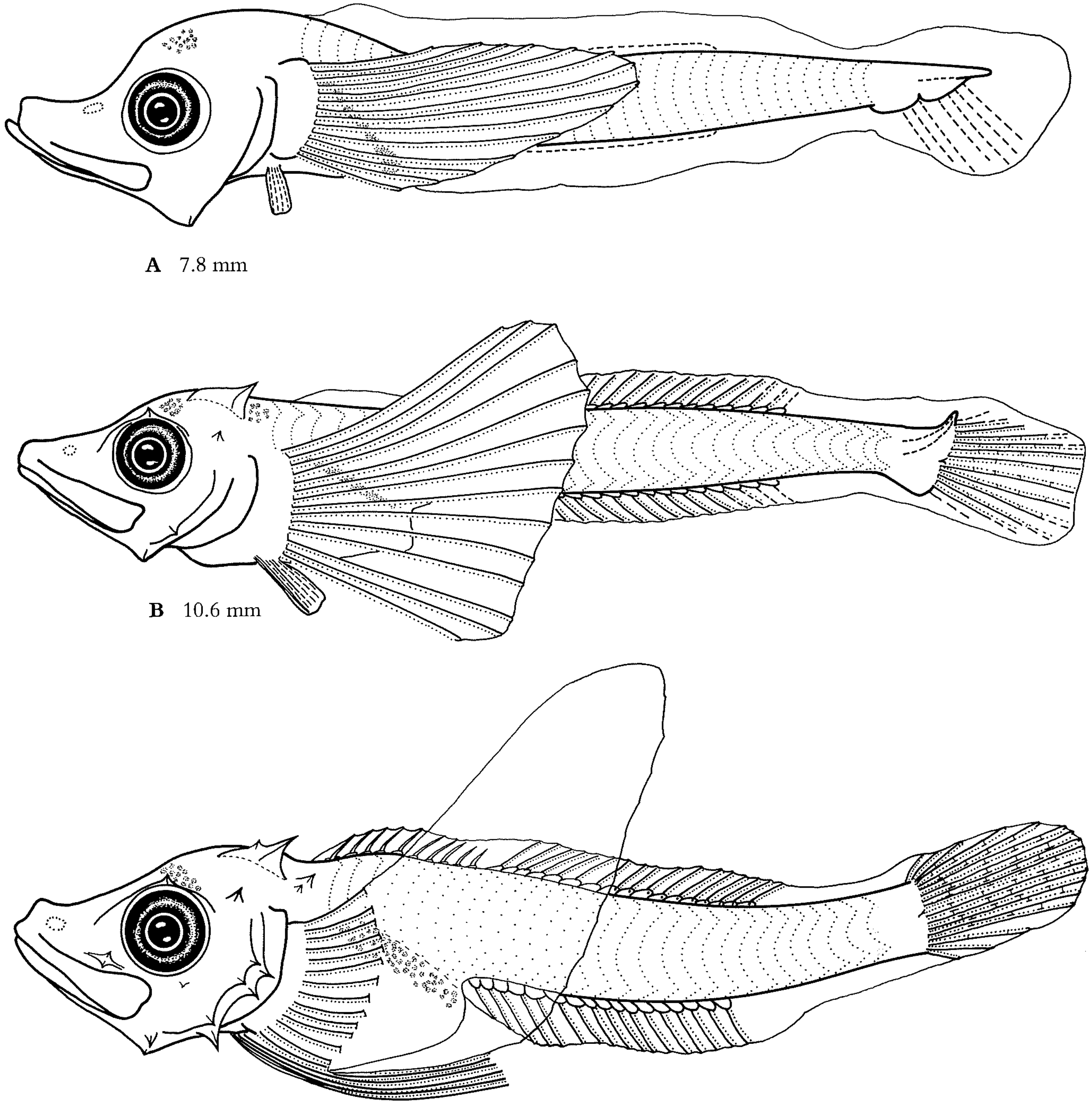
Formation of fins:
Pectoral <7.8 mm; Pelvic <7.8–11.2 mm; Caudal <7.8–11.2 mm; Dorsal 7.8–11.2 mm; Anal 7.8–11.2 mm

Pigmentation Larvae are lightly pigmented. *External*: Series of 10–14 small melanophores along second dorsal-fin base in postflexion larvae. Pigment on lower pectoral-fin rays in postflexion larvae. *Internal*: Light pigment over midbrain and dorsally over gas bladder and gut from preflexion stage. Light pigment over nape during flexion stage, not visible by postflexion stage.

Material examined 12 larvae, 7.8–16.6 mm BL, coastal waters of eastern Tasmania.

Additional references –

Figure 46 Larvae of *Lepidotrigla vanessa*. **A** Preflexion; note developing dorsal, anal and pelvic fins. **B** Late flexion. **C** Postflexion; pectoral-fin rays omitted to show internal pigment on gut. A–C from eastern Tas coastal waters. Redrawn by F. J. Neira.



A 7.8 mm

B 10.6 mm

C 12.2 mm

Triglidae *Pterygotrigla polyommata* (Richardson, 1839) Latchet

D VII–VIII + 12 A 12 P_1 12 + 3 P_2 I, 5 C 13 V 27

Adults Endemic to southern Australia from Jurien Bay (WA) to Port Stephens (NSW), including Tasmania. Demersal species found on sandy and muddy bottoms in coastal marine waters at depths of 35–400 m, and in shallow estuaries in southern Tasmania. The taxonomy of the genus is unclear, with a closely related form recently identified from southern Australia. Adults of *P. polyommata* have large eyes, whereas those of the undescribed species are small. Maximum size 57 cm (Gomon *et al.*, 1994; Williams *et al.*, 1996).

Importance to fisheries Fished commercially by trawling as part of the South East Trawl fishery, with catches of up to 50–100 tonnes per annum. Small quantities are also trawled along the Great Australian Bight and inshore waters around southern Australia (Lyle & Ford, 1993). Catch records are most likely to be a combination of *P. polyommata* and the undescribed 'small-eyed' latchet species.

Spawning Eggs undescribed. Eggs of *Pterygotrigla picta* from New Zealand are pelagic and spherical, 1.6–1.8 mm in diameter, and have a smooth chorion, a segmented yolk, and a single oil globule 0.33 mm (Robertson, 1975a). Larvae have been caught in coastal waters of eastern Tasmania from October to January (Marshall & Jordan, 1992).

Diagnostic characters

- 8–10 + 16–18 = 26–28 myomeres
- Small rostral projection from infraorbital spine
- Posttemporal spine very elongate and finely serrate by late flexion stage
- Lightly pigmented trunk and pectoral-fin membrane

Description of larvae

Morphology Body moderate (BD 20–25%). Head large (HL 33–39%), with a long, concave, duckbill snout. Small teeth in both jaws by end of flexion stage. Spine at angle of lower jaw, and supraocular, pterotic, parietal, posttemporal, anterior preopercular and posterior preopercular spines in smallest larva examined (7.9 mm). Posttemporal spine serrate and very long from flexion stage, becoming an ornamented bony plate and extending beyond opercular margin in postflexion larvae from 12 mm. Supraocular spine large and serrate during flexion stage, blunt and as a raised serrate ridge by 12 mm. Infraorbital spines by late flexion stage, with a moderate rostral projection from anterior infraorbital spine. Nasal spines by end of flexion stage. Gut long (PAL 50–61%), coiled and compact. Small gas bladder over foregut. Large pectoral fin, reaching beyond anus (P_1L 23–30%).

Size at

Hatching	<7.9 mm
Notochord flexion	~7.9–11.5 mm
Settlement	>12.0 mm
Formation of fins:	

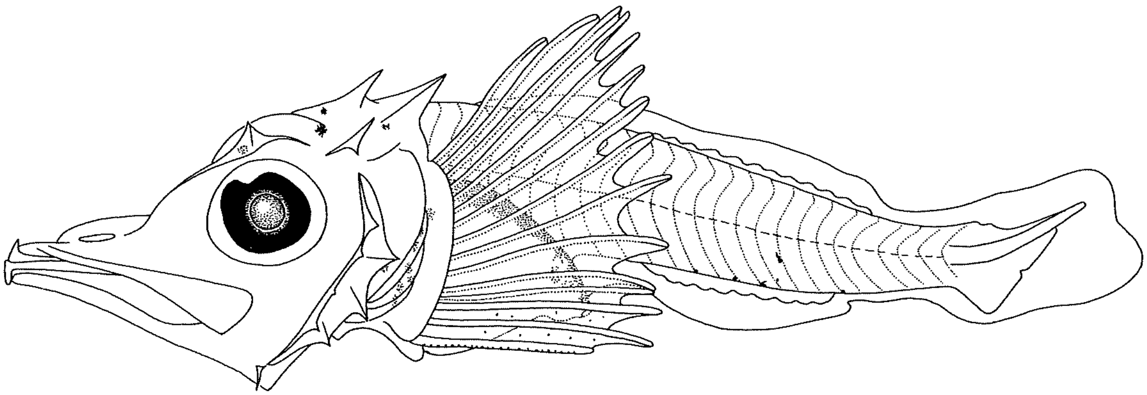
Pectoral <7.9 mm; Caudal <7.9–11.5 mm; Dorsal 7.9–11.5 mm; Anal 7.9–11.5 mm; Pelvic 7.9–11.5 mm

Pigmentation Larvae are lightly pigmented. *External*: A few melanophores over midbrain. Series of 2–5 small melanophores along ventral midline of tail in preflexion larvae, and along anal-fin base in flexion larvae. A few small melanophores scattered on pectoral-fin membrane in flexion larvae, absent in postflexion larvae by 12 mm. *Internal*: Light pigment dorsally over gas bladder and gut, heavier from flexion stage.

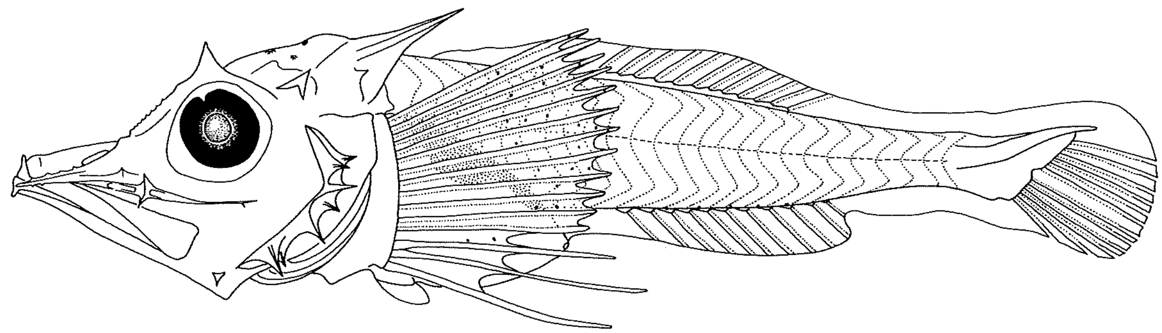
Material examined 4 larvae, 7.9–12.0 mm BL, coastal waters of eastern Tasmania.

Additional references –

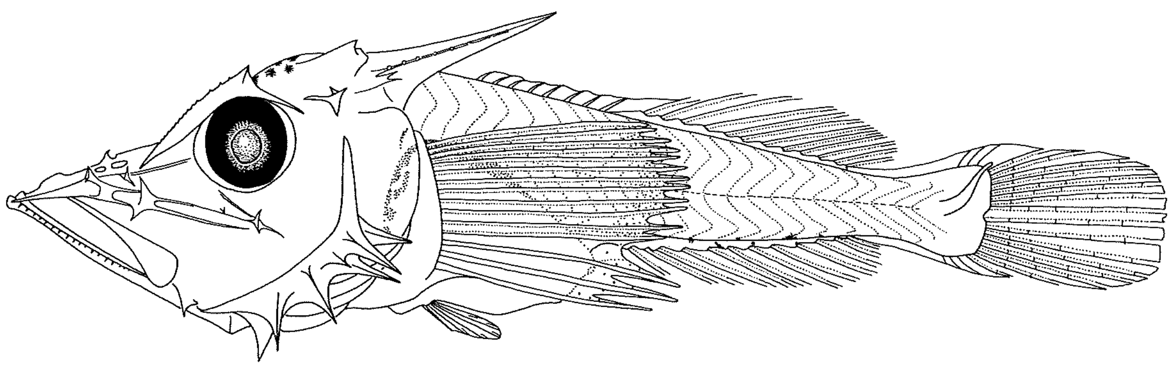
Figure 47 Larvae of *Pterygotrigla polyommata*. **A** Flexion; note developing dorsal and anal fins. **B** Late flexion. **C** Early postflexion; note serrate posttemporal spine. **D** Postflexion. A–D from eastern Tas coastal waters. Illustrated by J.C. Javech.



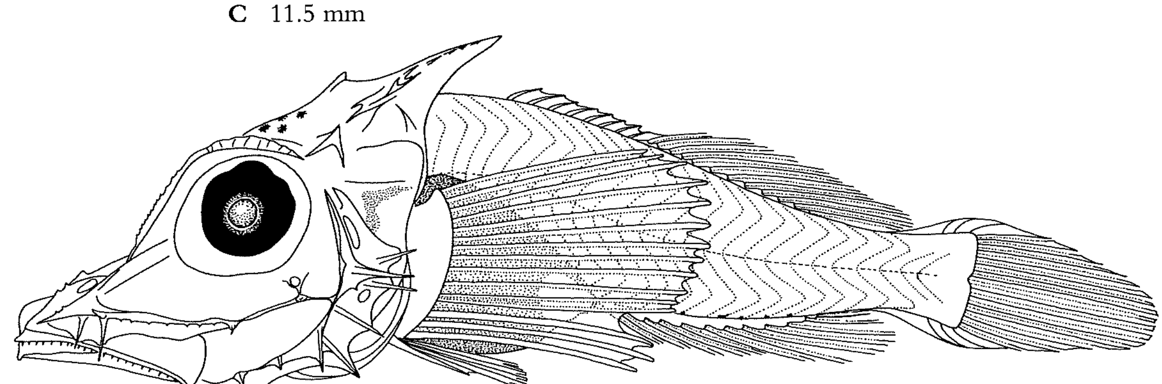
A 7.9 mm



B 9.6 mm



C 11.5 mm



D 12.0 mm

PERCIFORMES

The Perciformes is by far the largest, most diverse order of both teleostean fishes and vertebrates as a whole. Members of the group are predominantly shorefishes, dominants in estuarine and marine as well as freshwater habitats in tropical and temperate regions of the world. The order comprises 18 suborders, 148 families, over 1500 genera and about 9300 species (Nelson, 1994). This book deals with 8 suborders, including the Percoidei, Labroidei and Gobioidei which collectively account for over 75% of all perciform species (Nelson, 1994). Because of the enormous diversity of the order, perciform fishes cannot be defined by a single set of morphological characters. However, they are mostly characterised by the possession of seven or fewer branchiostegal rays, spines in the dorsal and anal fins, pelvic fins placed directly below or anterior to the pectoral fins and with one spine and five or fewer rays, 17 or fewer principal caudal-fin rays, mostly ctenoid scales, and no adipose fin (Johnson & Gill, 1994). The order is regarded by many as polyphyletic (e.g. Greenwood *et al.*, 1966; Nelson, 1994), although some authors argue that it may be paraphyletic (Johnson & Patterson, 1993). The phylogeny of percomorphs is reviewed by Johnson (1993) and Johnson & Patterson (1993).

Because of the considerable size of the order, families included in this book are treated under subordinal groupings. The classification and sequence in which the suborders are presented follow Nelson (1994). For convenience, all families in each of the following suborders, as well as species within each family, are arranged in alphabetical order.

Suborders (number of families) included here

Percoidei (28)
Labroidei (1)
Notothenioidei (1)
Trachinoidei (4)
Blennioidei (1)
Gobioidei (2)
Scombroidei (3)
Stromateoidei (1)

Percoidei

The Percoidei constitutes the largest perciform suborder of fishes, with 71 families, 528 genera and about 2860 species (Nelson, 1994). About 78% of the species occur in all types of estuarine and marine habitats, with the remainder confined to fresh water. About 53% of the species in the suborder belong to 7 families; in decreasing number of species, these are the Serranidae, Sciaenidae, Apogonidae, Percidae, Haemulidae, Carangidae and Lutjanidae (Nelson, 1994). Of the 71 percoid families listed by Nelson (1994), larvae have been described for representatives of all except 12 (see review of early life history stages by Johnson, 1984; see also Russell, 1976; Fahay, 1983; Leis & Rennis, 1983; Okiyama, 1988a; Leis & Trnski, 1989; Matarese *et al.*, 1989; Moser, 1996a). Of those 12 families, larval descriptions of members of the Aplodactylidae, Chironemidae and Enoplosidae are provided here for the first time. Larvae of representatives of the remaining 9 families, all of which contain 10 or less species, are undescribed. Among them are the Dinolestidae and Glaucosomatidae, both of which occur in southern Australia (Hutchins & Swainston, 1986; Gomon *et al.*, 1994). The list of percoid families given by Nelson (1994) does not include families such as the Ephippidae (placed within Acanthuroidei by Nelson) which some authors place under Percoidei and for which larvae are known (e.g. Okiyama, 1988a; Leis & Trnski, 1989; Moser, 1996a). The genus *Gadopsis*, placed in the Percichthyidae by Nelson (1994), is treated here as belonging to the Gadopsidae.

Families and species included here

ACROPOMATIDAE
Apogonops anomalus
APLODACTYLIDAE
Crinodus lophodon
APOGONIDAE
Apogon rueppellii
Siphamia cephalotes
ARRIPIDAE
Arripis trutta
BRAMIDAE
Brama brama
CALLANTHIIDAE
Callanthias australis
CARANGIDAE
Pseudocaranx dentex
Pseudocaranx wrighti
Seriola spp.
Trachurus declivis
Trachurus novaezelandiae
CHANDIDAE
(= Ambassidae)
Ambassis jacksoniensis
Ambassis marianus
CHEILODACTYLIDAE
Nemadactylus macropterus
CHIRONEMIDAE
Chironemus marmoratus
ENOPLOSIDAE
Enoplosus armatus
GADOPSIDAE
Gadopsis bispinosus
GERREIDAE
Gerres subfasciatus
Parequula melbournensis
GIRELLIDAE
Girella tricuspidata
KYPHOSIDAE
Kyphosus sp.
LATRIDAE
Latris lineata
MICROCANTHIDAE
Atypichthys strigatus
Microcanthus strigatus
MONODACTYLIDAE
Monodactylus argenteus
NEMIPTERIDAE
Pentapodus vitta
PERCICHTHYIDAE
Maccullochella macquariensis
Maccullochella peelii peelii
Macquaria ambigua
PLESIOPIDAE
Beliops xanthokrossus
Paraplesiops bleekeri
Trachinops taeniatus
POMATOMIDAE
Pomatomus saltatrix
SCIAENIDAE
Argyrosomus japonicus
Atractoscion aequidens
SCORPIDIDAE
Scorpis (*lineolata* ?)
SERRANIDAE (Anthiinae)
Acanthistius serratus
Hypoplectrodes maccullochi
SILLAGINIDAE
Sillaginodes punctata
Sillago bassensis
Sillago ciliata
Sillago maculata
Sillago schomburgkii
SPARIDAE
Acanthopagrus australis
Acanthopagrus butcheri
Pagrus auratus
Rhabdosargus sarba
TERAPONTIDAE
Amniataba caudavittata
Pelates octolineatus
Pelates sexlineatus

Acropomatidae: Glowbellies, splitfins

A.G. Miskiewicz and B.D. Bruce

Acropomatids are marine fishes found in shelf and slope waters of the Atlantic, Indian and Pacific oceans, to a depth of about 1000 m (May & Maxwell, 1986; Nelson, 1994). The generic composition of the family is unclear, and some authors place acropomatid genera such as *Apogonops*, *Doederleinia*, *Malakichthys* and *Synagrops* in the Percichthyidae (Gosline, 1966; May & Maxwell, 1986; Paxton & Hanley, 1989l; Gomon *et al.*, 1994). We follow Johnson (1984) and Nelson (1994) in regarding the Acropomatidae as a distinct family comprising at least 8 genera and about 30 species. One species has been recorded from temperate Australia (Paxton & Hanley, 1989l). Adults have two separate but adjacent dorsal fins, the first with spines and the second with or without a spine, and two or three anal-fin spines. Members of *Acropoma* possess ventral luminescent organs from which the name 'glowbellies' is derived. Eggs of *Acropoma japonicum* are pelagic and spherical, 0.7–0.8 mm in diameter (Mito, 1963). Larvae have been described for representatives of *Acropoma*, *Doederleinia*, *Malakichthys* and *Synagrops* (Johnson, 1984; Konishi, 1988a; Leis & Trnski, 1989). The moderately to well developed and extensive head spination, some of which may be retained in the adults of some species, constitute the only apparent specialisation of acropomatid larvae to pelagic life (Leis & Trnski, 1989).

Meristic characters of the acropomatid genus of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Apogonops	(1)	IX + I, 10	III, 6–7	14	I, 5	17	10 + 15 = 25

Main characters of acropomatid larvae

- 25 myomeres
- Body elongate to deep (BD 23–43%), laterally compressed
- Mouth large and oblique, with small villiform teeth in both jaws
- Moderately to well developed and extensive head spination, including preopercular, subopercular, opercular and supracleithral spines, and a serrate supraocular ridge; supraoccipital crest present in some genera except *Apogonops* and *Malakichthys*
- Gut moderate to long (PAL 48–62%), coiled and compact
- Large, inflated gas bladder
- Small to moderate gap between anus and origin of anal fin; anus is located closer to pelvic-fin base than to anal fin origin by postflexion stage (*Acropoma* and *Apogonops*)
- Prominent internal melanophore at nape in most taxa
- Gut heavily pigmented
- Little or no pigment on tail

References to acropomatid larvae

Johnson (1984), Konishi (1988a), Leis & Trnski (1989).

Families with similar larvae

Apogonidae (taxa with extensive head spination) – 23–25 myomeres; anal fin II, 7–10; lack prominent internal melanophore at nape.

Carangidae – Weak opercular spine, no interopercular spines; emergent median supraoccipital crest in most taxa; long-based dorsal fin, VI–VIII + I, 22–37; long-based anal fin, II + I, 16–29; body moderately to heavily pigmented, melanophore series along dorsal and ventral surfaces of trunk and tail, and along lateral midline of tail.

Serranidae (Anthiinae) – 26–28 myomeres; single, continuous dorsal fin, X–XIII, 13–22, second or third dorsal-fin spine produced in some taxa; first pelvic-fin ray elongate in some taxa; body lightly to heavily pigmented.

Acropomatidae *Apogonops anomalus* Ogilby, 1896 Three-spined cardinalfish

D IX + I, 10 A III, 6–7 P_1 14 P_2 I, 5 C 17 V 25

Adults Distributed around southern Australia from Eucla (WA) to Brisbane (Qld), including Tasmania. Demersal species found in a wide range of habitats and depths from estuaries to the continental slope, but most common in outer shelf and upper slope waters to a depth of 600 m. Adults have a pair of opercular spines dorsally and are olive-brown dorsally and silvery–white ventrally. Maximum size 15 cm (Paxton & Hanley, 1989l; Last *et al.*, 1983; Gomon *et al.*, 1994).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in coastal waters of northern and central New South Wales from January to September, and in coastal waters off Sydney from August to May (Gray, 1995).

Diagnostic characters

- 10–11 + 14–15 = 25 myomeres
- Early forming villiform teeth on premaxilla
- Small, persistent gap between anus and origin of anal fin
- Body lightly pigmented
- Pigment on tip of jaws and 1 large internal melanophore on nape

Description of larvae

Morphology Body moderate (BD 23–31%). Head moderate to large (HL 25–37%). Villiform teeth along both jaws by late preflexion stage. Small to moderate anterior and posterior preopercular spines from late preflexion stage, increasing in number with growth. One interopercular spine from late preflexion stage, and 1 opercular and 1 nasal spine from late flexion stage. Supraocular ridge from flexion stage, serrate from early postflexion stage. Supracleithral and posttemporal spines in postflexion larvae, and a small subopercular spine in late postflexion larvae. Gut long (PAL 51–63%), coiled and large. Large, inflated gas bladder over foregut in preflexion larvae, increasing in size and extending posteriorly over gut with growth. Small, persistent gap between anus and origin of anal fin. Scales begin to form at about 15 mm.

Size at

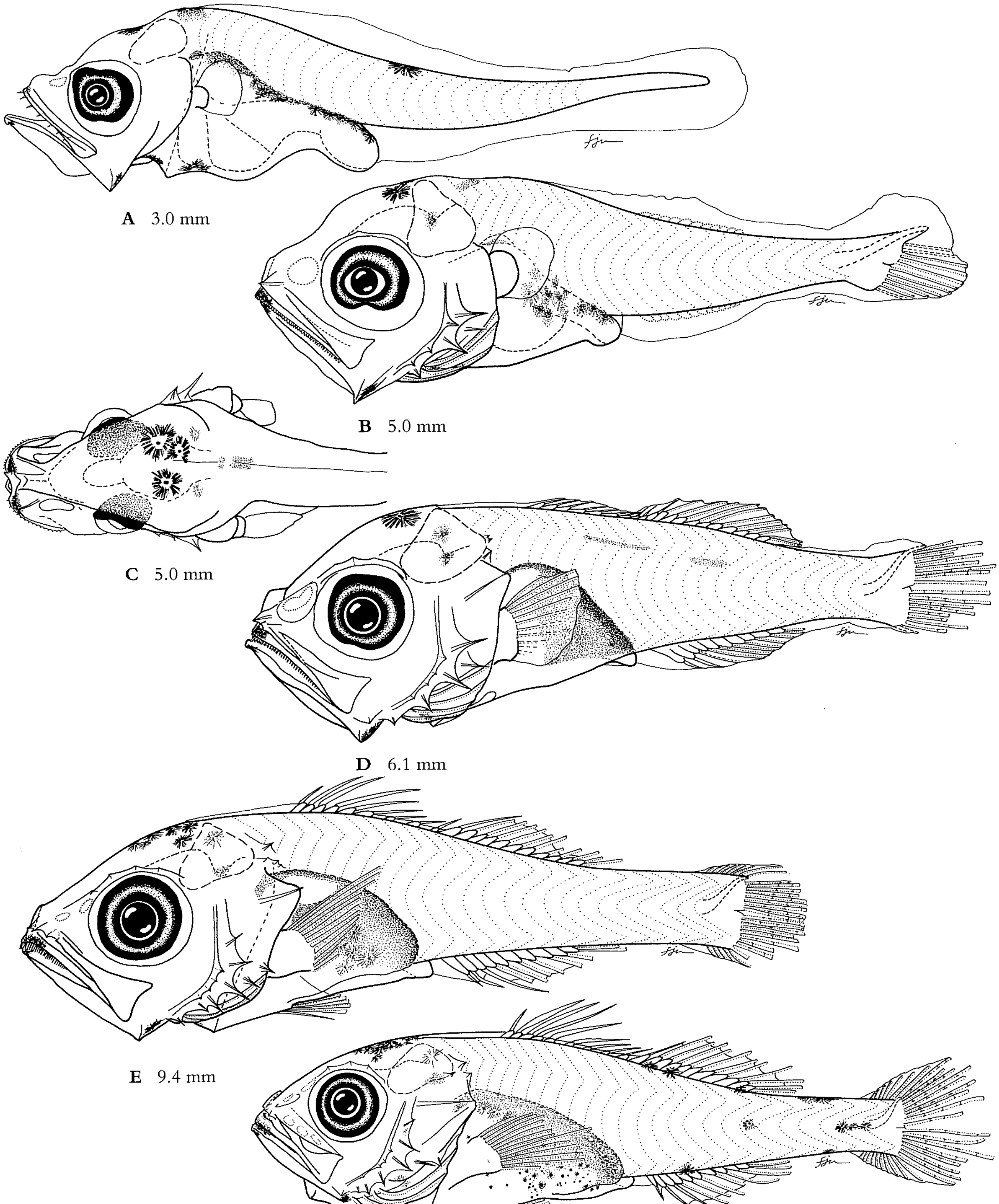
Hatching	<3.0 mm
Notochord flexion	4.7–6.0 mm
Settlement	~15.0–16.0 mm
Formation of fins:	
Caudal 4.3–6.1 mm; Dorsal 4.3–6.8 mm; Anal 4.3–7.5 mm; Pectoral 5.8–7.8 mm; Pelvic 6.1–8.1 mm	

Pigmentation Larvae are lightly pigmented. *External:* 1–3 large melanophores over brain, a pair at tip of upper and lower jaws, 1 at angle of lower jaw, 1 small on isthmus, and 1 large at cleithral symphysis in postflexion larvae; additional melanophores dorsally on head with development. Scattered melanophores laterally over gut by flexion stage, gut heavily pigmented by postflexion stage. Little pigment dorsally along trunk, and dorsally and ventrally along tail during development. One melanophore midway along dorsal midline of tail in early preflexion larvae, disappearing in late preflexion larvae. Three melanophores along dorsal-fin base, 1 dorsally on caudal peduncle, 1 midway along lateral midline of tail, a few laterally on caudal peduncle, 1 midway along anal-fin base and 1 ventrally on caudal peduncle by 10.5 mm. *Internal:* 1 large melanophore at nape; a pair of melanophores at junction of mid- and hindbrain by late preflexion stage. Heavy pigment dorsally over gas bladder and gut, extending laterally with growth. Series of melanophores above vertebrae in early postflexion larvae, obscured by overlying tissue in later stages.

Material examined 31 larvae, 3.0–15.9 mm BL, coastal waters of northern and central New South Wales.

Additional references –

Figure 48 Larvae of *Apogonops anomalus*. **A** Preflexion. **B** Flexion; note developing dorsal and anal fins. **C** Dorsal view of head of larva in B. **D** Early postflexion; note pelvic-fin bud. **E** Postflexion. **F** Postflexion. A, B, D–F from NSW coastal waters. Illustrated by F. J. Neira.



A 3.0 mm

B 5.0 mm

C 5.0 mm

D 6.1 mm

E 9.4 mm

F 13.7 mm

Aplodactylidae: Seacarps

A.G. Miskiewicz, D. Rissik and F. J. Neira

Aplodactylids are marine fishes found in coastal waters of Australia, New Zealand, Peru and Chile. They commonly occur around shallow inshore rocky reefs where they predominantly graze on algae (Gomon *et al.*, 1994). The family comprises three genera and five species (Nelson, 1994). Two genera and three species have been recorded from temperate Australia (Kuiter, 1993, 1996; Gomon *et al.*, 1994). Adults (to 60 cm) are elongate and robust, and have a relatively small head, a single, long and deeply notched dorsal fin, and large pectoral fins with unbranched, thickened lower rays (Last *et al.*, 1983; Gomon *et al.*, 1994). Eggs are unknown. Larvae, which are described here for the first time, are pelagic and have no apparent specialisations to pelagic life.

Meristic characters of aplodactylid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Aplodactylus	(2)	XVI–XVIII, 16–19	III, 7–8	15–16	I, 5	15–16	15–16 + 19–20 = 35
Crinodus	(1)	XVI–XVII, 21	II–III, 6–7	14–16	I, 5	15–16	15–16 + 19–20 = 35

Main characters of aplodactylid larvae

- 35 myomeres
- Body very elongate to elongate (BD 9–20%)
- No head spines
- Gut long (PAL 52–63%), initially straight but becoming coiled during late preflexion stage
- Prominent finfold enclosing most of body in preflexion larvae; long, prominent preanal membrane which persists in postflexion larvae
- Short-based anal fin
- Body heavily pigmented from early flexion stage
- Light pigment ventrally along gut in preflexion larvae, heavy in postflexion larvae
- No pigment along lateral midline of tail
- Many small melanophores on caudal finfold and around notochord tip

References to aplodactylid larvae –

Families with similar larvae

Bovichtidae (*Bovichtus*) – 37–38 myomeres; long, sharp opercular spine; pelvic fins jugular; 2 dorsal fins, first with VIII spines; anal fin spineless, 12–18 rays; no pigment on caudal finfold.

Cheilodactylidae – Body deep and laterally compressed in postflexion larvae; 24–34 dorsal-fin rays; 8–19 anal-fin rays; melanophore series along lateral midline of tail from preflexion stage; no pigment on caudal finfold or around notochord tip; large size prior to settlement (up to 90 mm).

Chironemidae – 33 myomeres; melanophore series along lateral midline of tail in preflexion larvae; melanophore series ventrally along gut in preflexion larvae; some pigment on caudal finfold.

Latridae – Long-based dorsal fin, XVII–XXIII, 23–40; long-based anal fin, III, 18–35; moderate gap between anus and origin of anal fin; gut straight; no pigment ventrally along gut or on caudal finfold in early larvae.

Sillaginidae (early stages) – 32–45 myomeres; weak striations along midgut in some taxa; anal fin II, 15–24; body lightly pigmented; no melanophores on caudal finfold in early larvae.

Aplodactylidae *Crinodus lophodon* (Günther, 1859) Rock cale

D XVI–XVII, 21   A II–III, 6–7 P_1 14–16 P_2 I, 5   C 15–16   V 35

Adults Endemic to southeastern Australia from southern Queensland to Mallacoota (Vic). Occurs in exposed rocky, intertidal surge zones with abundant kelp and weed, to a depth of about 10 m. Adults have a short-based anal fin, pectoral fins with thickened lower rays, and are grey to blue-black with lighter mottling on the sides and light spots on the fins. Maximum size 45 cm (Hutchins & Swainston, 1986; Kuiter, 1993, 1996).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in coastal waters off central New South Wales in July and August (I.M. Suthers, UNSW, pers. comm.).

Diagnostic characters

- 16–18 + 17–19 = 35 myomeres (difficult to count by flexion stage)
- Gut long (PAL >50%)
- Series of melanophores ventrally along anterior portion of gut in preflexion larvae
- Body covered with stellate melanophores by early postflexion stage
- Numerous small melanophores on caudal finfold and around notochord tip

Description of larvae

Morphology Body very elongate to elongate in preflexion larvae (BD 9–15%), elongate in flexion and postflexion larvae (BD 15–20%). Dermal sac encloses most of body in preflexion larvae. Head small to moderate (HL 12–27%), without spines. Gut long (PAL 52–63%), initially straight, coiled anteriorly by late preflexion stage. Small gas bladder over anterior of gut, generally not inflated. Preanal membrane present through to postflexion larvae.

Size at

Hatching	<4.0 mm
Notochord flexion	7.0–8.3 mm
Settlement	>9.5 mm
Formation of fins:	

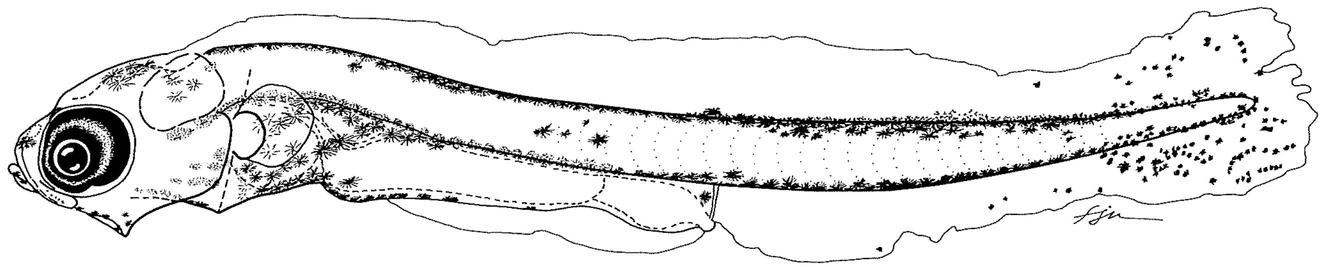
Caudal 5.5–8.3 mm; Dorsal 7.4–>9.5 mm; Anal 7.4–>9.5 mm; Pectoral 7.6–9.4 mm; Pelvic 8.1–>9.5 mm

Pigmentation Larvae are moderately to heavily pigmented. *External*: Numerous melanophores over brain, tip of upper jaw, along lower jaw and midline of gular membrane, and a few at angle of lower jaw in preflexion larvae. Melanophores on opercular area from flexion stage; heavy pigment on head by postflexion stage. Numerous small melanophores ventrally on isthmus and along anterior portion of gut. Scattered melanophores on lateral surface of gut in preflexion larvae, increasing in number in postflexion larvae. Series of stellate melanophores along dorsal surface of trunk and tail, and along ventral surface of tail in preflexion larvae; additional melanophores laterally over trunk and tail in flexion larvae. Small melanophores scattered on caudal finfold and around tip of notochord in preflexion larvae; pigment along caudal-fin rays in flexion and postflexion larvae. Heavy pigment over most of body by postflexion stage; little or no pigment on pectoral-fin base. *Internal:* Pigment under otic capsule, under brain and in nasal region. Pigment over gas bladder and series of melanophores dorsally along entire gut.

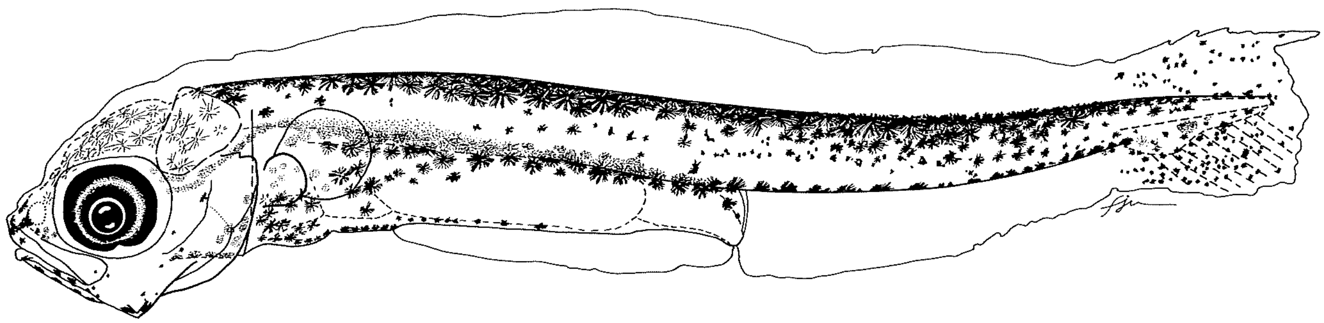
Material examined 25 larvae, 4.0–9.5 mm BL, coastal waters off Terrigal (NSW).

Additional references –

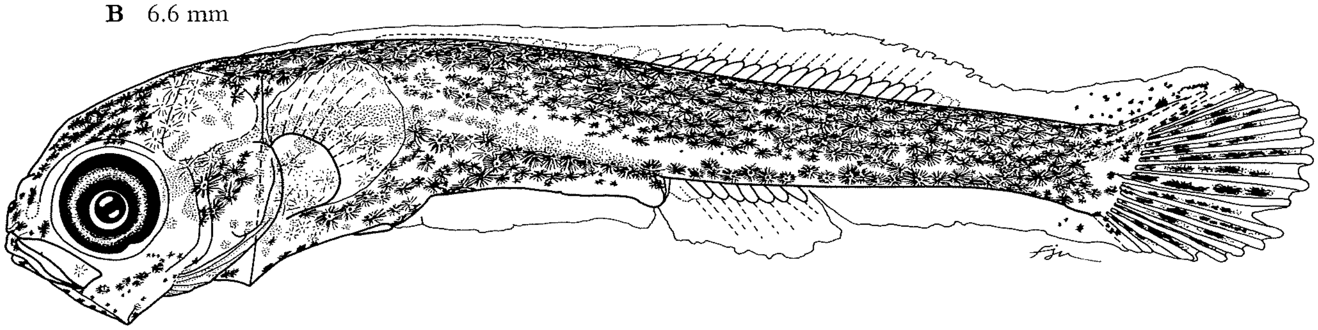
Figure 49 Larvae of *Crinodus lophodon*. **A** Preflexion; note dermal sac enclosing most of body; not all myomeres drawn. **B** Late preflexion; note developing caudal fin. **C** Flexion. **D** Ventral view of larva in C; note pelvic-fin buds. **E** Postflexion. Myomeres in B, C and E obscured by heavy pigment. A–C, E from NSW coastal waters. Illustrated by F. J. Neira.



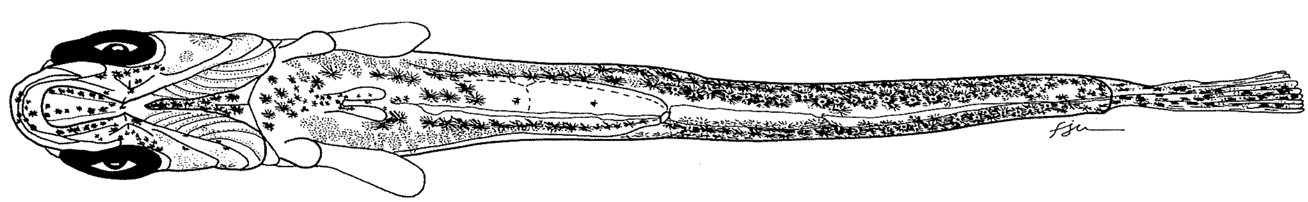
A 5.0 mm



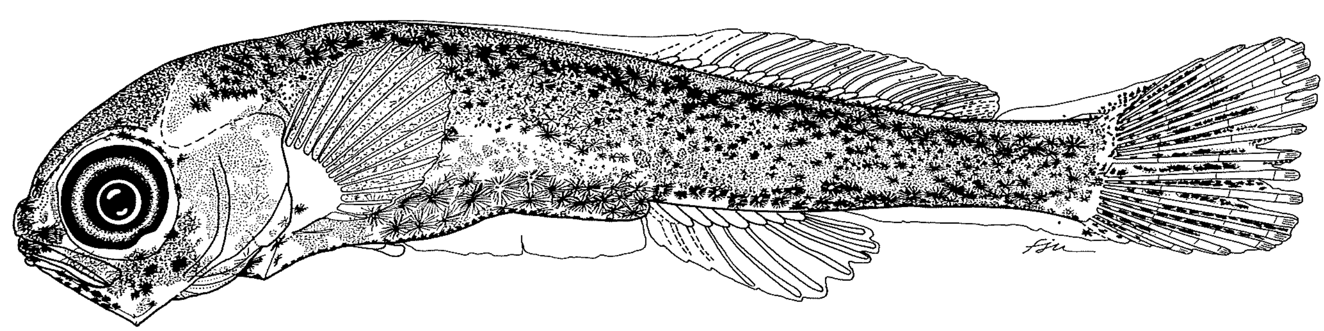
B 6.6 mm



C 8.1 mm



D 8.1 mm



E 9.4 mm

Apogonidae: Cardinalfishes

F. J. Neira and B.D. Bruce

Apogonids are a very diverse group of usually nocturnal, primarily marine fishes found in coastal waters and coral reefs in tropical to temperate regions of the Atlantic, Indian and Pacific oceans, with a few species in fresh water and estuaries. The family contains 22 genera and about 207 species in the subfamilies Apogoninae and Pseudaminae (Fraser, 1972; Allen & Swainston, 1988; Allen & Cross, 1989d; Nelson, 1994). Sixteen genera and 91 species (46 species of *Apogon*) have been recorded from Australia, with 3 genera and about 13 species in temperate waters (Last *et al.*, 1983; Hutchins & Swainston, 1986; Allen & Cross, 1989d; Gomon *et al.*, 1994; Pollard, 1996). The genera *Epigonus* and *Rosenblattia*, which are included by some authors in the Apogonidae and are also found in temperate Australia (Allen & Cross, 1989d; Gomon *et al.*, 1994), belong to the family Epigonidae (Johnson, 1984, 1993; Nelson, 1994). Adult apogonids (most taxa <10 cm) have a moderately deep body, prominent eyes and two well separated, short-based dorsal fins. Most apogonine apogonids incubate their eggs orally, and brooding in most cases is carried out by the males; oral brooding in pseudamine apogonids has not been reported (Breder & Rosen, 1966; Fraser, 1972; Leis & Rennis, 1983; Neira, 1991). Eggs are spherical, some slightly ovoid, and range in diameter from 0.16–0.70 mm in some species of *Apogon*, *Phaeoptyx* and *Sphaeramia*, to 2.2–2.5 mm in *A. rueppellii*, and to 4.5 mm in *Vincentia conspersa* (Fraser, 1972; Neira, 1991). Larvae have been described for several members of both subfamilies (e.g. Leis & Rennis, 1983; Kojima & Hayashi, 1988; Neira, 1991; Sandknop & Watson, 1996a). Depending on egg size and duration of incubation, larvae from orally brooded eggs may be either poorly developed at hatching (e.g. *A. affinis*, *A. semilineatus*, *S. orbicularis*), or moderately well developed (e.g. *A. rueppellii*) (Neira, 1991). Larvae vary considerably in morphology and developmental patterns. The head spines, and the long dorsal-fin spines, pelvic and pectoral fins of larvae of some apogonids constitute specialisations to pelagic life although larvae of many taxa have no apparent specialisations (Leis & Rennis, 1983).

Meristic characters of apogonid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Apogon	(4)	VII–VIII + I, 8–9	II, 8–10	12–17	I, 5	17	10 + 14 = 24
Siphamia	(3)	VI–VIII + I, 7–10	II, 7–10	11–15	I, 5	17	10 + 14 = 24
Vincentia	(6)	VII–VIII + I, 7–10	II, 7–10	14–15	I, 5	17	10 + 15 = 25

Main characters of apogonid larvae
- 23–25 myomeres, typically 24
- Body elongate to deep (BD 19–44%), laterally compressed
- Mouth large, with small villiform teeth from early stages
- Head spines, when present (e.g. preopercular, opercular, posttemporal), become greatly reduced or disappear just before settlement
- Gut moderate to long depending on taxon (PAL 39–67%), initially straight but becoming coiled and compact with development
- Conspicuous gas bladder, often extending above entire gut, pigmented
- Small to no gap between anus and origin of anal fin
- 2 well separated dorsal fins; first spine of second dorsal fin and anal-fin spines are initially soft rays but transform into spines before settlement
- Body lightly to heavily pigmented

References to apogonid larvae
Leis & Rennis (1983), Kojima & Hayashi (1988), Neira (1991), Sandknop & Watson (1996a).

Families with similar larvae

Acropomatidae – Moderately to well developed head spination; dorsal fin XI + I, 10; anal fin III, 6–7; prominent internal melanophore at nape in most taxa.
Berycidae – Preopercular spines in postflexion larvae; single, continuous dorsal fin; elongate, early forming pelvic-fin rays; body lightly pigmented.
Carangidae – 24–26 myomeres; well developed and extensive head spination, including an emergent median supraoccipital crest in most taxa; II + I anal-fin spines; melanophore series along dorsal and ventral surfaces of trunk and tail, and a series along lateral midline of tail.
Gobiidae – 24–34 myomeres, typically 25–27; no head spines; gut straight and usually slightly looped anterior to anus; gas bladder over midgut.
Opistognathidae – 25–35 myomeres, typically 25–28; prominent lower jaw angle; large pectoral fins, with early forming rays.
Pempheridae – Early forming pelvic-fin buds, located high and laterally on gut; short-based, single dorsal fin and long-based anal fin; little or no pigment on tail after flexion stage.
Sciaenidae – 24–29 myomeres, typically 25–26; head usually deep, with moderate spination; tail slightly narrow; long-based dorsal fin, XI, 26–31; large gap between anus and origin of anal fin in most taxa.

Apogonidae *Apogon rueppellii* Günther, 1859 Gobbleguts

D VII + I, 9 A II, 9–10 P_1 15–17 P_2 I, 5 C 17 V 24

Adults Endemic to northwestern and western Australia from Arnhem Land (NT) to Albany (WA). Oral brooding species found in estuaries and on inshore reefs in coastal embayments. Adults have two separate dorsal fins, and a brown translucent body with a series of black spots along the lateral line. Maximum size 11.2 cm (Chubb *et al.*, 1979; Chrystal *et al.*, 1985; Hutchins & Swainston, 1986).

Importance to fisheries –

Spawning Late-stage brooded eggs are nearly spherical, 2.2–2.5 mm in diameter (Neira, 1991). Members of the population within the Swan Estuary (WA) are sexually mature between 45 and 49 mm TL, and breed between December and March. Males brood from 50 to 230 fertilised eggs for about two weeks until hatching (Chrystal *et al.*, 1985). Larvae have been caught throughout the Swan Estuary, mostly in the upper reaches, from December to March, with a peak abundance in January (Neira *et al.*, 1992).

Diagnostic characters

- 9–10 + 14–15 = 23–25 myomeres
- Large size at hatching (≥5.5 mm)
- Notochord flexion complete at hatching
- Second dorsal, anal and caudal fins formed at hatching
- Melanophores along base of dorsal and anal fins
- Melanophore at centre of caudal-fin base

Description of larvae

Morphology Body moderate (BD 24–35%). Head moderate to large (HL 29–37%). Small villiform teeth in both jaws. Two anterior preopercular and 3 posterior preopercular spines in newly hatched larvae; anterior preopercular spines disappear by 12 mm, posterior preopercular spines increase to 8; preopercle finely serrate prior to settlement. Posttemporal spine present from hatching. Opercular spine from 7.3 mm. Gut moderate to long in newly hatched larvae (PAL 49–52%), long prior to settlement (PAL 54–59%), coiled and compact. Conspicuous gas bladder. Yolk sac is resorbed by 6.8 mm.

Size at

Hatching	5.5–6.4 mm
Notochord flexion	Prior to hatching
Settlement	>16.3 mm

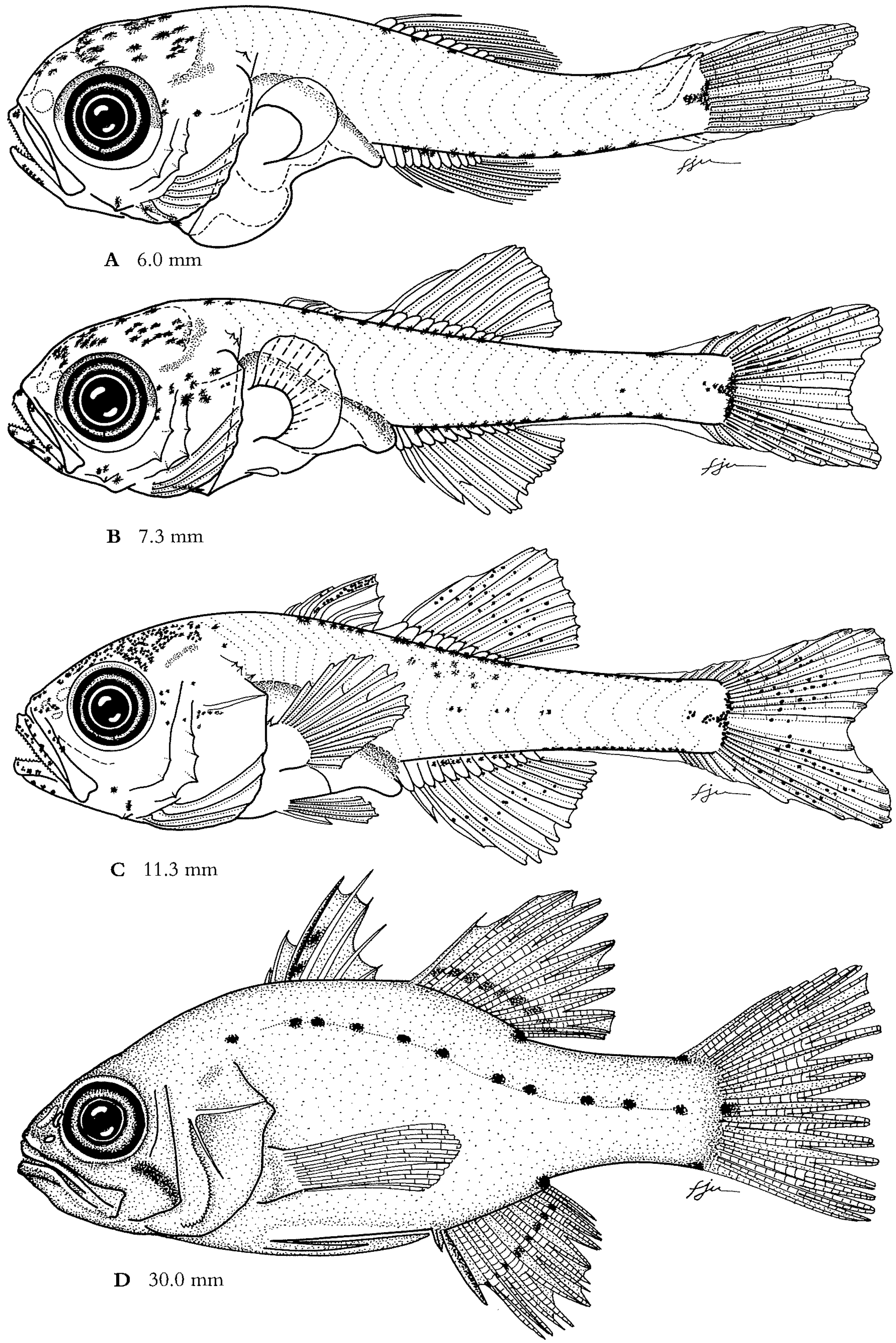
Formation of fins:
Caudal Formed at hatching; Second dorsal Formed at hatching; Anal Formed at hatching; First dorsal 6.8–8.5 mm; Pelvic 6.9–7.7 mm; Pectoral 6.9–10.2 mm

Pigmentation Larvae are lightly pigmented. *External*: Melanophores scattered on snout, dorsal surface of head and on opercle; 2–3 melanophores on ventral surface of lower jaw, 1 at angle of lower jaw, and 2 on isthmus. Paired melanophore series along dorsal- and anal-fin bases; series along dorsal and ventral midlines of caudal peduncle. One prominent melanophore at centre of caudal-fin base. Scattered melanophores on second dorsal-, anal- and caudal-fin membranes prior to settlement; patch of melanophores on membrane between dorsal-fin spines III and IV in larvae from 9 mm. Juveniles have a dark patch on preopercle below eye, a series of 9–11 small dark blotches along lateral line, and dark blotches at bases of last soft ray of second dorsal and anal fins. *Internal*: Pigment at base of hindbrain and dorsally over gas bladder and gut.

Material examined 81 larvae, 5.5–16.3 mm BL, Swan Estuary (WA).

Additional references Neira (1991).

Figure 50 Postflexion larvae and juvenile of *Apogon rueppellii*. **A** Newly-hatched larva; note remnants of yolk sac. **B** Larva with developing first dorsal-fin spines and pelvic-fin bud. **C** Larva with all fins formed. **D** Juvenile; scales omitted. A–D from Swan Estuary (WA) (modified from Neira, 1991). Illustrated by F. J. Neira.


A 6.0 mm
B 7.3 mm
C 11.3 mm
D 30.0 mm

Apogonidae *Siphamia cephalotes* (Castelnau, 1875) Wood's siphonfish

D VI + I, 7–8 A II, 7–8 P_1 12–14 P_2 I, 5 C 17 V 24

Adults Endemic to southern Australia from Shark Bay (WA) to northern New South Wales, including Tasmania. Oral brooding species found in the lower reaches of estuaries and on inshore reefs in coastal embayments. Adults possess a bioluminescent organ containing symbiotic bacteria in the form of a tube-like subcutaneous gland ventrally along the trunk, which continues along either side of the anal fin to the caudal peduncle. Maximum size 5 cm (Fraser, 1972; Last *et al.*, 1983; Kuiter, 1993).

Importance to fisheries –

Spawning Eggs undescribed. Adults in South Australian waters have been observed brooding eggs in January, and larvae have been caught in Spencer Gulf (SA) from December to March. Larvae as small as 5.3 mm (flexion stage) have been observed swimming with epibenthic adults. Adults, and larvae from 4.8 mm are regularly caught in oblique plankton tows at night.

Diagnostic characters

- 10–11 + 13–14 = 24 myomeres
- Weak preopercular spines
- Small gap between anus and origin of anal fin
- 4–9 large stellate melanophores laterally along tail
- Light diffusers ventrally along trunk and anterior of tail, heavily pigmented in larvae >8.1 mm

Description of larvae

Morphology Body moderate (BD 21–31%). Head moderate to large (HL 29–34%). Small villiform teeth along both jaws in postflexion larvae. Two small anterior preopercular and posterior preopercular spines in early postflexion larvae, disappearing by 9.4 mm. Opercular spine from 8.9 mm. Gut moderate in flexion larvae (PAL 45–47%), long in postflexion larvae (PAL 51–56%), coiled and compact. Conspicuous gas bladder above foregut. Light diffusers externally visible by 8.1 mm as a pearliness in muscles ventrally on either side of gut, near pelvic-fin base; diffusers extend both anteriorly and posteriorly reaching to isthmus and anus by 9.4 mm, to base of last anal-fin ray by 12.7 mm, and to anterior third of caudal peduncle by 16.1 mm. Small gap between anus and anal-fin origin. Scales form by 12.7 mm.

Size at

Hatching	<4.8 mm
Notochord flexion	<4.8–6.1 mm
Settlement	5.3–22.0 mm

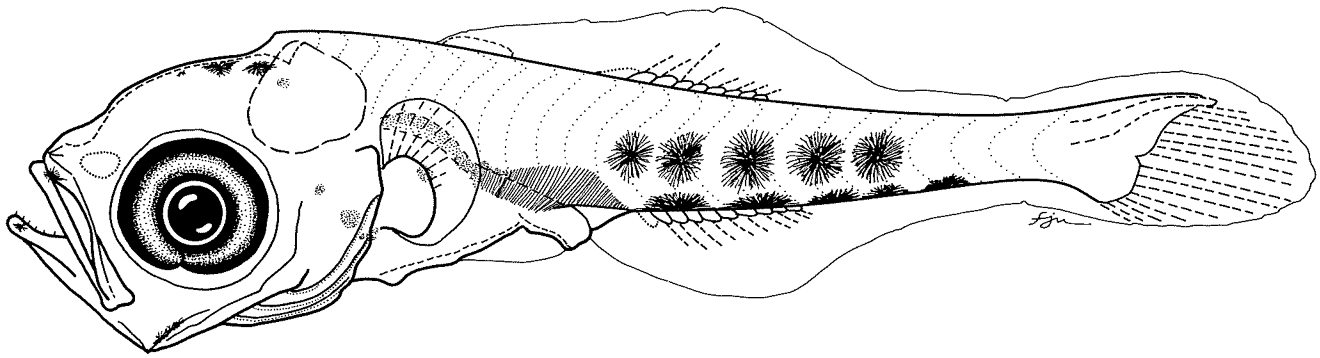
Formation of fins:
Caudal <4.8–6.1 mm; Anal <4.8–6.1 mm; Dorsal <4.8–8.0 mm; Pectoral <4.8–9.4 mm; Pelvic 6.8–9.4 mm

Pigmentation Larvae are moderately pigmented. *External*: Melanophores at tip of upper and lower jaws, angle of lower jaw, and scattered dorsally over head. Scattered melanophores over opercle by 10.3 mm. Melanophores over ventral surface of head and trunk from 8 mm, extending over pectoral-fin base in settlement-stage larvae. Four to nine large, stellate melanophores laterally along tail in flexion larvae, increasing in number but decreasing in prominence with growth and forming an almost single series in settlement-stage larvae. Four to six large melanophores along ventral midline of tail. Additional scattered melanophores along dorsal, lateral and ventral surfaces of trunk and tail from 8.5 mm. One or two prominent melanophores on caudal-fin base by postflexion stage. Pigment along caudal-fin rays by postflexion stage. *Internal*: Melanophores over hindbrain, dorsally over gas bladder and gut. Stellate melanophores laterally on gut, increasing in number during development. Heavily pigmented light organ above pelvic-fin base in postflexion larvae, more prominent on left side. Heavy pigment along edges of light diffusers.

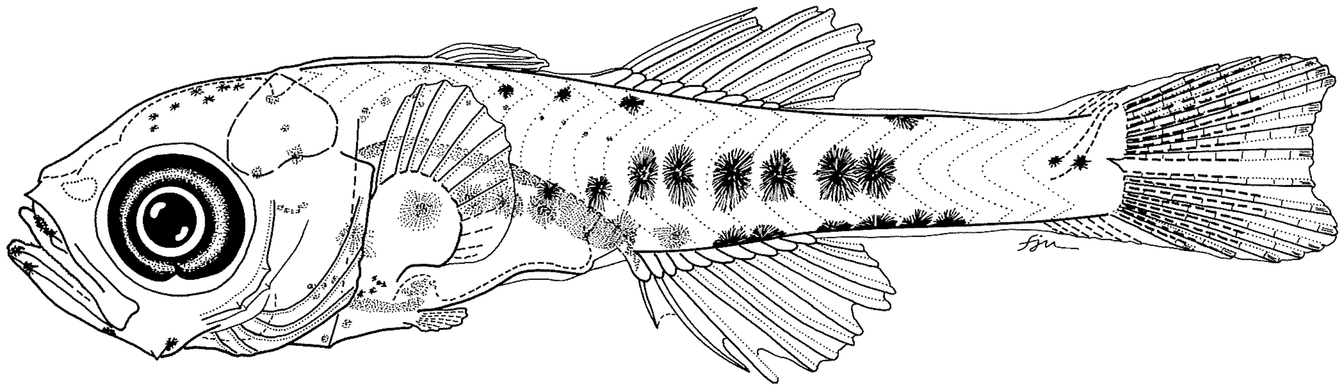
Material examined 25 larvae, 4.8–22.1 mm BL, Spencer Gulf (SA).

Additional references –

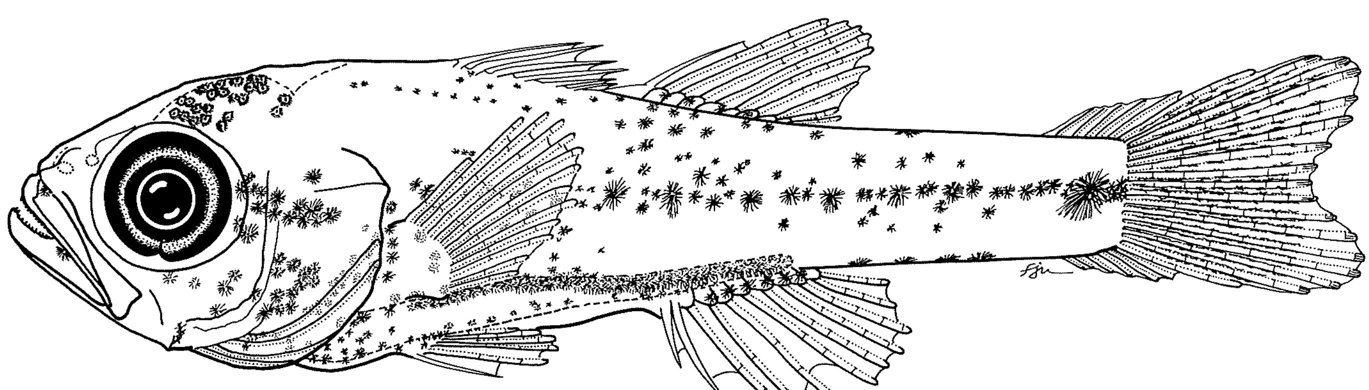
Figure 51 Larvae of *Siphamia cephalotes*. **A** Flexion; note developing first dorsal fin. **B** Early postflexion; note developing pelvic fin. **C** Postflexion; note luminous organ (light diffusers) along ventral surface of trunk and anal-fin base; myomeres and scales omitted. A–C from SA coastal waters. Illustrated by F. J. Neira.



A 5.3 mm



B 7.9 mm



C 12.7 mm

Arripidae: Australian salmons

B.D. Bruce, F. J. Neira and A.G. Miskiewicz

Arripids are pelagic, schooling fishes endemic to coastal temperate waters of Australia and New Zealand. The family contains the genus *Arripis* with four species, three of which (*A. georgianus*, *A. trutta* and *A. truttaceus*) have been recorded from temperate Australia (Paulin, 1993). While *A. georgianus* is readily distinguished by dorsal-fin ray counts, there has been much confusion with the remaining two temperate Australian species. Representatives from Western Australia have been previously regarded as a subspecies of *A. trutta* (Whitley, 1951; Maxwell, 1980), as a separate but undescribed species (MacDonald, 1980), as *A. esper* (Edgar *et al.*, 1982; Last *et al.*, 1983), or as *A. truttaceus* (Hutchins & Swainston, 1986; May & Maxwell, 1986). The family review by Paulin (1993) validated *A. truttaceus* as the Western Australian species and included a new species, *A. xylabion*, restricted to Lord Howe Island, northern New Zealand and the Kermadec Islands. All species have commercial and recreational importance (Kailola *et al.*, 1993; Paulin, 1993). Adults (40-90 cm) are elongate, fusiform and moderately compressed, have a single dorsal fin with the spinous and soft portions separated by a low notch, and a deeply forked caudal fin. Gill-raker counts on the first gill arch are important for separating species (Kuiter, 1993; Paulin 1993). Eggs are pelagic and spherical, 0.8–1.0 mm in diameter, and have a single oil globule (I.S.R. Munro, unpublished diagrams). Larvae have only been described for *A. trutta* (Neira *et al.*, 1997c). The moderate head spination is the only apparent specialisation of arripid larvae to pelagic life (Neira *et al.*, 1997c).

Meristic characters of the arripid genus of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Arripis	(3)	IX, 13–17*	III, 9–10	16–18	I, 5	17	10 + 15 = 25

* Paulin's (1993) revision of the family gives fewer dorsal-fin rays (13–16), but we have counted up to 17 rays in our material.

Main characters of arripid larvae

- 25–26 myomeres
- Body moderate (BD 22–31%), laterally compressed by postflexion stage
- Moderately well developed head spination, including preopercular, opercular, interopercular, supracleithral and posttemporal spines
- Gut moderate to long (PAL 39–68%), initially straight but becoming coiled and compact during preflexion stage
- Large gap between anus and origin of anal fin, closed in early juveniles
- Body initially moderately pigmented, becoming progressively heavily pigmented during postflexion stage
- Internal melanophores on nape and anterior of trunk, and ventrally along posterior caudal vertebrae
- Melanophores along posterior dorsal and ventral midlines of tail, and dorsally and ventrally along notochord tip
- External melanophores along posterior lateral midline of tail

References to arripid larvae

Neira *et al.* (1997c).

Families with similar larvae

Centrolophidae – No gap between anus and origin of anal fin; no melanophores dorsally along notochord tip (except *Icichthys*); long-based dorsal and anal fins, >29 elements; pigment blotches along dorsal and ventral surfaces of tail from preflexion stage.

Girellidae – Weak head spination; XIII–XVI dorsal-fin spines; lightly pigmented body; no melanophores dorsally along notochord tip; 1 internal melanophore at nape.

Kyphosidae – No gap between anus and origin of anal fin; XI dorsal-fin spines; no melanophores dorsally along notochord tip; no pigment along lateral midline of tail in preflexion and flexion larvae.

Microcanthidae – Moderate preopercular spination, including interopercular spines; anal fin III, 13–19; none to a few melanophores along dorsal midline of trunk and tail, melanophores widely spaced when present; no pigment along lateral midline of tail in preflexion and flexion larvae.

Pomatomidae – 2 dorsal fins, VII–VIII + I, 23–28; long-based anal fin, I–III, 24–28; body lightly pigmented; no melanophores dorsally along notochord tip.

Scombridae – 30–66 myomeres; head moderate to large; short, rounded to elongate snout; 2 dorsal fins, first with >IX spines, second short-based and followed by finlets; anal fin short-based, followed by finlets.

Scorpididae – Long-based dorsal and anal fins, IX–X, 23–28 and III, 25–28 respectively; body moderately pigmented; 1 internal melanophore at nape.

Arripidae *Arripis trutta* (Foster, 1801) Eastern Australian salmon

D IX, 15–17 A III, 9–10 P_1 16–18 P_2 I, 5 C 17 V 25

Adults Distributed along southeastern Australia from Brisbane (Qld) to Port Phillip Bay (Vic), including Tasmania and Lord Howe and Norfolk islands; also in New Zealand. Found in estuaries and coastal bays to a depth of 30 m. Adults possess 9–13 + 20–24 gill rakers on the first gill arch, and are dark blue-green above and silvery below, with irregularly defined spots arranged laterally in indistinct rows. Maximum size 89 cm (Hutchins & Swainston, 1986; Kuiter, 1993; Paulin, 1993).

Importance to fisheries Fished commercially in or near spawning areas, with a total annual catch of about 1000 tonnes. Caught primarily by beach seines and trawlers for human consumption, pet food and rock lobster bait. Also targeted by recreational fishers (Kailola *et al.*, 1993; Edgar, 1997).

Spawning Eggs are pelagic and spherical, 0.9–1.0 mm in diameter, and have a smooth chorion, an unsegmented yolk, and a single oil globule 0.24–0.28 mm (Robertson, 1975a; I.S.R. Munro, unpublished diagrams). Adults migrate to waters between Bermagui (NSW) and the Gippsland Lakes (Vic) from November to February to spawn (Stanley & Malcolm, 1977). Larvae have been caught in coastal waters off Sydney (NSW) from November to May (Gray, 1995), and in shelf and offshore waters of eastern Tasmania between March and May.

Diagnostic characters

- 6–10 + 15–19 = 25–26 myomeres
- Small preopercular spines by flexion stage
- 5–6 internal melanophores along nape and anterior of trunk
- 3–8 internal melanophores ventrally along posterior of notochord from late flexion stage, between postanal myomeres 15–23
- Melanophores around notochord tip

Description of larvae

Morphology Body moderate (BD 22–31%). Head moderate in preflexion larvae (HL 25–29%), moderate to large flexion and postflexion larvae (HL 31–36%). Small villiform teeth along both jaws from flexion stage. Maxilla with a sharp spine, overlapping premaxilla from mid-flexion stage. Two small posterior preopercular spines and a low supraocular ridge by early flexion stage; 7 posterior preopercular spines in postflexion larvae, preopercle serrate in juveniles. Two or three small anterior preopercular and 2 supracleithral spines, and 1 cleithral, 1 posttemporal, 1 opercular, 1 subopercular and 1 interopercular spine in early postflexion larvae. Gut moderate in preflexion larvae (PAL 39–44%), long in postflexion larvae (PAL 61–68%); straight at hatching (I.S.R. Munro, unpublished diagrams), coiled and compact by 2.7 mm and voluminous in postflexion larvae. Gas bladder over foregut, visible when inflated. Large gap between anus and origin of anal fin, reduced by late postflexion stage. Scales form during transformation, and are all present by 16.1 mm.

Size at

Hatching	<2.7 mm
Notochord flexion	3.8–5.7 mm
Transformation	>8.3 mm
Formation of fins:	

Caudal 3.2–5.7 mm; Anal 3.8–7.2 mm; Dorsal 3.8–7.2 mm; Pelvic 4.5–7.2 mm; Pectoral 4.9–7.2 mm

Pigmentation Larvae are initially moderately pigmented, becoming heavily pigmented by late postflexion stage. *External*: Large melanophores dorsally over head, extending anteriorly by postflexion stage; 1–5 along isthmus in postflexion larvae. Melanophores laterally on gut. Melanophores along dorsal midline of tail, from myomeres 12–16 to notochord tip; series of melanophores along dorsolateral surface of trunk by early flexion stage, extending laterally and posteriorly onto tail by postflexion stage; 3–6 melanophores along lateral midline of tail from late preflexion stage, between myomeres 16 and 22, forming a midlateral stripe by postflexion stage. Melanophores along ventral midline of posterior of tail to end of caudal peduncle; pigment along caudal-fin base in postflexion larvae. Pigment on membrane between dorsal-fin spines and heavy pigment over entire trunk and tail, except for pectoral- and caudal-fin bases, prior to transformation. Pigment over posteriormost dorsal-fin rays, anal-fin spines and last four anal-fin rays by 10 mm. *Internal*: Pigment below otic capsule and 1 melanophore on inner surface of upper preopercle in preflexion larvae. Large melano-phore on tip of snout by early flexion stage. Numerous melanophores in opercular area by postflexion stage; 4–6 large melanophores at nape and anterior of trunk from late preflexion stage. Heavy pigment over peritoneum and dorsally over gas bladder and gut. Three to eight melanophores ventrally along posterior of notochord from late preflexion stage, between myomeres 15 and 23. A few widely spaced melanophores ventrally along anterior of tail until flexion stage.

Material examined 15 larvae, 2.7–10.0 mm BL, and 3 juveniles, 16.0–19.7 mm BL, coastal and offshore waters off Sydney (NSW) and eastern Tasmania.

Additional references Neira *et al.* (1997c).

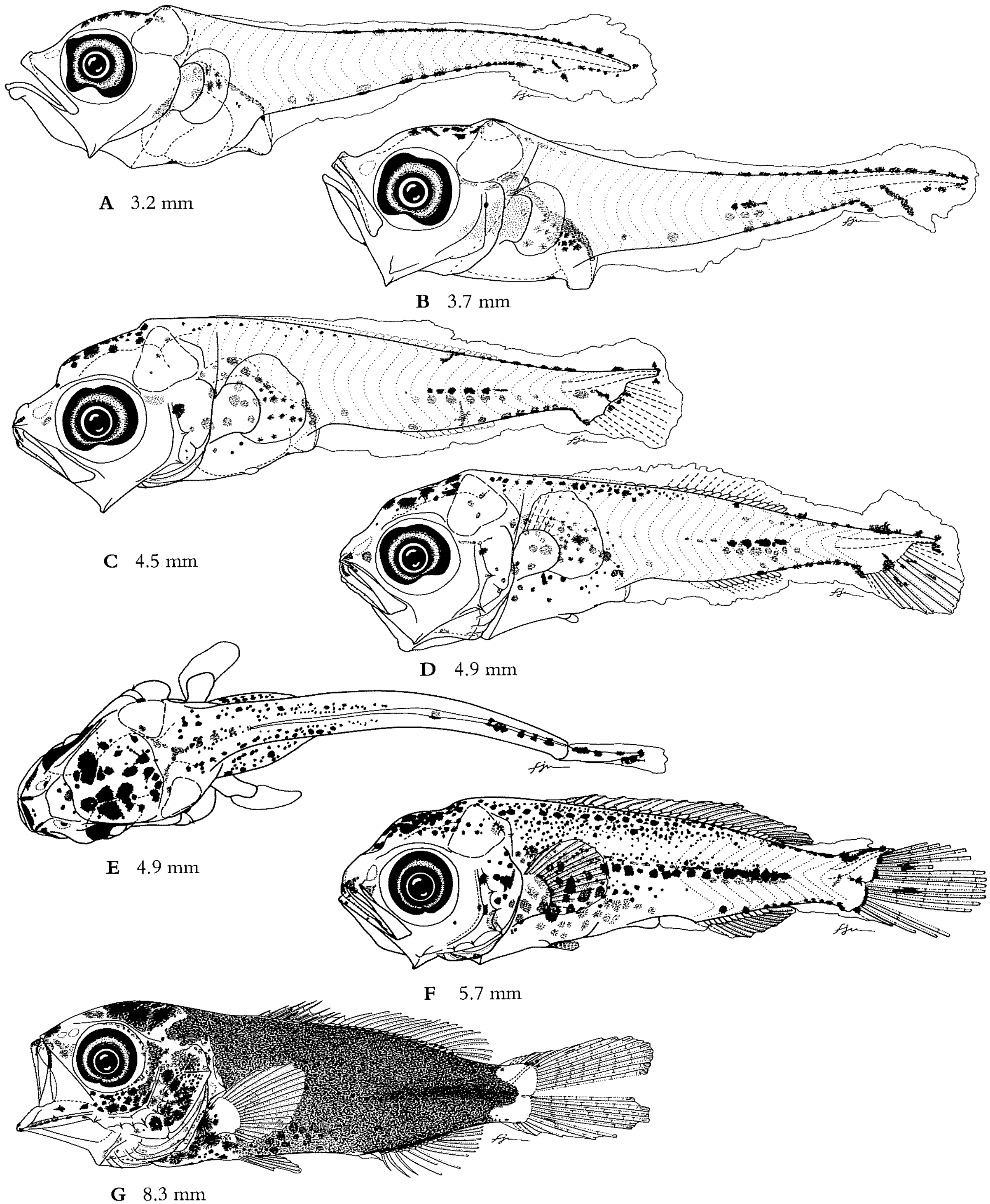


Figure 52 Larvae and transforming stage of *Arripis trutta.* **A** Preflexion; note developing caudal fin. **B** Late preflexion. **C** Flexion; note pelvic-fin bud. **D** Late flexion. **E** Dorsal view of larva in D; note internal melanophores along nape and anterior of trunk. **F** Postflexion. **G** Transforming stage; scales omitted. A–D from Port Hacking (NSW); F from Long Reef (NSW); G from eastern Tas offshore waters (modified from Neira *et al.*, 1997c). Illustrated by F.J. Neira.

Bramidae: Pomfrets

M. Moteki and F. J. Neira

Bramids are epipelagic and mesopelagic fishes found in oceanic waters worldwide except the polar regions. The family comprises 7 genera and 20 species worldwide, with all 7 genera and 11 species recorded from temperate Australia, although most occur in offshore waters (Mead, 1972; Yatsu & Nakamura, 1989; Pavlov, 1991; Last & Baron, 1994; Moteki *et al.*, 1995). Body shape varies considerably among genera. Adults (0.1–1.0 m) are deep bodied and very compressed, have a large rounded head with a blunt snout and a high forehead, a hard body with firmly attached scales, a single long-based dorsal fin with 2–3 anterior unbranched rays, a long-based spineless anal fin, thoracic or jugular pelvic fins, and a deeply forked caudal fin. The anteriormost dorsal-fin rays are usually elongate. Juveniles are often found in stomachs of tuna and lancetfishes (Borodulina, 1974; Moteki *et al.*, 1993). Little is known of the biology of bramids except for the feeding, reproductive biology and migration of *Brama japonica* (e.g. Shimazaki & Nakamura, 1981; Wada & Murata, 1985; Savinykh, 1994) and some aspects of the biology of *B. australis* (Pavlov, 1994). Eggs of *Brama* spp. are pelagic and spherical, 1.2–1.7 mm in diameter, and have a single oil globule (Schimdt & Strubberg, 1918; Sanzo, 1928; Padoa, 1956b; Yoon & Shimazaki, 1981; Moser & Mundy, 1996). Larvae have been described for a few representatives of all genera except *Xenobrama* (e.g. Sanzo, 1928; Mead, 1972; Johnson, 1978; Fahay, 1983; Kinoshita, 1988e; Matarese *et al.*, 1989; Olivar & Fortuño, 1991; Seki & Mundy, 1991; Moser & Mundy, 1996). The moderate head spines, the large pectoral fins, and the spinuous scales constitute apparent specialisations of bramid larvae to pelagic life.

Meristic characters of bramid genera of temperate Australia*

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Brama	(2)	33–40	27–33	19–23	I, 5	17	15–18 + 23–27 = 39–45
Eumegistus	(1)	32–35	23–35	20–22	I, 5	17	16–18 + 23–25 = 40–42
Pteraclis	(2)	46–55	40–49	15–21	I, 5	17	20–22 + 23–33 = 45–54
Pterycombus	(1)	47–50	37–41	19–22	I, 5	17	20–23 + 24–26 = 45–48
Taractes	(2)	30–35	21–25	17–22	I, 5	17	17–19 + 20–25 = 39–43
Taractichthys	(2)	33–38	26–30	18–22	I, 5	17	19–22 + 22–26 = 42–47
Xenobrama	(1)	38–42	27–30	20–24	I, 5	17	16–18 + 32–35 = 49–51

* All except *Brama* spp. occur in offshore waters but might be found occasionally in coastal waters.

Main characters of bramid larvae

- 36–54 myomeres
- Body moderate to deep (BD 20–47%), laterally compressed
- Head small to large (HL 15–41%), rounded and deep
- Mouth oblique and large, upper jaw extending to middle of or beyond eye
- Series of curved, canine-like teeth along premaxilla and dentary from late preflexion stage, externally visible during postflexion stage
- Moderate to well developed head spination, including few to many, slightly to moderately curved preopercular spines
- Tail slender and elongate in preflexion larvae, becoming moderate to deep in postflexion larvae; caudal peduncle narrow and caudal fin deeply forked in postflexion larvae
- Gut moderate to long (PAL 39–52%), coiled and compact
- Early forming, elongate pelvic fins
- Elongate, early forming pectoral-fin rays; pectoral fins large in postflexion larvae

- Head heavily pigmented from preflexion stage; head and trunk heavily pigmented in postflexion stage
- Melanophores on caudal finfold, and above and/or under notochord tip in some taxa

References to bramid larvae

Mead (1972), Fahay (1983), Kinoshita (1988e), Matarese *et al.* (1989), Olivar & Fortuño (1991), Moser & Mundy (1996).

Families with similar larvae

Berycidae – 24–25 myomeres; gut long (PAL 45–60%); dorsal fin IV–VII, 11–20; anal fin III–IV, 12–30; body lightly pigmented.

Ephippidae – 24 myomeres; body globose, head and trunk broad; well developed head spination, including a serrate, posteriorly directed supraoccipital spine and elongate posterior preopercular spines; spines in dorsal and anal fins.

Sciaenidae – 24–29 myomeres, typically 25; dorsal fin XI, 25–31; short-based anal fin, II, 7–9; large gap between anus and origin of anal fin; head lightly pigmented.

Trachichthyidae – 26–30 myomeres; short-based dorsal and anal fins, with spines; pelvic fins I, 6, early forming and heavily pigmented; pectoral-fin rays not elongate.

Bramidae *Brama brama* (Bonnaterre, 1788) Pomfret, Ray's bream

D 35–40 A 27–33 P_1 19–23 P_2 I, 5 C 17 V 41–45

Adults Distributed around southern Australia from Israelite Bay (WA) to Narooma (NSW), including Tasmania and Lord Howe Island. Also found in temperate to cold oceanic waters of the North Atlantic and the southern Indian and Pacific oceans, including New Zealand, South Africa and western South America. Found in surface waters at night and deep waters during the day, to a depth of about 400 m. Adults have a compressed, deep body with a steeply curved head profile, and a deeply forked tail. Maximum size to 60 cm FL (Mead, 1972; Last *et al.*, 1983; Yatsu, 1990; Gomon *et al.*, 1994; Last & Baron, 1994).

Importance to fisheries Fished commercially mainly with longlines and driftnets in the Atlantic Ocean off Spain and Portugal. Marketed both fresh and canned, the flesh is apparently of exceptional quality (Mead, 1972; Gomon *et al.*, 1994).

Spawning Eggs are pelagic and spherical, average 1.6 mm in diameter, and have a smooth chorion, an unsegmented yolk, and a single oil globule 0.4 mm (Sanzo, 1928, as *B. raji*). Larvae have been caught in coastal waters off Geraldton (WA) in September (AMS records), and in coastal waters off Sydney (NSW) from May to August (Gray, 1995).

Diagnostic characters

- 6–11 + 29–38 = 39–43 myomeres
- Small larvae are tadpole-like, with a large, rounded head, compact gut and compressed tail
- Up to 12 small to moderate preopercular spines
- Early forming, elongate pelvic fins, reaching well beyond anus in postflexion larvae
- Heavily pigmented head in early postflexion larvae
- Scattered melanophores on branchiostegal membrane from late preflexion stage

Description of larvae

Morphology Body moderate to deep (BD 20–47%), trunk and tail laterally compressed. Head small to large (HL 15–41%), rounded. Small, sharp canine teeth along both jaws from late preflexion stage. Three posterior preopercular spines in late preflexion larvae, 12 in late postflexion larvae; preopercle serrate by transformation. Low supraocular ridge from late flexion stage. One supracleithral spine in late flexion larvae. One subopercular and 4 interopercular spines by early postflexion stage; 7 interopercular spines by late postflexion stage. Gut moderate to long (PAL 39–52%), coiled and compact. Early forming, elongate pelvic fins, reaching well beyond anus in postflexion larvae. Scales over operculum and trunk in postflexion larvae by 12.1 mm, each bearing a tiny spine.

Size at

Hatching	<3.5 mm
Notochord flexion	5.6–6.8 mm
Transformation	>13.5–<20.0 mm
Formation of fins:	

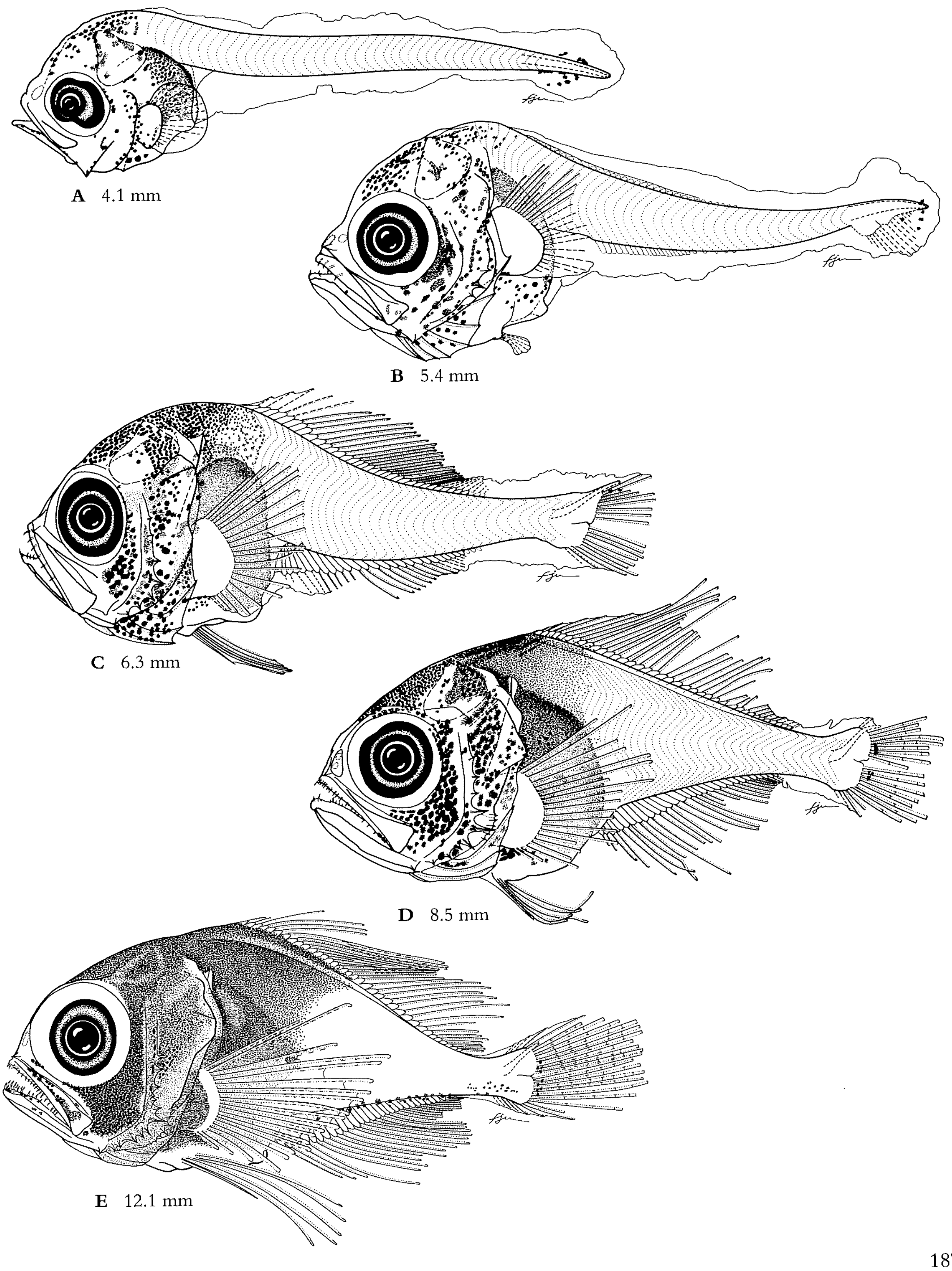
Pectoral <3.5–7.2 mm; Pelvic 4.8–6.1 mm; Caudal 4.8–6.6 mm; Dorsal 5.0–10.3 mm; Anal 5.0–10.3 mm

Pigmentation Larvae are initially lightly pigmented, becoming heavily pigmented by postflexion stage. *External:* Pigment dorsally over head and nape, and along lower jaw in early preflexion larvae; head heavily pigmented by early postflexion stage. A few melanophores along maxilla from late postflexion stage. Pigment over opercle and melanophores scattered over branchiostegal membrane from late preflexion stage. Melanophores on isthmus in early postflexion larvae. Small melanophores along edge of pectoral-fin base in mid-preflexion larvae, and along pectoral-fin rays from 12 mm. Melanophores scattered over trunk and tail in preflexion larvae; pigment heavier with growth, extending posteriorly to below dorsal-fin rays 19–20 from 12 mm. A few melanophores above and below notochord tip in preflexion larvae; ventral melanophores remain along base of caudal-fin rays. Series of small melanophores along ventral midline of tail and several on ventrolateral surface of caudal peduncle by 12 mm. *Internal:* Pigment over midbrain, over anterior surface of gut and dorsally over gas bladder and gut; gut heavily pigmented from late flexion stage.

Material examined 29 larvae, 3.5–13.5 mm BL, and 1 juvenile, 20.0 mm BL, coastal waters off Geraldton (WA) and Sydney (NSW).

Additional references Schmidt & Strubberg (1918), Sanzo (1928, as *B. raji*).

Figure 53 Larvae and juvenile of *Brama brama*. **A** Preflexion; note developing pectoral-fin rays. **B** Late preflexion; note developing dorsal, anal and pelvic fins. **C** Flexion; anteriormost myomeres omitted. **D** Early postflexion; dorsal and anal fins still developing. **E** Juvenile; myomeres and spiny scales omitted. A–D from central NSW coastal waters; E from Geraldton offshore waters (WA). Illustrated by F. J. Neira



A 4.1 mm

B 5.4 mm

C 6.3 mm

D 8.5 mm

E 12.1 mm

Callanthiidae: Yellow-fin basses

T. Trnski and A.G. Miskiewicz

Callanthiids are planktivorous, schooling fishes found over deep reefs in tropical to temperate regions of the eastern Atlantic, Indian and Pacific oceans. The family contains the genera *Callanthias* with eight species, and the monotypic *Grammatonotus* (Nelson, 1994). Two species of *Callanthias* have been recorded from temperate Australia (Kuiter, 1993; Gomon *et al.*, 1994). Adults (to 50 cm) are extremely colourful and sexually dimorphic, and have a single dorsal fin with the elements increasing in length posteriorly, a lateral line along the base of the entire dorsal fin, and a midlateral row of modified scales (Nelson, 1994). Eggs are pelagic but undescribed (Johnson, 1984). Larvae have been described for representatives of both genera (Sparta, 1932; Fourmanoir, 1976; Leis & Rennis, 1983; Okiyama, 1988i; Kim & Okiyama, 1989). The moderately to well developed and extensive head spination is the only apparent specialisation of callanthiid larvae to pelagic life.

Meristic characters of the callanthiid genus of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Callanthias	(2)	XI, 10–12	III, 10–11	18–23	I, 5	17	10 + 14 = 24

Main characters of callanthiid larvae

- 22–25 myomeres
- Body moderate to deep (BD 31–53%), moderately to strongly compressed
- Moderately to well developed and extensive head spination, including small to elongate preopercular spines (weak in postflexion *Grammatonotus*), several subopercular and interopercular spines (absent in postflexion *Grammatonotus*), and a prominent supracleithral spine
- Gut moderate to long (PAL 43–51%), coiled and compact
- Body lightly pigmented, melanophores scattered dorsally over head, trunk and tail in postflexion larvae

References to callanthiid larvae

Sparta (1932), Leis & Rennis (1983), Okiyama (1988i), Kim & Okiyama (1989).

Families with similar larvae

Berycidae – Weak to moderate head spination from late flexion stage; early forming dorsal fin, IV–VII, 11–20; anal fin III–IV, 12–30; early forming, elongate pelvic fins, I, 7–13; gut long (PAL 45–60%); body lightly pigmented.

Carangidae – Emergent median supraoccipital crest in most taxa; 2 separate dorsal fins, VI–VIII + I, 22–37; long-based anal fin, II + I, 16–29; body moderately to heavily pigmented, melanophore series along dorsal and ventral surfaces of trunk and tail, and along lateral midline of tail.

Serranidae (Anthiinae) – 26–28 myomeres; dorsal fin X–XIII, 13–22, second or third dorsal-fin spine elongate in some taxa; first pelvic-fin ray elongate in some taxa; body lightly to heavily pigmented.

Callanthiidae *Callanthias australis* Ogilby, 1899 Splendid perch

D XI, 10–12 A III, 10–11 P_1 18–23 P_2 I, 5 C 17 V 24

Adults Distributed around southern Australia from Shark Bay (WA) to Port Macquarie (NSW), including Tasmania; also in New Zealand. Found on rocky reefs in coastal waters at depths of 20–200 m. Adults have a continuous dorsal fin, typically 11 dorsal- and anal-fin rays, and an emarginate caudal fin with elongate outer rays. They are sexually dimorphic, with males brightly coloured. Maximum length 49 cm (Hutchins & Swainston, 1986; Kuiter, 1993; Gomon *et al.*, 1994).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in coastal waters off Sydney from April to November, with peak abundances in April and May (Gray, 1993).

Diagnostic characters

- 9–12 + 12–15 = 24 myomeres
- Numerous large preopercular spines
- One large supracleithral spine and several subopercular and interopercular spines
- Scales form during flexion stage
- Body lightly pigmented until postflexion stage
- Patch of pigment at tip of lower jaw

Description of larvae

Morphology Body moderate to deep in preflexion larvae (BD 32–42%), deep in flexion and postflexion larvae (BD 48–53%). Head large (HL 31–44%). Small teeth along both jaws in preflexion larvae by 3.3 mm. One anterior preopercular and 3 posterior preopercular spines in smallest preflexion larva; 4 anterior preopercular and 10 posterior preopercular spines in postflexion larvae, spines near preopercular angle the longest. Supracleithral spine in early preflexion larvae, increasing in size with growth. One large interopercular and 1 subopercular spine from mid-preflexion stage, 3 interopercular and 5 subopercular spines by postflexion stage. One opercular spine in late flexion larvae and a low, smooth supraocular ridge in postflexion larvae. Gut long (PAL 55–64%), coiled and compact. Small gas bladder above foregut. Scales start to form during flexion stage by 4.7 mm.

Size at

Hatching	<2.5 mm
Notochord flexion	3.9–5.2 mm
Settlement	>7.6 mm
Formation of fins:	

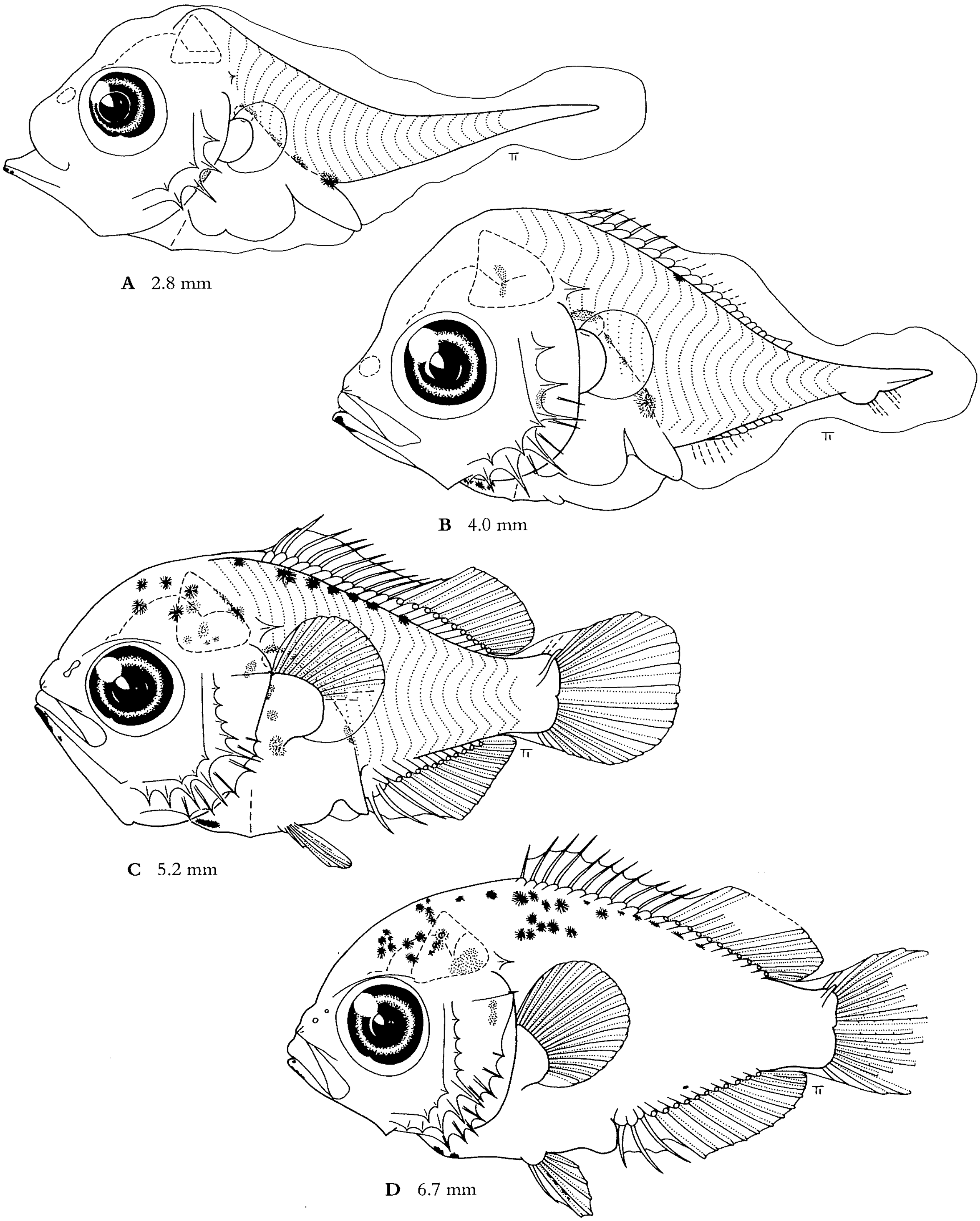
Dorsal 3.3–5.2 mm; Anal 3.3–5.2 mm; Caudal 3.5–5.2 mm; Pelvic 3.9–5.8 mm; Pectoral 4.7–6.6 mm

Pigmentation Larvae are lightly pigmented. *External:* Patch of pigment at tip of lower jaw; scattered melanophores dorsally over head in postflexion larvae. Usually 1 and up to 3 small melanophores on isthmus from late flexion stage. Series of melanophores along dorsal-fin base in flexion larvae; additional melanophores dorsolaterally on nape and along dorsal- and anal-fin bases in postflexion larvae. Small melanophores at base of and along pelvic-fin rays by 6.8 mm. *Internal:* Moderate pigment dorsally over gas bladder; at least 1 large melanophore dorsally over midgut and 2 dorsally over hindgut. Pigment laterally on mid- and hindbrain in late preflexion larvae, spreading in postflexion larvae.

Material examined 15 larvae, 2.5–7.6 mm BL, coastal waters of northern and central New South Wales, and off Sydney (NSW).

Additional references –

Figure 54 Larvae of *Callanthias australis*. **A** Preflexion; note preopercular spination. **B** Late preflexion; note early developing dorsal-fin spines and pelvic-fin bud. **C** Early postflexion; eight midlateral scale rows present but not illustrated. **D** Postflexion; scales omitted. A–D from NSW coastal waters. Illustrated by T. Trnski.



A 2.8 mm

B 4.0 mm

C 5.2 mm

D 6.7 mm

Carangidae: Trevallys, jacks

T. Trnski

Carangids are schooling or solitary, pelagic to semi-pelagic fishes found in estuarine to oceanic waters in tropical to temperate regions worldwide. The family contains 32 genera and 140 species (Smith-Vaniz, 1984; Gunn, 1990; Kuiter, 1993; Johnson & Gill, 1994; Nelson, 1994). About 63 species occur in Australia, most of which are found in the tropics. Three genera and about 8 species occur in temperate Australia, although the juveniles and adults of many tropical species (e.g. *Seriola*) are seasonally found in temperate waters (Gunn, 1990; Kuiter, 1993). Many species have considerable commercial and recreational importance (Kailola *et al.*, 1993). Adults (0.35–2.5 m) are typically strongly compressed and vary in shape from elongate and fusiform to deeply ovate. They have two dorsal fins, the second long-based and roughly equal in length to the anal fin, the first two anal-fin spines separated from the third, a narrow caudal peduncle and, in some species, detached dorsal and anal finlets posterior to both fins (included in counts) and lateral-line scales modified into scutes (Gunn, 1990; Johnson & Gill, 1994; Nelson, 1994). Eggs of *Caranx*, *Pseudocaranx*, *Seriola* and *Trachurus* are pelagic and spherical, 0.7–1.5 mm in diameter, and have a single oil globule (Robertson, 1975a; Laroche *et al.*, 1984; Ikeda & Mito, 1988; Akazaki & Yoden, 1990a; Tachihara *et al.*, 1993). Larvae have been described for representatives of most genera (see Laroche *et al.*, 1984, and references therein; see also Ahlstrom & Ball, 1954; Johnson, 1978; Fahay, 1983; Zhang *et al.*, 1985; Manabe & Ozawa, 1988; Manabe *et al.*, 1988; Leis & Trnski, 1989; Watson *et al.*, 1996). The well developed and extensive head spination, particularly the elongate preopercular spines, constitute major specialisation of carangid larvae to pelagic life (Leis & Trnski, 1989).

Meristic characters of carangid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Pseudocaranx	(2)	VIII + I, 22–28	II + I, 18–25	18–21	I, 5	17	10 + 14–15 = 24–25
Seriola	(4)	VI–VII + I, 22–37	II + I, 16–22	18–22	I, 5	17	10–11 + 13–14 = 24–25
Trachurus	(2)	VIII + I, 27–35	II + I, 22–29	20–22	I, 5	17	10 + 14 = 24

Main characters of carangid larvae

- 24–26 myomeres, typically 24–25
- Body elongate to deep (BD 17–64%), strongly to moderately compressed
- Extensive head spination, including short to long preopercular spines, one at angle usually long, and, in most taxa, posttemporal and supracleithral spines, a smooth to strongly serrate supraocular ridge, and an emergent median, serrate or smooth supraoccipital crest (present but non-emergent in *Seriola*)
- 3 anal-fin spines, first 2 separated from third (II + I), gap between spines more pronounced after transformation; third anal-fin spine is initally a soft ray
- Gut moderate to very long (PAL 44–75%), initially straight but becoming coiled and large (triangular-shaped) early in development
- Prominent gas bladder, pigmented
- Preanal membrane persisting through to postflexion stage, often lightly to heavily pigmented in preflexion and flexion stages
- Melanophore series along dorsal and ventral surfaces of trunk and tail, often in alternate and/or paired pattern dorsally along tail
- Melanophore series along lateral midline of tail

References to carangid larvae

Ahlstrom & Ball (1954), Fahay (1983), Laroche *et al.* (1984), Manabe & Ozawa (1988), Manabe *et al.* (1988), Leis & Trnski (1989), Watson *et al.* (1996).

Families with similar larvae

Acropomatidae – Strong opercular and interopercular spine; short-based, posteriorly located anal fin, III, 6–7; little or no pigment along tail in early stages.

Apogonidae (taxa with extensive head spination) – Supraoccipital crest, when present, small and with 1 spine; 2 short, well separated dorsal fins; anal fin typically II, 7–10; no pigment dorsally along tail in early larvae.

Callanthiidae – Single dorsal fin, XI, 10–12; short-based anal fin, III, 10–11; lack median supraoccipital crest.

Chaetodontidae – Early forming bony plates on head; small mouth; prominent, posteriorly directed preopercular spine at angle, either flat, serrate or strongly barbed; first two anal-fin spines not separated from third.

Emmelichthyidae – Lack median supraoccipital crest; no teeth; dorsal fin XI–XIV, 9–12; short-based anal fin, III, 9–11; little or no pigment along tail.

Enoplosidae (c.f. preflexion *Seriola*) – preopercular spines absent until postflexion stage; no pigment around notochord tip.

Kyphosidae – Weak head spination, including short preopercular spine at angle; lack median supraoccipital crest; dorsal fin XI, 12–16; anal fin III, 10–11.

Menidae – Head large and triangular; mouth large, oblique to vertical, and extremely protrusible; long ascending premaxillary process; lack anterior preopercular spines.

Nomeidae (some taxa) – 30–42 myomeres; body deep; head deep with rounded snout; weak preopercular spines; lack median supraoccipital crest; early forming, often pigmented pelvic fins (e.g. *Nomeus, Psenes*); X–XII dorsal-fin spines (*Cubiceps*).

Pempheridae – Weak preopercular spines; single, short-based dorsal fin; early forming pelvic fins, located high and laterally on gut; lack median supraoccipital crest; little pigment on tail after flexion stage.

Pomacanthidae – Lack median supraoccipital crest; long, thin notochord tip; early forming body spines (scale precursors); body moderately to heavily pigmented from early stages.

Pomatomidae – Weak preopercular spines; first 2 anal spines not separated from third; lack median supraoccipital crest; moderate gap between anus and origin of anal fin.

Serranidae (Anthiinae, Serraninae) – 26–28 myomeres; interopercular spine; short-based anal fin, III, 6–10; early forming dorsal and pelvic fins; second or third dorsal-fin spine elongate and serrate in some taxa; first pelvic-fin ray elongate in some taxa.

Carangidae *Pseudocaranx dentex* (Bloch & Schneider, 1801) Silver trevally

D VIII + I, 25–28 A II + I, 21–25 P_1 18–21 P_2 I, 5 C 17 V 25

Adults Distributed around southern Australia from North West Cape (WA) to the southern Great Barrier Reef (Qld), including Tasmania and Lord Howe and Norfolk islands; also in New Zealand and in the Atlantic and Indian oceans. Often found near surface waters, but also forming dense schools near the shelf seafloor to a depth of 120 m. Juveniles are common in estuaries, bays and coastal marine waters. Adults have a maxilla with the rear edge sloping slightly forward to its main axis, a large, diffuse dark blotch on the operculum, and a lateral line with 57–78 scales in the curved portion and 34–46 posterior scutes. Maximum size 94 cm SL (Hutchins & Swainston, 1986; Hoese & Hanley, 1989d; Kailola *et al.*, 1993; Kuiter, 1993; Gomon *et al.*, 1994; Tilzey, 1994b; Edgar, 1997).

Importance to fisheries Fished commercially with beach seines, gill and trawl nets mostly in New South Wales. Total commercial catches in southern Australia ranged from 800 to 1700 tonnes between 1982 and 1990. Also targeted by recreational fishers. Used mainly for human consumption (Kailola *et al.*, 1993; Tilzey, 1994b).

Spawning Eggs are pelagic and spherical, 0.8–0.9 mm in diameter, and have a smooth chorion, a segmented yolk, and a single oil globule 0.20–0.24 mm (Robertson, 1975a, as *Caranx georgianus*; James, 1976). Reared larvae hatch after 28 hours at 21°C (James, 1976). Spawns in summer in Australia and New Zealand, and appears to be a serial spawner at least in Australia (James, 1984; Kailola *et al.*, 1993). Larvae have been caught entering Lake Macquarie (NSW) from December to February (Miskiewicz, 1987), and in coastal waters off Sydney from August to May (Gray *et al.*, 1992; Gray, 1993).

Diagnostic characters

- 10–12 + 12–15 = 24–25 myomeres
- Posterior preopercular spine at angle long from early preflexion stage
- Supraoccipital crest high and serrate, with a single peak posteriorly
- One supracleithral spine from early flexion stage, a second spine in postflexion stage
- Paired melanophore series along dorsal midline of trunk and tail

Description of larvae

Morphology Body moderate in preflexion larvae (BD 23–34%), moderate to deep in postflexion larvae (BD 38–41%). Head moderate to large in preflexion larvae (HL 23–35%), large in postflexion larvae (HL 35–40%). Small teeth along premaxilla from preflexion stage, and along dentary by late postflexion stage. Posterior preopercular spines short to moderate, spine at angle long from early preflexion stage; anterior preopercular spines short. High, serrate supraoccipital crest, with a single peak posteriorly in early preflexion larvae, becoming small and low in postflexion larvae and persisting until transformation. One supracleithral and 1 posttemporal spine in early flexion larvae, a second supracleithral spine in postflexion larvae from 6.7–8.9 mm. Low, smooth supraocular ridge from early flexion stage. Gut long (PAL 50–62%), coiled and compact. Gas bladder conspicuous, inflated. Preanal membrane present through to transformation stage. Scales develop during transformation.

Size at

Hatching [1]	1.6 mm
Notochord flexion	4.6–5.6 mm
Transformation	13.0–15.0 mm
Formation of fins:	

Caudal 3.0–5.8 mm; Dorsal 3.8–9.1 mm; Anal 3.8–9.1 mm; Pectoral 5.3–<12.8 mm; Pelvic 5.6–8.9 mm

[1] James (1976)

Pigmentation Larvae are moderately pigmented, becoming heavily pigmented by postflexion stage. *External:* One melanophore at tip of lower jaw and several along dentary from late preflexion stage; a few on snout and 1 to several near angle of lower jaw from early preflexion stage; additional melanophores on premaxilla from flexion stage. A few melanophores over midbrain, spreading over fore- and hindbrain by late preflexion stage. One expanded melanophore in centre of opercle by flexion stage. One to a few melanophores along isthmus from late preflexion stage. Melanophores series along midline of gut and preanal membrane. Paired series of 9 or more expanded melanophores along dorsal midline of trunk and tail in preflexion larvae, increasing to at least 22 in flexion larvae. One small melanophore on dorsal midline near notochord tip, disappearing by late preflexion stage. Melanophore series along lateral and ventral midlines of tail, latter reaching notochord tip. Pigment over dorsolateral surface of trunk and tail, and ventrolateral surface of tail from late preflexion stage. Pigment spreads over head and body from flexion stage. *Internal:* Melanophores on roof of mouth, at junction of mid- and hindbrain, under opercle, and dorsally over gut and gas bladder; pigment over entire gut in postflexion larvae.

Material examined 22 larvae and transformed juveniles, 3.0–15.6 mm BL, coastal waters off Lake Macquarie and Sydney (NSW).

Additional references Padoa (1956d, as *Caranx dentex*), James (1976), Manabe *et al.* (1988).

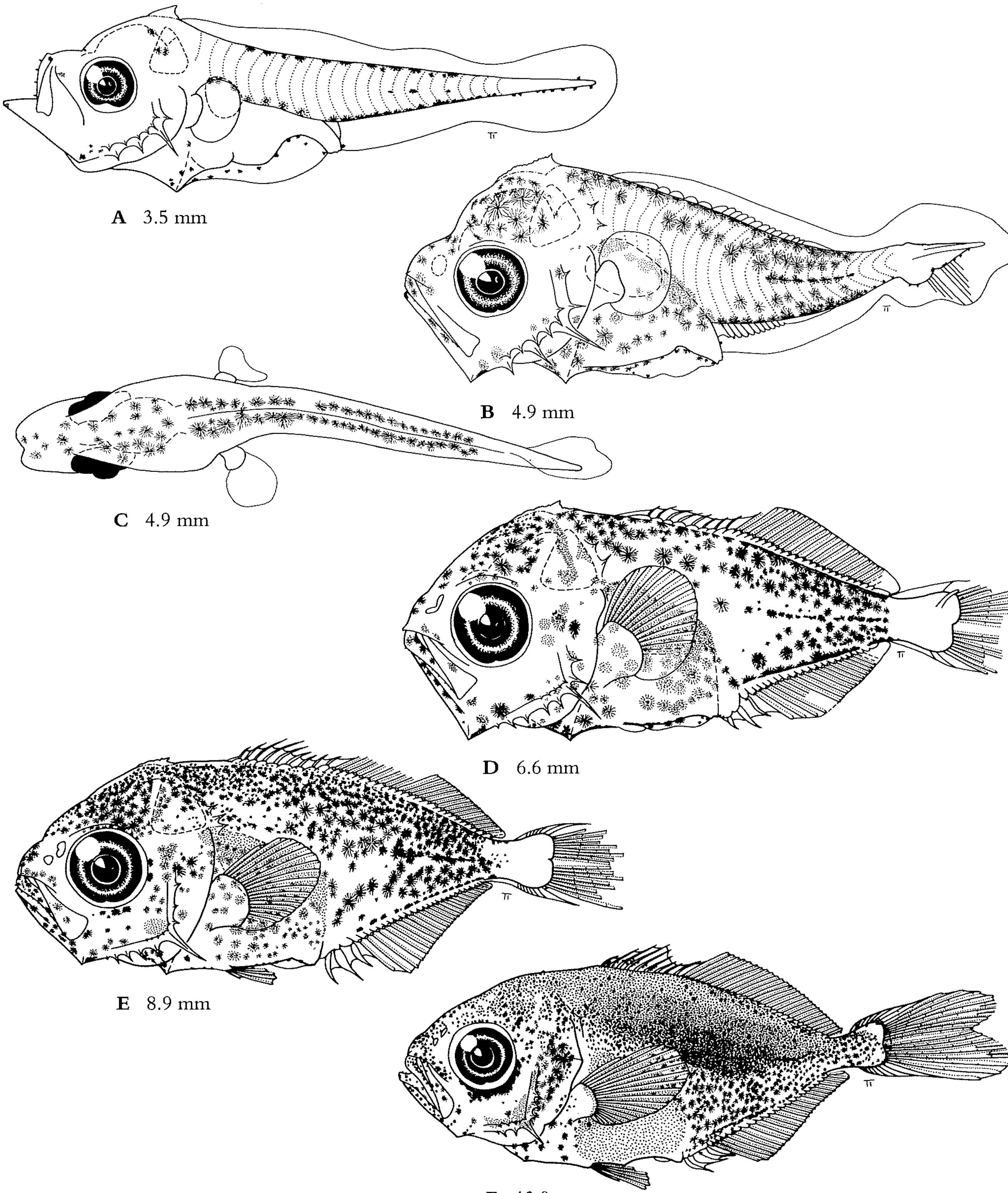


Figure 55 Larvae and transforming stage of *Pseudocaranx dentex*. **A** Preflexion. **B** Late preflexion. **C** Dorsal view of larva in B; note dorsal pigment pattern. **D** Early postflexion. **E** Postflexion. **F** Transforming stage; note supraoccipital crest barely emergent as a small spine. A, B, D–F from Sydney coastal waters (NSW). Illustrated by T. Trnski.

Carangidae *Pseudocaranx wrighti* (Whitley, 1931) Skipjack or sand trevally

D VIII + I, 22–26 A II + I, 18–22 P_1 18–19 P_2 I, 5 C 17 V 24

Adults Endemic to southern Australia from Exmouth Gulf (WA) to eastern Bass Strait, including Tasmania. Found in dense schools in estuaries, bays and coastal marine waters, to a depth of 30 m. Adults have a maxilla with the rear edge sloping rearwards to its main axis, a small, well defined dark blotch on the operculum, and a lateral line with 37–48 scales in the curved portion and 24–35 posterior scutes. Maximum size 70 cm (May & Maxwell, 1986; Hoese & Hanley, 1989d; Kailola *et al.*, 1993; Kuiter, 1993; Gomon *et al.*, 1994).

Importance to fisheries Not fished commercially although young fish are taken in large quantities as by-catch in prawn trawlers in coastal waters of South Australia (Gomon *et al.*, 1994).

Spawning Eggs undescribed. Eggs of *P. dentex* are pelagic and spherical, 0.8–0.9 mm in diameter, and have a single oil globule (Robertson, 1975a; James, 1976). Larvae have been caught in Cockburn Sound and the lower Swan Estuary (WA) (Neira *et al.*, 1992; Jonker, 1993), and in the upper Spencer Gulf (SA) from September to March (B.D. Bruce, pers. comm.).

Diagnostic characters

- 9–12 + 12–15 = 24–25 myomeres
- Posterior preopercular spine at angle long from early postflexion stage to about 8 mm
- Supraoccipital crest low, weakly serrate and without a peak, absent from late postflexion stage
- 1 supracleithral spine
- Low pterotic ridge from 8.3 mm
- Expanded melanophore laterally on gut below pectoral-fin base until early postflexion stage
- 8 or more (rarely 5) expanded melanophores along dorsal midline of trunk and tail

Description of larvae

Morphology Body moderate (BD 21–39%), deeper with growth. Head moderate to large in preflexion larvae (HL 22–35%), large in postflexion larvae (HL 35–40%). Small teeth along premaxilla from preflexion stage, and along dentary by late postflexion stage. Posterior preopercular spines short to moderate; spine at angle long from early preflexion stage until about 8 mm; anterior preopercular spines short. Low, weakly serrate supraoccipital crest in early preflexion larvae, no longer visible by 9 mm, always without a peak. One supracleithral and 1 posttemporal spine from early flexion to late postflexion stage; low, smooth supraocular ridge from early flexion stage; low pterotic ridge from 8.3 mm. Gut moderate to long (PAL 48–63%), coiled and compact. Gas bladder conspicuous, inflated. Preanal membrane present through to late postflexion stage. Scales develop during transformation.

Size at

Hatching	<1.9 mm
Notochord flexion	4.6–6.1 mm
Transformation	14.0–16.0 mm
Formation of fins:	

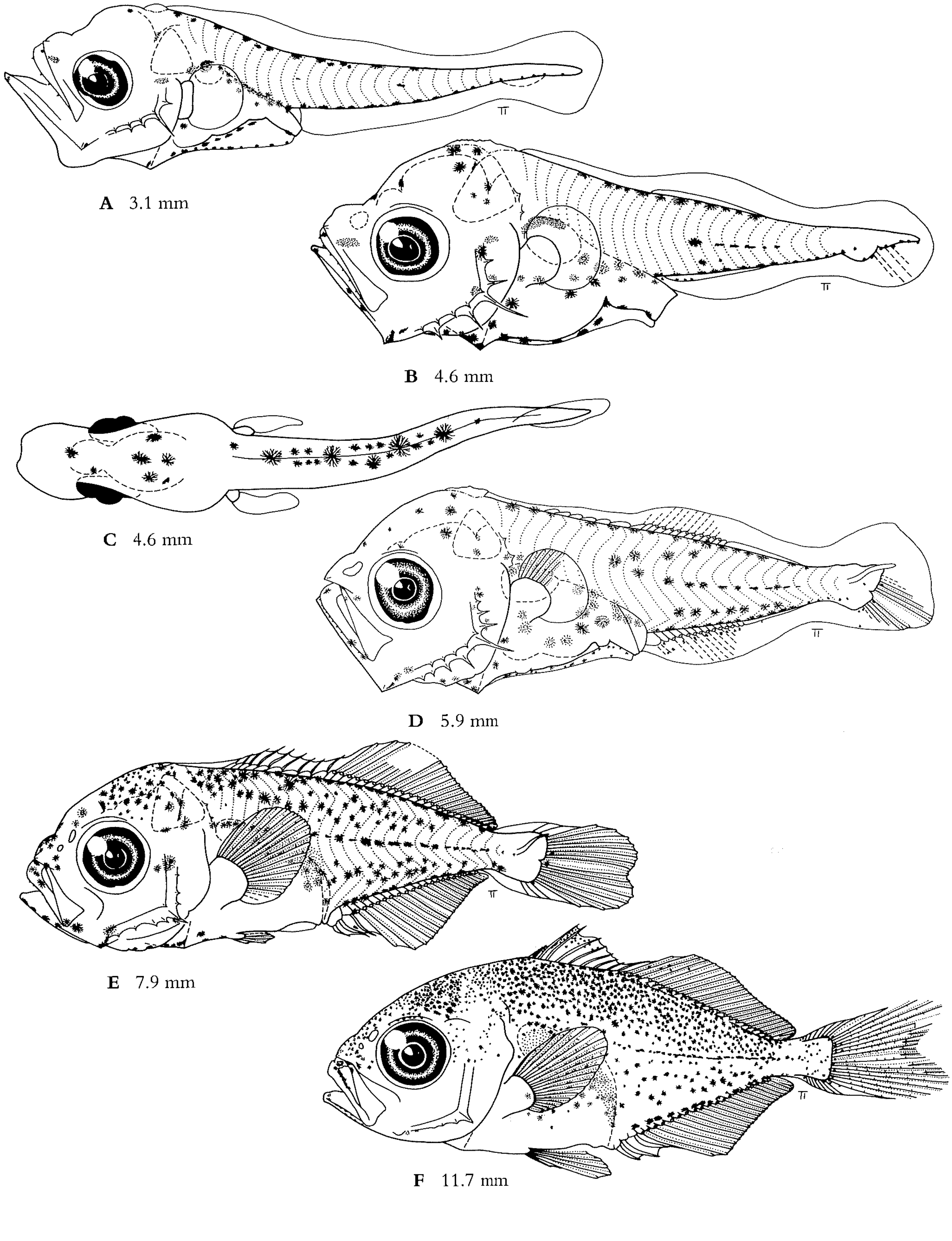
Caudal 3.0–6.1 mm; Dorsal 3.8–8.1 mm; Anal 3.8–8.1 mm; Pelvic 5.3–8.3 mm; Pectoral 5.4–8.3 mm

Pigmentation Larvae are moderately pigmented, becoming heavily pigmented by postflexion stage. *External:* One melanophore at tip of lower jaw; several along dentary from late preflexion stage; 1 to several near angle of lower jaw; a few on snout from early preflexion stage. A few melanophores over midbrain, spreading to fore- and hindbrain by flexion stage. One expanded melanophore at centre of opercle by start of flexion stage. Melanophore series along isthmus and 1 at cleithral symphysis by late preflexion stage; melanophore series posteriorly along midline of gut and preanal membrane. One expanded melanophore laterally on gut below pectoral-fin base in preflexion and flexion larvae. Series of 8 or more (rarely as few as 5) expanded melanophores along dorsal midline of trunk and tail; paired series of smaller melanophores between these from flexion stage. Melanophore series along lateral and ventral midlines of tail, latter reaching notochord tip. Pigment over dorsolateral surface of trunk and tail, and ventrolateral surface of tail from early flexion stage. Pigment spreads over head and body from 9 mm, becoming heavier dorsally. *Internal:* Melanophores on roof of mouth, at junction of mid- and hindbrain, under opercle, and dorsally and laterally over gut and gas bladder.

Material examined 21 larvae, 1.9–14.9 mm BL, and 2 juveniles, 15.9–21.0 mm BL, lower Swan Estuary and Cockburn Sound (WA), and upper Spencer Gulf (SA).

Additional references –

Figure 56 Larvae and transforming stage of *Pseudocaranx wrighti*. **A** Preflexion; note low supraoccipital crest. **B** Late preflexion. **C** Dorsal view of larva in B. **D** Late flexion; note pelvic-fin bud. **E** Postflexion; very low supraoccipital crest is overgrown by skin. **F** Transforming stage. A, F from lower Swan Estuary (WA); B, E from upper Spencer Gulf (SA); D from Rockingham (WA). Illustrated by T. Trnski.


A 3.1 mm
B 4.6 mm
C 4.6 mm
D 5.9 mm
E 7.9 mm
F 11.7 mm

Carangidae *Seriola* spp. Kingfish, amberjack, samson fish

D VI–VII + I, 22–37 A II + I, 16–22 P_1 18–23 P_2 I, 5 C 17 V 24–25

Adults Four species occur in Australia: *Seriola dumerili, S. hippos, S. rivoliana* and *S. lalandi*. The first three species each have a disjunct subtropical distribution on the west and east coasts, while the latter occurs around southern Australia from Perth (WA) to the southern Great Barrier Reef, including Tasmania. Members of this genus also occur in tropical and subtropical regions of all oceans and in the Mediterranean Sea. Some species occur in shallow waters, usually associated with reefs, while others prefer deeper waters. Adults are elongate and fusiform, and have very low first dorsal-fin spines, elongate anteriormost soft dorsal- and anal-fin elements, and a broad yellowish band laterally from the snout to the caudal peduncle. Maximum size 1–2 m (Hutchins & Swainston, 1986; Hoese & Hanley, 1989d; Kailola *et al.*, 1993; Kuiter, 1993, 1996; Gomon *et al.*, 1994).

Importance to fisheries Fished commercially with subsurface traps, handlines, setlines and trolling lines mostly in New South Wales; traps are now banned in New South Wales. Combined total annual catches of *S. lalandi* and *S. hippos* range between 300 and 750 tonnes since 1985. Also targeted by recreational fishers with hook and line near fish aggregating devices, and occasionally from shore. Considered excellent eating and desirable game fishes (Kailola *et al.*, 1993; Kuiter, 1993; B. Gillanders, FRI, pers. comm.).

Spawning Eggs of *S. dumerili* and *S. lalandi* are pelagic and spherical, 1.0–1.4 mm in diameter, and have a single oil globule 0.22–0.32 mm (Johnson, 1978; Akazaki & Yoden, 1990a; Tachihara *et al.*, 1993). *Seriola lalandi* appears to spawn in offshore surface waters between November and January (Kailola *et al.*, 1993; B. Gillanders, FRI, pers. comm.). Larvae have been caught entering Lake Macquarie (NSW) from March to April (Miskiewicz, 1987), and in coastal waters off Sydney from October to May (Gray, 1995).

Diagnostic characters

- 13–19 + 7–11 = 24–26 myomeres
- Gut long (PAL 66–75%), voluminous
- Posterior preopercular spines smooth, spine at angle long from mid-preflexion stage
- Weak, non-emergent supraoccipital crest and large posttemporal spines
- Supraocular ridge bearing 1–10 spines depending on species
- Body heavily pigmented

Description of larvae

Morphology Body moderate (BD 20–35%). Head initially moderate (HL 26–32%), large from mid-preflexion stage (HL 35–41%). Small teeth along dentary in preflexion larvae, and along dentary in postflexion larvae. Posterior preopercular spines short to moderate, spine at angle long from mid-preflexion stage; anterior preopercular spines short. Weak, non-emergent (subdermal) supraoccipital crest from mid-preflexion stage. Large posttemporal spine from late preflexion stage, a second spine by flexion stage, and a third small spine anterior to latter two spines by postflexion stage. Prominent supraocular ridge by mid-preflexion stage, with 1 large spine or up to 10 small spines depending on species. Large supracleithral spine and a broad, smooth pterotic ridge from flexion stage. Gut long to very long (PAL 66–75%), coiled and voluminous. Gas bladder small and inconspicuous. Preanal membrane present through to at least late postflexion stage.

Size at

Hatching [1]	2.7–3.8 mm
Notochord flexion	4.7–6.7 mm
Transformation [1]	9.0–19.4 mm

Formation of fins:
Caudal 3.4–6.5 mm; Dorsal 3.8–9.0 mm; Anal 3.9–9.0 mm; Pelvic 4.3–8.3 mm; Pectoral 4.3–8.3 mm

[1] Johnson (1978), Akazaki & Yoden (1990a,b), Tachihara *et al.* (1993).

Pigmentation Larvae are heavily pigmented. *External:* Several melanophores on tip of snout, many dorsally on head and laterally on opercle, a series along dentary, and a few along base of branchiostegal rays. Melanophores along ventral midline of trunk and tail from isthmus to anterior portion of tail, continuing as a series of small melanophores to notochord tip. Saddle of stellate melanophores dorsally over trunk and anterior portion of tail, continuing as a series of small melanophores to notochord tip. Broad band of melanophores mid-laterally and ventrolaterally on trunk, and anterior portion of tail. Pigment on membranes of dorsal, anal, caudal and pelvic fins in postflexion larvae. Pigment spreads over entire head and body with growth, except for posterior of caudal peduncle. Transverse pigment bands of juveniles first appear between 18–25 mm (Johnson, 1978). *Internal:* Melanophores on roof of mouth; stellate melanophores over midbrain, several under opercle, a series dorsally over gas bladder and gut, and many laterally on gut.

Material examined 19 larvae, 2.9–9.0 mm BL, coastal waters of northern and central New South Wales.

Additional references Padoa (1956d), Johnson (1978), Manabe & Ozawaz (1988), Akazaki & Yoden (1990b), Masuma *et al.* (1990), Tachihara *et al.* (1993).

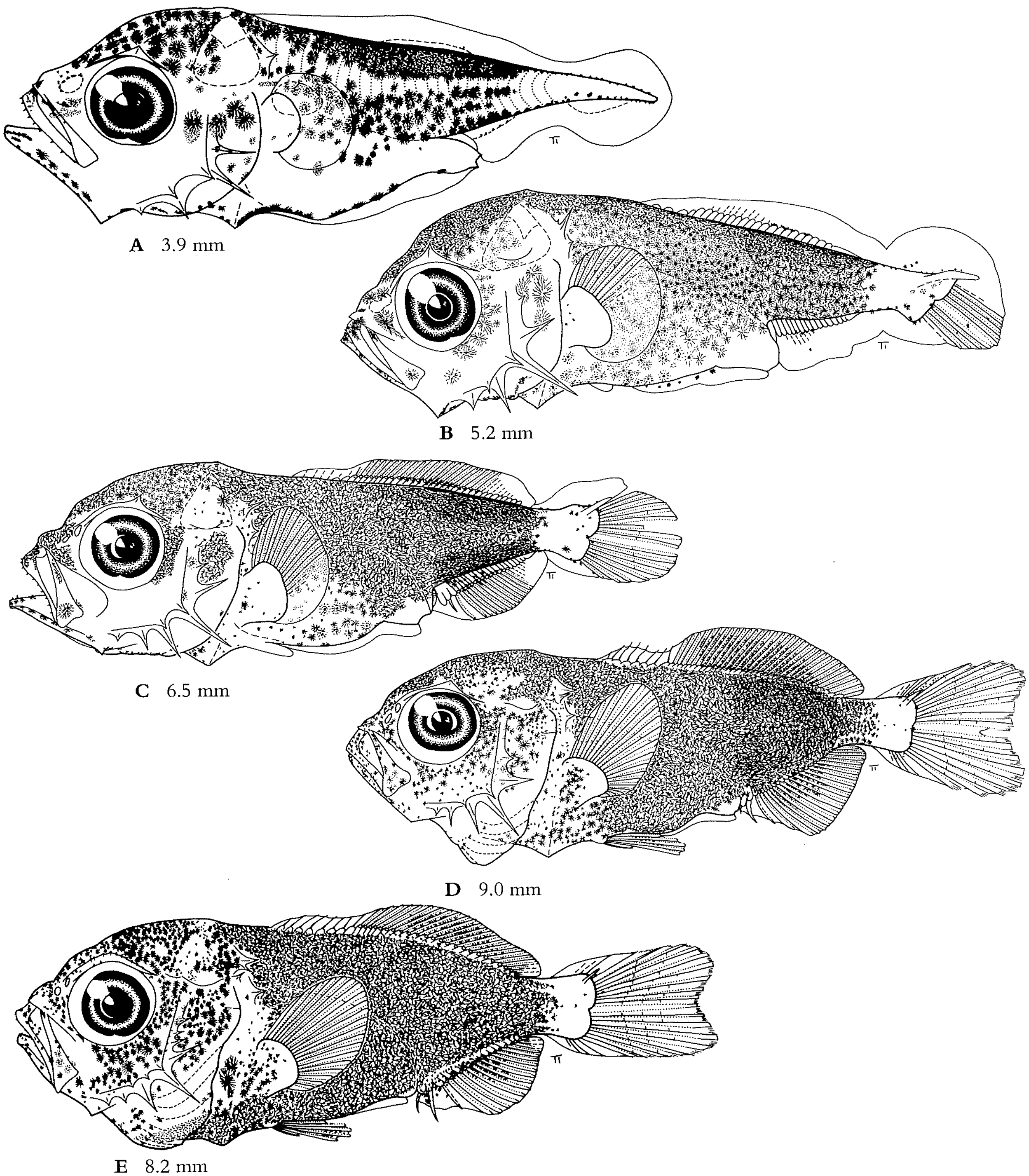


Figure 57 Larvae of *Seriola (rivoliana?)* (A–D) and *Seriola hippos* (E). **A** Preflexion. **B** Flexion; note pelvic-fin bud. **C** Late flexion. **D** Postflexion; note supraocular spine. **E** Late postflexion; note serrate supraocular ridge. A–D from northern NSW coastal waters; E from central NSW coastal waters. Illustrated by T. Trnski.

Carangidae *Trachurus declivis* (Jenyns, 1841) Jack mackerel

D VIII + I, 29–35 A II + I, 24–29 P_1 20–21 P_2 I, 5 C 17 V 24

Adults Distributed around southern Australia from Shark Bay (WA) to Wide Bay (Qld), including Tasmania; also in New Zealand. Found in dense schools near surface coastal marine waters, but also recorded to a depth of 460 m. Adults are elongate and slightly compressed, and have a primary lateral line with 71–89 scutes, and a secondary lateral line reaching to below dorsal-fin rays 7–9. Maximum size 64 cm (Hutchins & Swainston, 1986; Hoese & Hanley, 1989d; Kailola *et al.*, 1993; Gomon *et al.*, 1994).

Importance to fisheries Fished commercially mainly with purse seines, and also mid-water trawls and fixed tidal traps, in coastal waters of central eastern Tasmania and eastern Bass Strait. Catches are highly variable, reaching up to 40 000 tonnes per year. Also targeted by recreational fishers with hook and line. Used mostly for fish meal, pet food and bait (Maxwell, 1979; Kailola *et al.*, 1993; Klaer & Pullen, 1994).

Spawning Eggs are pelagic and spherical, 1.1–1.3 mm in diameter, and have a smooth chorion, a segmented yolk, and a single oil globule 0.25 mm (Robertson, 1975a). Spawning has been reported off eastern Tasmania between mid-December and mid-February (Marshall *et al.*, 1993; Jordan, 1994). Larvae have been caught in coastal waters of eastern Tasmania from December to April (Marshall & Jordan, 1992).

Diagnostic characters

- 10–13 + 11–14 = 24–25 myomeres
- Serrate supraoccipital crest from mid-preflexion stage
- 1 melanophore laterally on gut below pectoral-fin base, becoming internal by late preflexion stage
- Melanophores along dorso- and ventrolateral surfaces of body by end of preflexion stage

Description of larvae

Morphology Body elongate to moderate in preflexion larvae (BD 19–26%), moderate in postflexion larvae (BD 27–33%). Head moderate in preflexion larvae (HL 22–31%), large in postflexion larvae (HL 34–39%). Small teeth along premaxilla from preflexion stage. Posterior preopercular spines short to moderate, spine at angle long from flexion stage; anterior preopercular spines short. Serrate supraoccipital crest from mid-preflexion stage. One supracleithral and 1 posttemporal spine by late preflexion stage, a second supracleithral spine by late flexion stage. Low, smooth supraocular ridge from flexion stage. Gut long (PAL 52–63%), coiled and compact from 3.8 mm. Gas bladder conspicuous, inflated. Preanal membrane present until early postflexion stage.

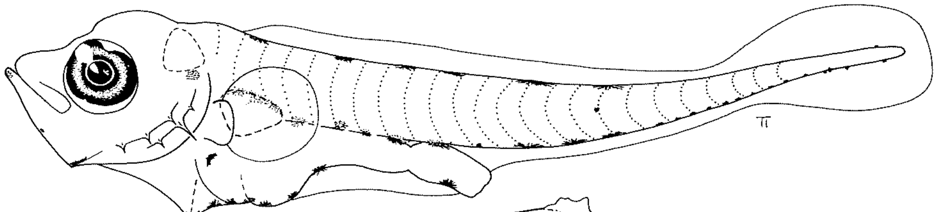
Size at	
Hatching	<3.6 mm
Notochord flexion	5.3–7.1 mm
Transformation	>12.8 mm
Formation of fins:	
Caudal 4.0–7.2 mm; Dorsal 5.0–>12.8 mm; Anal 5.0–>12.8 mm; Pelvic 5.3–10.3 mm; Pectoral 6.7–>12.8 mm	

Pigmentation Larvae are moderately pigmented. *External:* Melanophores at tip of lower jaw; 1-6 melanophores along dentary, 1 at angle of lower jaw. Several melanophores on tip of snout by mid-preflexion stage; a few over fore- and midbrain, and 1 expanded melanophore at centre of opercle from flexion stage, and a few over hindbrain by postflexion stage. One to four ventral melanophores along isthmus, and 1 near cleithral symphysis from late preflexion stage. Series of melanophores along ventral midline of gut and preanal membrane. One melanophore laterally on gut below pectoral-fin base, internal by late preflexion stage. Six expanded melanophores along dorsal midline of trunk and tail, increasing in number and becoming an alternating paired series of 13–20 by flexion stage, >16 by postflexion stage. Series of melanophores along lateral and ventral midlines of tail, latter reaching notochord tip. Melanophores on dorsolateral surface of trunk and tail, and ventrolateral surface of tail by late preflexion stage. *Internal:* Pigment at junction of mid- and hindbrain by late preflexion stage, under opercle, and dorsally over gas bladder and gut; pigment laterally over gut by early postflexion stage.

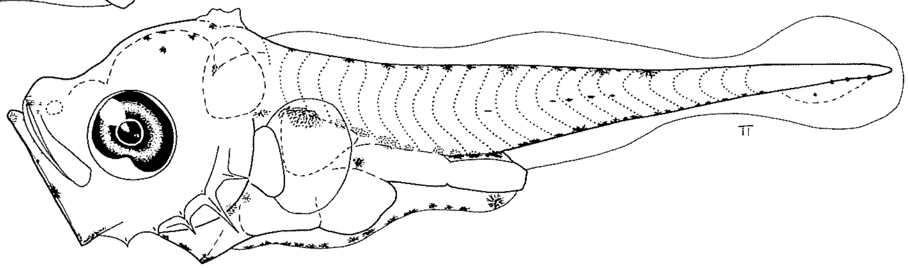
Material examined 21 larvae, 3.6–12.8 mm BL, coastal waters of eastern Tasmania.

Additional references Crossland (1982).

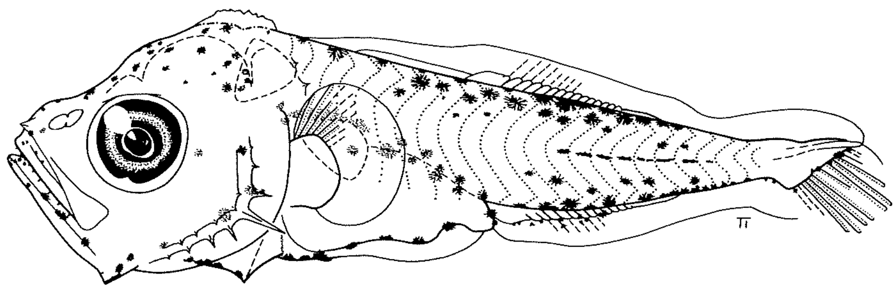
Figure 58 Larvae of *Trachurus declivis*. **A** Preflexion. **B** Preflexion. **C** Early flexion; note pelvic-fin bud. **D** Dorsal view of larva in C. **E** Postflexion. **F** Late postflexion. A–C, E, F from eastern Tas coastal waters. Illustrated by T. Trnski.



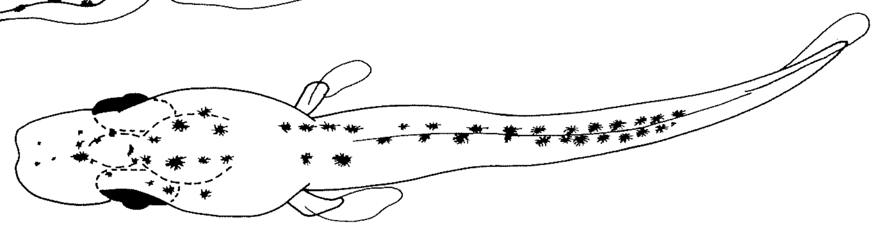
A 3.6 mm



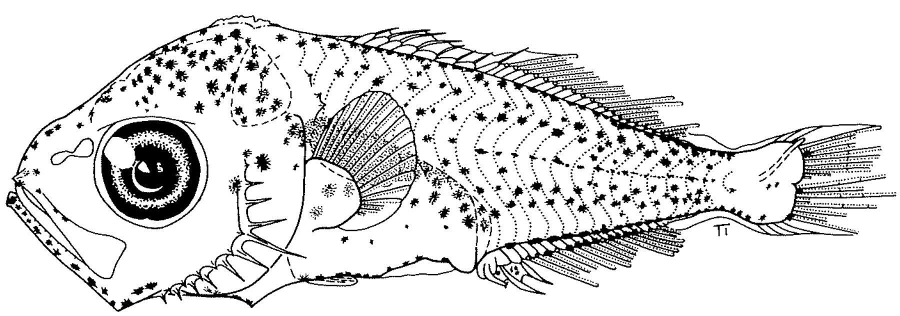
B 4.6 mm



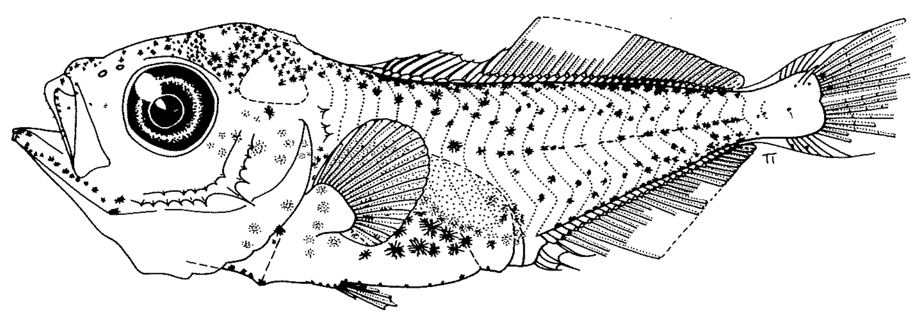
C 6.7 mm



D 6.7 mm



E 7.8 mm



F 12.8 mm

Carangidae *Trachurus novaezelandiae* Richardson, 1843 Yellowtail scad

D VIII + I, 27–33 A II + I, 22–29 P_1 21–22 P_2 I, 5 C 17 V 24

Adults Distributed around southern Australia from Exmouth Gulf (WA) to Wide Bay (Qld), rare in Tasmania; also around Lord Howe Island and New Zealand. Usually found in large schools in estuaries, bays and shallow coastal marine waters, but also recorded to a depth of 500 m. Adults are elongate and compressed, and have a primary lateral line with 67–81 scutes, a secondary lateral line reaching to dorsal-fin ray 2, and a yellow caudal fin. Maximum size 50 cm (Last *et al.*, 1983; Hoese & Hanley, 1989d; Kailola *et al.*, 1993; Kuiter, 1993, 1996; Gomon *et al.*, 1994).

Importance to fisheries Fished commercially with purse seines mostly in New South Wales, with small catches from Western Australia. Total catches up to 200 tonnes per year. Used for human consumption and bait for recreational and commercial fishers (Kailola *et al.*, 1993).

Spawning Eggs are pelagic and spherical, 0.8–0.9 mm in diameter, and have a segmented yolk, and a single oil globule 0.20–0.27 mm (Crossland, 1981a). Spawning in New Zealand has been recorded in coastal waters at least 30 m deep between October and February (Crossland, 1982). Larvae have been caught entering Lake Macquarie (NSW) and adjacent coastal waters from September to June (Miskiewicz, 1987), and in coastal waters off Sydney throughout the year (Gray *et al.*, 1992; Gray, 1993).

Diagnostic characters

- 9–12 + 12–15 = 24 myomeres
- Serrate supraoccipital crest from early preflexion stage, low by 10 mm
- Melanophore laterally on gut below pectoral-fin base usually present, internal by 7–9 mm
- Melanophores along dorso- and ventrolateral surfaces of body from early postflexion stage

Description of larvae

Morphology Body moderate (BD 25–33%). Head moderate in preflexion larvae (HL 27–33%), large in postflexion larvae (HL 34–37%). Small teeth along premaxilla from preflexion stage, along dentary from late postflexion stage. Posterior preopercular spines short to moderate, spine at angle long until 10 mm; anterior preopercular spines short. Serrate supraoccipital crest from early preflexion stage, low but visible from 10 mm. One supracleithral and 1 posttemporal spine by late preflexion stage, a second supracleithral spine by late flexion stage. Low, smooth supraocular ridge from flexion stage. Gut long (PAL 52–60%), coiled and compact by 3.6 mm. Gas bladder conspicuous, inflated. Preanal membrane present until transformation stage. Scales begin to form at transformation.

Size at

Hatching	<3.3 mm
Notochord flexion	4.7–5.9 mm
Transformation	14.0–15.0 mm
Formation of fins:	

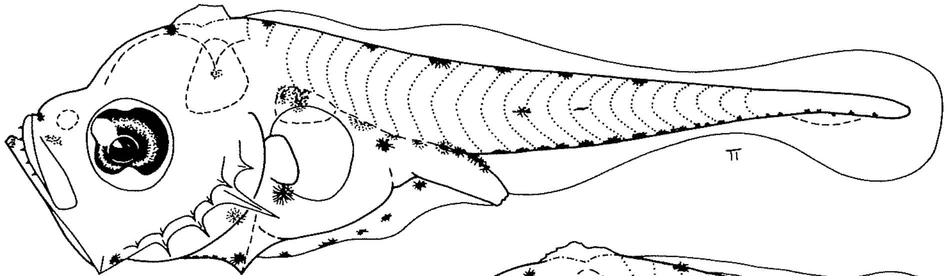
Caudal 3.6–5.9 mm; Anal 4.2–12.2 mm; Dorsal 4.4–12.2 mm; Pelvic 5.3–10.0 mm; Pectoral 5.3–12.2 mm

Pigmentation Larvae are initially lightly pigmented, becoming moderately pigmented from about 10 mm. *External:* None to a few melanophores on tip of snout and tip of lower jaw, 1–4 along dentary from preflexion stage, and 1 at angle of lower jaw. Melanophores over fore- and midbrain by flexion stage, over hindbrain by postflexion stage. One expanded melanophore at centre of opercle in postflexion larvae. One to three ventral melanophores along isthmus and 1 at cleithral symphysis from late preflexion stage. Series of melanophores along ventral midline of gut and preanal membrane. One expanded melanophore laterally on gut below pectoral-fin base (sometimes absent on one side), internal by 7–9 mm. Five to seven expanded melanophores along dorsal midline of trunk and tail in preflexion larvae, >15 in postflexion larvae. Melanophore series along lateral and ventral midlines of tail, latter reaching notochord tip. Melanophores ventrolaterally on tail and over dorsolateral surface of trunk and tail from early postflexion stage. *Internal:* Melanophores on roof of mouth, at junction of mid- and hindbrain, under opercle, and dorsally over gas bladder and gut; pigment laterally over gut by postflexion stage.

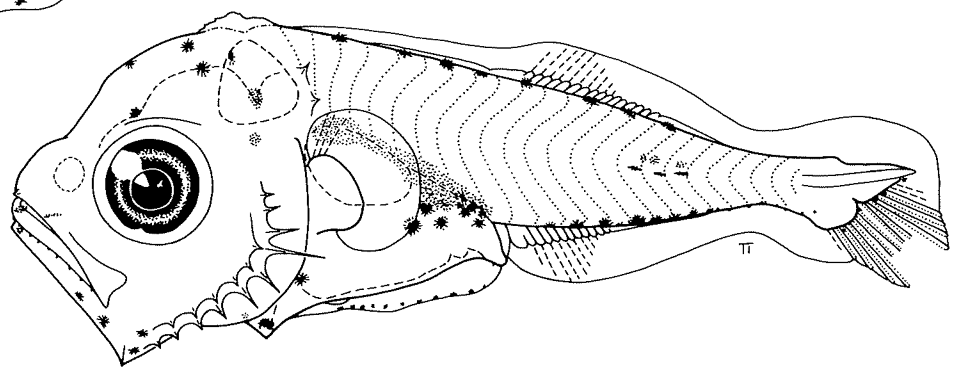
Material examined 21 larvae, 3.3–14.4 mm BL, and 5 juveniles, 15.0–21.0 mm BL, coastal waters of northern and central New South Wales, and Botany Bay (NSW).

Additional references Crossland (1981a).

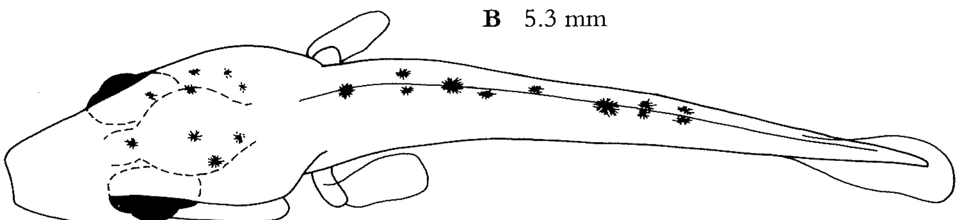
Figure 59 Larvae of *Trachurus novaezelandiae*. **A** Preflexion. **B** Flexion; note pelvic-fin bud. **C** Dorsal view of larva in B. **D** Postflexion. **E** Late postflexion. A, B, D, E from NSW coastal waters. Illustrated by T. Trnski.



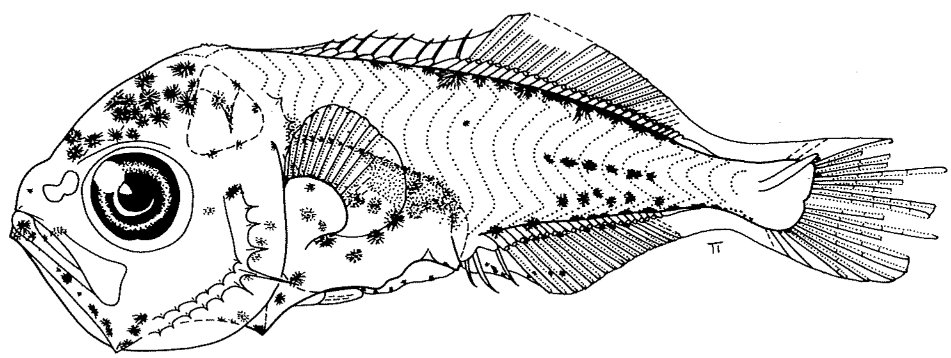
A 3.6 mm



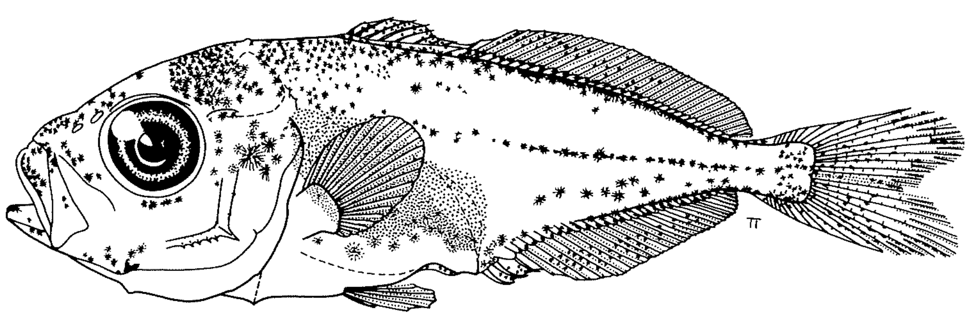
B 5.3 mm



C 5.3 mm



D 7.1 mm



E 13.8 mm

Chandidae (=Ambassidae): Glassfishes

A.G. Miskiewicz

Chandids are small, partly transparent fishes found in fresh, estuarine and coastal marine waters of the Indo-Pacific (Allen & Burgess, 1990). The family (also named Ambassidae) comprises 8 genera and 41 species (Nelson, 1994). Three genera and 14 species have been recorded from Australia, one genus and three species (one freshwater) in temperate regions (Allen & Cross, 1989b; Allen, 1996). Adults (most <10 cm) have a deeply notched, single dorsal fin, and serrations on various head bones including the preorbital, infraorbital and preopercular (Allen & Burgess, 1990; Allen, 1996). Eggs of *Ambassis* spp. are pelagic and spherical, 0.5–0.8 mm in diameter, and have a single oil globule (Nair, 1957; Eng, 1969; Venkataramanujam, 1975; Semple, 1985). Larvae have been described for representatives of *Ambassis* and have no apparent specialisations to pelagic life (Kinoshita, 1988b; Leis & Trnski, 1989).

Meristic characters of the chandid genus of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Ambassis	(3)	VII–VIII, 7–11	III, 7–11	11–15	I, 5	17	10 + 14 = 24

Main characters of chandid larvae
- 24–25 myomeres
- Body moderate (BD 27–36%), laterally compressed
- Small size at flexion (2.7–4.5 mm)
- Weak head spination, including small preopercular spines, infraorbital and interopercular spines, and weak supraocular and supracleithral ridges
- Gut moderate to long (PAL 35–53%), tightly coiled and compact
- Moderate gap between anus and origin of anal fin, becoming smaller as anus migrates posteriorly with growth
- Prominent gas bladder, initially over foregut but extending posteriorly with growth
- Pelvic fins thoracic, inserted posterior to origin of pectoral fins
- Melanophore at angle of lower jaw
- Melanophores along ventral midline of tail; little or no pigment in other areas of tail
- Pigment dorsally over gut and gas bladder
- Large internal melanophore at nape, and internal pigment over anterior surface of gut

References to chandid larvae

Kinoshita (1988b), Leis & Trnski (1989).

Families with similar larvae

Gerreidae – Long ascending premaxillary process; IX–X dorsal-fin spines.
Microcanthidae – X–XII dorsal-fin spines; 3–4 prominent, widely spaced melanophores ventrally along tail; pigment around notochord tip.
Nemipteridae – No head spines except for small posterior preopercular spines in some taxa after flexion stage (e.g. *Scolopsis*); X dorsal-fin spines; no melanophore at angle of lower jaw and none internally at nape.
Oplegnathidae – 25 vertebrae; >VIII dorsal-fin spines; small gap between anus and origin of anal fin; no pigment ventrally along tail.
Pinguipedidae – 29–34 myomeres; long-based dorsal and anal fins, with >19 rays; no gap between anus and origin of anal fin; pelvic fins inserted anterior to origin of pectoral fin.
Pomacentridae – 26–27 myomeres, typically 26; anal fin II, 10–18; pigment over head from early preflexion stage.
Sciaenidae – 24–29 myomeres, typically 25–26; long-based dorsal fin with >20 rays; large gap between anus and origin of anal fin; short-based, posteriorly located anal fin.
Sparidae – Body moderate to deep (BD 21–44%); small to moderate gap between anus and origin of anal fin.
Terapontidae – XI–XIII dorsal-fin spines; large gap between anus and origin of anal fin.

Chandidae *Ambassis jacksoniensis* (Macleay, 1881) Port Jackson perchlet

D VIII, 9–11 A III, 8–9 P_1 14–15 P_2 I, 5 C 17 V 24

Adults Endemic to eastern Australia from Moreton Bay (Qld) to Narooma (NSW). Small schooling species found in estuaries and coastal marine waters. Adults have a single supraorbital spine, a short-based, deeply notched dorsal fin, and are transparent and silvery. Maximum size 7 cm (Allen & Burgess, 1990; Kuiter, 1993).

Importance to fisheries –

Spawning Eggs undescribed. Eggs of *Ambassis* spp. are pelagic and spherical, 0.5–0.7 mm in diameter, and have a single oil globule 0.15–0.20 mm (Nair, 1957; Eng, 1969; Venkataramanujam, 1975; Semple, 1985). In New South Wales, larvae have been caught entering Lake Macquarie from September to July, with peak abundances between February and May (Miskiewicz, 1987), entering Tuggerah Lakes from January to May and in August (Marsden, 1986), and in coastal waters off Sydney from November to May (Gray *et al.*, 1992).

Diagnostic characters

- 6–10 + 14–19 = 24–25 myomeres
- BDA 12–17% in preflexion larvae, 20–25% in postflexion larvae
- Saddle of heavy pigment extending from nape to under midbrain in preflexion and flexion larvae
- Enlarged stellate melanophore on ventral surface of tail in preflexion and flexion larvae, becoming small and internal in postflexion larvae

Description of larvae

Morphology Body moderate (BD 25–34%); BDA 12–17% in preflexion larvae, 20–25% in postflexion larvae. Head moderate (HL 22–33%). Minute teeth along both jaws by early flexion stage. Small posterior preopercular spines from late flexion stage, a few anterior preopercular spines by postflexion stage. One interopercular spine by 6.8 mm, 1 opercular spine by 9.5 mm, and 1 supraorbital spine by about 11 mm. Gut moderate to long (PAL 35–53%), coiled and compact. Prominent gas bladder above foregut in preflexion larvae, increasing in size and extending posteriorly over gut with growth. Moderate gap between anus and origin of anal fin, reduced as anus migrates posteriorly. Scales form at about 10 mm.

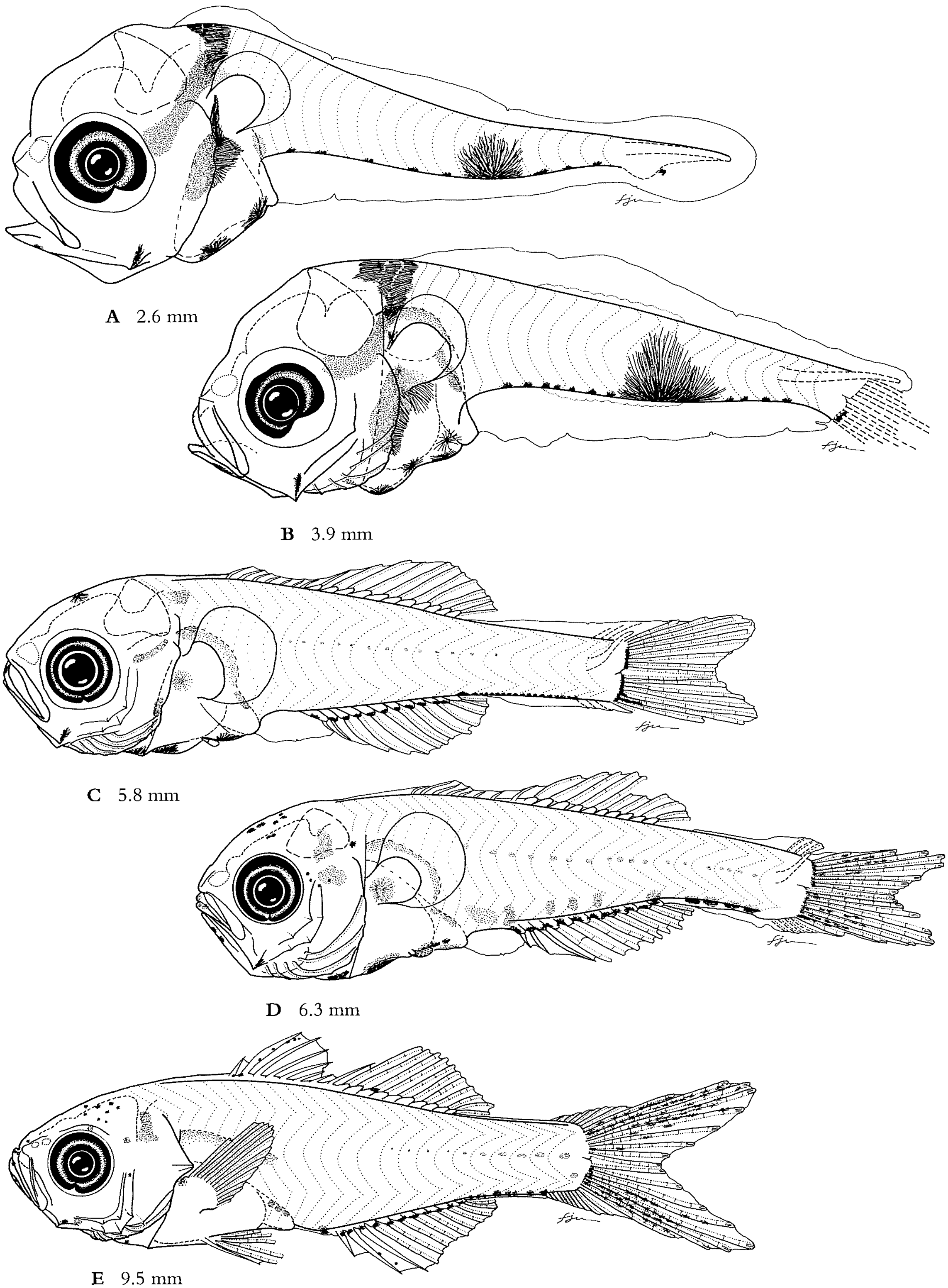
Size at	
Hatching	<2.0 mm
Notochord flexion	3.4–4.5 mm
Settlement	~10.0 mm
Formation of fins:	
Caudal 2.6–4.5 mm; Dorsal 3.9–5.8 mm; Anal 3.9–6.3 mm; Pelvic 5.7–7.5 mm; Pectoral 7.1–9.5 mm	

Pigmentation Larvae are lightly pigmented. *External:* 1 prominent melanophore at angle of lower jaw, 1–2 on gular membrane. A few melanophores over midbrain from early postflexion stage, over hindbrain by 9.5 mm; heavy pigment dorsally over head by settlement. Several melanophores scattered on snout, jaws and opercular area in postflexion larvae. Pigment on nape in preflexion and flexion larvae, becoming internal in late flexion larvae. Two large melanophores ventrally on gut, 1 at pectoral-fin base. Series of 8–11 small melanophores along ventral midline of tail in preflexion and flexion larvae, melanophore about midway along tail enlarged and stellate; anterior melanophores lie on distal tip of each anal-fin pterygiophore, enlarged melanophore becomes small and remains at rear of anal-fin base, and posterior melanophores remain ventrally along caudal peduncle in postflexion larvae. One or two melanophores under notochord tip in preflexion larvae; numerous along caudal-fin base in postflexion larvae, and along caudal-fin rays from about 6 mm. A few melanophores along dorsal-fin base, and on membrane of dorsal and anal fins from about 6.5 mm. *Internal:* Heavy pigment extending from nape to under midbrain in preflexion and flexion larvae. Dense pigment dorsally over gas bladder, 1 large stellate melanophore over peritoneum and 1 dorsally over hindgut. Series of melanophores ventrally along tail in early postflexion larvae. Series of melanophores dorsally over caudal vertebrae in postflexion larvae from 5.5 mm.

Material examined 32 larvae and juveniles, 2.0–13.7 mm BL, Lake Macquarie and Sydney Harbour (NSW).

Additional references Miskiewicz (1987).

Figure 60 Larvae of *Ambassis jacksoniensis*. **A** Preflexion. **B** Flexion. **C** Early postflexion; note pelvic-fin bud. **D** Postflexion. **E** Postflexion. A–E from Lake Macquarie (NSW). Illustrated by F. J. Neira.



A 2.6 mm

B 3.9 mm

C 5.8 mm

D 6.3 mm

E 9.5 mm

Chandidae *Ambassis marianus* Günther, 1880 Estuary perchlet

D VII–VIII, 9–10 A III, 10–11 P_1 13–15 P_2 I, 5 C 17 V 24

Adults Endemic to eastern Australia from Maryborough (Qld) to Narooma (NSW). Small schooling species found in the lower reaches of streams and in estuaries. Adults have 2–4 supraorbital spines, a short-based and deeply notched dorsal fin, and are transparent and silvery with dusky scale edges. Maximum size 10 cm (Allen & Burgess, 1990; Kuiter, 1993; Allen, 1996).

Importance to fisheries –

Spawning Eggs undescribed. Eggs of *Ambassis* spp. are pelagic and spherical, 0.5–0.7 mm in diameter, and have a single oil globule 0.15–0.20 mm in diameter (Nair, 1957; Eng, 1969; Venkataramanujam, 1975; Semple, 1985). Larvae have been caught in the entrance channel and within Lake Macquarie (NSW) from November to April, with peak abundances between December and March (Miskiewicz, 1987), and in the entrance channel of Tuggerah Lakes (NSW) in February and March (Marsden, 1986).

Diagnostic characters

- 7–10 + 14–17 = 24 myomeres
- BDA 15–18% in preflexion larvae, 29–33% in late postflexion larvae
- Series of small melanophores along ventral midline of tail

Description of larvae

Morphology Body moderate (BD 31–36%); BDA 15–18% in preflexion larvae, 29–33% in late postflexion larvae. Head moderate to large (HL 27–38%). Small teeth on premaxilla in early preflexion larvae. Small posterior preopercular spines from late flexion stage, anterior preopercular spines by early postflexion stage. One interopercular spine by about 6.3 mm; 1 opercular spine by about 11 mm. Gut moderate in preflexion larvae (PAL 37–44%), moderate to long in flexion and postflexion larvae (PAL 43–53%), coiled and compact. Prominent gas bladder above foregut in preflexion larvae, increasing in size and extending posteriorly over gut with growth. Moderate gap between anus and origin of anal fin, reduced as anus migrates posteriorly. Scales form by 7.5 mm.

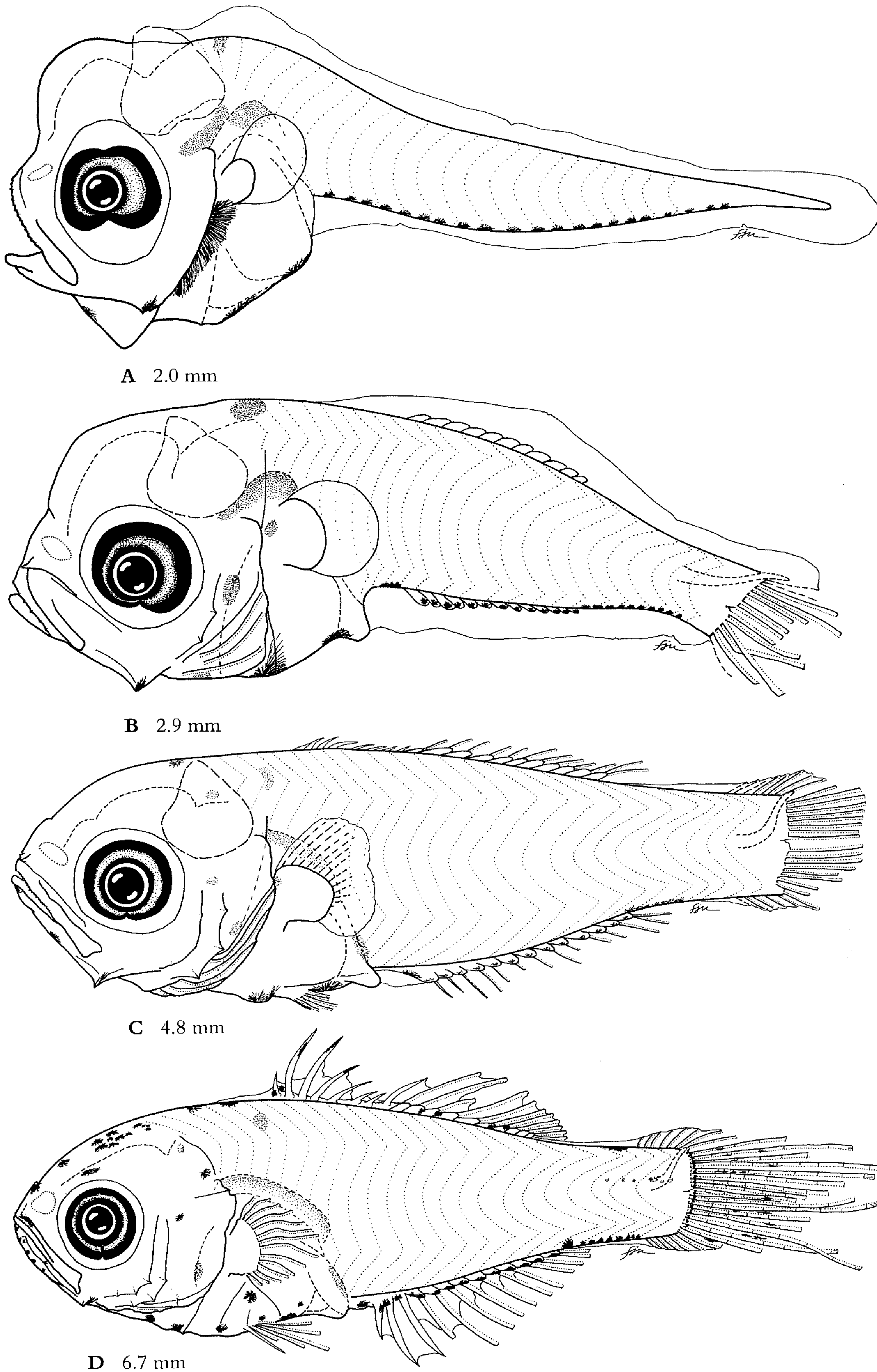
Size at	
Hatching	<1.6 mm
Notochord flexion	2.7–3.5 mm
Settlement	~10.0 mm
Formation of fins:	
Caudal 2.1–3.5 mm; Dorsal 2.5–5.0 mm; Anal 2.5–5.0 mm; Pelvic 4.3–4.8 mm; Pectoral 4.8–6.7 mm	

Pigmentation Larvae are lightly pigmented. *External:* Small melanophore at angle of lower jaw and 0–3 on gular membrane from preflexion stage; several melanophores scattered dorsally over head from late postflexion stage. Pair of melanophores at tip of upper and lower jaws, a pair on snout, and 1 on opercular region from 6.5 mm. Additional pigment on snout, jaws and opercle with growth. One small melanophore ventrally on isthmus, 2 large on ventral surface of gut, and 1 small on pectoral-fin base from 2.4 mm, latter absent by 6.7 mm; additional pigment on ventral and lateral surfaces of gut in postflexion larvae. Series of small melanophores along ventral midline of tail in preflexion larvae; anterior melanophores on distal tip of each anal pterygiophore from late flexion stage, posterior melanophores along caudal peduncle by 6.5 mm. A few melanophores scattered on base of dorsal-fin rays, tip of dorsal-fin spines and on caudal peduncle in late postflexion larvae. One or two melanophores occasionally present under notochord tip in preflexion larvae; pigment on base and along caudal-fin rays in late postflexion larvae. *Internal:* 1 large melanophore on nape. Dense pigment dorsally over gas bladder; 1 large stellate melanophore on peritoneum and 1 dorsally over hindgut. Series of melanophores dorsally along posterior caudal vertebrae from 6.5 mm.

Material examined 27 larvae and juveniles, 1.6–12.8 mm BL, Lake Macquarie, Botany Bay and Port Hacking (NSW).

Additional references Miskiewicz (1987).

Figure 61 Larvae of *Ambassis marianus*. **A** Preflexion. **B** Flexion; note developing dorsal and anal fins. **C** Early postflexion. **D** Postflexion. A–C from Lake Macquarie (NSW); D from Botany Bay (NSW). Illustrated by F. J. Neira.


A 2.0 mm
B 2.9 mm
C 4.8 mm
D 6.7 mm

Cheilodactylidae: Morwongs

B.D. Bruce

Cheilodactylids are demersal marine fishes found in the northwest Pacific and temperate regions of the southern Atlantic, Indian and Pacific oceans, with a small number of species also extending into tropical waters. They occur primarily in shelf waters, with at least one species reaching the upper slope (Lamb, 1990). The family contains 5 genera (although the status of these is conjectural) and about 18 species (Allen & Heemstra, 1976; Smith, 1980, 1986c; Randall, 1983; Lamb, 1990; Nelson, 1994). Three genera and 9 species have been recorded from temperate Australia (Lamb, 1990; Kuiter, 1993; Gomon *et al.*, 1994). Several species have commercial importance (Kailola *et al.*, 1993). Adults (to 1 m) are oblong and compressed, have a small, terminal, thick-lipped mouth, and pectoral fins with the lower 4–7 rays usually thickened, unbranched and partially detached from the rest of the fin. Eggs are pelagic and spherical, 0.9–1.1 mm in diameter, and have a single, pigmented oil globule (Mito, 1966; Robertson, 1975a, 1978; Brownell, 1979; Ikeda & Mito, 1988). Larvae have been described for representatives of *Cheilodactylus* and *Nemadactylus* (Brownell, 1979; Konishi, 1988f; Bruce, 1989b). Most species appear to have an extended pelagic 'paperfish' stage, during which they become silvery, deep and laterally compressed, and attain lengths of 60–90 mm (Vooren, 1972; Allen & Heemstra, 1976). The strongly compressed body, and the prominent ventral keel attained during the late postflexion stage, are the only apparent specialisations of cheilodactylid larvae to pelagic life (Bruce, 1989b).

Meristic characters of cheilodactylid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Cheilodactylus	(5)	XVI–XVIII, 24–34	III, 8–10	13–14	I, 5	15	34–35
Dactylophora	(1)	XV–XVI, 24–26	III, 9–10	14	I, 5	15	–
Nemadactylus	(3)	XVI–XVIII, 25–31	III, 14–19	14–15	I, 5	15	35–36

Main characters of cheilodactylid larvae
- 34–36 myomeres
- Body initially elongate, becoming moderate to deep and laterally compressed by postflexion stage (BD 14–35%)
- No head spines
- Gut long (PAL 51–61%), loosely coiled; hindgut straight in early stages
- Two ventral keels by late postflexion stage, anterior sharp and prominent and extending from isthmus to anus, posterior less conspicuous and along caudal peduncle
- Persistent preanal membrane, initially long but shortens with development
- Melanophore series over dorsal midline of trunk and tail, and lateral and ventral midlines of tail in early larvae; body heavily pigmented by postflexion stage
- Melanophores around notochord tip in some taxa
- Large size prior to settlement (up to 90 mm)

References to cheilodactylid larvae
Nielsen (1963), Mito (1966), Vooren (1972), Dudnik (1977), Tong & Saito (1977), Robertson (1978), Brownell (1979), Johnson (1984), Konishi (1988f), Bruce (1989b).

Families with similar larvae

Aplodactylidae – 16–21 dorsal-fin rays; 6–8 anal-fin rays; body heavily pigmented from early flexion stage; melanophores scattered on caudal finfold and around notochord tip in preflexion larvae; no pigment along lateral midline of tail in early stages.

Chironemidae – 33 myomeres; 14–20 dorsal-fin rays; 6–8 anal-fin rays; pigment on caudal finfold and around notochord tip; body heavily pigmented from late flexion stage.

Kyphosidae – 25–26 myomeres; weak head spination; short-based dorsal fin, XI, 12–16; no pigment along lateral midline of tail in early stages.

Latridae (*Latris*) – Long-based anal fin, III, 18–35; moderate gap between anus and origin of anal fin; gut straight; no pigment along lateral midline of tail.

Pomatomidae – 25–27 myomeres; weak preopercular spines; 2 dorsal fins; long-based anal fin, I–III, 23–28; gut coiled and voluminous from early preflexion stage; moderate gap between anus and origin of anal fin.

Scorpididae – 25–26 myomeres; moderate head spination; gut coiled from early preflexion stage; large gap between anus and origin of anal fin; pigment around notochord tip.

Sillaginidae (early stages) – Weak striations on midgut in some taxa; body lightly pigmented; melanophore series ventrally along gut.

Cheilodactylidae *Nemadactylus macropterus* (Foster, 1801) Jackass morwong

D XVII–XVIII, 25–28 A III, 14–15 P_1 14–15 P_2 I, 5 C 15 V 35

Adults Distributed around southern Australia from Rottnest Island (WA) to Sydney (NSW), including Tasmania; also in New Zealand, southern Africa and South America. Adults are found as individuals or in large schools in shelf and slope waters at depths of 25 to 450 m. Juveniles in southern Tasmania have been found in shallow, sheltered bays. Adults have elongate upper pectoral-fin rays and are silvery with a broad black band from the nape to the pectoral-fin base. Maximum size 70 cm (Last *et al.*, 1983; Hutchins & Swainston, 1986; Kailola *et al.*, 1993; Gomon *et al.*, 1994; Smith, 1994a; Kuiter, 1996).

Importance to fisheries Fished commercially mostly by trawling throughout southern Australia and in New Zealand, in shelf waters 100–200 m deep. Total catch in 1993 was 1250 tonnes. Also targeted by recreational fishers with hook and line (Kailola *et al.*, 1993; Gomon *et al.*, 1994; Smith, 1994a; Staples & Tilzey, 1994).

Spawning Eggs are pelagic and spherical, 0.9–1.0 mm in diameter, and have a smooth chorion, a narrow perivitelline space, an unsegmented yolk, and a single, pigmented oil globule 0.18–0.23 mm (Robertson, 1973). Spawning has been reported in Bass Strait between February and May (Smith, 1994a), and is thought to take place in midwater at night (Robertson, 1978). Larvae have been caught in coastal and offshore waters of Tasmania from March to June (Bruce *et al.*, 1996).

Diagnostic characters

- 14–15 + 20–22 = 34–36 myomeres
- Body moderate to deep from 12.5 mm (BD >35%)
- Two ventral keels, anterior extending from isthmus to anus and prominent, posterior along caudal peduncle and less obvious
- Conspicuous melanophore above angle of lower jaw from flexion stage
- 8–10 melanophores along ventral midline of tail

Description of larvae

Morphology Body elongate in preflexion larvae (BD 18–19%), moderate to deep in postflexion larvae (BD 24–41%), round and laterally compressed. Head moderate (HL 23–32%). Gut long (PAL 52–59%), loosely coiled. Gas bladder large when inflated, extending from over foregut to two-thirds distance to anus. First dorsal- and anal-fin rays transform into spines by 19–20 mm. Two ventral keels by late postflexion stage, anterior prominent and between isthmus and anus, posterior less obvious and along caudal peduncle; anterior ventral keel extends posteriorly from isthmus to pelvic fin by 9.1 mm and to anus by 11.4 mm; posterior ventral keel along caudal peduncle by 11 mm. Persistent preanal membrane until late postflexion stage; membrane between pelvic-fin base and anus gradually thickens to form extension of anterior ventral keel. Scales develop from 9.1–12.5 mm.

Size at

Hatching [1]	2.9–3.2 mm
Notochord flexion	5.2–7.5 mm
Settlement [2]	60.0–80.0 mm

Formation of fins:
Caudal 4.2–7.2 mm; Dorsal 4.6–12.4 mm; Anal 4.6–12.4 mm; Pectoral 6.4–12.4 mm; Pelvic 7.4–12.4 mm

[1] Robertson (1978), size shortly after hatching.
[2] Vooren (1972); A.R. Jordan, SFRL (pers. comm.).

Pigmentation Larvae are initially moderately pigmented, heavily pigmented by postflexion stage. *External:* Scattered melanophores over snout by late preflexion stage, contracted to tip of upper jaw during flexion stage. Scattered stellate melanophores dorsally over head; a dense melanistic shield anterodorsal to orbit by postflexion stage. One melanophore on lower jaw from preflexion stage, and at angle of lower jaw by flexion stage; additional melanophores over preopercle, opercle and base of branchiostegal rays from flexion stage. Two to five melanophores along isthmus from flexion stage. Single series of melanophores along dorsal midline of trunk and tail, paired from late preflexion stage, and extending from nape to caudal peduncle from postflexion stage. Series of 8–10 melanophores along ventral midline of tail, anteriormost 5–7 internal during flexion stage. Small melanophores along lateral midline of tail, extending dorsally and ventrally by early flexion stage, and anteriorly and posteriorly by early postflexion stage. Melanophore series dorsolaterally along trunk by early postflexion stage, forming a solid band from below nape to caudal peduncle by 9.1 mm. Melanophores coalesce over trunk and tail to form an evenly pigmented zone dorsolaterally by 9 mm, and ventrolaterally on tail by 11 mm. One melanophore on anterior margin of anal-fin bases and scattered over ventral keel by 19.3 mm. *Internal:* Melanophores on nape and scattered on otic capsule. Heavy pigment dorsally over gut and gas bladder. Anteriormost 5–7 melanophores along ventral midline of tail from flexion stage.

Material examined 18 larvae, 4.2–26.7 mm BL, coastal and offshore waters of eastern Tasmania.

Additional references Robertson (1973).

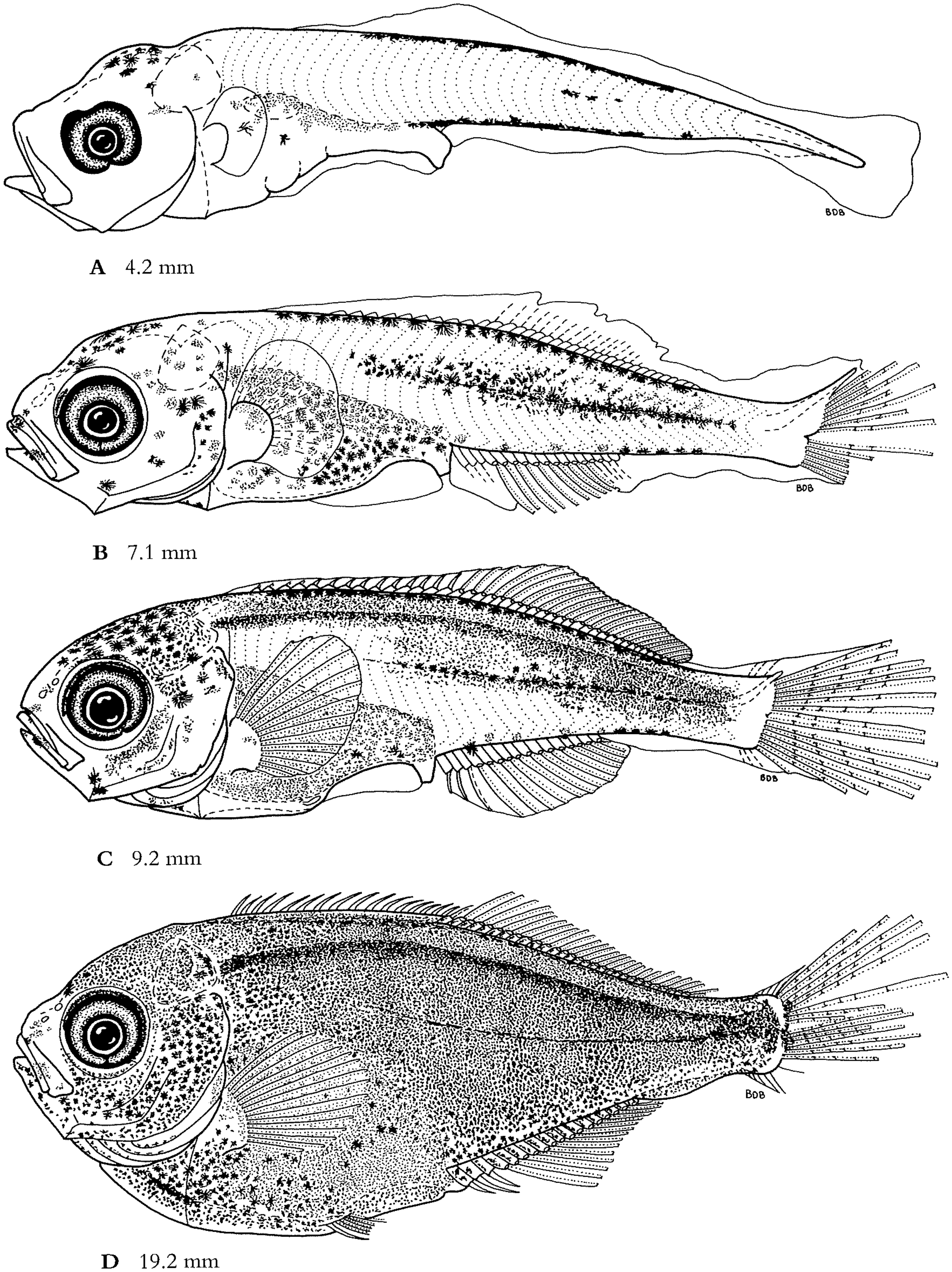


Figure 62 Larvae and paperfish stage of *Nemadactylus macropterus.* **A** Preflexion. **B** Late flexion. **C** Postflexion; note ventral keel anterior to pelvic-fin bud and preanal finfold. **D** Paperfish stage; myomeres and scales omitted. A–D from eastern Tas offshore waters. Illustrated by B.D. Bruce.

Chironemidae: Kelpfishes

F. J. Neira, A.G. Miskiewicz and D. Rissik

Chironemids are benthic marine fishes found in shallow coastal waters of Australia and New Zealand. The family comprises two genera and four species (Nelson, 1994). Both genera and three species have been recorded from temperate Australia (Kuiter 1993; Gomon *et al.*, 1994). Adults (20–40 cm) have a long-based, continuous dorsal fin with 28–37 elements, a long-based anal fin, large pectoral fins with elongate, unbranched lower rays, and a truncated or slightly rounded caudal fin (Last *et al.*, 1983). Eggs of *Chironemus spectabilis* are pelagic and spherical, 0.87–0.95 mm in diameter, and have a single oil globule (Robertson, 1975a). Larvae, which are described here for the first time, have no apparent specialisations to pelagic life.

Meristic characters of chironemid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Chironemus	(2)	XIV–XVI, 14–20	III, 6–8	14–15	I, 5	15–16	13–14 + 19–20 = 33
Threpterius	(1)	XIV, 18–19	III, 8	14	I, 5	15–16	13–14 + 19–20 = 33

Main characters of chironemid larvae
- 33 myomeres
- Body elongate to moderate (BD 10–28%); prominent finfold enclosing most of body in preflexion larvae
- No head spines
- Gut long (PAL 52–58%), initially straight but becoming coiled during late flexion stage
- Prominent preanal membrane present through to postflexion stage
- Pelvic fins abdominal, inserted midway between pectoral-fin bases and anus
- Body heavily pigmented from late flexion stage
- Melanophore series ventrally along gut in preflexion larvae
- Melanophore series along lateral midline of tail
- A few melanophores on caudal finfold and pigment around notochord tip

References to chironemid larvae –

Families with similar larvae

Aplodactylidae – 35 myomeres; light pigment ventrally along gut in preflexion larvae; no pigment along lateral midline of tail in early larvae; many small melanophores scattered on caudal finfold.

Bovichtidae (*Bovichtus*) – 37–38 myomeres; opercular spine; pelvic fins jugular; 2 dorsal fins, first with VIII spines; anal fin spineless, 12–18; no pigment on caudal finfold.

Cheilodactylidae – Body deep and laterally compressed in postflexion stage; long-based dorsal fin, 24–34 rays; 8–19 anal-fin rays; large size prior to settlement (up to 90 mm); no pigment on caudal finfold in preflexion larvae; most taxa lack pigment around notochord tip.

Latridae – 33–45 myomeres; long-based dorsal fin, XVII–XXIII, 23–40; long-based anal fin, III, 18–35; moderate gap between anus and origin of anal fin; gut straight; no pigment ventrally along gut or on caudal finfold in early larvae.

Sillaginidae (early stages) – 32–45 myomeres; weak striations on midgut in some taxa; anal fin II, 15–24; body lightly pigmented; no melanophores on caudal finfold in early larvae.

Chironemidae *Chironemus marmoratus* Günther, 1860 Eastern kelpfish

D XIV–XV, 16–20 A III, 6–8 P_1 15 P_2 I, 5 C 15–16 V 33

Adults Distributed along southeastern Australia from Cape Byron (NSW) to Wilsons Promontory (Vic), including northeastern Tasmania and Lord Howe Island; also in New Zealand. Commonly found in kelp and weed areas of shallow rocky reefs exposed to strong surge and wave action, to a depth of 20 m. Adults have evenly spaced white spots over the entire head and body. Maximum size 40 cm (Hutchins & Swainston, 1986; Kuiter, 1993; Gomon *et al.*, 1994; Edgar, 1997).

Importance to fisheries –

Spawning Eggs undescribed. Fertilised eggs have been reported attached to weeds inside holes (Pollard, 1980). Larvae have been caught in coastal waters of central New South Wales in July and August (I.M. Suthers, UNSW, pers. comm.).

Diagnostic characters

- 14–16 + 17–19 = 33 myomeres (difficult to count in heavily pigmented larvae)
- Short-based anal fin
- Series of melanophores along entire ventral surface of gut
- Series of melanophores along lateral midline of tail
- Melanophores scattered on caudal finfold and around notochord tip

Description of larvae

Morphology Body elongate to moderate in preflexion and flexion larvae (BD 10–21%), moderate in postflexion larvae (BD 25–28%). Dermal sac encloses most of body in preflexion larvae. Head small to moderate in preflexion larvae (HL 17–23%), moderate in flexion and postflexion larvae (HL 20–27%). Gut long (PAL 52–58%), intially straight, coiled anteriorly from late preflexion stage. Small gas bladder over foregut, usually not inflated. Preanal membrane present in all larvae.

Size at

Hatching	<3.7 mm
Notochord flexion	6.0–7.8 mm
Settlement	>8.2–<19.9 mm
Formation of fins:	

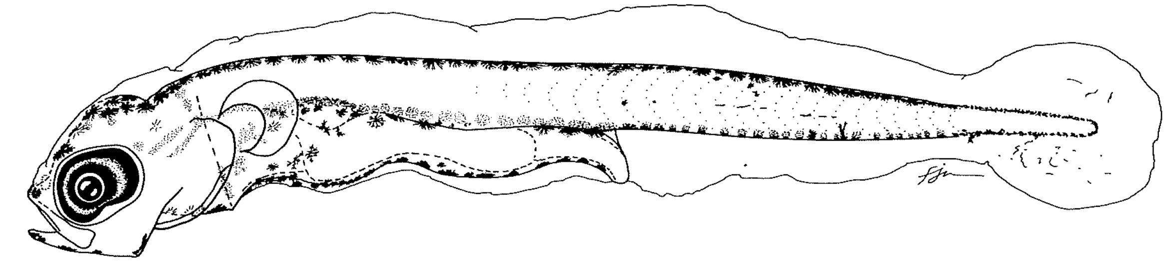
Caudal 5.3–7.9 mm; Dorsal 5.9–>8.2 mm; Anal 5.9–>8.2 mm; Pectoral 6.0–>8.2 mm; Pelvic 7.1–>8.2 mm

Pigmentation Larvae are moderately to heavily pigmented. *External:* One melanophore at angle of lower jaw; several over brain, tip of upper jaw, along lateral margin of lower jaw and on gular membrane. Melanophores on opercle by flexion stage, head heavily pigmented in postflexion larvae. Continuous series of melanophores from isthmus to anus; no pigment on preanal membrane. Scattered melanophores laterally on gut in preflexion larvae, increasing in number in postflexion larvae. Continuous melanophore series along entire dorsal surface of trunk and tail, and ventrally along tail. Melanophore series along lateral midline of tail in preflexion larvae, extending anteriorly along trunk and tail with growth. Heavy pigment over entire trunk and tail by postflexion stage. Numerous small melanophores around notochord tip; dorsal melanophores gradually disappear, ventral melanophores remain along base of caudal-fin rays in postflexion larvae. Scattered melanophores on caudal finfold in preflexion larvae; additional melanophores on caudal-fin membrane and along caudal-fin rays in postflexion larvae. *Internal:* Pigment in nostril region, on mid- and hindbrain, and under brain. Heavy pigment dorsally over gas bladder and gut.

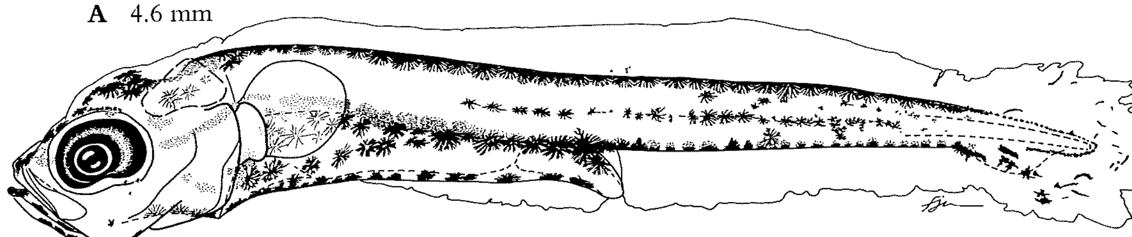
Material examined 24 larvae, 3.7–8.2 mm BL, and 6 juveniles, 19.9–21.3 mm BL, coastal waters of northern and central New South Wales.

Additional references –

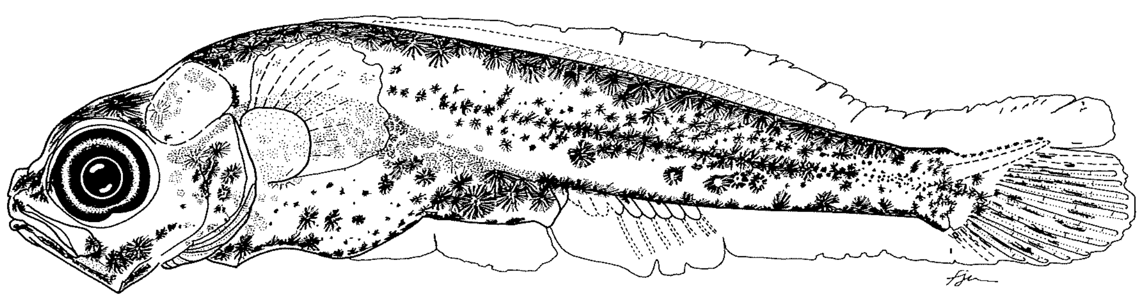
Figure 63 Larvae of *Chironemus marmoratus*. **A** Preflexion; note dermal sac enclosing most of body; anteriormost trunk myomeres not visible. **B** Late preflexion; note developing caudal fin. **C** Flexion; note developing pectoral-fin rays, and dorsal and anal fins. **D** Ventral view of larva in C. **E** Postflexion; note pelvic-fin bud. Myomeres omitted in B, C and E. A–C, E from NSW coastal waters. Illustrated by F. J. Neira.



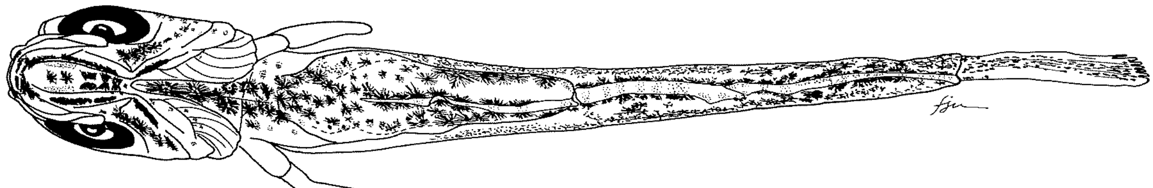
A 4.6 mm



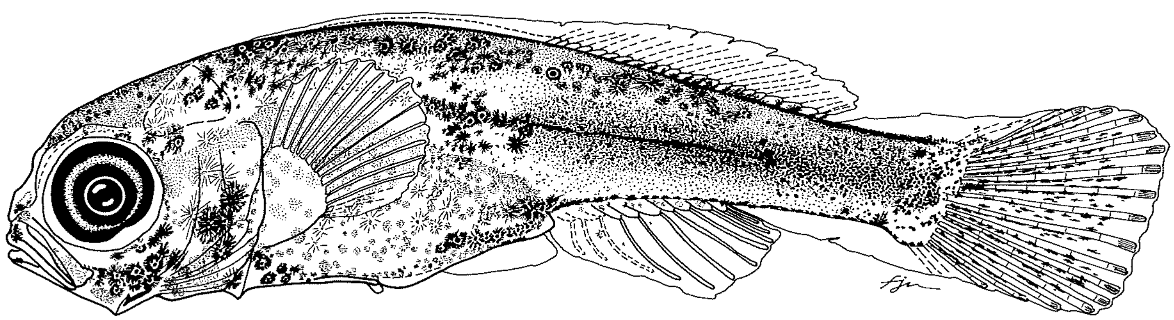
B 5.3 mm



C 6.6 mm



D 6.6 mm



E 8.2 mm

Enoplosidae: Old wife

A.G. Miskiewicz and T. Trnski

Enoplosids are a monotypic family endemic to coastal marine waters of southern Australia, with a single species, *Enoplosus armatus*. Adults (to 25 cm) are deep and laterally compressed, and have two produced, separate dorsal fins, the first with stout, venomous spines, large pelvic fins each with a strong spine, two sharp spines at the lower preopercular angle, and a silvery body with about eight black lateral vertical bars (Robins *et al.*, 1991; Kuiter, 1993; Gomon *et al.*, 1994). Adults resemble boarfishes (family Pentacerotidae) to which they have been proposed to be closely related (Nelson, 1984; Robins *et al.*, 1991). The similarity in appearance between small juveniles of the Enoplosidae and those of the Banjosidae and Terapontidae also led to suggestions of a possible relationship between the three families (Kuiter, 1993). However, neither proposal is supported by recent studies on larval pentacerotids (Johnson, 1984; Mundy & Moser, in press) or terapontids (Leis & Trnski, 1989; this book). Eggs are pelagic and spherical, 1.0–1.2 mm in diameter, and have a single oil globule (H. Arai, TSLP, pers. comm.). Larvae are described here for the first time. The small to moderate preopercular spines, two of which are retained in the adults, are the only apparent specialisation of enoplosid larvae to pelagic life.

Meristic characters of the enoplosid species of temperate Australia

	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Enoplosus armatus	VIII + I, 14–15	III, 14–15	12–14	I, 5	17	10 + 16 = 26

Main characters of enoplosid larvae

- 26 myomeres
- Body elongate to moderate (BD 19–37%), depth increasing with growth
- Mouth reaches to below anterior half of eye
- Moderate posterior preopercular spines
- Gut long (PAL 57–69%), initially straight and coiled after flexion stage
- Body moderately to heavily pigmented; caudal peduncle unpigmented
- Prominent pigment on tip of premaxilla and dentary
- Small melanophores scattered along preanal finfold and over anal finfold in early larvae

References to enoplosid larvae –

Families with similar larvae

Carangidae (preflexion *Seriola*) – Prominent preopercular and supraocular spines; pigment around notochord tip.

Chaetodontidae (early stages) – Early forming bony plates on head; small mouth; prominent, broadly based preopercular spine at angle, either flat, serrate or strongly barbed.

Haemulidae (some heavily pigmented taxa) – Early forming, moderate preopercular spines; late forming fin spines.

Macrorhamphosidae (early stages) – Elongate snout; keel along lateral midline of tail (modified scales).

Mugilidae – No head spines except for weak serrations on infraorbital in some taxa; 2 well separated, short-based dorsal fins; posteriorly located pelvic fins; gut large and voluminous.

Pentacerotidae – Well developed and extensive head spination, including a median supraoccipital crest, prominent preopercular spines, and a large, strongly serrate supraocular spine; single dorsal fin with >VIII spines; elongate pelvic fins.

Plesiopidae (heavily pigmented taxa) – 24–35 myomeres (excludes *Trachinops*); large mouth, reaching below middle to posterior of eye; single dorsal fin with >X spines; pelvic fins I, 2 or I, 4; caudal peduncle laterally compressed and deep in postflexion stage.

Pomacentridae – Single dorsal fin with >VIII spines; anal fin II, 10–18; small gap between anus and origin of anal fin in some taxa; body lightly pigmented in most taxa, moderately pigmented after flexion stage.

Serranidae (Anthiinae, *Acanthistius*) – Moderate to extensive head spination, including prominent preopercular spines and an interopercular spine; single dorsal fin, XIII, 13–15; anal fin III, 8; body heavily pigmented from late preflexion stage.

Sphyraenidae – Gut straight and long, extending to about midbody, with striations; 2 well separated, short-based dorsal fins; posteriorly located, short-based anal fin; body moderately pigmented prior to late postflexion stage.

Enoplosidae *Enoplosus armatus* (White, 1790) Old wife

D VIII + I, 14–15 A III, 14–15 P_1 12–14 P_2 I, 5 C 17 V 26

Adults Endemic to southern Australia from Kalbarri (WA) to Noosa Head (Qld), including northern Tasmania. Juveniles reside in estuaries while adults occur in estuaries and in kelp beds on coastal reefs to a depth of at least 90 m, either in large schools, in pairs or as solitary individuals. Adults are a silver to brown with black vertical stripes. Maximum size 25 cm (Hutchins & Swainston, 1986; Kuiter, 1993, 1996; Edgar, 1997).

Importance to fisheries An attractive aquarium fish (Edgar *et al.*, 1982).

Spawning Eggs are pelagic and spherical, 1.0–1.2 mm in diameter, and have a smooth chorion, an unsegmented yolk, and a single oil globule 0.25–0.28 mm (H. Arai, TSLP, pers. comm.). Spawning has been reported in spring, with adults forming closely associated pairs (Thresher, 1984). Spawning has also been reported in winter in Victoria, based on the occurrence of small juveniles in early spring (Kuiter, 1993). Larvae have been caught entering Lake Macquarie and in coastal waters off Sydney (NSW) from November to March (Miskiewicz, 1987; Gray, 1995).

Diagnostic characters

- 10–16 + 11–16 = 26–27 myomeres (difficult to see after preflexion stage because of heavy pigment)
- Moderate preopercular spines in postflexion larvae
- Body heavily pigmented; pigment concentrated on dorsal and ventral surfaces of trunk and tail in preflexion larvae

Description of larvae

Morphology Body elongate to moderate in preflexion and flexion larvae (BD 19–28%), moderate in postflexion larvae and juveniles (BD 26–39%). Head moderate in preflexion larvae (HL 25–32%), large from flexion stage (HL 35–43%). Small teeth along lower jaw by late flexion stage. Two small posterior preopercular spines at angle from late flexion stage, up to 7 in postflexion larvae, most reducing in size with growth; preopercle serrate by settlement, 2 spines at angle remaining in adults. Gut long (PAL 57–69%), initially straight, coiled by late flexion stage. Small gas bladder over foregut, obscured by pigment with growth.

Size at	
Hatching [1]	2.5–2.7 mm
Notochord flexion	~ 4.0–6.3 mm
Settlement	12.0–15.0 mm
Formation of fins:	
Caudal 3.2–6.3 mm; Dorsal 3.4–7.8 mm; Anal 3.4–7.8 mm; Pelvic 4.7–8.7 mm; Pectoral 5.7–8.7 mm	

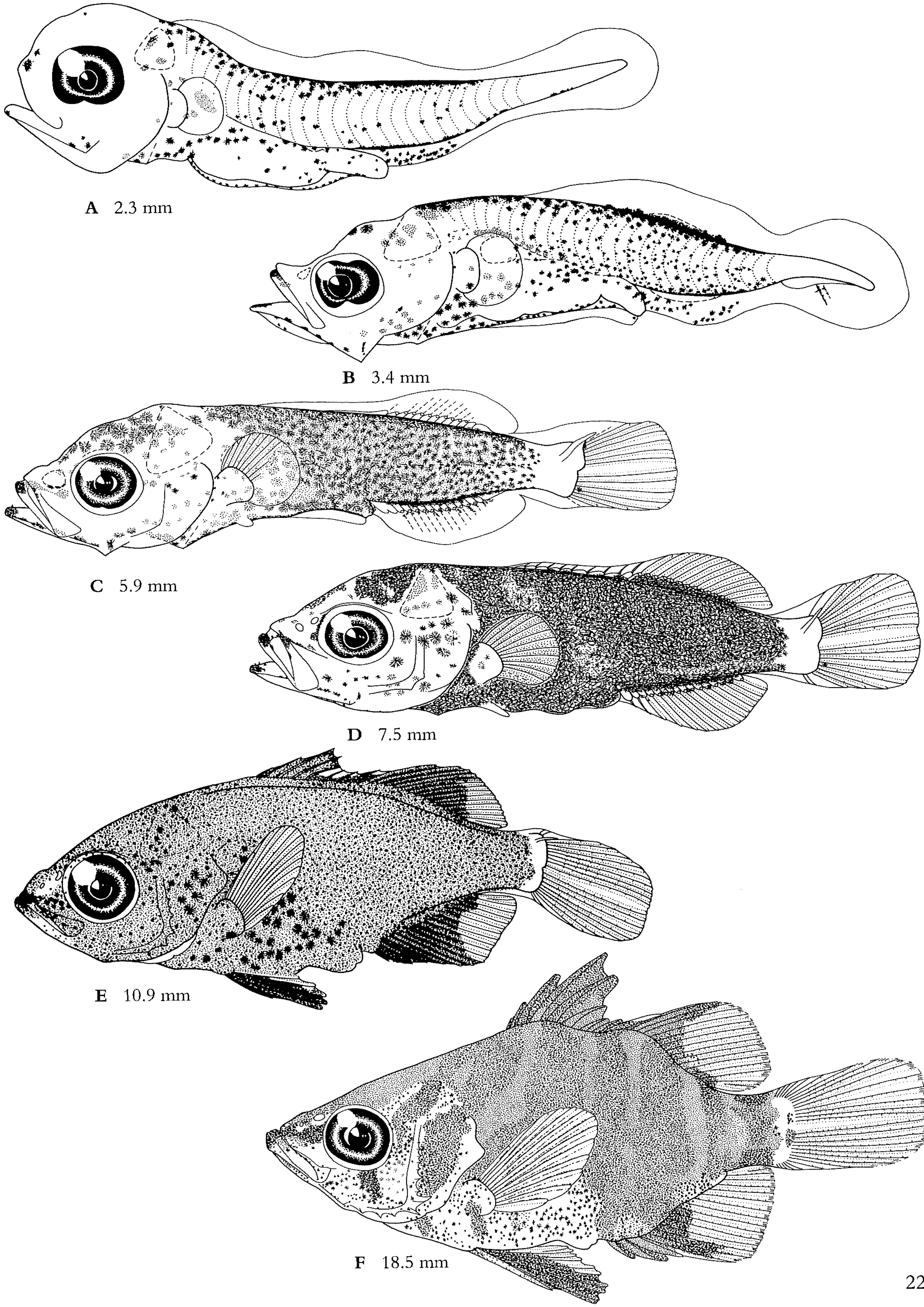
[1] Total length from larvae reared by H. Arai (TSLP).

Pigmentation Larvae are heavily pigmented. *External:* 1 melanophore each on tip of upper and lower jaws, a series of small melanophores along margin of dentary, 1 at angle of lower jaw, and several over brain in preflexion larvae. Pigmentation on head and opercle increases with growth. A patch of pigment on isthmus and 1–2 melanophores on cleithrum. Heavy pigment on ventral midline and lateral surface of gut. Numerous melanophores scattered on trunk and tail, heaviest along dorsal and ventral surfaces, increasing in density with growth. One or two melanophores ventrally along tip of notochord, remaining along base of lower caudal-fin rays in postflexion larvae until about 8 mm. One melanophore on pectoral-fin base in preflexion larvae; pigment along pectoral-fin rays in postflexion larvae. Pigment over membranes of dorsal, anal and pelvic fins in postflexion larvae, extending to tip of spines and to anteriormost rays. *Internal:* Saddle of pigment over hindbrain, and pigment under brain. Heavy pigment dorsally over gas bladder and gut.

Material examined 23 larvae, 2.3–13.9 mm BL, and 1 juvenile, 12.0 mm BL, Lake Macquarie, and coastal waters off central and southern New South Wales; 3 juveniles, 14.6–16.1 mm BL, Kangaroo Island (SA); 1 juvenile, 18.5 mm BL, Cockburn Sound (WA).

Additional references –

Figure 64 Larvae and juvenile of *Enoplosus armatus*. **A** Preflexion. **B** Preflexion; note developing dorsal and anal fins. **C** Late flexion; note pelvic-fin bud. **D** Postflexion. **E** Postflexion. **F** Juvenile. A–C from Sydney coastal waters (NSW); D from coastal waters off Botany Bay (NSW); E from Botany Bay (NSW); F from Cockburn Sound (WA). Illustrated by T. Trnski.



A 2.3 mm

B 3.4 mm

C 5.9 mm

D 7.5 mm

E 10.9 mm

F 18.5 mm

Gadopsidae: Freshwater blackfishes

J.M. Kalish, M. Lintermans and F. J. Neira

Gadopsids are endemic to fresh waters of southeastern Australia including Tasmania. They are typically found in fast-flowing streams with a cobble and sand substrate and shelter in the form of woody debris (Davies, 1989; Koehn, 1990). The family comprises the genus *Gadopsis* and two species, *G. bispinosus* and *G. marmoratus* (Last *et al.*, 1983; Merrick & Schmida, 1984; Sanger, 1984; Allen, 1989; Jackson *et al.*, 1996). Johnson (1984) placed *Gadopsis* in the Percichthyidae, based on several specialisations that it shares with some percichthyids including enlarged sensory pores on the dentary and a separate inner division of the adductor mandibulae section. While Eschmeyer & Bailey (1990) and Nelson (1994) also place *Gadopsis* in the Percichthyidae, we have retained the genus in the Gadopsidae until a more detailed taxonomic review of the group. Adults (to 63 cm) are elongate, have a large mouth, long-based dorsal and anal fins, jugular pelvic fins reduced to a single bifid ray, and small cycloid scales. Both gadopsid species appear to spawn between late spring and early summer. Eggs are demersal and adhesive, 3–4 mm in diameter; fertilised eggs are guarded by the male until hatching (Jackson, 1978; Jackson *et al.*, 1996). Larvae have been described for *G. marmoratus* (Jackson, 1978), and have no apparent specialisations to pelagic life.

Merisitic characters of the gadopsid species of temperate Australia

	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
G. bispinosus	I–III, 35–38	III, 17–20	15–18	1	17	20–21 + 25–29 = 46–49
G. marmoratus	VI–XIII, 22–31	II–IV, 16–20	15–19	1	17	16–22 + 24–28 = 40–50

Main characters of gadopsid larvae
- 40–51 myomeres
- Body elongate (BD 11–18%)
- No head spines
- Gut moderate to long (PAL 49–60%), straight
- Long-based dorsal fin with 28–44 elements
- Pelvic fins jugular, with a single bifid ray
- Body lightly to heavily pigmented

References to gadopsid larvae

Jackson, (1978).

Families with similar larvae

Percichthyidae – 24–37 myomeres; posterior preopercular and opercular spines in transforming larvae; short-based dorsal fin, VII–XIII, 7–17; pelvic fins thoracic, I, 5.

Gadopsidae *Gadopsis bispinosus* Sanger, 1984 Two-spined blackfish

D I–III, 35–38 A III, 17–20 P_1 15–18 P_2 1 C 17 V 46–49

Adults Distributed in southeastern New South Wales, northeastern Victoria and the Australian Capital Territory (ACT), in drainages on the western slopes of the Great Dividing Range (southern and eastern catchments of the Murray River). Often abundant at altitudes of 200–700 m. Found in clear, cool streams with coarse gravel and boulder substrates. Adults are brown to blackish along the sides, with variable mottled or blotched patterns bordered by yellow, and whitish ventrally. Maximum size about 32 cm, although individuals larger than 25 cm are rare (Allen, 1989; Jackson *et al.*, 1996).

Importance to fisheries Often caught by recreational fishers when targeting trout, although not a desirable target species due to its small size. An attractive aquarium fish (Jackson *et al.*, 1996).

Spawning Eggs are demersal and adhesive, roughly hemispherical, about 3–4 mm in diameter, and golden-yellow. Eggs hatch after about 15–17 days at 15°C. Fecundity varies from 120 to 320 eggs. Spawning occurs between November and December and has only been observed in artificial tubes. Males guard the eggs and developing larvae until yolk sac is almost completely resorbed. Yolk-sac larvae remain attached to the substrate (Jackson *et al.*, 1996).

Diagnostic characters

- 20 + 29–30 = 49–50 myomeres
- Large yolk sac, resorbed by early postflexion stage
- Pelvic-fin buds form in yolk-sac larvae during flexion stage
- High number of dorsal-fin elements (36–41)
- Body lightly pigmented until late postflexion stage

Description of larvae

Morphology Body elongate (BD 11–18%). Head moderate (HL 17–30%). Gut moderate to long (PAL 49–60%), straight. Large yolk sac present through to late postflexion stage.

Size at

Hatching	6.5–7.0 mm
Notochord flexion	7.0–10.0 mm
Settlement	~ 11.0–13.0 mm

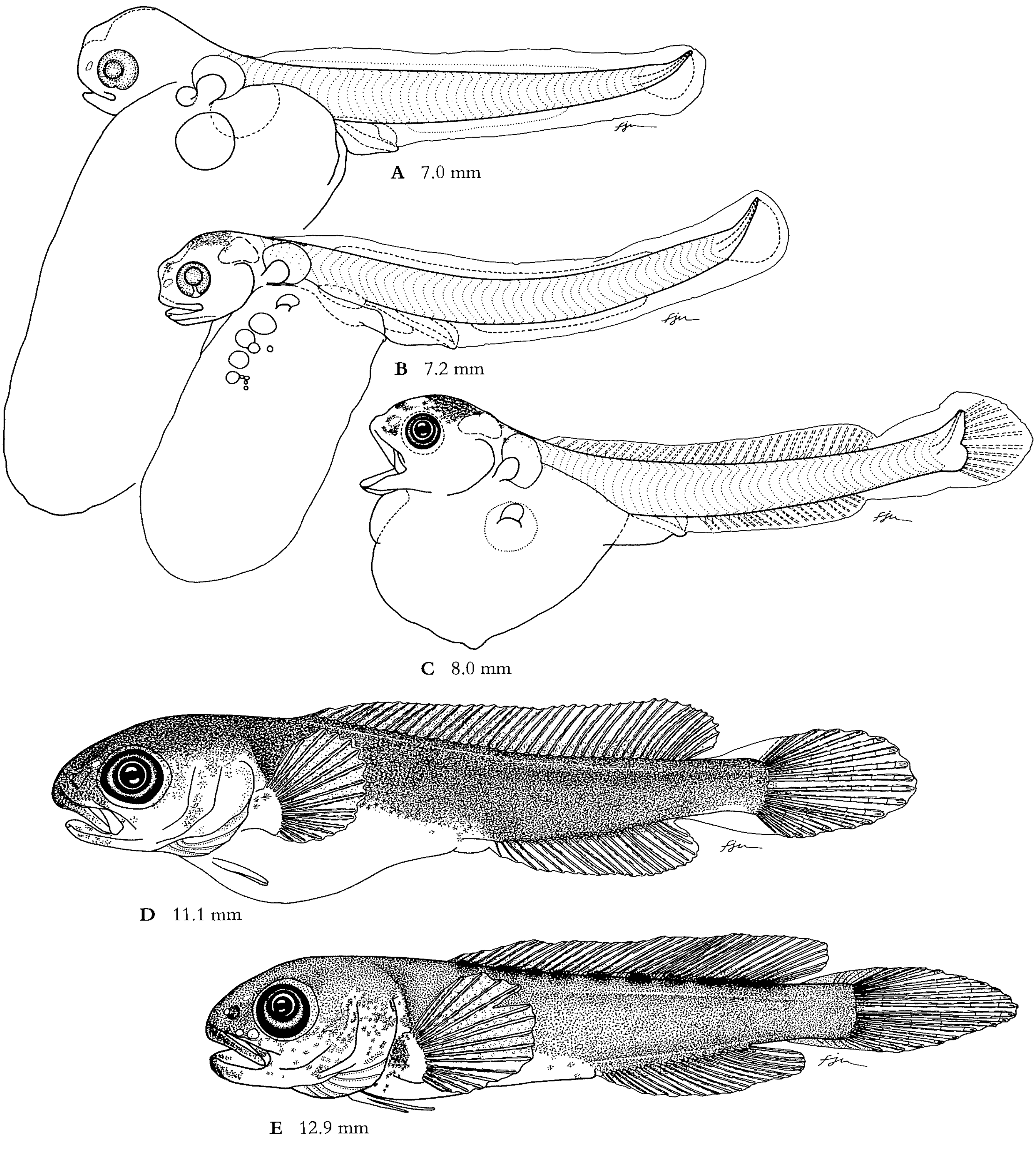
Formation of fins:
Dorsal 7.0–11.0 mm; Anal 7.0–11.0 mm; Caudal 7.0–12.0 mm; Pelvic 7.0–12.0 mm; Pectoral 8.5–11.0 mm

Pigmentation No pigment in early yolk-sac larvae, heavy pigment from late postflexion stage. *External:* Melanophores scattered on snout, dorsal surface of head and nape in early flexion larvae. Pigment intensifies from early postflexion stage and covers most of body except ventral surface of head and gut prior to settlement. Pigment on pectoral-fin base. Melanophores along spines, rays and on membranes between rays of all except pelvic fins in postflexion larvae from 11 mm. Pigment blotches along dorsal-fin base in settled juveniles. *Internal:* Melanophores over brain and peritoneum in postflexion larvae.

Material examined 18 larvae, 6.5–12.7 mm BL, laboratory-reared at the Australian National University, Canberra (ACT); 2 transformed juveniles, 11.1–12.9 mm BL, Upper Cotter River, Namadgi National Park (ACT).

Additional references –

Figure 65 Larvae and juvenile of *Gadopsis bispinosus*. **A** Late preflexion, 1 day old; spherical structures on upper yolk sac in this and larva in B are oil globules. **B** Early flexion, 5 days old; note pelvic-fin bud on upper region of yolk sac, and developing dorsal, caudal and anal fins. **C** Early postflexion, 11 days old. **D** Late postflexion; note remnants of yolk sac. **E** Juvenile. A–C reared at ANU (ACT); D, E from Cotter River (ACT). Illustrated by F. J. Neira.



A 7.0 mm

B 7.2 mm

C 8.0 mm

D 11.1 mm

E 12.9 mm

Gerreidae: Silver biddies

A.G. Miskiewicz and B.D. Bruce

Gerreids are predominantly marine fishes found in estuarine and coastal waters in tropical to temperate regions of the Indo-Pacific and the Atlantic Ocean. The family comprises 8 genera and about 40 species (Nelson, 1994). Two genera and 2 species have been recorded from temperate Australia (Kuiter, 1993; Gomon *et al.*, 1994). Adults (to 35 cm) have highly protrusible jaws, deciduous scales and a deeply forked caudal fin. Eggs of *Gerres* and of the Atlantic genera *Diapterus* and *Eugerres* are pelagic and spherical, 0.6–0.8 mm in diameter, and have a single oil globule (Mito, 1963; Rass, 1972; Ikeda & Mito, 1988; Eiras-Stofella & Fanta, 1991). Larvae have been described for representatives of *Eucinostomus*, *Eugerres* and *Gerres* (Leis & Rennis, 1983; Kinoshita, 1988f; Eiras-Stofella & Fanta, 1991; Watson, 1996i). The weak head spination is the only apparent specialisation of gerreid larvae to pelagic life (Leis & Rennis, 1983).

Meristic characters of gerreid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Gerres	(1)	IX–X, 9–11	III, 7–8	15–17	I, 5	17	10 + 14 = 24
Parequula	(1)	IX, 16–17	III, 16–18	14–15	I, 5	17	10 + 14 = 24

Main characters of gerreid larvae

- 24–25 myomeres
- Body elongate to moderate (BD 19–28%)
- Prominent, elongate ascending premaxillary process, visible from late preflexion stage; mouth highly protrusible in postflexion larvae due to ascending process
- Weak head spination, including small preopercular and supracleithral spines
- Gut short to long (PAL 22–54%), tightly coiled and compact
- Small to large gap between anus and origin of anal fin
- 2 melanophores ventrally along gut
- Melanophore series along ventral midline of tail

References to gerreid larvae

Uchida *et al.* (1958), Leis & Rennis (1983), Johnson (1984), Kinoshita (1988f), Watson (1996i).

Families with similar larvae

Chandidae – Lack elongate premaxillary ascending process; small to moderate gap between anus and origin of anal fin; internal pigment over anterior surface of gut; VII–VIII dorsal-fin spines.

Haemulidae – 26–28 myomeres; lack elongate premaxillary ascending process; gut long, extending from midbody to 74% BL.

Kuhliidae – Body elongate and compressed; lack elongate premaxillary ascending process; prominent melanophore cluster on hypural complex; body moderately pigmented in postflexion stage.

Microcanthidae – 25–26 myomeres; premaxillary ascending process short in most taxa; moderate head spination; pigment around notochord tip; pigment along dorsal midline of trunk and tail.

Mullidae – Lack elongate premaxillary ascending process; no head spines in most taxa; 3 melanophores in a triangular pattern on midbrain in late preflexion larvae; 2 well separated dorsal fins, first with VII–VIII spines; anal fin I, 6–7.

Nemipteridae – Lack elongate premaxillary ascending process; no head spines except for small posterior preopercular spines in some taxa by postflexion stage; X dorsal-fin spines.

Plesiopidae – 24–35 myomeres (37–40 in *Trachinops*); lack elongate premaxillary ascending process; X–XX dorsal-fin spines; pelvic fins I, 2 or I, 4.

Pomacentridae – 26–27 myomeres; ascending premaxillary process moderate in many taxa, never elongate; anal fin II, 10–18.

Sciaenidae – Lack elongate premaxillary ascending process; moderate head spination; dorsal fin XI, 25–31.

Sparidae – Body mostly moderate to deep (BD 21–44%); moderate head spination, including weak to strong preopercular spines; lack elongate premaxillary ascending process; X–XIII dorsal-fin spines.

Terapontidae – Weak to well developed head spination; lack elongate premaxillary ascending process; XI–XIII dorsal-fin spines.

Tripterygiidae – 33–43 myomeres; premaxillary ascending process moderate; no head spines; pelvic fins I, 2.

Gerreidae *Gerres subfasciatus* Cuvier, 1830 — Silver biddy

D IX–X, 9–11   A III, 7–8 P_1 15–17 P_2 I, 5   C 17   V 24

Adults Distributed around northern Australia from Albany (WA) to Wollongong (NSW). Occurs in estuarine and coastal marine waters to a depth of 40 m. *Gerres ovatus* is a junior synonym. Adults have a laterally compressed body, extremely protrusible jaws, and weakly attached cycloid scales. Maximum size 20 cm (Kuiter, 1993, 1996).

Importance to fisheries Fished commercially on a small scale in New South Wales and Western Australia. About 150 tonnes are sold each year and mostly for human consumption (Kailola *et al.*, 1993; Edgar, 1997).

Spawning Eggs undescribed. Eggs of *Gerres* sp. from Japan are pelagic and spherical, 0.6–0.8 mm in diameter (Mito, 1963). Based on larval occurrence, spawning appears to take place in estuaries and shallow coastal waters. Larvae have been caught in Western Australia within the lower Swan Estuary between December and March (Neira *et al.*, 1992), and in Cockburn Sound between October and April (Jonker, 1993); in New South Wales, entering and within Lake Macquarie from September to May, with a peak abundance in February (Miskiewicz, 1987), entering Tuggerah Lakes from January to March and in October (Marsden, 1986), and in coastal waters off Sydney from November to April (Gray *et al.*, 1992).

Diagnostic characters

- 5–8 + 16–19 = 24 myomeres
- Small size at notochord flexion (3.2–5.0 mm)
- 15–18 small melanophores along ventral midline of tail in preflexion larvae
- 1–3 melanophores under notochord tip in preflexion larvae

Description of larvae

Morphology Body moderate (BD 22–28%). Head moderate (HL 22–32%). Small teeth along both jaws from late preflexion stage. Elongate ascending premaxillary process from late preflexion stage. One small anterior preopercular and 1 posterior preopercular spine by end of flexion stage; up to 3 anterior preopercular and 3 posterior preopercular spines by postflexion stage. One cleithral spine by 7.9 mm, 1 supracleithral spine by 10.2 mm, and a serrate posttemporal ridge by 11.4 mm. Gut moderate (PAL 37–49%), coiled and compact. Small gas bladder above foregut, inflated only in larvae caught at night; it enlarges and extends posteriorly with growth. Large gap between anus and origin of anal fin, reduced by settlement. Scales begin to form at settlement.

Size at

Hatching	<2.1 mm
Notochord flexion	3.2–5.0 mm
Settlement	10.3–13.6 mm
Formation of fins:	

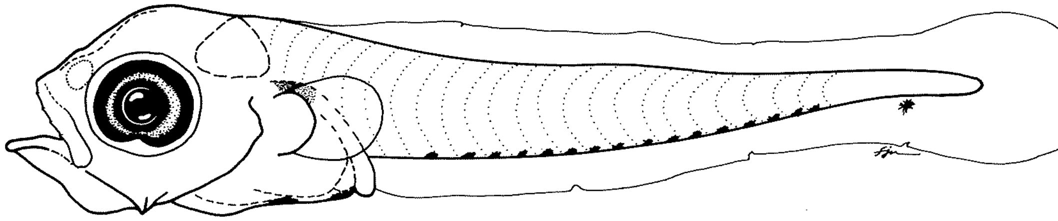
Caudal 3.0–5.4 mm; Dorsal 3.7–6.3 mm; Anal 3.7–6.3 mm; Pectoral 5.0–7.9 mm; Pelvic 5.3–8.2 mm

Pigmentation Larvae are lightly pigmented. *External:* 1 melanophore over midbrain by end of flexion stage, and 1 on snout and on opercle from 6 mm, number increasing with growth. Numerous melanophores over brain and along both jaws in late postflexion larvae. One melanophore on isthmus from late flexion stage and 2 large melanophores on ventral surface of gut. Series of 15–18 small melanophores along ventral midline of tail in preflexion larvae, remaining along anal-fin base and ventral midline of caudal peduncle in postflexion larvae. One to three small melanophores under notochord tip, remaining along base of caudal-fin rays in postflexion larvae. Melanophore series along lateral midline of trunk and tail, along dorsal-fin base, on membrane of dorsal-fin spines and along caudal-fin rays in late postflexion larvae. *Internal:* 1 melanophore in otic region and 1 laterally on hindbrain from 6.3 mm. Pigment dorsally over gas bladder; 2 melanophores dorsally over gut in preflexion and flexion larvae, heavy pigment dorsally on gut in postflexion larvae. Melanophore series dorsally along vertebrae in late postflexion larvae.

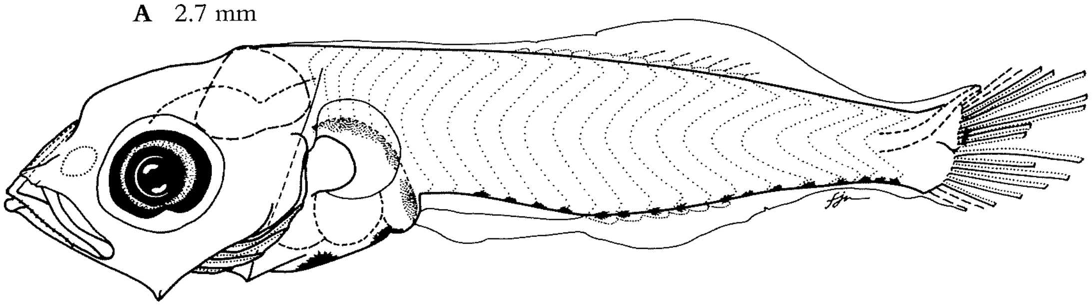
Material examined 28 larvae, 2.1–13.2 mm BL, and 7 juveniles, 10.3–13.6 mm BL, Cudgen Lake, Lake Macquarie and Sydney Harbour (NSW); 24 larvae, 2.7–8.9 mm BL, Cockburn Sound, Peel–Harvey Estuary and coastal waters off Mandurah (WA).

Additional references Miskiewicz (1987).

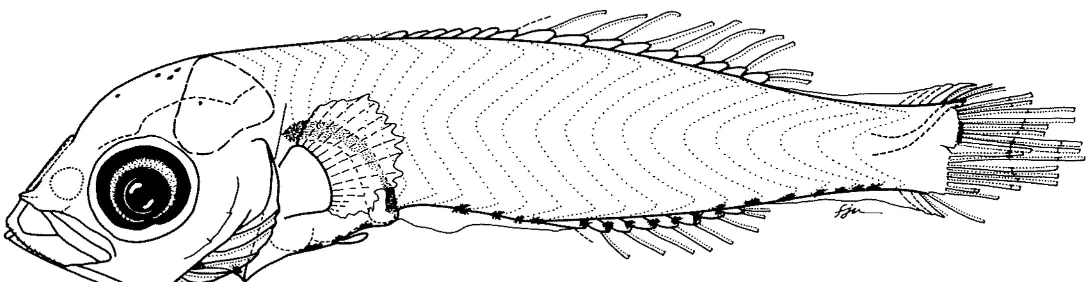
Figure 66 Larvae of *Gerres subfasciatus*. **A** Preflexion. **B** Flexion; note ascending premaxillary process. **C** Early postflexion; note pelvic-fin bud. **D** Postflexion; body pigment faded. **E** Postflexion. A from coastal waters off Mandurah (WA); B, C from Botany Bay (NSW); D from Cudgen Lake (NSW); E from Lake Macquarie (NSW). Illustrated by F. J. Neira.



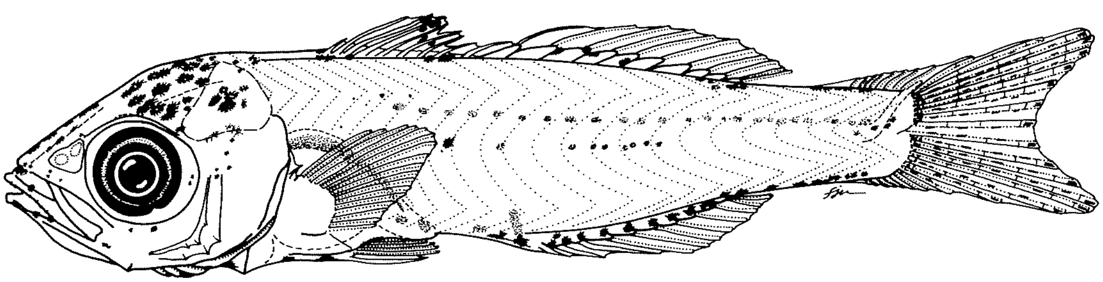
A 2.7 mm



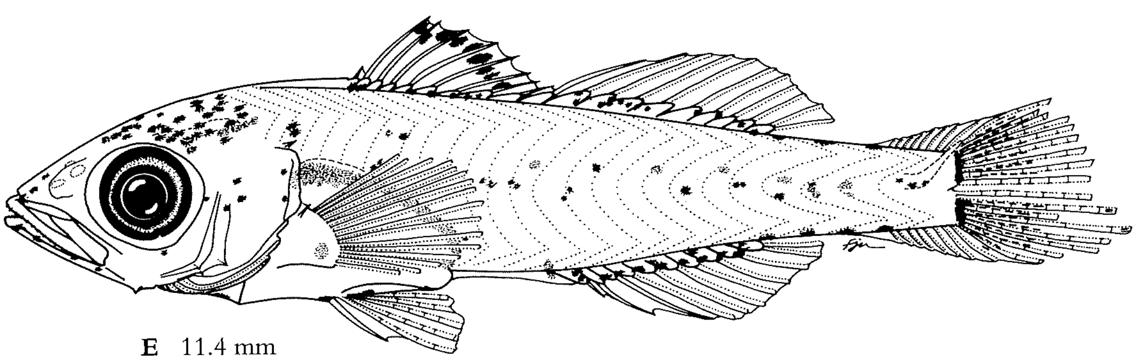
B 4.0 mm



C 5.3 mm



D 7.9 mm



E 11.4 mm

Gerreidae *Parequula melbournensis* (Castelnau, 1872) Silverbelly

D IX, 16–17 A III, 16–18 P_1 14–15 P_2 I, 5 C 17 V 24

Adults Endemic to southern Australia from Houtman Abrolhos Islands (WA) to Merimbula (NSW), including Tasmania. A schooling species found in estuarine and coastal waters, often in large numbers in seagrass beds and over sand and mud bottoms, to a depth of 100 m. Adults have a laterally compressed body, a concave head profile above the eye, short anterior dorsal-fin spines and weakly attached scales. Maximum size 21 cm (Last *et al.*, 1983; Kuiter, 1993, 1996; Gomon *et al.*, 1994; Hutchins, 1997).

Importance to fisheries Frequent component of the by-catch of shallow trawl fisheries, but of no commercial importance (Gomon *et al.*, 1994). The most abundant trawl fish in shallow coastal waters of southwestern Western Australia, contributing about 42% to the total number of fish trawled between Rottnest Island and Cape Naturaliste (Sarre *et al.*, 1997).

Spawning Eggs undescribed. Representatives from southwestern Australia are serial spawners and spawn throughout most of the year, with a peak in summer (Sarre, 1992; Sarre *et al.*, 1997). Larvae have been caught in Port Lincoln (SA) in summer.

Diagnostic characters

- 4–10 + 14–20 = 24–25 myomeres
- Large size at notochord flexion (5.5–7.4 mm)
- 12–22 melanophores along ventral midline of tail in preflexion larvae, with a cluster of small melanophores between myomeres 17–20

Description of larvae

Morphology Body elongate to moderate (BD 19–29%). Head small to moderate (HL 17–33%). Small teeth along both jaws by mid-preflexion stage. Elongate ascending premaxillary process from mid-preflexion stage. One anterior preopercular spine in preflexion larvae from 4.1 mm; 2 anterior preopercular and 2 posterior preopercular spines in postflexion larvae. Opercular spine by late flexion stage. Gut short to moderate in preflexion and flexion larvae (PAL 22–48%), moderate to long in postflexion larvae (PAL 48–51%), coiled and compact. Small gas bladder above foregut, inflated only in larvae caught at night; it enlarges with growth. Small gap between anus and origin of anal fin.

Size at

Hatching	<2.4 mm
Notochord flexion	5.5–7.4 mm
Settlement	>8.8 mm
Formation of fins:	

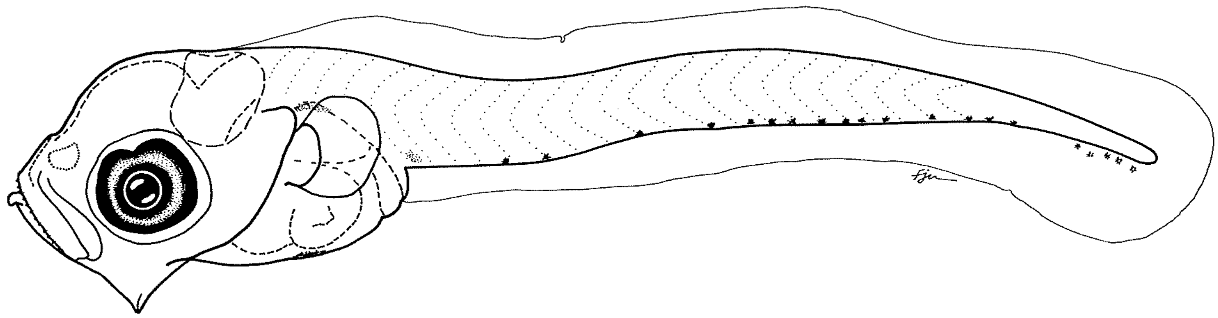
Caudal 4.0–7.4 mm; Dorsal 4.5–8.8 mm; Anal 4.5–8.8 mm; Pelvic 4.7–6.6 mm; Pectoral 7.4–8.8 mm

Pigmentation Larvae are lightly pigmented. *External:* 1–3 large melanophores ventrally along gut in preflexion larvae. Series of 12–22 small melanophores along ventral midline of tail, with a cluster of small melanophores between myomeres 17 and 20 in preflexion larvae; a few remain along anal-fin base and ventral surface of caudal peduncle in postflexion larvae. Usually 1–2 small melanophores under notochord tip in preflexion larvae, absent in postflexion larvae (pigment is faded in all postflexion larvae examined). One melanophore ventrally on caudal peduncle in postflexion larvae. *Internal:* Melanophores at junction of mid- and hindbrain in flexion larvae. Pigment dorsally over gas bladder, and 0–3 melanophores dorsally over anus.

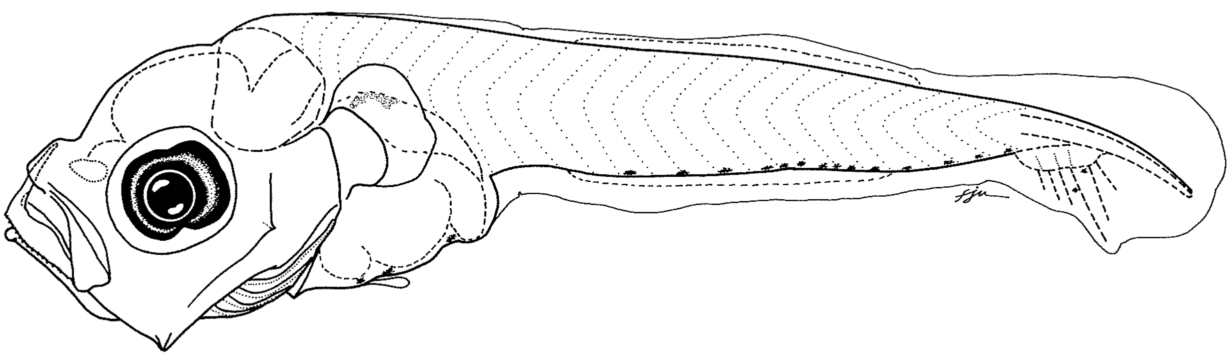
Material examined 26 larvae, 2.4–8.8 mm BL, Port Lincoln (SA).

Additional references –

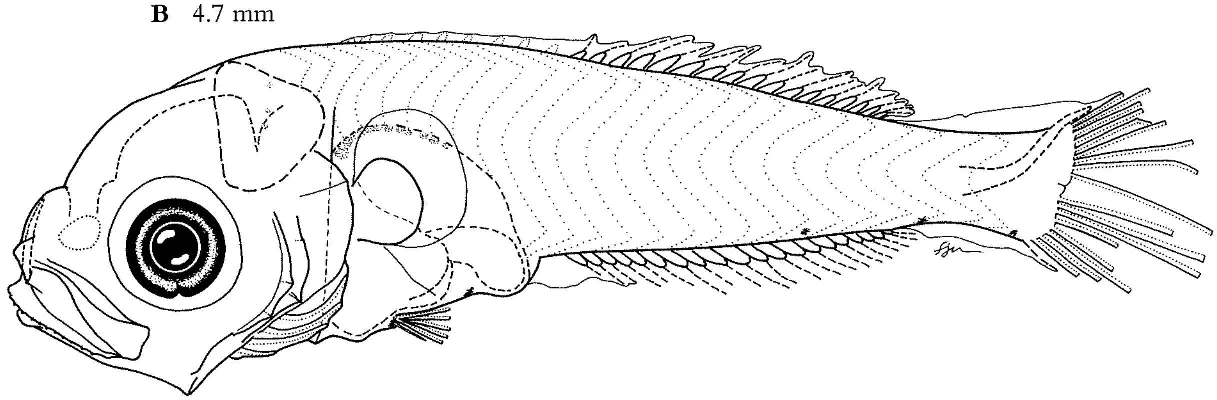
Figure 67 Larvae of *Parequula melbournensis*. **A** Preflexion. **B** Late preflexion; note ascending premaxillary process and pelvic-fin bud. **C** Late flexion. **D** Postflexion; pigment faded. A–D from Port Lincoln (SA). Illustrated by F. J. Neira.



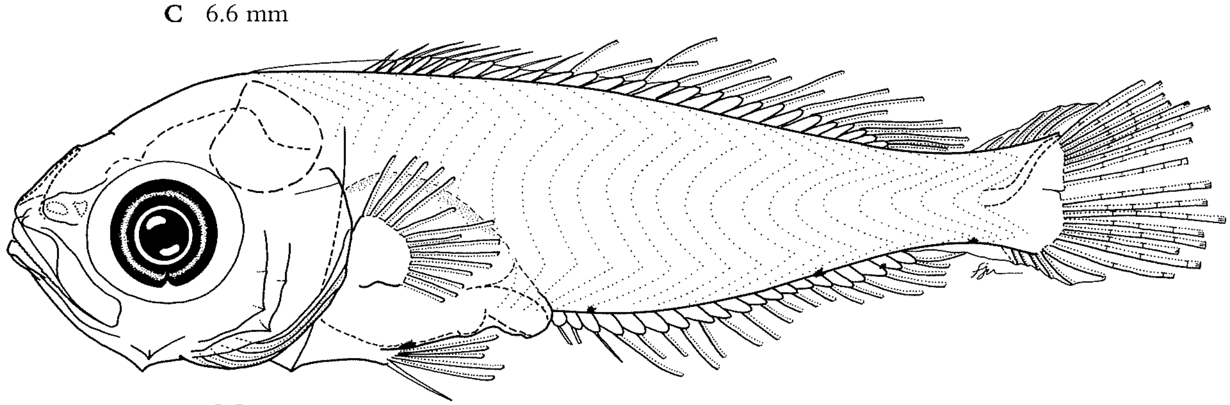
A 3.7 mm



B 4.7 mm



C 6.6 mm



D 8.8 mm

Girellidae: Blackfishes, luderick

A.G. Miskiewicz and T. Trnski

Girellids are found in subtropical to temperate waters around the continental margins of the Pacific Ocean, the eastern Indian Ocean to southwestern Australia, and the Atlantic Ocean (Kuiter, 1993; Gomon *et al.*, 1994). The Girellidae is treated herein as a separate family from the Kyphosidae, Microcanthidae and Scorpididae following Johnson (1984, 1993). The family contains 2 genera, *Girella* with about 16 species, and the monotypic *Graus* (Johnson & Fritzsche, 1989; Nelson, 1994). Five species of *Girella* have been recorded from Australia, four in temperate waters (Kuiter, 1993; Gomon *et al.*, 1994). Adults (50–80 cm) are robust, and have a small mouth with tricuspid teeth and both maxillae concealed by their respective preorbital bones (Gomon *et al.*, 1994). Eggs of *Girella punctata* are pelagic and spherical, 1.00–1.05 mm in diameter (Mito, 1957, 1958a; Ikeda & Mito, 1988). Larvae have been described for *G. melanichthys* (Konishi, 1988c), *G. nigricans* (Stevens *et al.*, 1989; Watson, 1996j), *G. punctata* (Mito, 1957, 1958a; Kobayashi & Igarashi, 1961; Konishi, 1988c), and *G. tricuspidata* (Munro, 1945; Kingsford, 1988; Neira *et al.*, 1997c). The weak head spination is the only apparent specialisation of girellid larvae to pelagic life.

Meristic characters of the girellid genus of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Girella	(4)	XIII–XVI, 11–15	III, 11–12	16–19	I, 5	17	11 + 16 = 27

Main characters of girellid larvae

- 26–27 myomeres
- Body moderate (BD 20–26%), laterally compressed by postflexion stage
- Weak head spination, small preopercular spines
- Gut moderate to long (PAL 41–52%), coiled and compact
- Large gap between anus and origin of anal fin that remains until late postflexion stage
- Body lightly pigmented, melanophore series along dorsal midline of trunk and tail, and lateral and ventral midlines of tail
- Pigment dorsally over gas bladder and gut
- Melanophores ventrally along notochord tip in early preflexion larvae

References to girellid larvae

Konishi (1988c), Stevens *et al.* (1989), Watson (1996j), Neira *et al.* (1997c).

Families with similar larvae

Arripidae – IX dorsal-fin spines; body moderately to heavily pigmented, melanophores posteriorly on tail and around notochord tip in early stages; 5–6 internal melanophores along nape and anterior of trunk.

Centrolophidae – Moderate head spination, including interopercular spines (head spines absent in *Centrolophus*); gut long (PAL 51–66%); no gap between anus and origin of anal fin; body moderately to heavily pigmented, pigment blotches dorsally and ventrally along tail from preflexion stage.

Kyphosidae – XI dorsal-fin spines; no gap between anus and origin of anal fin; body moderately to heavily pigmented, small to large stellate melanophores over trunk and tail in postflexion larvae; no pigment along lateral midline of tail in preflexion and flexion larvae.

Leptobramidae – 24 myomeres; several small posterior preopercular spines, none along anterior margin of preopercle; dorsal fin IV, 26–30, located posterior to anal-fin origin; no gap between anus and origin of anal fin.

Microcanthidae – Weak to moderate head spination, including interopercular spines; X–XII dorsal-fin spines; no pigment along lateral midline of tail in preflexion and flexion larvae.

Mullidae – Head spines absent in most taxa; 2 short, well separated dorsal fins; short-based anal fin, I, 6–7; 3 melanophores in a triangular pattern on midbrain in late preflexion larvae.

Pomatomidae – 2 separate dorsal fins, VII–VIII + I, 23–28; long-based anal fin, I–III, 23–28; gut moderate to long (PAL 43–62%), voluminous.

Scorpididae – Body moderately to heavily pigmented, melanophores around notochord tip; moderate preopercular spines and interopercular spines; long-based dorsal and anal fins, IX–X, 23–28 and III, 25–28 respectively.

Girellidae *Girella tricuspidata* (Quoy & Gaimard, 1824) Luderick, blackfish

D XIV–XVI, 11–13 A III, 11–12 P_1 16 P_2 1, 5 C 17 V 27

Adults Distributed around southern Australia from Adelaide (SA) to Noosa Head (Qld), including northeastern Tasmania; also in northern New Zealand. Herbivorous species found in estuaries and in shallow coastal marine waters around rocky reefs and headlands, to a depth of 20 m. Juveniles occur among seagrass beds in estuaries. Adults have an oblong body, a small mouth with the maxilla concealed by the suborbital bone, outer teeth tricuspid and in several rows, and a series of thin vertical dark bars along the body. Maximum length 71 cm (Hutchins & Swainston, 1986; Kuiter, 1993, 1996; Gomon *et al.*, 1994).

Importance to fisheries Fished commercially mainly with gill nets and beach seines, especially in New South Wales estuaries; also fished with tunnel nets in Queensland. Total catch in 1990 was about 750 tonnes. Also targeted by recreational fishers (Kailola *et al.*, 1993).

Spawning Eggs undescribed. Spawns in surf zones, often near entrance to estuaries (Edgar, 1997). In New South Wales, larvae have been caught entering Lake Macquarie from September to April, with a peak abundance in November (Miskiewicz, 1987), entering Tuggerah Lakes from August to October (Marsden, 1986), and in coastal waters off Sydney from August to May (Gray, 1995).

Diagnostic characters

- 6–11 + 15–21 = 26–27 myomeres
- Small preopercular spines
- 3–6 large, widely spaced melanophores along dorsal midline of tail
- 5–8 prominent melanophores along ventral midline of tail
- 1–2 melanophores under notochord tip in preflexion larvae

Description of larvae

Morphology Body moderate (BD 20–26%). Head moderate to long (HL 22–34%). Small teeth along both jaws by mid-flexion stage. One small anterior preopercular spine in late preflexion larvae, and 1–2 posterior preopercular spines in late flexion larvae; 2 anterior preopercular and 3 posterior preopercular spines in postflexion larvae. One supracleithral spine by 8.9 mm, 1 opercular spine by 9.6 mm. Gut moderate in preflexion larvae (PAL 41–47%), moderate to long in postflexion larvae (PAL 48–52%), coiled and compact. Large gap between anus and origin of anal fin through to late postflexion stage, reduced by settlement. Scales begin to form at settlement.

Size at

Hatching	<3.0 mm
Notochord flexion	4.4–6.3 mm
Settlement	12.3–14.5 mm
Formation of fins:	

Caudal 3.9–6.3 mm; Dorsal 4.5–8.9 mm; Anal 4.5–8.9 mm; Pectoral 5.0–8.9 mm; Pelvic 6.3–8.9 mm

Pigmentation Larvae are lightly to moderately pigmented. *External:* A few stellate melanophores above midbrain in preflexion larvae. One stellate melanophore over forebrain, and 1 melanophore at tip of premaxilla, dentary, angle of lower jaw, laterally on hindbrain and on opercle by end of flexion stage; pigment on most of head in postflexion larvae. One melanophore on isthmus, several laterally on gut, and 2 on ventral midline of gut in preflexion larvae; gut heavily pigmented in postflexion larvae. Three to six widely spaced melanophores along dorsal midline of tail in preflexion larvae, and 3–6 along dorsal midline of caudal peduncle in postflexion larvae. Five to eight melanophores along ventral midline of tail in preflexion larvae; 1 melanophore near anus, 1 anterior to anal fin, several along anal-fin base, and 3–6 ventrally along caudal peduncle in postflexion larvae. Additional melanophores dorsally and ventrally along trunk and tail in postflexion larvae. Series of melanophores along lateral midline of tail by late preflexion stage, extending anteriorly with growth. One or two melanophores under notochord tip in preflexion and flexion larvae. One melanophore in hypural region in preflexion larvae, present along base of lower caudal-fin rays in flexion larvae; pigment along base of upper caudal-fin rays in postflexion larvae. *Internal:* 1 melanophore on snout; pigment in otic region from late preflexion stage. One large melanophore dorsally on foregut and heavy pigment dorsally over remainder of gut and over gas bladder. Pigment beneath opercle and 1 large melanophore at nape. Series of melanophores ventrally along posterior of notochord from preflexion stage, and dorsally from flexion stage, both series extending anteriorly with growth.

Material examined 25 larvae, 3.0–12.4 mm BL, Lake Macquarie (NSW), and 21 juveniles, 12.3–16.1 mm BL, Broken Bay and Jervis Bay (NSW).

Additional references Miskiewicz (1987), Kingsford (1988), Neira *et al.* (1997c).

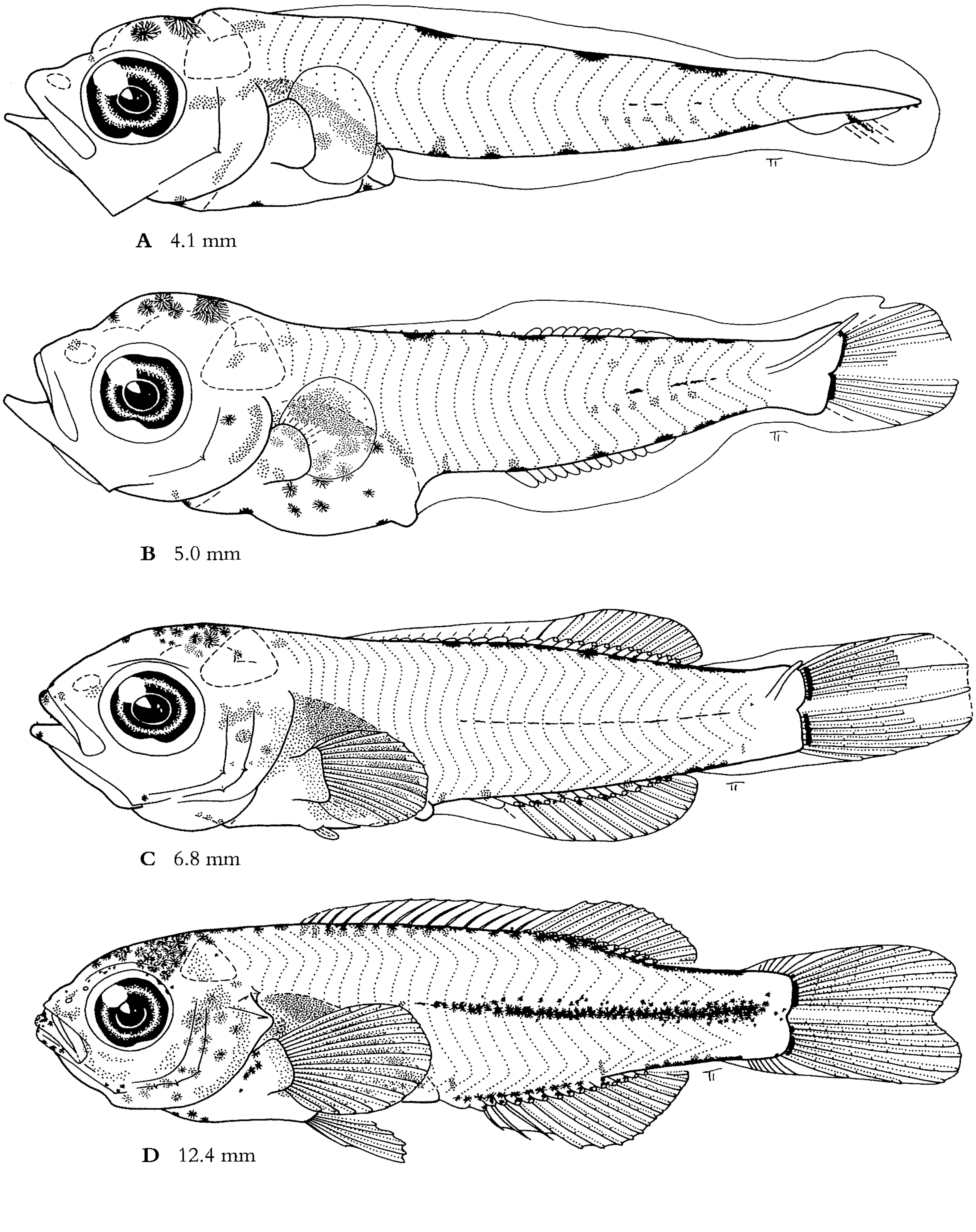


Figure 68 Larvae of *Girella tricuspidata*. **A** Preflexion. **B** Late flexion. **C** Early postflexion. **D** Postflexion; note small supracleithral spine. A–C from coastal waters off Lake Macquarie (NSW); D from Lake Macquarie (NSW) (from Neira *et al.*, 1997c). Illustrated by T. Trnski.

Kyphosidae: Drummers

F. J. Neira and A.G. Miskiewicz

Kyphosids are coastal schooling fishes found predominantly in tropical reef areas of the Indo-Pacific, and also in east Africa, the Red Sea and the Pacific and Atlantic coasts of the United States (Moore, 1962; Kuiter, 1993; Gomon *et al.*, 1994). We follow Johnson (1984, 1993) in treating the Kyphosidae as a separate family from the Girellidae, Microcanthidae and Scorpididae. The family comprises 4 genera (*Hermosilla*, *Kyphosus*, *Neoscorpis* and *Sectator*) and 11 species (Johnson & Fritzsche, 1989; Johnson, 1993). Except for *Kyphosus*, the other three genera are monotypic and do not occur in Australia. *Kyphosus* contains about eight species, four of which have been recorded from temperate Australia (P. Heemstra, unpublished key; Kuiter, 1993, 1996; Gomon *et al.*, 1994). Adults (40–80 cm) are very robust, have a small, nibbling-type mouth with fine teeth on the vomer, palatines and tongue, and a dorsal fin typically with XI spines. Eggs of *Kyphosus* sp. are pelagic and spherical, 1.0–1.1 mm in diameter, and have a single oil globule (Watson & Leis, 1974). Larvae are primarily neustonic and have been described for *Hermosilla azurea* (Stevens *et al.*, 1989; Watson, 1996j) and several representatives of *Kyphosus* (e.g. Mito, 1958b; Moore, 1962; Johnson, 1978; Miller *et al.*, 1979; Walker & Watson, 1983; Konishi, 1988d; Neira *et al.*, 1997c). The weak head spination constitutes the only apparent specialisation of kyphosid larvae to pelagic life (Walker & Watson, 1983).

Meristic characters of the kyphosid genus of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Kyphosus	(4)	XI, 12–16	III, 10–11	17–18	I, 5	17	10 + 15–16 = 25–26

Main characters of kyphosid larvae
- 25–26 myomeres
- Body initially elongate, becoming moderately deep in postflexion stage (BD 14–38%)
- Weak head spination, including small preopercular, supracleithral and opercular spines (small subopercular spines in *H. azurea* but absent in *Kyphosus*)
- Last spines of dorsal and anal fins are initially soft rays but transform into spines before settlement
- Gut moderate to long (PAL 48–69%), initially straight but becoming coiled and compact by flexion stage
- Small gas bladder over foregut
- Body moderately to heavily pigmented, pigment over head and a melanophore series along dorsal and ventral midlines of tail; trunk and tail covered by small to large stellate melanophores in postflexion larvae
- Melanophores on snout, particularly at tip of upper jaw (upper border of premaxilla)
- Melanophores under notochord tip in most taxa; caudal peduncle unpigmented prior to settlement

References to kyphosid larvae
Moore (1962), Johnson (1978), Miller *et al.* (1979), Walker & Watson (1983), Konishi (1988d), Stevens *et al.* (1989), Watson (1996j), Neira *et al.* (1997c).

Families with similar larvae

Arripidae – Large gap between anus and origin of anal fin; IX dorsal-fin spines; 5–6 internal melanophores along nape and anterior of trunk; pigment along lateral midline posteriorly on tail from preflexion stage.

Centrolophidae – Long-based dorsal and anal fins; interopercular spines in most taxa; body moderately to heavily pigmented, pigment blotches along dorsal and ventral surfaces of tail, and along lateral midline of tail from preflexion stage in most taxa.

Cheilodactylidae – 34–36 myomeres; no head spines; pigment along lateral midline posteriorly on tail from flexion stage; long-based dorsal fin, with XV–XVIII spines.

Carangidae – Well developed head spination, including an emergent median supraoccipital crest (present but non-emergent in *Seriola*), and prominent preopercular spines, spine at angle elongate; long-based anal fin, II + I, 16–29; distinct preanal finfold, usually pigmented.

Girellidae – Large, persistent gap between anus and origin of anal fin; XIII–XVI dorsal-fin spines; body lightly pigmented; large, widely spaced melanophores along dorsal midline of trunk and tail; pigment along lateral midline of tail from flexion stage.

Leptobramidae – 24 myomeres; dorsal fin originates posterior to anal-fin origin, IV, 26–30; pigment along lateral midline of tail from late preflexion stage; no pigment around notochord tip.

Microcanthidae – Small to large gap between anus and origin of anal fin; small to moderate preopercular spines, supraocular ridge and interopercular spines; 13–19 anal-fin rays; a few, small to large widely spaced melanophores along ventral midline of tail; pigment around notochord tip.

Pomatomidae – 2 separate dorsal fins, VII–VIII + I, 23–28; long-based anal fin, I–III, 26–28; body lightly pigmented prior to postflexion stage; pigment along lateral midline of tail from flexion stage; no pigment under notochord tip.

Scorpididae – Large gap between anus and origin of anal fin; interopercular spines; long-based dorsal and anal fins, IX–X, 23–28 and III, 25–28 respectively; pigment along lateral midline posteriorly on tail from preflexion stage; pigment around notochord tip.

Kyphosidae *Kyphosus* sp. Drummer

D XI, 12–16 A III, 10–11 P_1 17–18 P_2 I, 5 C 17 V 25–26

Adults Four species of *Kyphosus* occur in temperate Australia: *K. cornelii*, *K. diemenensis*, *K. gibsoni* and *K. sydneyanus*. The latter is the most common, occurring around southern Australia from Shark Bay (WA) to Moreton Bay (Qld), including northern Tasmania; often found as solitary individuals or in small groups, in high-energy zones such as rocky shores and inshore reefs, to a depth of 30 m. Members of the genus are variously distributed in tropical to temperate waters of all oceans and in the Mediterranean Sea, including northern New Zealand. Adults of *K. sydneyanus* are silvery grey with a black spot under the pectoral-fin base, and have black pigment on the posterior margin of the caudal fin. Maximum size 86 cm (Hutchins & Swainston, 1986; Last *et al.*, 1983; Kuiter, 1993, 1996; Gomon *et al.*, 1994).

Importance to fisheries Australian representatives are considered of poor taste and hence not fished commercially or recreationally despite their large sizes (Hutchins & Swainston, 1986; Kuiter, 1993). By contrast, the western Atlantic *Kyphosus sectatrix* is among the most important food and game fish in Bermuda waters (Moore, 1962).

Spawning Eggs undescribed. Eggs of *K. vaigiensis* are pelagic and spherical, 1.0–1.1 mm in diameter, and have a single, pigmented oil globule 0.25 mm (Watson & Leis, 1974, as *K. cinerascens*). *Kyphosus* sp. larvae have been caught in coastal waters off Lake Macquarie (NSW) from November to April (Miskiewicz, 1987), and in coastal waters off Sydney from October to May (Gray, 1995).

Diagnostic characters

- 10–11 + 15–16 = 25–26 myomeres
- Small posterior preopercular spines, a supracleithral spine, and smooth supraocular and posttemporal ridges
- 1 melanophore on nape, 3 along dorsal midline of trunk, followed by 11–12 large, stellate melanophores between myomeres 7–22 in preflexion larvae; anteriormost 4 melanophores become internal during flexion stage
- 12–13 melanophores along ventral midline of tail in preflexion and flexion larvae, which gradually become internal in postflexion larvae
- Several small melanophores under notochord tip in preflexion and flexion larvae

Description of larvae

Morphology Body moderate (BD 20–38%), deeper with growth. Head moderate to large in preflexion and flexion larvae (HL 24–35%), large in postflexion larvae (HL 36–39%). Small teeth along premaxilla by late preflexion stage. Two or three small posterior preopercular spines, and smooth supraocular and posttemporal ridges by flexion stage. One anterior preopercular and up to 7 posterior preopercular spines, 1 supracleithral and 1 weak opercular spine by early postflexion stage; preopercular spines reduce in size by late postflexion stage. Gut long (PAL 51–69%), initially straight, loosely coiled from late preflexion stage. Small gas bladder above foregut. Preanal membrane present until early postflexion stage. Scales form by 8.6 mm.

Size at

Hatching	~2.1 mm
Notochord flexion	4.5–5.5 mm
Settlement	>10.8 mm
Formation of fins:	

Caudal 2.7–5.5 mm; Dorsal 3.7–6.1 mm; Anal 3.7–6.2 mm; Pectoral 4.1–6.8 mm; Pelvic 5.2–<8.6 mm

Pigmentation Larvae are moderately to heavily pigmented. *External:* Melanophores on snout, tip of jaws, midbrain and 1 on upper preopercle in preflexion larvae. One melanophore on cleithral symphysis and 3–5 ventrally on gut from preflexion stage, several laterally on gut from flexion stage; heavy pigment over entire gut by postflexion stage. One melanophore on nape, 3 along dorsal midline of trunk, and 11–12 large, stellate melanophores along dorsal midline between myomeres 7 and 22 in preflexion stage; anteriormost 4 melanophores become internal during flexion stage. Scattered melanophores laterally on trunk and tail, except caudal peduncle, from late flexion stage; mid-lateral stripe posteriorly on tail by postflexion stage. Series of 12–13 melanophores along ventral midline of tail in preflexion larvae, becoming internal during flexion stage. Several small melanophores under notochord tip in preflexion larvae, becoming internal during flexion stage except for 1 which remains anterior to hypural plates. Pigment on base of caudal-fin rays in flexion and postflexion larvae. Heavy pigment over entire body from 8 mm, including caudal peduncle and all fins. *Internal:* 1 melanophore at roof of mouth, and pigment in otic region and under hindbrain. Pigment anteriorly and dorsally over gut in preflexion larvae, heavy over gut and gas bladder in postflexion larvae. Nape and dorsal trunk melanophores, and ventral tail melanophores from flexion stage.

Material examined 28 larvae, 2.1–10.8 mm BL, off Lake Macquarie and Sydney Harbour, and coastal waters of New South Wales (NSW).

Additional references Neira *et al.* (1997c).

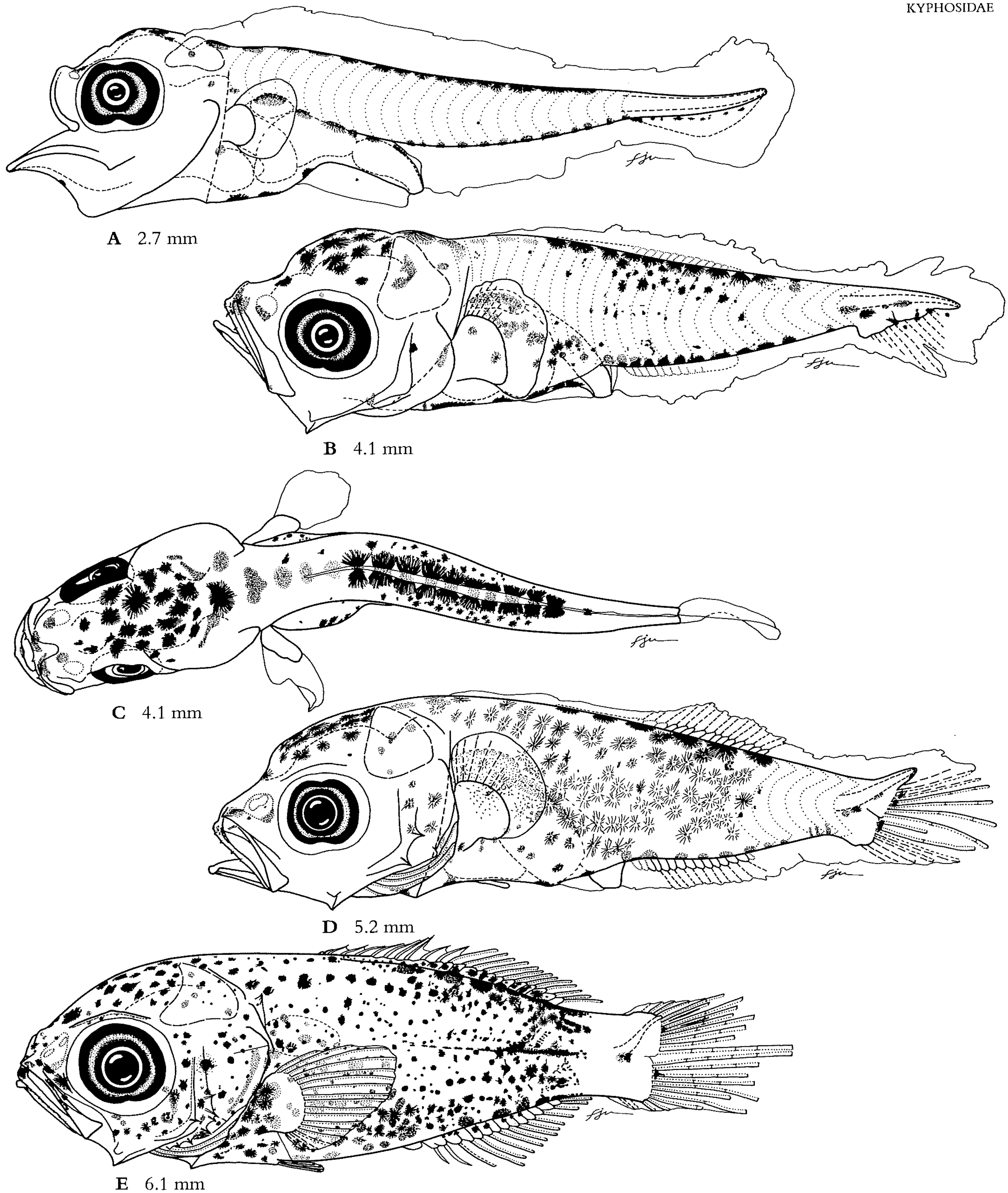


Figure 69 Larvae of *Kyphosus* sp. **A** Preflexion. **B** Late preflexion; note developing dorsal and anal fins, and pectoral-fin rays. **C** Dorsal view of larva in B; note internal melanophores along trunk. **D** Flexion; note pelvic-fin bud; anteriormost myomeres omitted. **E** Early postflexion. A, D from Lake Macquarie (NSW); B, E from NSW coastal waters (from Neira *et al.*, 1997c). Illustrated by F. J. Neira.

Latridae: Trumpeters

D.M. Furlani

Latrids are mostly coastal, schooling marine fishes found in temperate to cold regions of the southern Atlantic, and in Australia, New Zealand and Chile. The family contains 3 genera and 9 species (Nelson, 1994). The three genera, each containing one species, have been recorded from temperate Australia (Ayling & Cox, 1982; Last *et al.*, 1983; Gon & Heemstra, 1987; Kuiter, 1993; Gomon *et al.*, 1994). All members are carnivorous and feed on a range of invertebrates (Francis, 1981; Gon & Heemstra, 1987; Paulin *et al.*, 1989). Most species have commercial and recreational importance. Adults (0.6–1.2 m) have a long-based, notched dorsal fin with a large number of elements, and a long-based anal fin. Eggs of *Latris lineata* and *Mendosoma lineatum* are pelagic and spherical, 1.1–1.4 mm in diameter, and have one to several (2–7) oil globules (Robertson, 1975a; Furlani & Ruwald, 1998). Larvae have been described for *L. lineata* (Furlani & Ruwald, 1998), and have no apparent specialisations to pelagic life.

Meristic characters of latrid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Latridopsis	(1)	XVII, 38–40	III, 32–35	18	I, 5	15	–
Latris	(1)	XVIII, 34–36	III, 31–32	18	I, 5	15	34–38
Mendosoma	(1)	XXIII, 23–26	III, 18–19	16–17	I, 5	15	45

Main characters of latrid larvae

- 33–45 myomeres
- Body initially very elongate to elongate, moderate by postflexion stage (BD 4–24%)
- No head spines
- Gut long (PAL > 50%) and straight
- Moderate gap between anus and origin of anal fin
- Finfold enclosing most of body in early stages
- Prominent preanal membrane, persisting through to postflexion stage
- Dorsal and anal fins long-based
- Pelvic fins abdominal, located between pectoral-fin bases and anus
- Body heavily pigmented in *Latris*, pigment along dorsal and ventral surfaces of trunk and tail

References to latrid larvae

Furlani & Ruwald (1998).

Families with similar larvae

Aplodactylidae – Dorsal fin XVI–XVIII, 16–21; short-based anal fin, II–III, 6–8; no gap between anus and origin of anal fin; gut coiled by flexion stage; many small melanophores on caudal finfold and pigment around notochord tip.

Bovichtidae (*Bovichtus*) – Long opercular spine; pelvic fins jugular; 2 dorsal fins, first with VIII spines; anal fin spineless, 12–18; gut coiled; no gap between anus and origin of anal fin.

Cheilodactylidae – Body deep and laterally compressed by postflexion stage; anal fin III, 8–19; gut loosely coiled; no gap between anus and origin of anal fin; large size prior to settlement (up to 90 mm); pigment along lateral midline of tail.

Chironemidae – 33 myomeres; gut coiled by early postflexion stage; no gap between anus and origin of anal fin; dorsal fin XIV–XVI, 14–20; anal fin III, 6–8; pigment ventrally along gut in preflexion larvae; pigment along lateral midline of tail in preflexion larvae.

Sillaginidae – Moderately elongate snout; very small preopercular spines in most taxa; gut coiled, with weak striations on midgut in some taxa; 2 dorsal fins; anal fin II, 15–24; melanophore series ventrally along gut.

Latridae *Latris lineata* (Foster, 1801) Striped trumpeter, Tasmanian trumpeter

D XVIII, 34–36 A III, 31–32 P_1 18 P_2 I, 5 C 15 V 34–38

Adults Distributed around southern Australia from Albany (WA) to Montague Island (NSW), including Tasmania; also in New Zealand and Chile. Demersal species common on offshore reefs to a depth of 300 m, with juveniles in shallow coastal areas. Adults are elongate with a deeply notched dorsal fin, and dusky green or yellow dorsally and silvery ventrally, with three distinct brown stripes along the body. Maximum size 1.2 m (Hutchins & Swainston, 1986; Gomon *et al.*, 1994; Kuiter, 1996).

Importance to fisheries Fished commercially mainly with droplines in South Australia, Victoria and Tasmania. Annual catches in Tasmania range from 37 to 73 tonnes (Department of Primary Industry, 1997). Highly esteemed food fish, particularly for sushimi market (Kailola *et al.*, 1993).

Spawning Fertilised eggs are spherical, 1.3–1.4 mm in diameter, have a slightly textured chorion, and a single oil globule 0.27–0.33 mm. Pigment on embryos is confined to the body, and does not extend onto the finfold or oil globule (Furlani & Ruwald, 1998). Mature fish move closer to shore before spawning (May & Maxwell, 1986). Populations on the west coast of Tasmania spawn between late winter and early spring. Larvae have been caught mostly in coastal waters of western Tasmania from September to October.

Diagnostic characters

- 13–19 + 18–23 = 33–39 myomeres
- Gut long (PAL 50–63%)
- Long-based anal fin
- Continuous paired melanophore series along ventral midline of tail
- Internal melanophore series dorsally along gut continuing as external series along ventral midline of tail
- Paired series of melanophores along entire dorsal midline of trunk and tail

Description of larvae

Morphology (excludes yolk-sac larvae) Body very elongate to elongate in preflexion larvae (BD 8–13%), elongate in flexion and postflexion larvae (BD 12–24%). Head small in preflexion larvae (HL 17–21%), moderate in flexion and postflexion larvae (HL 19–28%). Gut long (PAL 50–63%) and straight. Gas bladder inflated from preflexion stage by 4.8 mm (12 days old). Yolk sac is fully resorbed in preflexion larvae by about 5 mm (10 days old). Small gap between the anus and origin of anal fin. Pectoral-fin buds develop by about 4.2 mm (4 days old). Prominent preanal membrane, persisting through to postflexion stage.

Size at

Hatching	2.8–3.3 mm
Notochord flexion	5.6–8.7 mm
Settlement	>11.9 mm
Formation of fins:	

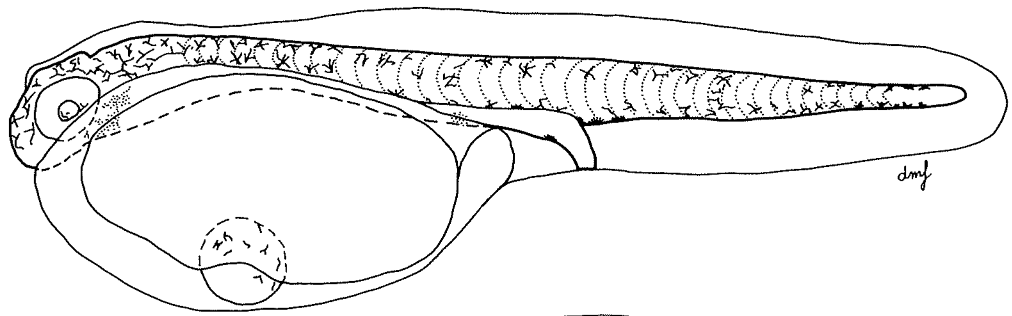
Caudal <6.6–7.5 mm; Dorsal 7.5–>11.9 mm; Anal 7.5–>11.9 mm; Pectoral 7.5–>11.9 mm; Pelvic 11.9– – mm

Pigmentation (excludes yolk-sac larvae) Larvae are moderately to heavily pigmented. *External:* A few melanophores dorsally on head, at tip of upper jaw, on lower jaw, gular region, and along isthmus in preflexion larvae. Paired series of melanophores along dorsal midline of trunk and tail, and along ventral surface of tail; a few melanophores along lateral midline of tail in preflexion larvae. Pigment over lateral surface of head and body by postflexion stage, heavier dorsolaterally. Pigment along anal-fin base and on caudal-fin rays by 8.8 mm. *Internal:* Pigment in otic and opercular areas by 5 mm. Series of melanophores dorsally along gut in preflexion larvae, spreading laterally over entire gut in postflexion larvae.

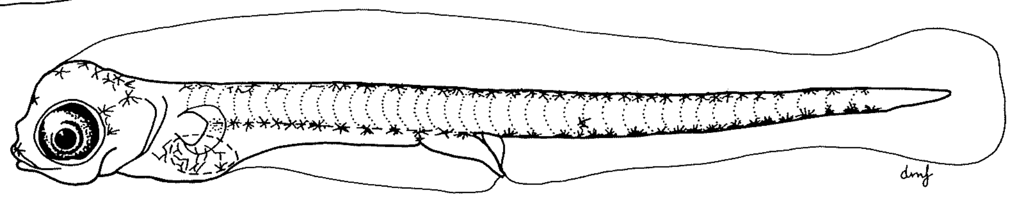
Material examined 450 larvae, 2.8–11.9 mm BL, reared at the Department of Primary Industries and Fisheries (Tas).

Additional references Furlani & Ruwald (1998).

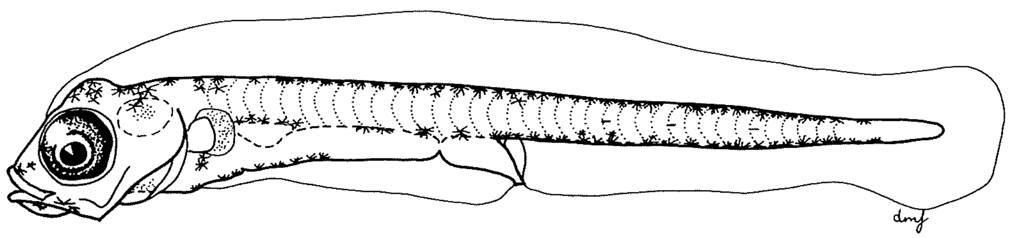
Figure 70 Larvae of *Latris lineata*. **A** Yolk sac, 1 day old. **B** Preflexion, 10 days old. **C** Preflexion, 20 days old. **D** Ventral view of larva in C; note external pigment along jaw and isthmus. **E** Postflexion, 33 days old. **F** Postflexion, 44 days old; note pelvic-fin bud. A–C, E, F reared at DPIF (Tas). Illustrated by D.M. Furlani.



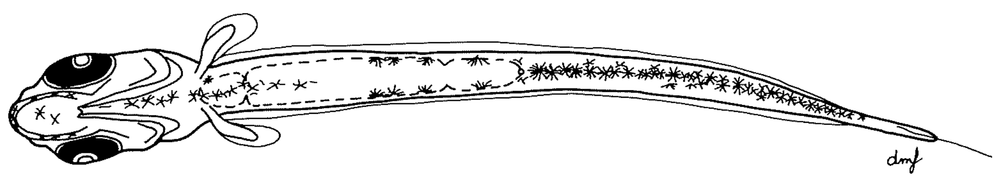
A 3.2 mm



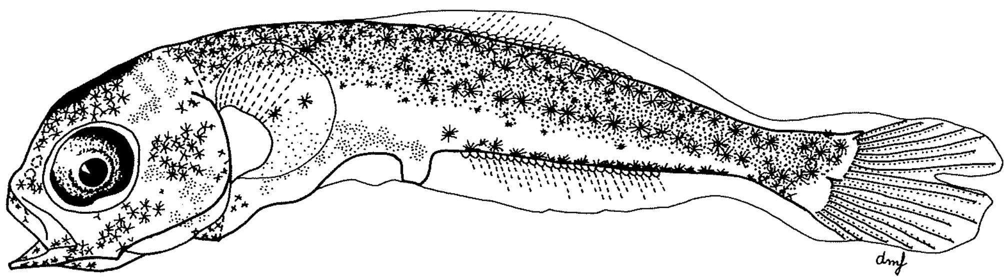
B 4.8 mm



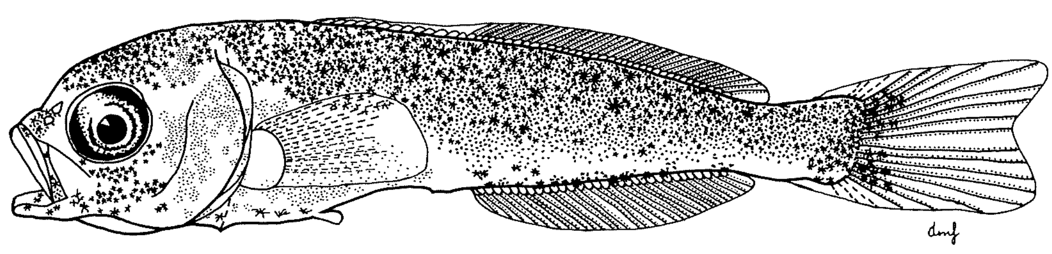
C 5.5 mm



D 5.5 mm



E 7.5 mm



F 11.9 mm

Microcanthidae: Stripeys

A.G. Miskiewicz and F. J. Neira

Microcanthids are schooling fishes found in estuarine and coastal marine waters of the Indo-Pacific. They frequently occur around rocky reefs and structures such as jetties and wharves. Microcanthids have previously been placed in various families including the Chaetodontidae (Fraser-Brunner, 1945), Kyphosidae (Nelson, 1994), and Scorpididae (Springer, 1982; Last *et al.*, 1983; Hutchins & Swainston, 1986; Kojima, 1988b; Eschmeyer & Bailey, 1990; Gomon *et al.*, 1994). We follow Johnson (1980, 1984) and Walker (1983) in treating the Microcanthidae as a distinct family, comprising four genera and five species. The four genera, each containing a single species, have been recorded from temperate Australia (Kuiter, 1993, 1996; Gomon *et al.* 1994). Adults (to 25 cm) are deep and laterally compressed, and have a distinctive pattern of lateral or vertical black bars on the body. Eggs are pelagic and undescribed (Johnson, 1984). Larvae have been described for *A. strigatus* (Neira *et al.*, 1997c) and *M. strigatus* (Uchida *et al.*, 1958; Walker, 1983; Kojima, 1988b). The small to moderate head spination is the only apparent specialisation of microcanthid larvae to pelagic life (Walker, 1983).

Meristic characters of microcanthid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Atypichthys	(1)	XI–XII, 16–18	III, 15–17	15–16	I, 5	17	10 + 15 = 25
Microcanthus	(1)	X–XI, 15–18	III, 13–16	16	I, 5	17	10 + 15 = 25
Neatypus	(1)	X, 20–22	III, 18	15	I, 5	17	10 + 15 = 25
Tilodon	(1)	X, 20–21	III, 17–19	17	I, 5	17	10 + 15 = 25

Main characters of microcanthid larvae

- 25–26 myomeres
- Body elongate to moderate (BD 18–36%), depth increasing with growth
- Weak to moderate head spination, including supraocular, preopercular, supracleithral, subopercular and interopercular spines
- Gut moderate to long (PAL 42–61%), coiled and compact
- Small to large gap between anus and origin of anal fin, closed by postflexion stage
- Head lightly pigmented in preflexion larvae, becoming heavily pigmented with growth
- None to a few melanophores along dorsal midline of trunk and tail, melanophores widely spaced when present
- A few small to large, widely spaced melanophores along ventral midline of tail
- Pigment around notochord tip

References to microcanthid larvae

Uchida *et al.* (1958), Walker (1983), Johnson (1984), Kojima (1988b), Neira *et al.* (1997c).

Families with similar larvae

Arripidae – IX dorsal-fin spines; 9–10 anal-fin rays; 5–6 internal melanophores along nape and anterior of trunk; pigment along lateral midline posteriorly on tail from preflexion stage.

Centrolophidae – Long-based dorsal and anal fins; no gap between anus and origin of anal fin; body moderately to heavily pigmented, pigment blotches along dorsal and ventral surfaces of tail from preflexion stage; no pigment around notochord tip in most taxa.

Chandidae – <VII–VIII dorsal-fin spines; continuous melanophore series along ventral midline of tail; no pigment around notochord tip; melanophore at angle of lower jaw.

Gerreidae – Long ascending premaxillary process; weak head spination; body lightly pigmented; no pigment along dorsal midline of tail before postflexion stage; no pigment around notochord tip.

Girellidae – Large gap between anus and origin of anal fin, persisting after fin is formed; XIII–XVI dorsal-fin spines; body lightly pigmented; pigment along lateral midline posteriorly on tail from flexion stage.

Kyphosidae – No gap between anus and origin of anal fin; no interopercular spines; dorsal fin XI, 12–16; anal fin III, 10–11; body moderately to heavily pigmented, melanophore series along dorsal and ventral midlines of tail, and small to large stellate melanophores over trunk and tail in postflexion larvae; pigment under notochord tip.

Oplegnathidae – No subopercular or interopercular spines; body lightly pigmented, no pigment dorsally along trunk and tail or ventrally along tail in early stages; no pigment around notochord tip.

Pomacentridae – Weak preopercular spines; moderate ascending premaxillary process in many taxa prior to flexion stage; II anal-fin spines.

Pomatomidae – 2 separate dorsal fins, VII–VIII + I, 23–28; long-based anal fin, I–III, 23–28; body lightly pigmented prior to postflexion stage; pigment along lateral midline of tail from flexion stage; no pigment around notochord tip.

Scorpididae – Long-based dorsal and anal fins, IX–X, 23–28 and III, 25–28 respectively; body moderately to heavily pigmented, continuous melanophore series along dorsal and ventral midlines of tail; pigment along lateral midline posteriorly on tail from preflexion stage.

Sparidae – Dorsal fin X–XIII, 9–15; anal fin III, 8–12; body lightly pigmented, rarely any pigment dorsally along trunk and tail prior to postflexion stage; melanophore series along ventral midline of tail; no pigment dorsally along notochord tip.

Microcanthidae *Atypichthys strigatus* (Günther, 1860) Mado

D XI–XII, 16–18 A III, 15–17 P_1 15–16 P_2 I, 5 C 17 V 25

Adults Endemic to southeastern Australia from Noosa Head (Qld) to Apollo Bay (Vic), including northern Tasmania and Lord Howe Island. Common in large schools in estuaries and inshore coastal reefs to a depth of about 30 m, and also around wharves and jetties. Adults are white to silver, with dark horizontal stripes along the body and yellow medial fins. Maximum size 25 cm (Hutchins & Swainston, 1986; Kuiter, 1993; Gomon *et al.*, 1994; Edgar, 1997).

Importance to fisheries An attractive aquarium species, and also caught for bait (Allen & Swainston, 1988; Kuiter, 1993; Edgar, 1997).

Spawning Eggs undescribed. Larvae have been caught in coastal waters off Lake Macquarie (NSW) in July and from September to January (Miskiewicz, 1987, as *Girella* sp.), and in coastal waters off Sydney (NSW) from August to May (Gray, 1995).

Diagnostic characters

- 8–10 + 16–18 = 25–26 myomeres
- Low, smooth supraocular ridge from early flexion stage, finely serrate from late flexion stage
- 1 subopercular and 1 supracleithral spine by late flexion stage; supracleithral ridge strongly serrate by postflexion stage
- Pigment on most of head by postflexion stage, little pigment on trunk and tail
- 4–5 large, widely spaced melanophores along dorsal midline of trunk and tail; anteriormost on nape becomes internal by late preflexion stage
- 3–4 large, widely spaced melanophores along ventral midline of tail

Description of larvae

Morphology Body elongate to moderate (BD 18–39%), deeper with growth. Head moderate to large (HL 19–34%). Two small anterior preopercular and 2 posterior preopercular spines by early flexion stage, increasing in number with growth; posterior preopercular spines near angle slightly long by late flexion stage. Low, smooth supraocular ridge from early flexion stage, finely serrate from late flexion stage. One subopercular and 1 supracleithral spine by late flexion stage; supracleithral ridge strongly serrate by postflexion stage. Opercular, inter-opercular, cleithral and posttemporal spines from about 8 mm. Gut moderate to long (PAL 41–54%), coiled and compact. Small gas bladder over foregut. Small gap between anus and origin of anal fin, reduced by settlement. Third anal-fin spine transforms from a soft ray in postflexion larvae. Scales form after settlement.

Size at	
Hatching	<2.9 mm
Notochord flexion	4.4–~6.8 mm
Settlement	12.2–15.0 mm
Formation of fins:	
Caudal 3.9–7.6 mm; Dorsal 3.9–9.8 mm; Anal 3.9–10.4 mm; Pectoral 5.9–9.8 mm; Pelvic 6.4–9.8 mm	

Pigmentation Larvae are moderately pigmented; head pigmented before trunk and tail. *External:* 1–3 large melanophores above midbrain in preflexion larvae. Several melanophores over forebrain, several at tip of premaxilla, 1 pair on dentary and 1 melanophore on opercle behind eye from flexion stage; head heavily pigmented from early postflexion stage. One small melanophore along isthmus in flexion larvae, number increasing in postflexion larvae. One, rarely 2, small melanophores ventrally on gut, and 1 ventral to anus in preflexion larvae, all disappearing by postflexion stage. Numerous melanophores laterally on gut during flexion stage, over entire gut area by postflexion stage. Four to five large, widely spaced melanophores along dorsal midline of trunk and tail, anteriormost at nape; nape melanophore becomes internal by late preflexion stage, others remain external. Three to four large, widely spaced melanophores along ventral midline of tail in preflexion larvae, remaining along anal-fin base and caudal peduncle in postflexion larvae. Series of melanophores along lateral midline of trunk and tail and dorsolaterally on trunk from about 10 mm. Pigment around notochord tip in preflexion larvae; dorsal pigment disappears by end of flexion stage, ventral pigment remains along caudal-fin base. Melanophores on pectoral-fin base, and on membranes of pelvic fin and spinous dorsal fin in late postflexion larvae. *Internal:* Pigment under otic capsule, nostril and opercle from late flexion stage. Pigment anteriorly on peritoneum and dorsally over gas bladder and gut, extending laterally over gut by postflexion stage. One melanophore dorsally and 1 ventrally on urostyle in flexion larvae. Series of melanophores dorsally over posterior caudal vertebrae from about 10 mm.

Material examined 24 larvae, 2.9–14.4 mm BL, coastal waters off Lake Macquarie and Sydney, and Botany Bay (NSW), and 5 juveniles, 12.2–14.1 mm BL, Jervis Bay and Green Cape (NSW).

Additional references Neira *et al.* (1997c).

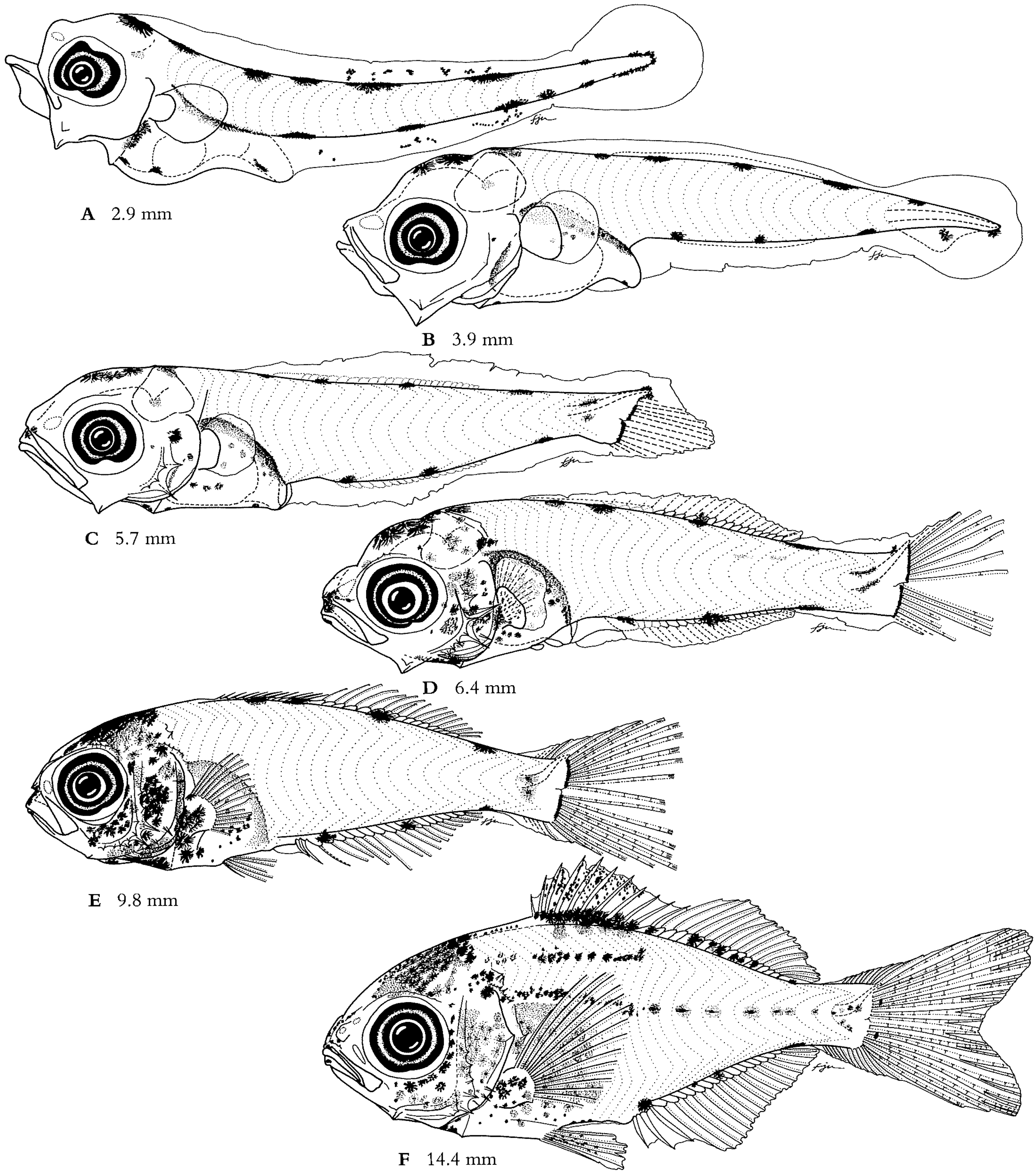


Figure 71 Larvae of *Atypichthys strigatus*. **A** Preflexion; note pigment around notochord tip. **B** Late preflexion; note developing caudal, dorsal and anal fins. **C** Flexion. **D** Early postflexion; note pelvic-fin bud. **E** Postflexion. **F** Postflexion, near settlement. A–C from coastal waters off Lake Macquarie (NSW); D, E from Sydney coastal waters, (NSW); F from Botany Bay (NSW) (modified from Neira *et al.*, 1997c). Illustrated by F. J. Neira.

Microcanthidae *Microcanthus strigatus* (Cuvier, 1831) Stripey

D X–XI, 15–18 A III, 13–16 P_1 16 P_2 I, 5 C 17 V 25

Adults Distributed along western and eastern Australia, from Exmouth Gulf to Cape Leeuwin (WA), and from southern Queensland to Merimbula (NSW). Also widely distributed in subtropical waters of the Indo-Pacific including Lord Howe Island, southern Japan, Taiwan and Hawaii. Occurs in estuaries and coastal reefs, usually in small schools around jetties. Adults are deep bodied with yellow and black horizontal stripes. Maximum size 16 cm (Hutchins & Swainston, 1986; Kuiter, 1993, 1996).

Importance to fisheries An attractive aquarium species (Kuiter, 1993).

Spawning Eggs undescribed. Larvae have been caught in coastal waters of northern and central New South Wales in May, and in coastal waters off Sydney (NSW) from August to November (Gray, 1995).

Diagnostic characters

- 8–10 + 15–16 = 25 myomeres
- Smooth supraocular ridge from about 8 mm
- Supracleithral ridge serrate from early postflexion stage
- 3–4 melanophores along ventral midline of tail
- 1–2 melanophores along dorsal midline of posterior region of tail

Description of larvae

Morphology Body moderate (BD 25–36%). Head moderate to large (HL 29–36%). Small teeth along both jaws by flexion stage. Small to moderate anterior and posterior preopercular spines by flexion stage, increasing in number but reducing in size during postflexion stage. A smooth supraocular ridge, 1 serrate supracleithral ridge, and 1 opercular, 1 interopercular and 1 posttemporal spine by 8 mm. Gut moderate to long in preflexion larvae (PAL 44–55%), long in postflexion larvae (PAL 50–61%), coiled and compact. Small gas bladder over foregut. Small gap between anus and origin of anal fin, reduced by settlement. Last dorsal-fin spine and third anal-fin spine transform from soft rays during postflexion stage. Scales form at settlement.

Size at	
Hatching	<2.7 mm
Notochord flexion	3.7–4.3 mm
Settlement	10.0–12.0 mm
Formation of fins:	
Caudal 2.9–<5.3 mm; Dorsal 3.7–7.9 mm; Anal 3.9–7.9 mm; Pectoral 3.9–7.9 mm; Pelvic 4.3–7.9 mm	

Pigmentation Larvae are initially lightly pigmented, becoming heavily pigmented prior to settlement. *External:* 3–4 melanophores dorsally on head in preflexion larvae; additional melanophores on head, and 1 on nape and 1 on opercle behind eye in flexion larvae. Heavy pigment on head from 9 mm. One to three melanophores along isthmus. Several melanophores laterally on gut during flexion stage; many large, stellate melanophores over entire gut by late postflexion stage. One or two melanophores along dorsal midline of posterior of tail and 3–5 along ventral midline of tail, becoming internal by end of flexion stage. Heavy pigment along dorsal-fin base, lateral midline of tail and anterior of anal-fin base, including spines, by 9 mm; large pigment patches on upper trunk and dorsally and ventrally on caudal peduncle in postflexion larvae. Pigment around notochord tip in preflexion larvae; dorsal pigment disappears during flexion stage, ventral pigment remains along caudal-fin base. Melanophores on pectoral-fin base, and over membranes of pelvic fin, spinous dorsal fin and anal fin in late postflexion larvae. Heavy pigment over entire body in juveniles. *Internal:* Pigment under otic capsule and hindbrain from flexion stage. One melanophore over peritoneum, and heavy pigment dorsally over gas bladder and gut, extending laterally over gut by postflexion stage. Series of melanophores dorsally over posterior of notochord from flexion stage.

Material examined 11 larvae, 2.7–4.3 and 10.5–13.0 mm BL, and 36 juveniles, 9.9–16.3 mm BL, coastal waters of northern and central New South Wales, and Botany Bay (NSW); 5 larvae, 5.3–9.1 mm BL, Hawaii.

Additional references Walker (1983), Kojima (1988b).

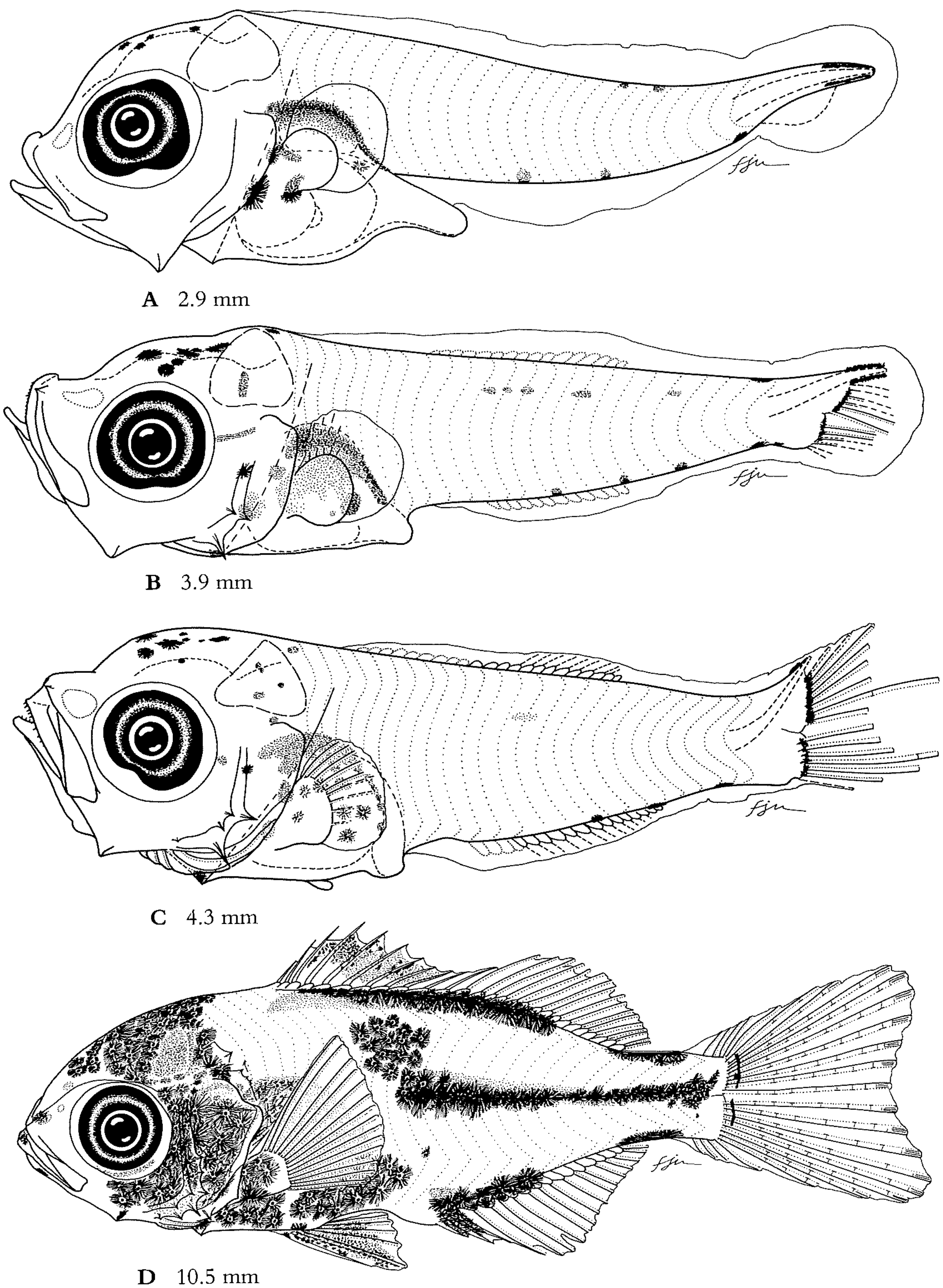


Figure 72 Larvae of *Microcanthus strigatus*. **A** Preflexion; note pigment around notochord tip. **B** Flexion; note developing dorsal and anal fins. **C** Early postflexion; note pelvic-fin bud. **D** Postflexion. A–D from northern and central NSW coastal waters. Illustrated by F. J. Neira.

Monodactylidae: Diamondfishes, fingerfishes

A.G. Miskiewicz

Monodactylids are schooling fishes found in estuarine and coastal marine waters, sometimes also in fresh water, in tropical to temperate regions of western Africa and the Indo-Pacific (Nelson, 1994). The family contains two genera and about five species (Nelson, 1994). Both genera and three species have been recorded from temperate Australia (Kuiter, 1993, 1996; Gomon *et al.*, 1994). Adults (to 20 cm) are deep bodied and strongly compressed, have long-based dorsal and anal fins roughly equal in length, and pelvic fins which are present in juveniles of both genera but which are vestigial or absent in adults of *Monodactylus*. Eggs of *M. sebae* are pelagic in sea water (they sink in fresh water), and spherical, 0.6–0.7 mm in diameter (Akatsu *et al.*, 1977), while eggs of *M. argenteus* are demersal and adhesive at least in fresh water (Breder & Rosen, 1966). Larvae have been described for *M. argenteus* and *M. sebae* (Akatsu *et al.*, 1977; Kinoshita, 1988g; Miskiewicz, 1989). The moderate head spination, and the early forming, elongate pelvic fins are the only apparent specialisations of monodactylid larvae to pelagic life (Miskiewicz, 1989).

Meristic characters of monodactylid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Monodactylus	(1)	VII–VIII, 27–31	III, 27–31	16–18	I, 5	17	10 + 14 = 24
Schuettea	(2)	V, 28–30	III, 28–32	14–18	I, 5	17	10 + 14 = 24

Main characters of monodactylid larvae (based on *Monodactylus*)

- 24–25 myomeres
- Body moderate to deep (BD 31–59%)
- Moderate head spination, including prominent preopercular spines, a low serrate supraocular ridge, and small interopercular, posttemporal and supracleithral spines
- Gut long (PAL 50–62%), coiled and compact
- Early forming pelvic-fin rays, elongate in early stages but reducing in size with growth
- Body initially moderately pigmented, becoming heavily pigmented with growth
- Distinct wide band of heavy pigment from snout ventrally across opercle to anus in preflexion larvae
- Pelvic fins heavily pigmented early in development
- 2 large opposing melanophores on dorsal and ventral surfaces of caudal peduncle in postflexion larvae

References to monodactylid larvae

Akatsu *et al.* (1977), Ogasawara *et al.* (1978), Johnson (1984), Kinoshita (1988g), Miskiewicz (1989).

Families with similar larvae

Nomeidae (e.g. *Nomeus*, *Psenes*) – 30–42 myomeres; weak preopercular spination; long-based dorsal fin with >VII spines; lack band of heavy pigment through head and trunk.

Pempheridae – Weak preopercular spines, supraocular ridge absent; early forming pelvic fins, located high and laterally on gut in early stages; lack band of heavy pigment through head and trunk; little pigment on tail after flexion stage.

Phycidae – 38–55 myomeres; no preopercular spines; prominent pterotic spines in some taxa; long-based, spineless dorsal and anal fins; pelvic fins inserted high and laterally on body; barbels on lower jaw and snout in a few taxa; pigmented bands usually along tail.

Trachichthyidae – 26–30 myomeres; usually prominent preopercular and opercular spines; short-based dorsal and anal fins, III–X, 8–18 and II–III, 8–11 respectively; pelvic fin I, 6; body moderately to heavily pigmented; lack band of heavy pigment through head and trunk.

Monodactylidae *Monodactylus argenteus* (Linnaeus, 1758)

Diamondfish, moonfish

D VII–VIII, 27–31 A III, 27–31 P_1 16–18 P_2 I, 5 C 17 V 24

Adults Distributed around northern Australia from the Dampier Archipelago (WA) to Jervis Bay (NSW). Also widespread in the tropical Indo-Pacific, from east Africa and the Red Sea to Japan and Samoa. Adults are common in estuaries, particularly near jetties, while juveniles occur in brackish waters and may move into fresh water. They have a deep, laterally compressed, diamond-shaped body, rudimentary pelvic fins, and dorsal and anal fins with black tips. Maximum size 27 cm (Hutchins & Swainston, 1986; Kuiter, 1993, 1996).

Importance to fisheries Occasionally sold as an aquarium fish (Nelson, 1994).

Spawning Eggs undescribed. Eggs of the tropical Atlantic species *Monodactylus sebae* are pelagic and spherical, 0.6–0.7 mm in diameter (Akatsu *et al.*, 1977), and are demersal and adhesive in fresh water (Breder and Rosen, 1966). In New South Wales, larvae of *M. argenteus* have been caught entering Lake Macquarie from December to May, with peak abundances between February and April (Miskiewicz, 1987), entering Tuggerah Lakes in February and March (Marsden, 1986), and in coastal waters off Sydney from December to February (Gray, 1995).

Diagnostic characters

- 8–12 + 12–16 = 24–25 myomeres
- Large posterior preopercular spines
- Early forming, elongate pelvic-fin rays, heavily pigmented
- Wide band of heavy pigment from snout to under opercle, continuing over entire gut to anus

Description of larvae

Morphology Body moderate in preflexion and flexion larvae (BD 30–40%), moderate to deep in postflexion larvae and early juveniles (BD 38–59%). Head moderate to large in preflexion and flexion larvae (HL 30–38%), large in postflexion larvae (HL 34–42%) and early juveniles (HL 38–59%). Small teeth along both jaws. One posterior preopercular spine by 2.1 mm; 5 small anterior preopercular and up to 9 moderate to large posterior preopercular spines by early postflexion stage, spines increasing in number with growth. Serrate supraocular ridge by late preflexion stage, and small interopercular, posttemporal and supracleithral spines from flexion stage; all these spines are overgrown by tissue in late postflexion larvae. One opercular spine from early postflexion stage. Gut long (PAL 50–62%), coiled and compact. Small gas bladder above foregut, visible only in larvae caught at night. Scales form by settlement.

Size at

Hatching	<2.1 mm
Notochord flexion	3.2–4.5 mm
Settlement	9.1–12.5 mm
Formation of fins:	

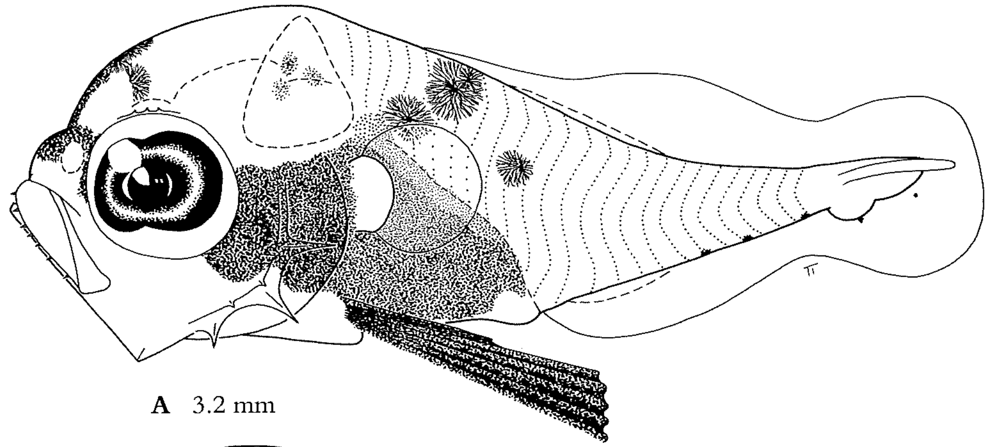
Pelvic <2.1–3.2 mm; Caudal 3.2–4.5 mm; Dorsal 3.2–5.8 mm; Anal 3.2–5.8 mm; Pectoral 3.6–5.8 mm

Pigmentation Larvae are moderately to heavily pigmented. *External:* Heavy pigment on snout, continuing diagonally to opercle and ventrally to lateral surface of gut and anus in preflexion and flexion larvae; heavy pigment on head and gut in postflexion larvae. One to several large melanophores on dorsolateral surface of trunk by flexion stage, forming an oblique, wide pigment band from spinous portion of dorsal fin to pectoral-fin base; heavy pigment over entire trunk posteriorly to about mid-tail by postflexion stage. Up to 6 small melanophores along ventral midline of posterior of tail; 1 melanophore remains at caudal peduncle and becomes large, all others disappear by flexion stage. Dorsal melanophore on caudal peduncle from early postflexion stage, directly opposite ventral melanophore, forming a continuous band of pigment around caudal peduncle by late postflexion stage (not shown in illustrated series). Up to 4 melanophores under notochord tip in preflexion and early flexion larvae. Pelvic fins heavily pigmented from preflexion stage. Pigment on trunk and tail spreads to dorsal and anal fins in postflexion larvae. *Internal:* 3 melanophores at junction of mid- and hindbrain. Heavy pigment dorsally over gut and gas bladder.

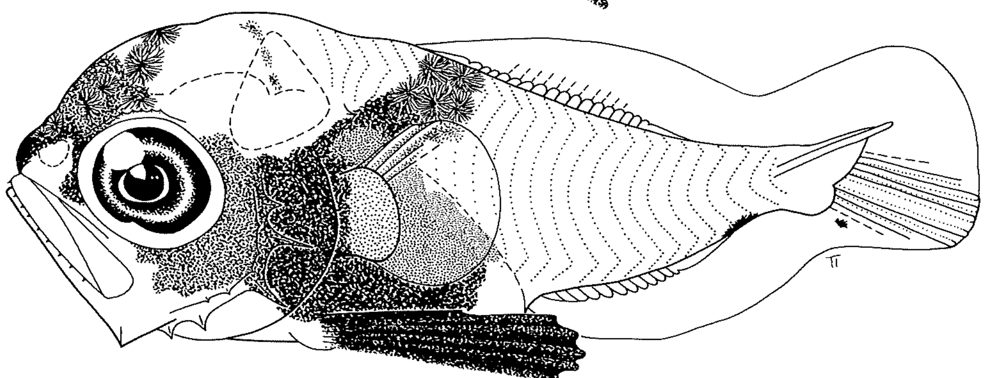
Material examined 21 larvae, 3.1–9.8 mm BL, and 4 juveniles, 9.1–14.5 mm BL, Lake Macquarie, Sydney Harbour and Botany Bay (NSW); 2 larvae, 2.1–2.8 mm BL, Darwin (NT).

Additional references Kinoshita (1988g), Miskiewicz (1989).

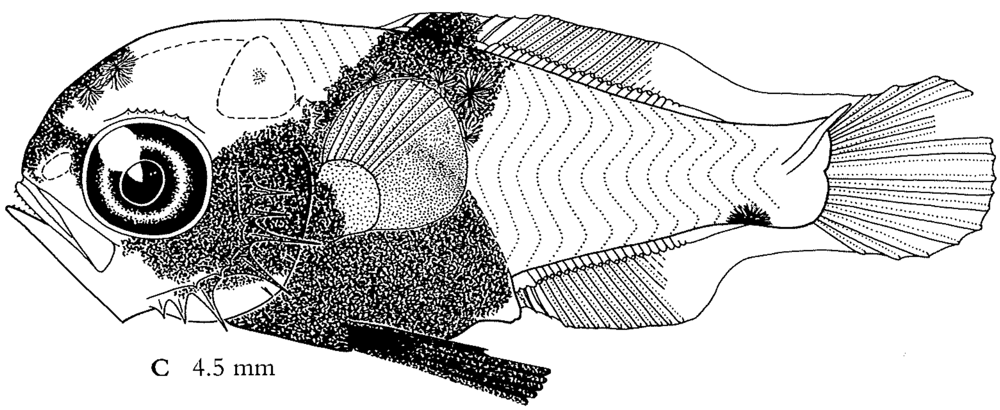
Figure 73 Larvae of *Monodactylus argenteus*. **A** Late preflexion. **B** Early flexion; note small supracleithral spine. **C** Early postflexion; note small interopercular and subopercular spines. **D** Postflexion. A from coastal waters off Lake Macquarie (NSW); B, C from Lake Macquarie (NSW); D off Port Hacking (NSW). C, D redrawn from Miskiewicz (1989). Illustrated by T. Trnski.



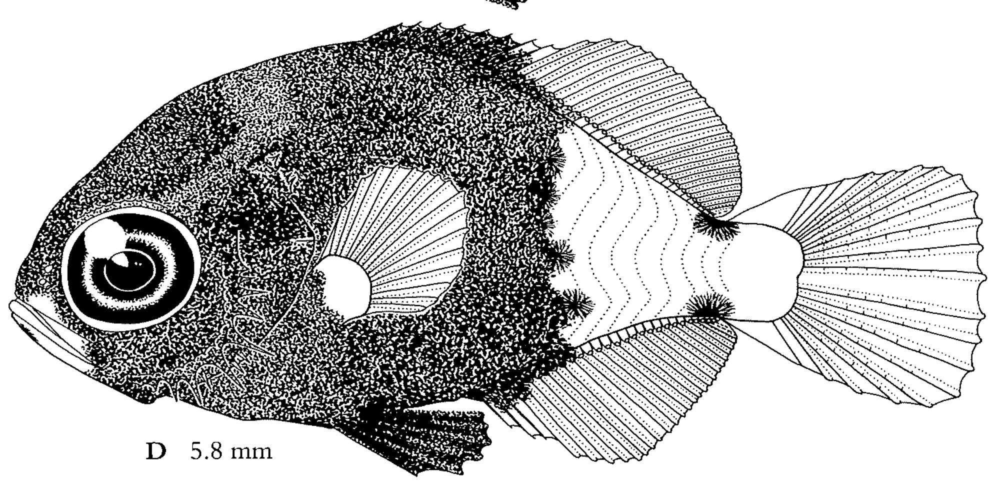
A 3.2 mm



B 3.6 mm



C 4.5 mm



D 5.8 mm

Nemipteridae: Threadfin breams, butterfishes

F. J. Neira

Nemipterids are benthic or demersal, solitary or schooling, marine fishes found in tropical to temperate coastal waters of the Indo-West Pacific (Allen & Swainston, 1988; Russell, 1990). They are common over sand and mud bottoms, and nearby reefs to a depth of 400 m, with some species confined solely to coral reefs (Russell, 1990). The family contains 5 genera and 62 species, most of which are difficult to separate at the species level except by using external coloration in live specimens (Russell, 1990; Nelson, 1994). One species occurs in temperate Australia (Hutchins & Swainston, 1986; Russell, 1990). Some species of *Nemipterus* are fished commercially and make an important contribution to the trawl catches throughout the Indo-West Pacific (Allen & Swainston, 1988; Russell, 1990). Adults (20–30 cm) are moderately elongate and laterally compressed, have thoracic pelvic fins and a continuous dorsal fin. The upper caudal-fin ray is markedly produced in some species, for which some members are commonly known as 'threadfin' or 'whiptail' breams. Eggs of *Nemipterus* are pelagic and spherical, 0.6–0.8 mm in diameter, and have a single oil globule (Aoyama & Sotogaki, 1955; Zhang & Lu, 1980; Zhang *et al.*, 1985). Larvae have been described for representatives of *Nemipterus*, *Pentapodus* and *Scolopsis* (Zhang & Lu, 1980; Leis & Rennis, 1983; Zhang *et al.*, 1985; Konishi, 1988e). Nemipterid larvae have no apparent specialisations to pelagic life (Leis & Rennis, 1983).

Meristic characters of the nemipterid genus of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Pentapodus	(1)	X, 9	III, 7	16–17	I, 5	17	10 + 14 = 24

Main characters of nemipterid larvae

- 22–24 myomeres
- Body moderate (BD 23–34%), laterally compressed by postflexion stage
- Head round, with a steep profile and a short, round snout
- No head spines except for small posterior preopercular spines in some taxa from postflexion stage (e.g. *Scolopsis*)
- Gut moderate to long (PAL 33–68%), tightly coiled and compact
- Small to moderate gap between anus and origin of anal fin, closed as anus migrates posteriorly
- Body lightly pigmented
- Series of small melanophores along entire ventral midline of tail in preflexion and flexion larvae, about 2 per myomere; number varies among taxa

References to nemipterid larvae

Leis & Rennis (1983), Konishi (1988e), Russell (1990).

Families with similar larvae

Chandidae –VII–VIII dorsal-fin spines; small preopercular spines; internal pigment at nape and 1 external melanophore at angle of lower jaw.

Gerreidae – Long ascending premaxillary process; weak preopercular spines; IX–X dorsal-fin spines.

Opistognathidae – 25–35 myomeres, typically 25–28; prominent lower jaw angle, and a large mouth with small villiform teeth; weak preopercular spines; large pectoral fins with early forming rays in some taxa; few melanophores ventrally along tail.

Pinguipedidae – 29–34 myomeres; moderate head spination, including posterior preopercular and up to 4 small opercular spines; long-based dorsal fin, IV–V, 21–25; anal fin I, 17–19; no gap between anus and origin of anal fin; expanded ventral melanophore on posterior region of tail.

Pomacentridae – 26–27 myomeres, typically 26; anal fin II, 10–18; pigment dorsally on head and nape from early stages; typically a few melanophores ventrally along tail.

Scombridae – Typically >30 myomeres; 2 dorsal fins, first with X–XIX spines; pigment over midbrain in early preflexion larvae.

Sparidae – 24–25 myomeres; moderate head spination, weak to strong preopercular spines; dorsal fin X–XIII, 9–15.

Nemipteridae *Pentapodus vitta* Quoy & Gaimard, 1824

Western Australian butterfish

D X, 9 A III, 7 P_1 16–17 P_2 I, 5 C 17 V 24

Adults Endemic to Western Australia from the Dampier Archipelago to Geographe Bay. Benthic schooling species found in seagrass beds and coastal reefs, to a depth of 15 m. Adults have a single, curved dark brown stripe bordered by blue lines extending from the snout to the caudal fin. Maximum size 31 cm (Hutchins & Swainston, 1986; Allen & Swainston, 1988; Russell, 1990; Edgar, 1997).

Importance to fisheries Occasionally caught by recreational fishers with handlines (Russell, 1990).

Spawning Eggs undescribed. Larvae have been caught in the lower Swan Estuary (WA) from September to February, with a peak abundance in January (Gaughan *et al.*, 1990; Neira *et al.*, 1992).

Diagnostic characters

- 7–9 + 15–17 = 24 myomeres
- No head spines
- 2–3 melanophores ventrally on gut
- 21–38 small melanophores along ventral midline of tail, about 2 per myomere

Description of larvae

Morphology Body moderate (BD 23–27%), laterally compressed in postflexion larvae. Head moderate (HL 20–30%), round, profile steep. Small conical teeth along both jaws in preflexion larvae. Gut moderate (PAL 33–47%), tightly coiled and compact. Small gas bladder over foregut. Moderate gap between anus and origin of anal fin.

Size at

Hatching	<2.3 mm
Notochord flexion	3.9–5.5 mm
Settlement	>5.3 mm
Formation of fins:	

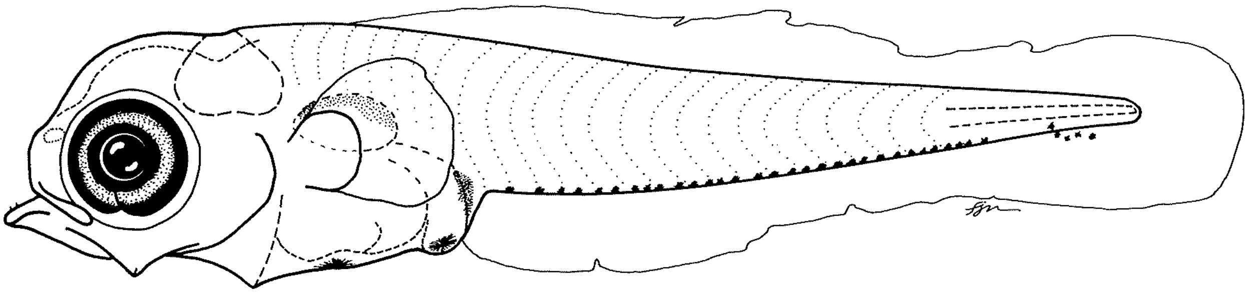
Caudal 3.6–5.3 mm; Pectoral 4.0–5.3 mm; Dorsal 4.0–>5.3 mm; Anal 4.0–>5.3 mm; Pelvic >5.3 mm

Pigmentation Larvae are lightly pigmented. *External:* 2 melanophores ventrally on gut, 1 posterior to cleithral symphysis and 1 just anterior to anus; 1 additional melanophore between these two in late flexion larvae. Series of 21–38 (usually 26–31) very small melanophores along entire ventral midline of tail in preflexion larvae, about 2 per myomere; number remains similar in postflexion larvae, with about 9–10 melanophores along anal-fin base, about 1 per pterygiophore. Several small melanophores under notochord tip in preflexion larvae, remaining along lower caudal-fin rays in flexion larvae. *Internal:* Pigment dorsally over gas bladder and 1 melanophore over hindgut above anus.

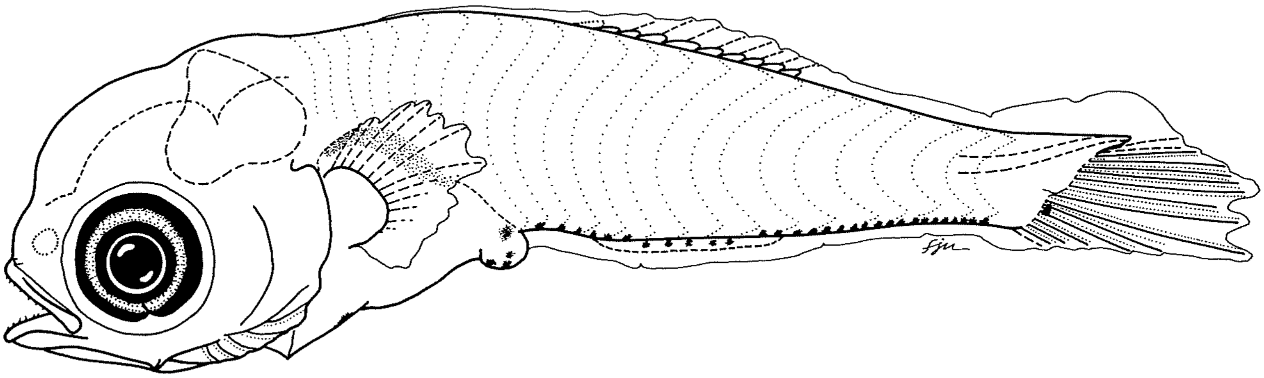
Material examined 20 larvae, 2.3–5.3 mm BL, lower Swan Estuary (WA).

Additional references –

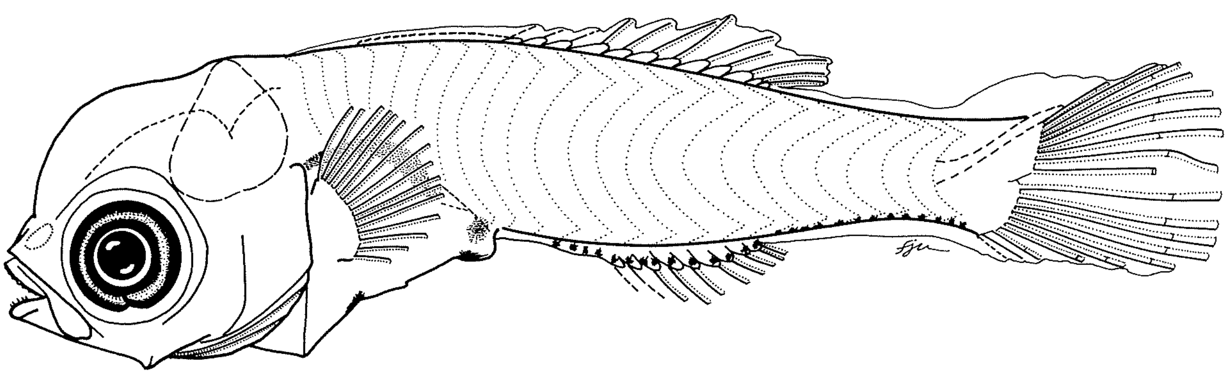
Figure 74 Larvae of *Pentapodus vitta*. **A** Preflexion. **B** Flexion; note developing dorsal and anal fins. **C** Late flexion. A–C from lower Swan Estuary (WA). Illustrated by F. J. Neira.



A 3.3 mm



B 4.5 mm



C 5.3 mm

Percichthyidae: Basses, perches, cods

P. Brown and F. J. Neira

Percichthyids are cryptic freshwater fishes (rarely brackish) found in temperate regions of Australia, and in South America, primarily in Argentina and Chile. The generic composition of the family has changed after some additions and exclusions made by Johnson (1984) and now is regarded as containing 11 genera and about 22 species (Nelson, 1994). Although the generic composition in the new percichthyid classification includes *Gadopsis* (Eschmeyer & Bailey; 1990; Nelson, 1994), we have retained this genus in its own family (see Gadopsidae, this book) until further taxonomic review of the group. Excluding *Gadopsis* and its two species, the family is represented in temperate Australia by 6 genera and 13 species (Allen, 1982, 1989; Paxton & Hanley, 1989l; Rowland, 1993; Nelson, 1994; Harris & Rowland, 1996). Adults (0.035–1.8 m) have a single, continuous dorsal fin with or without a notch, and, in some species, two blunt opercular spines. Reproductive habits are highly variable. Eggs are either pelagic and semibuoyant or demersal and adhesive, and spherical, 1.2–4.2 mm in diameter (Lake, 1967b; Johnson, 1984; Ingram & Rimmer, 1992). Larvae of species with pelagic eggs (e.g. *Macquaria ambigua*) hatch at sizes <5 mm BL and have a brief yolk-sac stage, while those of species with demersal eggs (e.g. *Maccullochella* spp.) hatch at sizes >5 mm BL and have an extended yolk-sac stage. Larvae have been described for *Maccullochella peelii peelii* and *M. ambigua* (Dakin & Kesteven, 1938; Lake, 1967b). Percichthyid larvae have no obvious specialisations to pelagic life.

Meristic characters of percichthyid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Bostockia	(1)	VII–VIII, 16–17	III, 11–12	13–15	I, 5	17	–
Edelia	(2)	VIII–IX, 7–9	III, 6–8	11–13	I, 5	17	–
Maccullochella	(3)	X–XII, 13–16	III, 10–15	18–21	I, 5	17	14–15 + 19–22 = 34–36
Macquaria	(4)	VIII–XIII, 8–14	III, 7–11	12–18	I, 5	17	24–31
Nannatherina	(1)	VII–VIII, 9–11	III, 8–10	12–13	I, 5	17	14–15 + 18–19 = 32–34
Nannoperca	(2)	VII–IX, 7–10	III, 7–9	11–15	I, 5	17	–

Main characters of percichthyid larvae

- 24–37 myomeres
- Body very elongate to moderate (BD 9–35%)
- Posterior preopercular spines and 1 opercular spine in transforming larvae; a smaller second opercular spine may develop in early juveniles
- Gut moderate to long (PAL 39–66%), straight to slightly coiled
- Small to moderate gap between anus and origin of anal fin
- Continuous dorsal fin
- Pelvic fins thoracic, with I, 5 elements
- Melanophore series along ventral midline of tail

References to percichthyid larvae

Dakin & Kesteven (1938), Lake (1967b), Johnson (1984).

Families with similar larvae

Gadopsidae – 45–51 myomeres; no head spines; long-based dorsal fin, 28–44 elements; pelvic fins jugular, with a single bifid ray.

Percichthyidae *Maccullochella macquariensis* (Cuvier, 1829) Trout cod

D XI–XII, 14–16 A III, 10–13 P_1 18–20 P_2 I, 5 C 17 V 34–36

Adults Endangered species with remnant populations in parts of the Murray River (southern NSW) and Goulburn River (central Vic) systems, although once widespread throughout the Murray–Darling river system. Hatchery-bred juveniles have recently been stocked into many southern tributaries of the Murray–Darling basin. A carnivorous top predator, it prefers areas with snags and woody debris in fast-flowing streams. Adults are large, and have relatively large eyes, and a subterminal mouth with the maxilla reaching below the posterior edge of the eye. Maximum size 85 cm (Lake, 1971; Ingram & Rimmer, 1992; Douglas *et al.*, 1994; Harris & Rowland, 1996).

Importance to fisheries An excellent angling fish, once keenly sought by recreational and commercial fishers. This endangered species is now protected by legislation in New South Wales, Victoria and the Australian Capital Territory. A recovery plan is currently being implemented (Douglas *et al.*, 1994; Harris & Rowland, 1996).

Spawning Eggs are adhesive and spherical, 2.5–4.0 mm in diameter, and have a single oil globule 0.74–0.76 mm (S. Thurstan, NFC, pers. comm.). Eggs hatch after 5–10 days at 15.5–23.0°C (Ingram & Rimmer, 1992). Spawning has only once been observed in captive fish; eggs were found in a single patch adhered to a concrete structure and were probably spawned in early October after water temperatures rose above 14°C (S. Thurstan, pers. comm.). Hormone-induced spawning was successful at temperatures of 14–22°C in late September and October (Ingram & Rimmer, 1992; Harris & Rowland, 1996).

Diagnostic characters

- 14–16 + 20–22 = 33–37 myomeres
- Mouth slightly subterminal from late postflexion stage
- Ratio SnL:ED 102–193% in transformed larvae
- Large yolk sac at hatching, persisting until postflexion stage
- Blotches of pigment laterally over trunk in transforming larvae

Description of larvae

Morphology Body very elongate to moderate (BD 9–27%). Head small to moderate in preflexion and flexion larvae (HL 14–25%), moderate to large in postflexion larvae (HL 23–35%). Mouth slightly subterminal in late postflexion larvae. Ratio SnL:ED 73–102% prior to transformation, 102–193% in transformed larvae. Larvae hatch with pigmented eyes. One to three anterior preopercular and 2–4 posterior preopercular spines, and 1 opercular spine in early postflexion larvae; second opercular spine and up to 6 posterior preopercular spines in late postflexion larvae. Anterior preopercular spines disappear in large juveniles. Gut moderate to long in preflexion and flexion larvae (PAL 47–61%), long in postflexion larvae (PAL 55–61%); straight and poorly differentiated prior to flexion stage, slightly coiled by postflexion stage. Gas bladder inflated in preflexion larvae from about 7.4 mm. Large yolk sac is resorbed by transformation.

Size at

Hatching	6.9–7.5 mm
Notochord flexion	8.1–8.4 mm
Transformation	9.3–10.7 mm

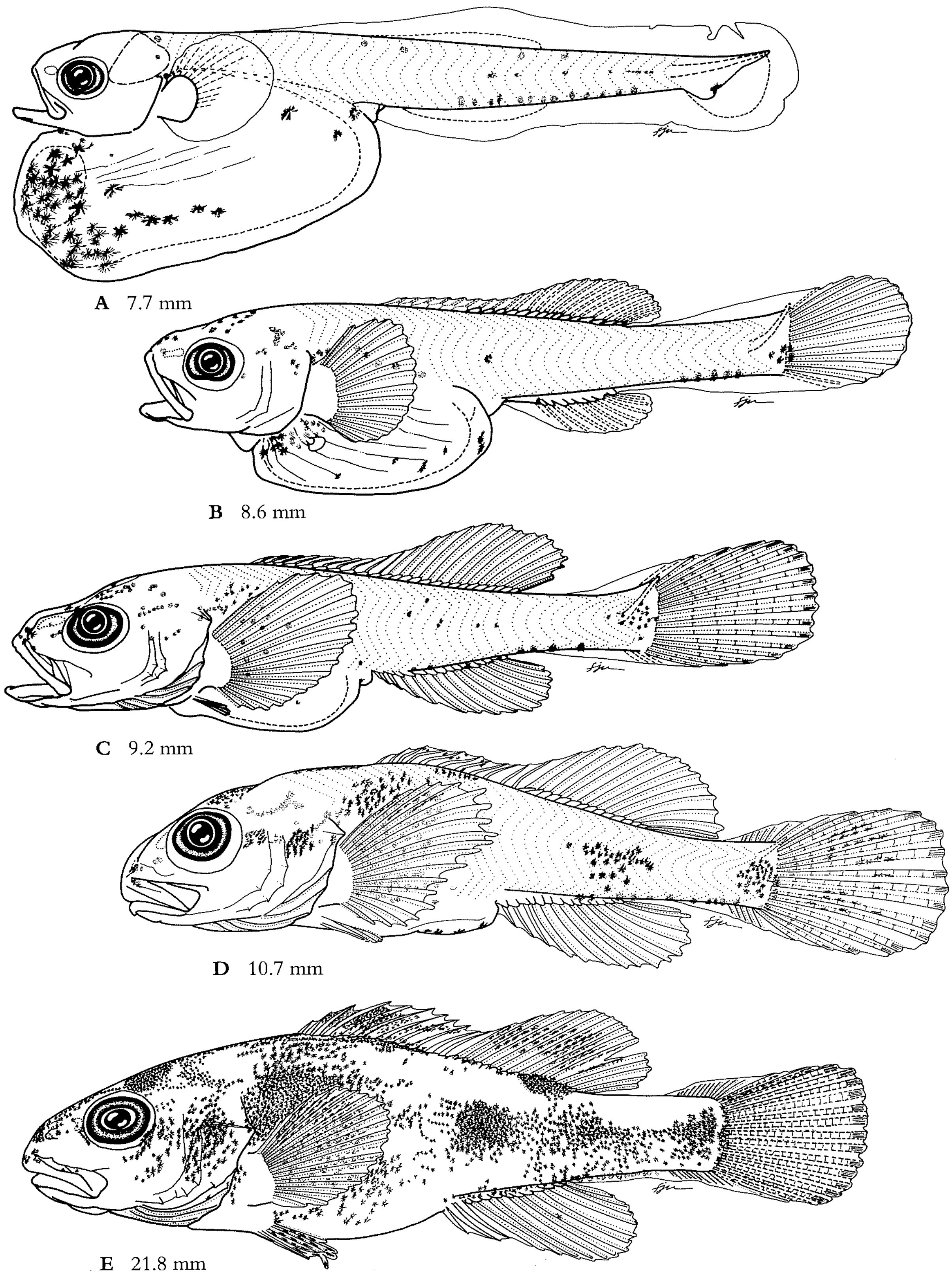
Formation of fins:
Caudal 7.2–8.8 mm; Dorsal 7.2–10.2 mm; Anal 7.2–10.2 mm; Pectoral 7.5–9.2 mm; Pelvic 7.5–13.3 mm

Pigmentation Larvae are moderately pigmented; pattern in wild larvae may differ from that in reared larvae. *External:* Pigment on snout, supraoccipital and opercular regions from flexion stage. Single melanophore series occasionally on nape in preflexion larvae. Scattered melanophores on yolk sac at hatching, a few persisting ventrally on gut until late postflexion stage. Melanophores scattered along dorsal and ventral midlines of trunk and tail at hatching, becoming internal by flexion stage; paired melanophore series and scattered pigment dorsally over trunk and tail by transformation; paired melanophore series along anal-fin base, and a series along ventral midline of caudal peduncle from transformation. Large blotches of pigment laterally along body by transformation, from pectoral-fin base to caudal peduncle. Pigment on fins forms sequentially on pectoral, dorsal, caudal and pelvic fins in juveniles. Anal fin remains unpigmented. One large melanophore at centre of caudal peduncle may be present at hatching. *Internal:* Pigment dorsally over gas bladder in preflexion larvae. Pigment along dorsal and ventral midlines of trunk and tail by flexion stage. Pigment on midbrain and otic capsule in flexion larvae, and snout and peritoneum in postflexion larvae.

Material examined 15 larvae, 6.9–9.3 mm BL, and 15 juveniles, 9.3–26.9 mm BL, reared at the Narrandera Fisheries Centre (NSW).

Additional references –

Figure 75 Larvae and juvenile of *Maccullochella macquariensis*. **A** Early flexion, 2 days old; note large yolk sac. **B** Late flexion, 10 days old; note pelvic-fin bud. **C** Postflexion, 15 days old; note remnants of yolk sac. **D** Postflexion, 24 days old. **E** Juvenile, 41 days old. A–E reared at NFC (NSW). Illustrated by F. J. Neira.


A 7.7 mm
B 8.6 mm
C 9.2 mm
D 10.7 mm
E 21.8 mm

Percichthyidae *Maccullochella peelii peelii* (Mitchell, 1838) Murray cod

D X–XII, 13–16 A III, 11–15 P_1 18–21 P_2 1, 5 C 17 V 34–36

Adults Found throughout the Murray–Darling river system, although now rare in South Australia. Stocking has been introduced to water storage impoundments throughout southeastern Australia. A carnivorous top predator found in small, clear rocky streams to turbid, slow-flowing rivers and creeks, usually in or near deep holes. Adults are large, and have a short, depressed snout, relatively small eyes, and a large mouth. Maximum size 1.8 m (Rowland, 1989, 1993; Harris & Rowland, 1996).

Importance to fisheries Historically important, although the commercial fishery has declined significantly. Supports a small commercial fishery in southwestern New South Wales. Targeted by recreational fishers in rivers and impoundments. There is some commercial aquaculture interest (Harris & Rowland, 1996).

Spawning Eggs are adhesive and spherical, 3.0–4.0 mm in diameter, and have a rough opaque chorion, and a single oil globule 0.74–0.76 mm. Up to 40 000 eggs are deposited on hard substrates (Lake, 1967b, as *M. macquariensis*; Rowland, 1983a). Spawning in ponds occurs at water temperatures above 16.5°C in response to increased day length in spring (Rowland, 1983a; Cadwallader & Gooley, 1985; Gooley *et al.*, 1995). Males apparently guard eggs and larvae (Rowland, 1983b). Larvae in rearing ponds have no planktonic stage and settle shortly after hatching. No eggs or larvae have to date been caught in the wild (Rowland, 1992).

Diagnostic characters

- 11–20 + 14–23 = 31–35 myomeres
- Mouth terminal in late postflexion larvae
- Ratio SnL:ED 85–136% in transformed larvae
- Large yolk sac at hatching, persisting until postflexion stage
- Series of melanophores along ventral midline of tail in preflexion larvae, decreasing in number and becoming internal during flexion stage

Description of larvae

Morphology Body elongate to moderate (BD 12–28%). Head small to moderate in preflexion and flexion larvae (HL 11–22%), moderate to large in postflexion larvae (HL 23–38%). Mouth terminal in postflexion larvae. Ratio SnL:ED 80–85% prior to transformation, 85–136% in transformed larvae. Larvae hatch with pigmented eyes. One to three anterior preopercular spines in late postflexion larvae, disappearing after transformation. Up to 11 posterior preopercular spines from postflexion stage; posterior preopercular edge finely serrate in juveniles. One or two opercular spines in transformed larvae. Gut moderate to long in preflexion and flexion larvae (PAL 43–53%), long in postflexion larvae (PAL 55–66%); initially straight, slightly coiled in postflexion larvae. Large yolk sac is resorbed by transformation.

Size at

Hatching	6.8–6.9 mm
Notochord flexion	7.9–8.6 mm
Transformation	8.5–9.1 mm
Formation of fins:	

Caudal 7.3–8.9 mm; Dorsal 7.9–9.0 mm; Anal 7.9–9.0 mm; Pectoral 7.9–9.1 mm; Pelvic 8.4–11.0 mm

Pigmentation Larvae are moderately pigmented; pattern in wild larvae may differ from that in reared larvae. *External:* Melanophores on snout and dorsally on head from flexion stage, and on opercle and nape by postflexion stage. Melanophores scattered on yolk sac at hatching, persisting until transformation. Single melanophore series along dorsal and ventral midlines of trunk and tail at hatching; dorsal series disappears, ventral series becomes internal during flexion stage. Paired melanophore series along dorsal- and anal-fin bases, and single series dorsally and ventrally along caudal peduncle in transformed larvae. Heavy pigment on snout, opercle, dorsally on head, and dorsolateral surface of trunk, with bars and blotches laterally along body in transformed larvae. Little or no pigment ventrally on gut in transforming larvae. Pigment forms sequentially on dorsal, pectoral and caudal fins in transformed larvae. Anal fin remains unpigmented. One melanophore below notochord tip at hatching, remaining on caudal-fin base in postflexion larvae; a few over urostyle in postflexion larvae. *Internal:* Pigment around otic capsule and dorsally over gas bladder in late preflexion larvae. Melanophore series along ventral midline of tail during flexion stage. Pigment on midbrain in flexion and postflexion larvae; around snout, peritoneum and hindgut in transforming larvae.

Material examined 15 larvae, 6.8–8.6 mm BL, and 15 juveniles, 8.5–22.4 mm BL, reared at Narrandera Fisheries Centre (NSW).

Additional references Dakin & Kesteven (1938), Lake (1967b, as *M. macquariensis*).

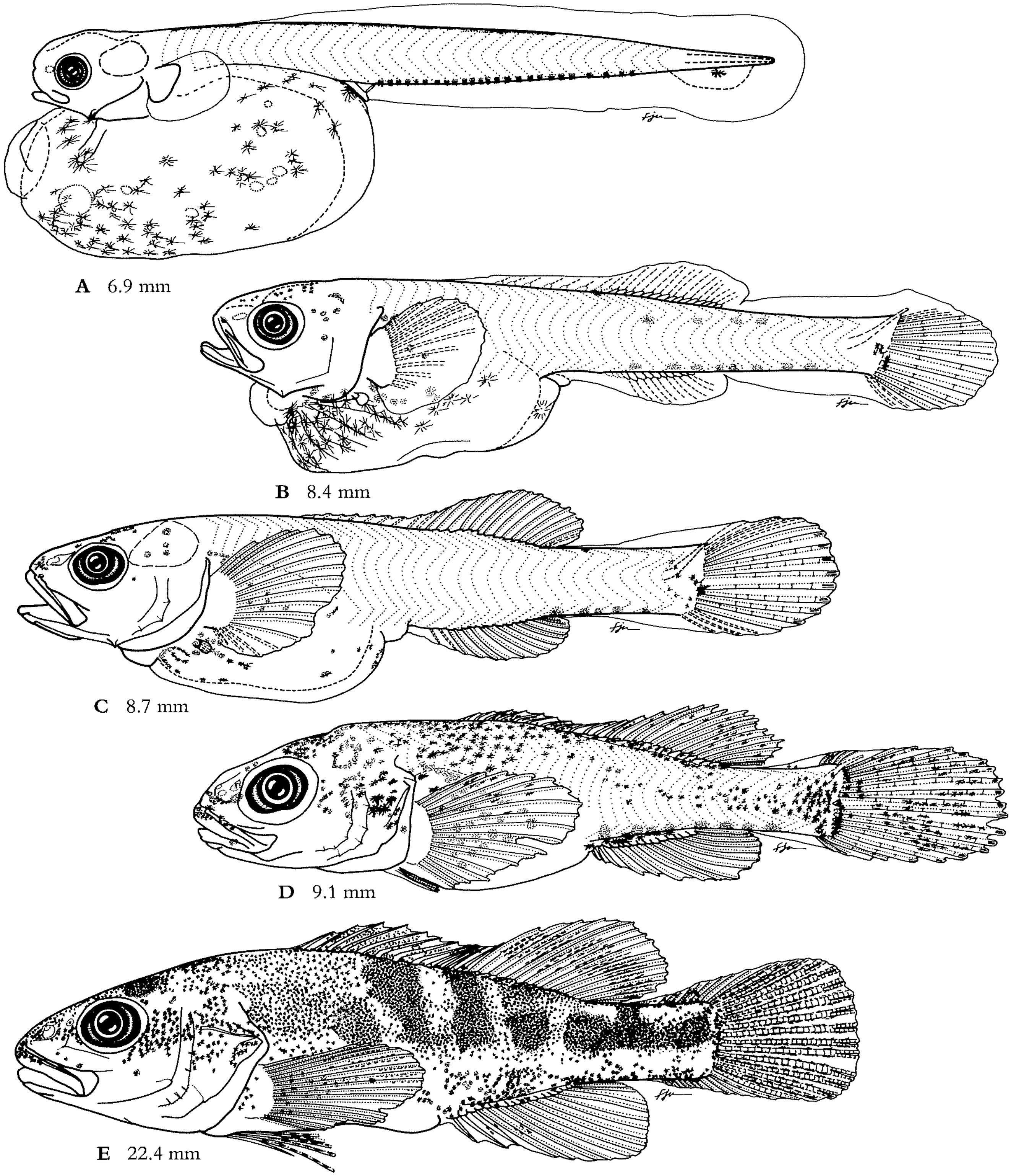


Figure 76 Larvae and juvenile of *Maccullochella peelii peelii*. **A** Preflexion, 1 day old; note large yolk sac. **B** Flexion, 8 days old; note pelvic-fin bud. **C** Early postflexion, 11 days old. **D** Postflexion, 20 days old; note remnants of yolk sac. **E** Juvenile, 46 days old. A–E reared at NFC (NSW). Illustrated by F. J. Neira.

Percichthyidae *Macquaria ambigua* (Richardson, 1845) Golden perch

D VIII–XI, 11–13 A III, 7–10 P_1 15–18 P_2 I, 5 C 17 V 24–28

Adults Naturally confined to the Murray–Darling river system. Golden perch found in the Bulloo–Bancannia and Lake Eyre drainages, and in the Dawson River system in central eastern Australia, appear to form part of an undescribed species complex (Musyl & Keenan, 1992). Artificial stocking has extended its range to include the Hunter River (central eastern NSW), southern Victoria, western and northern Australia. Found in warm, turbid, slow-flowing rivers and their floodplain lakes. Adults have a strongly concave snout with an arched nape, large eyes, a large mouth extending to below middle of eye, and a lower jaw protruding slightly. Maximum size 76 cm (Llewellyn & MacDonald, 1980; Merrick & Schmida, 1984; Harris & Rowland, 1996).

Importance to fisheries Commercial fishery currently declining, although it contributes to almost half of the catch of a small multi-species fishery in the lower Murray–Darling system which averages 200 tonnes per annum. Caught with drum nets and gill nets. Popular recreational fish in rivers and artificial impoundments. There is some commercial aquaculture interest (Harris & Rowland, 1996).

Spawning Eggs are pelagic and spherical, 3.3–4.2 mm in diameter, and have a smooth chorion, a large perivitelline space, and a single oil globule 0.76–0.84 mm. Eggs hatch after 24–33 hours at 20–31°C (Lake, 1967b, as *Plectroplites ambiguus*). Spawning has been observed in the Lachlan River (central southern NSW) after flooding in October and November (Mackay, 1973). Spawning in flooded artificial ponds occurs at temperatures at or above 23.6°C (Lake, 1967a). Spawning for aquaculture is induced in late spring with hormone injections (Rowland, 1983b). Larvae have been caught in Lake Pamamaroo (Darling River, southwestern NSW) following flooding in January.

Diagnostic characters

- 9–12 + 15–17 = 24–28 myomeres, typically 26–27
- Large yolk sac at hatching, resorbed by flexion stage
- No pigment along dorsal and lateral surfaces of trunk and tail before postflexion stage
- 2–8 melanophores along ventral midline of tail, between myomeres 12–21

Description of larvae

Morphology Body elongate to moderate (BD 17–35%). Head small to moderate in preflexion larvae (HL 10–25%). Eyes pigmented in preflexion larvae by 4 mm. Small posterior preopercular spines in late preflexion larvae; 2–4 small anterior preopercular spines and a posttemporal spine may form in postflexion larvae. Single opercular spine from settlement stage. Gut moderate to long in preflexion and flexion larvae (PAL 45–58%), long in postflexion larvae (PAL 54–63%); initially straight, slightly coiled from flexion stage. Large yolk sac is resorbed by flexion stage. Scales form in juveniles from 14.4 mm.

Size at

Hatching	2.5–3.0 mm
Notochord flexion	4.9–7.3 mm
Settlement	9.1–10.6 mm

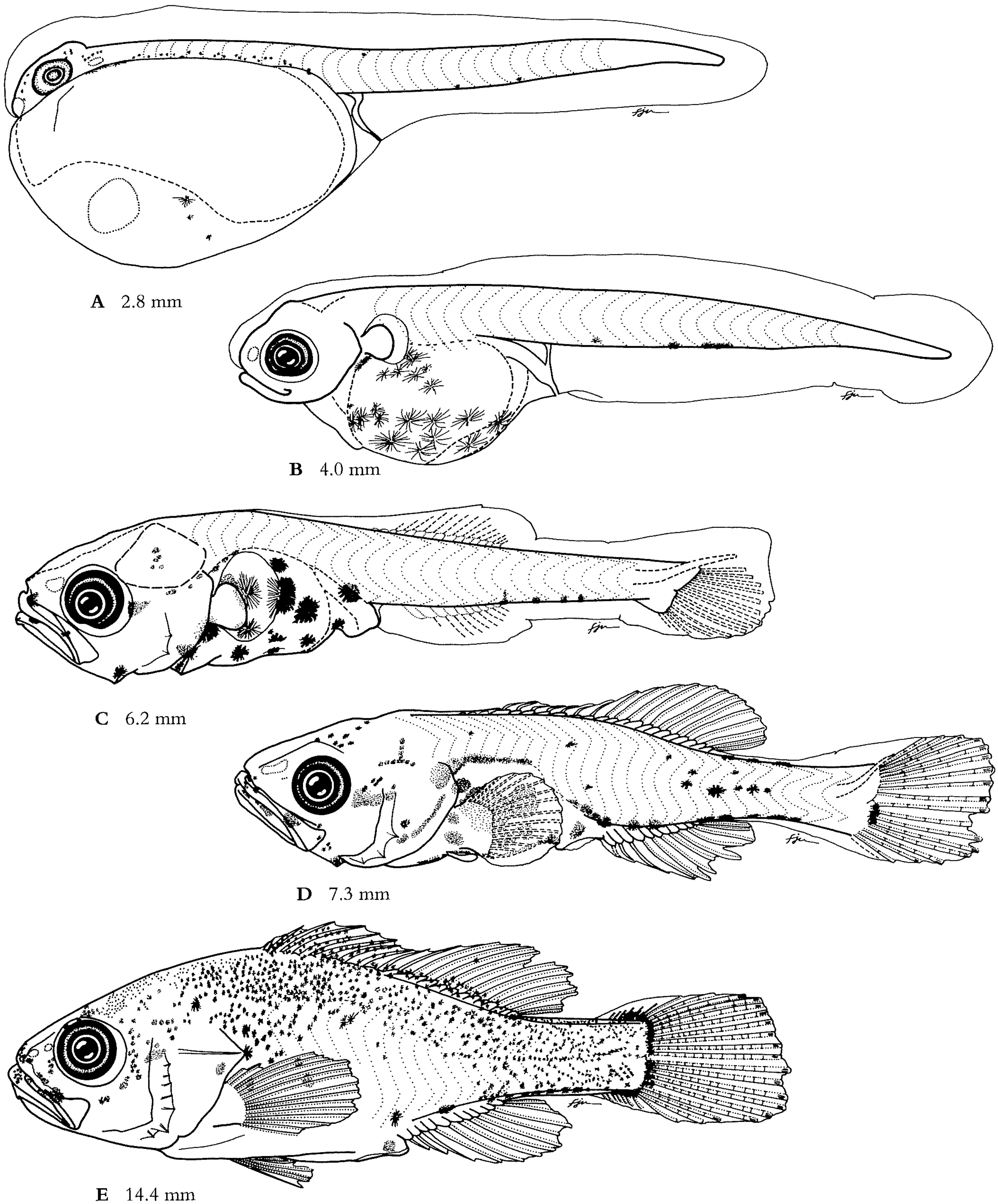
Formation of fins:
Caudal 4.4–7.3 mm; Dorsal 4.9–10.6 mm; Anal 4.9–11.0 mm; Pectoral 7.3–8.4 mm; Pelvic 7.3–12.4 mm

Pigmentation Larvae are lightly pigmented; reared larvae are generally more heavily pigmented than wild-caught larvae. *External:* Melanophores on snout, and dorsal and lateral surfaces of head by early postflexion stage, on maxilla and premaxilla, and opercular and supraoccipital areas by settlement. No pigment on nape until settlement. Light pigment laterally and ventrally on gut in late preflexion larvae. Single series of 2–8 melanophores along ventral midline of tail, between myomeres 12 and 21; series absent in wild-caught juveniles. Additional melanophores laterally and dorsally on trunk and tail, and on caudal-fin base prior to settlement. Scattered melanophores on dorsal fin in juveniles. *Internal:* Melanophores around brain and otic capsule in preflexion larvae, and on snout in some postflexion larvae. Pigment dorsally over gas bladder in all reared larvae until late postflexion stage, not visible in wild-caught juveniles.

Material examined 24 larvae, 2.5–9.1 mm BL, reared at Narrandera Fisheries Centre (NSW), and 6 settled larvae, 10.6–14.4 mm BL, Lake Pamamaroo (Darling River, southwestern NSW).

Additional references Lake (1967b, as *Plectroplites ambiguus*).

Figure 77 Larvae and settlement stage of *Macquaria ambigua*. **A** Preflexion, 1 day old; note yolk sac. **B** Preflexion, 3 days old. **C** Flexion, 14 days old. **D** Early postflexion, 19 days old; note pelvic-fin bud. **E** Settlement stage, 27 days old. A–E reared at NFC (NSW). Illustrated by F. J. Neira.


A 2.8 mm
B 4.0 mm
C 6.2 mm
D 7.3 mm
E 14.4 mm

Plesiopidae: Hulafishes, prettyfins

F. J. Neira

Plesiopids are cryptic marine fishes confined to shallow (most to 30 m), coastal tropical to temperate waters of the Indo-Pacific, mostly in rocky and coral reefs. A detailed phylogenetic revision of the family by Mooi (1993) incorporated the Acanthoclinidae (Hardy, 1985) within the Plesiopidae, after an earlier revision of the former by Smith-Vaniz & Johnson (1990). The family now includes 6 subfamilies, 11 genera and about 30 species (Smith-Vaniz & Johnson, 1990; Mooi, 1993). Nine genera and 19 species have been recorded from Australia, 4 genera and 10 species in temperate waters (Allen, 1977; Hoese & Kuiter, 1984; Hardy, 1985; Hutchins, 1987; Hoese & Hanley, 1989b,c; Smith-Vaniz & Johnson, 1990). Adults (3–30 cm) are very elongate to moderately deep and robust, have a blunt, rounded head, thoracic pelvic fins with either I, 2 (Acanthoclininae) or I, 4 (Paraplesiopinae and Trachinopinae), an incomplete or disjunct lateral line, a continuous dorsal fin with VIII–XXVI, 2–21, and an anal fin with III–XVI, 2–23 (Smith-Vaniz & Johnson, 1990). Most plesiopids deposit spherical to ovoid eggs, ~1.0 mm in diameter, tightly bound together by adhesive filaments in a spherical egg mass that is guarded by the male until hatching (Jillett, 1968; Mooi, 1990). *Plesiops* deposits its eggs individually on the substrate (Mito, 1955) while *Assessor* is the only taxon in the family known to be a mouth brooder (Allen & Kuiter, 1976; Mooi, 1993). Larvae have been described for representatives of *Acanthoclinus*, *Calloplesiops* and *Plesiops* (Jillett, 1968; Crossland, 1981a, 1982; Kinoshita, 1988c; Leis & Trnski, 1989; Wassink, 1989). The gas bladder which is present in *Acanthoclinus* larvae but absent in the adults, and the relatively weak head spination in *Paraplesiops* and *Plesiops* larvae, constitute specialisations to pelagic life (Jillett, 1968; Leis & Trnski, 1989).

Meristic characters of plesiopid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal (branched)	Vertebrae
ACANTHOCLININAE							
Beliops	(1)	XVIII–XIX, 2–4	X, 2–3	16–18	I, 2	16(14)	10 + 16–17 = 26–27
Belonepterygion	(1)	XVII–XX, 4–5	X–XII, 3–5	17–19	I, 2	16(14)	10–11 + 17–18 = 27–29
PARAPLESIOPINAE							
Paraplesiops	(4)	XI–XII, 9–10	III, 9–11	15–19	I, 4	17(15)	10 + 16–17 = 26–27
TRACHINOPINAE							
Trachinops	(4)	X–XV, 16–21	III, 17–23	14–18	I, 4	17(15)	12–13 + 24–27 = 37–40*

* From cleared and stained specimens

Main characters of plesiopid larvae

- 24–40 myomeres; 24–35 in most genera, 37–40 in *Trachinops*
- Body elongate to moderate (BD 16–24%); caudal peduncle laterally compressed and deep in postflexion larvae
- Mouth large, premaxilla reaches below middle to posterior edge of eye
- Weak to moderate head spination, including small to moderate preopercular spines; subopercular spines may also be present (e.g. *Plesiops*)
- Gut moderate to long (PAL 48–65%), initially straight and moderately voluminous but becoming coiled and compact prior to flexion stage
- Gas bladder large and inflated in larvae caught at night

- Pelvic fins thoracic, either with I, 2 or I, 4 elements
- Body lightly (e.g. *Trachinops*) to heavily pigmented; no melanophores around posterior region of caudal peduncle in heavily pigmented larvae (Acanthoclininae)
- Series of melanophores along ventral surface of each dentary and along midline of gular membrane (Acanthoclininae)
- Pigment dorsally over gas bladder

References to plesiopid larvae

Mito (1955), Jillett (1968), Kinoshita (1988c), Leis & Trnski (1989), Wassink (1989).

Families with similar larvae

Enoplosidae – Moderate preopercular spines in postflexion larvae; mouth moderate, reaching to anterior of eye; 2 dorsal fins, first with VIII spines; pelvic fin I, 5.

Gerreidae – 24–25 myomeres; long ascending premaxillary process; gut short to long; IX–X dorsal-fin spines; pelvic fin I, 5; body lightly pigmented.

Gobiesocidae – No head spines; short-based, posteriorly located dorsal and anal fins; small size at flexion (3.8–4.4 mm); gut long, extending past midbody, straight; early forming pelvic fin, forming a sucking disk; melanophores usually laterally along gut and extending ventrally along caudal peduncle.

Haemulidae – Moderate head spination, including early forming preopercular spines and, in some taxa, a serrate supraocular ridge; short-based anal fin; gut long, extending from midbody to 74% BL.

Labridae – No head spines; small mouth; eyes ovoid, round, or squarish, often with a mass of choroid tissue ventrally; little or no body pigment; pelvic fin I, 5.

Odacidae – 30–54 myomeres, 30–42 myomeres in most taxa; no head spines prior to settlement (preopercular serrate in juveniles); mouth almost vertical, angle of lower jaw pronounced and ventrally directed; gut long (PAL 54–74%), initially straight and tubular; little or no body pigment in most taxa.

Pseudochromidae – Weak head spination; striations along gut in preflexion larvae; little or no body pigment, melanophores along dorsal surface of tail in some taxa; long-based dorsal fin with I–III spines and >19 rays.

Sillaginidae (cf. preflexion/early postflexion *Trachinops* larvae) – 32–45 myomeres, 32–37 in most taxa; body moderately pigmented, melanophore series along ventral midline of trunk and tail.

Sparidae – 24–25 myomeres; moderate head spination, weak to strong preopercular spines; small to moderate gap between anus and origin of anal fin; pelvic fin I, 5.

Plesiopidae *Beliops xanthokrossos* Hardy, 1985 Rockfish

D XVIII–XIX, 2–4 A X, 2–3 P_1 16–18 P_2 I, 2 C 16 V 26–27

Adults Endemic to southwestern and southern Australia from Geraldton (WA) to Kangaroo Island (SA). Small benthic species restricted to shallow inshore reefs in depths of 3–15 m. Adults have 1–2 sharp opercular spines, and 2 lateral lines, the uppermost extending from the upper opercle along the dorsal-fin base to almost the last dorsal-fin spine, and the second mid-laterally along the tail. Maximum size 2.6 cm (Hardy, 1985; Hoese & Hanley, 1989c; Smith-Vaniz & Johnson, 1990; Gomon *et al.*, 1994).

Importance to fisheries –

Spawning Eggs undescribed. Eggs of the acanthoclinine *Acanthoclinus fuscus* are adhesive and spherical, average 1.43 mm in diameter, and have a large yolk and a single oil globule. Spawned eggs of *A. taumakoides* are spheroidal, 1.78 × 1.69 mm, and have 20–24 hooks evenly spaced over the chorion, each hook bearing 6–10 filaments (Mooi, 1990). Ovarian eggs of the acanthoclinine *Belonepterygion fasciolatum* are spheroidal, 1.12 × 0.96 mm, and have about 35 hooks (Mooi, 1990; Gill & Mooi, 1993). Larvae of *Beliops xanthokrossos* have been caught in coastal waters off Fremantle (WA) in November and December.

Diagnostic characters

- 26–27 myomeres
- Body heavily pigmented from flexion stage
- Melanophores along dentary and a few along gular membrane
- Internal pigment behind midbrain, and a series of internal melanophores along cleithrum
- Internal pigment over branchiostegal membrane and anterior surface of gut
- No pigment on posterior portion of caudal peduncle

Description of larvae

Morphology Body moderate (BD 21–23%). Head moderate (HL 29–30%). No head spines except for 1 opercular spine in newly settled juvenile examined. Gut long (PAL 60–63%), coiled and voluminous. Small preanal membrane in flexion larvae. Scales are fully formed in juvenile examined.

Size at	
Hatching	—
Notochord flexion	<4.7–>5.2 mm
Settlement	>5.2–<13.1 mm
Formation of fins:	

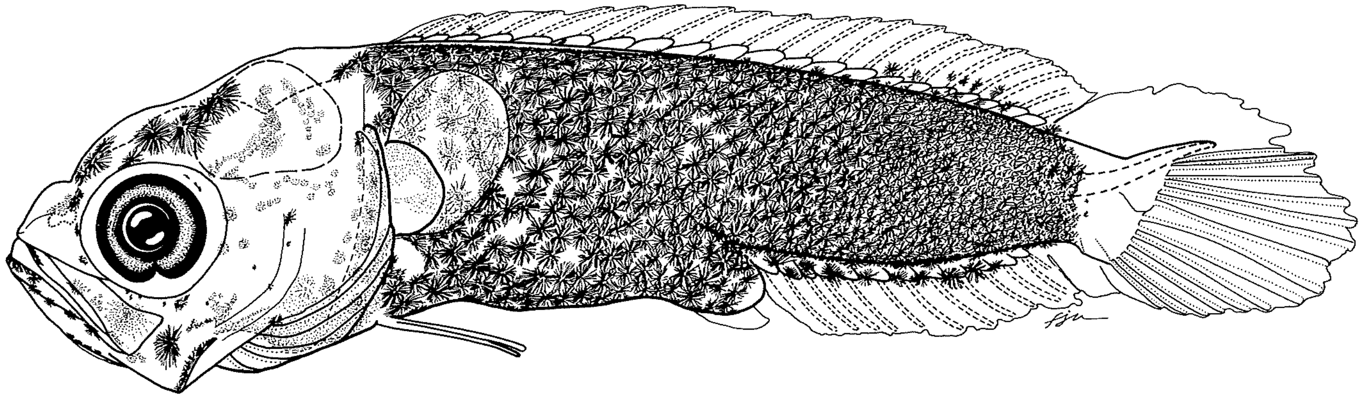
Caudal <4.7–>5.2 mm; Dorsal <4.7–>5.2 mm; Anal <4.7–>5.2 mm; Pelvic <4.7–>5.2 mm; Pectoral >5.2–<13.1 mm

Pigmentation The few larvae examined are heavily pigmented. *External:* Large stellate melanophores dorsally on head, melanophores at tip of upper and lower jaws, 3–6 melanophores along ventral surface of dentary and along midline of gular membrane, 1 large melanophore posterior to distal end of premaxilla, and pigment at angle of lower jaw. Stellate melanophores densely distributed over dorsal, lateral and ventral surfaces of trunk and tail, and a few along posterior portion of bases of dorsal and anal fins. A few melanophores posteriorly on dorsal-fin membrane; no pigment on membranes of pectoral, caudal and anal fins until settlement. No pigment on posterior portion of caudal peduncle prior to settlement. Juvenile with small melanophores evenly distributed over entire body, and dark patches on distal edge of pelvic-, dorsal-, caudal- and anal-fin membranes. *Internal:* Dense patch of melanophores posteriorly on midbrain. Melanophores on snout, below maxilla, hindbrain, opercular area and along cleithrum. Pigment over branchiostegal membrane and gut.

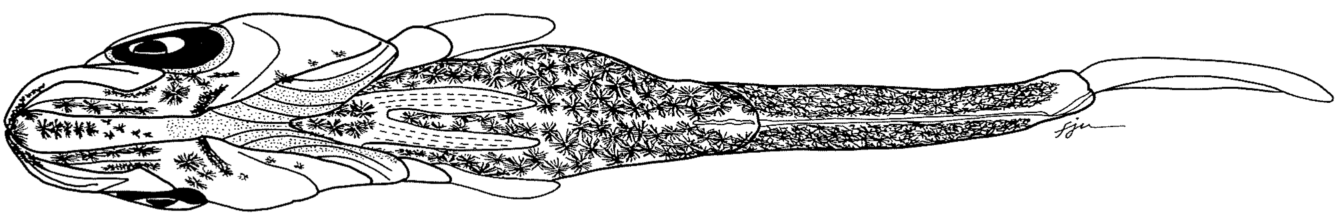
Material examined 4 larvae, 4.7–5.2 mm BL, coastal waters off Fremantle (WA); 1 juvenile, 13.1 mm BL, Recherche Archipelago (WA).

Additional references –

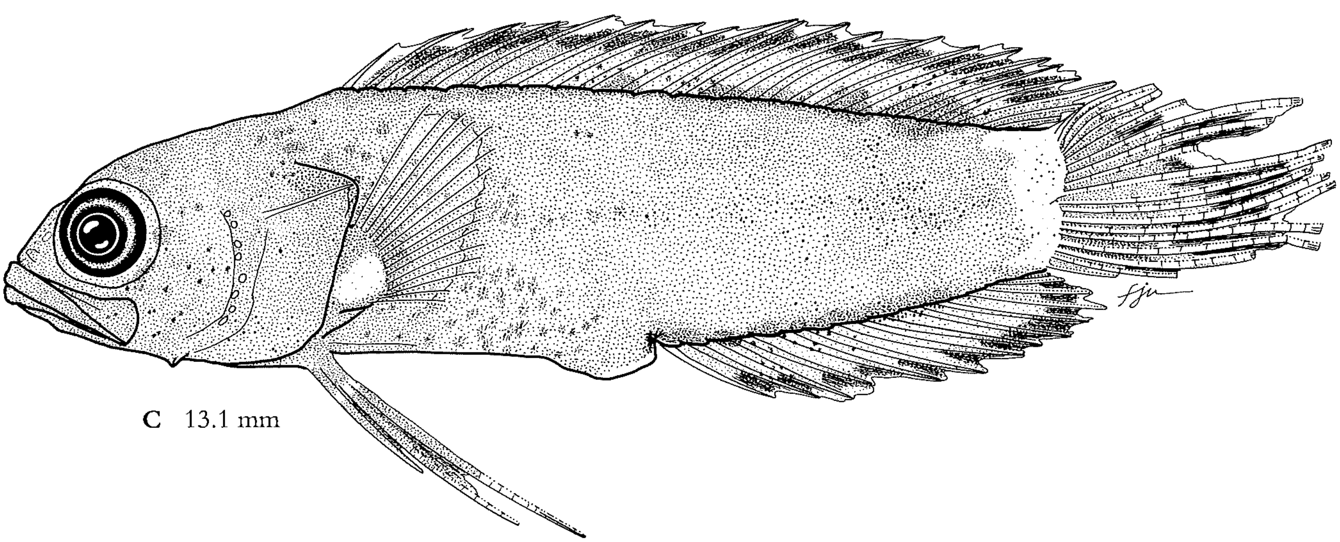
Figure 78 Larvae and juvenile of *Beliops xanthokrossos*.
A Flexion; note small preanal membrane. **B** Ventral view of larva in A. **C** Juvenile; scales and lateral line omitted. A from Fremantle coastal waters (WA); C from Recherche Archipelago (WA). Illustrated by F. J. Neira.



A 5.2 mm



B 5.2 mm



C 13.1 mm

Plesiopidae *Paraplesiops bleekeri* (Günther, 1861) Eastern blue devil

D XI–XII, 10 A III, 9–10 P_1 14–18 P_2 I, 4 C 17 V 26

Adults Endemic to eastern Australia from the Gold Coast (Qld) to Montague Island (NSW). A secretive species common in caves and under ledges along coastal reefs, in depths between 3 and 30 m. Adults have elongate pelvic fins, and a bluish coloration with numerous iridescent blue spots over the head, yellow pectoral fins and caudal peduncle, and dark and white transverse bands across the body. Maximum size 40 cm (Hoese & Kuiter, 1984; Hutchins & Swainston, 1986; Kuiter, 1993, 1996).

Importance to fisheries Actively collected by aquarium collectors. Considered one of the most attractive reef fishes in New South Wales, this species is now protected and its capture prohibited without a permit (Kuiter, 1993).

Spawning Eggs undescribed. Ovarian eggs of *P. alisonae* are spheroidal, 1.4 × 1.2 mm, and have 42–46 evenly distributed, anchor-shaped hooks each bearing additional filamentous projections (Mooi, 1990). Larvae of *P. bleekeri* have been caught in coastal waters off Sydney (NSW) from November to February, and in April and May (Gray, 1995).

Diagnostic characters

- 2–14 + 13–14 = 26–27 myomeres
- 4–7 melanophores ventrally along dentary, and one at tip of lower jaw
- 2–5 melanophores on palate, usually 2–3, only visible when mouth is open
- 1–4 melanophores, usually 2–3, along midline of gular membrane
- Numerous large, stellate melanophores on lateral surface of trunk above hindgut and most of ventrolateral surface of tail, without extending onto caudal-fin base

Description of larvae

Morphology Body moderate (BD 20–24%), laterally compressed. Head moderate to large (HL 24–36%). Mouth large, reaching to posterior edge of eye in postflexion larvae. Very small villiform teeth along both jaws. One small anterior preopercular and 2 small posterior preopercular spines from early flexion stage; a second anterior preopercular spine by early postflexion stage. Smooth supraocular ridge from late flexion stage. Gut long (PAL 53–65%), initially straight, coiled by late preflexion stage. Conspicuous gas bladder above foregut, inflated in all larvae. Preanal membrane in all larvae. Pelvic-fin rays elongate from 7.7 mm.

Size at

Hatching	<4.2 mm
Notochord flexion	5.6–7.2 mm
Settlement	>10.0 mm
Formation of fins:	

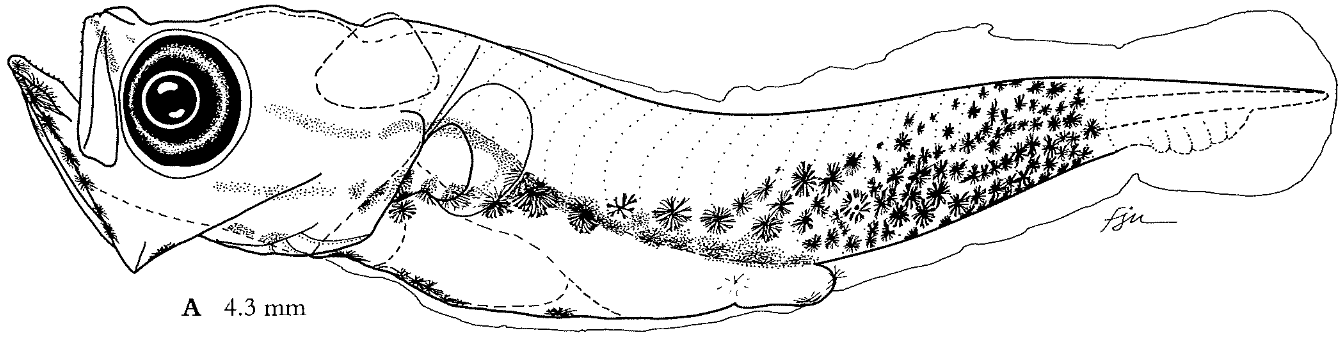
Caudal 4.2–8.0 mm; Dorsal 4.4–10.0 mm; Anal 4.4–10.0 mm; Pelvic 5.0–7.7 mm; Pectoral 5.0–10.0 mm

Pigmentation Larvae are moderately pigmented; pigment concentrates on ventrolateral surface of tail. *External:* Series of 4–7 melanophores along ventral surface of dentary and 1 at tip of lower jaw; 1–4 melanophores, usually 2–3, along midline of gular membrane; 1 at angle of lower jaw. No pigment dorsally on head except for 1 melanophore on nape from 7.7 mm. One or two melanophores along isthmus. One to three moderately large melanophores on anterolateral region of gut, under pectoral-fin base, and a few laterally on gut. One to several small melanophores in pelvic region in preflexion larvae, reduced to 1 melanophore between pelvic-fin bases in most larvae from flexion stage. Usually 1–4 melanophores, rarely 0, ventrally along gut, 1 ventrally at anus. Numerous large, stellate melanophores densely grouped on lateral surface above hindgut and most of ventrolateral surface of tail, not extending onto caudal-fin base. Series of 2–6 melanophores along dorsal midline of tail in most preflexion and flexion larvae, reduced to 1 at base of last dorsal-fin ray in late flexion larvae. *Internal:* Two to five, usually 2–3, large melanophores on palate, visible only when mouth is open. Pigment along ventral surface of brain, continuing dorsally over gas bladder and along gut; large melanophore above anus in most larvae. One to three large melanophores on peritoneum.

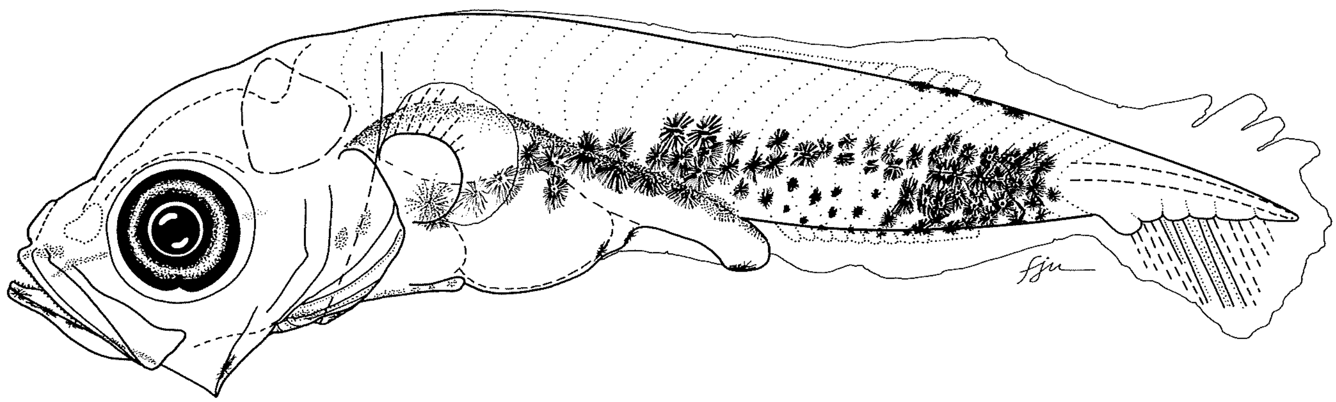
Material examined 18 larvae, 4.2–10.0 mm BL, coastal waters off Sydney (NSW).

Additional references –

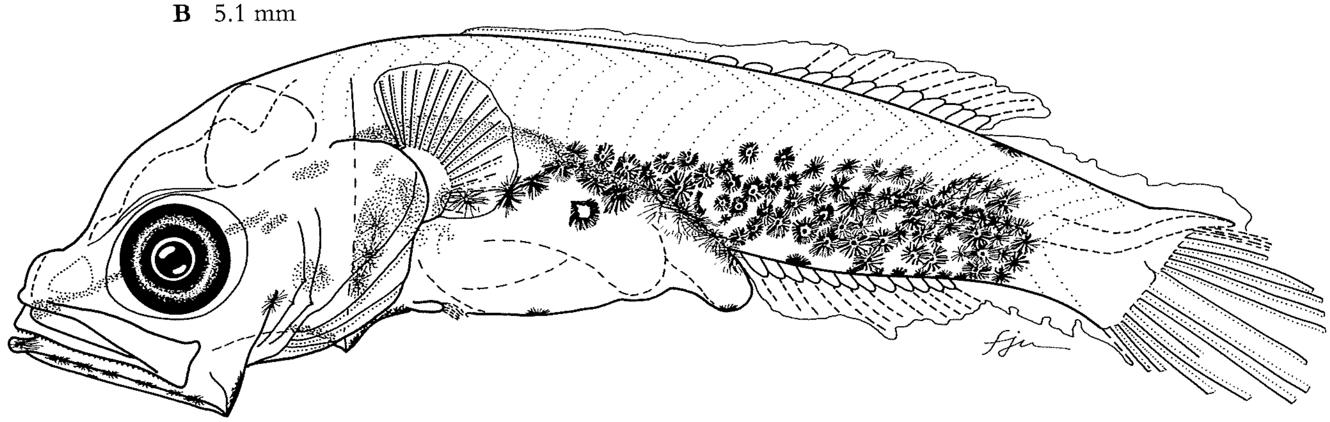
Figure 79 Larvae of *Paraplesiops bleekeri*. **A** Preflexion; note developing caudal fin. **B** Late preflexion; note pelvic-fin bud. **C** Late flexion. **D** Postflexion; note elongate pelvic-fin rays. A–D from NSW coastal waters. Illustrated by F. J. Neira.



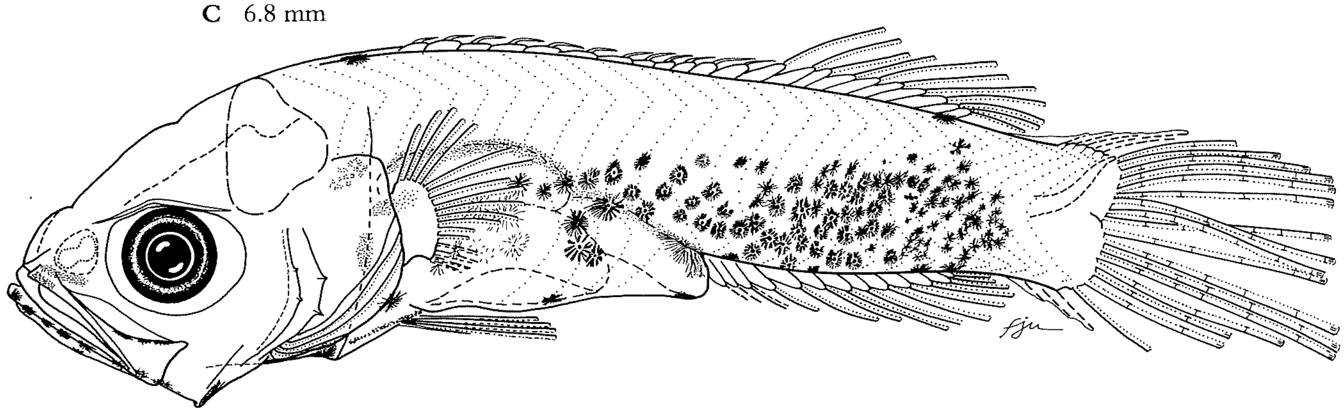
A 4.3 mm



B 5.1 mm



C 6.8 mm



D 7.7 mm

Plesiopidae *Trachinops taeniatus* Günther, 1861 Eastern hulafish

D XIV, 16–18 A III, 18–20 P_1 16–17 P_2 I, 4 C 17 V * 37
* From cleared and stained specimens

Adults Endemic to eastern Australia from Noosa Head (Qld) to Cape Conran (Vic). Found in small to large schools in estuaries and on coastal rocky reefs, in depths of 10–20 m. Adults have a broad reddish brown to black stripe along the dorsolateral surface of the body, and a lanceolate caudal fin with elongate medial rays. Maximum size 10 cm (Allen, 1977; Hutchins & Swainston, 1986; Hoese & Hanley, 1989b; Kuiter, 1993, 1996).

Importance to fisheries An attractive aquarium fish (Kuiter, 1979).

Spawning Eggs are spheroidal, 0.98 × 0.87 mm, and have 56–72 evenly distributed anchor-shaped hooks over the chorion, with filaments arising from only one or two of the hooks (Mooi, 1990). Eggs are deposited in a mass tightly bound together by the filaments (Thresher, 1984) and are guarded by the male (Kuiter, 1996). Larvae have been collected in Botany Bay (NSW) in early January (A.S. Steffe, pers. comm.).

Diagnostic characters

- 12–14 + 23–25 = 37–38 myomeres
- Body lightly pigmented in early postflexion larvae
- Broad pigment stripe along lateral surface of trunk and tail in late postflexion larvae
- Large internal melanophore dorsally on hindgut near anus

Description of larvae

Morphology Body elongate to moderate (BD 16–24%). Head moderate (HL 25–30%), dorsal profile gently sloping. Small villiform teeth on premaxilla in early postflexion larvae. There are no head spines. Gut moderate to long (PAL 48–50%), coiled anteriorly. Gas bladder conspicuous, inflated in larvae caught at night and above most of hindgut region when fully inflated. Scales form at settlement.

Size at

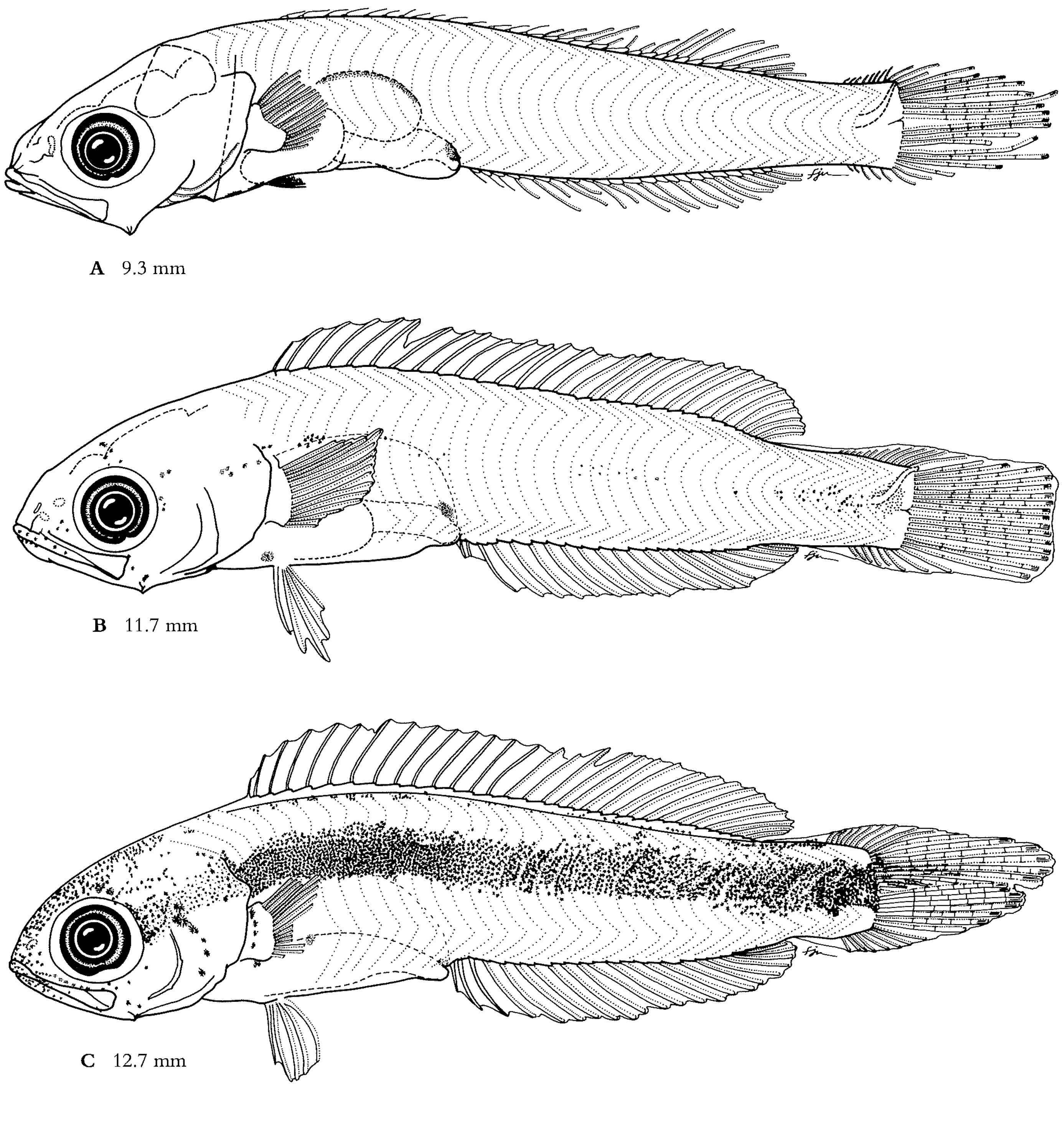
Hatching	—
Notochord flexion	<9.3 mm
Settlement	12.5–15.0 mm
Formation of fins:	
Caudal <9.3 mm; Dorsal <9.3–10.0 mm; Anal <9.3–10.0 mm; Pectoral <9.3 mm; Pelvic <9.3 mm	

Pigmentation Postflexion larvae are very lightly pigmented prior to settlement. *External:* Scattered melanophores on snout, dorsal and lateral surfaces of head by 11.7 mm; melanophores increase in number and spread around head prior to settlement. One elongate melanophore ventrally on isthmus and 1 elongate melanophore posterior to cleithral symphysis, disappearing in late postflexion larvae. A few melanophores laterally on caudal peduncle in early postflexion larvae, increasing in number and forming a broad mid-lateral band that reaches opercle in late postflexion larvae by 12.7 mm; lateral pigment spreads dorsally to most of dorsal-fin membrane in settled larvae. No pigment on ventrolateral and ventral surfaces of trunk and tail during development. *Internal:* Scattered melanophores along base of brain. Pigment dorsally over gas bladder. Dorsal melanophore above anus, becoming obscured in larvae prior to settlement; pigment on gas bladder merges with melanophore above anus prior to settlement.

Material examined 10 larvae, 9.3–15.0 mm BL, and 3 juveniles, 12.5–17.8 mm BL, Botany Bay and Port Hacking (NSW).

Additional references –

Figure 80 Postflexion larvae of *Trachinops taeniatus*. **A** Early postflexion. **B** Postflexion. **C** Postflexion, near settlement. A–C from Botany Bay (NSW). Illustrated by F. J. Neira.



A 9.3 mm

B 11.7 mm

C 12.7 mm

Pomatomidae: Tailor, bluefish

T. Trnski, F.J. Neira and A.G. Miskiewicz

Pomatomids are a monotypic family represented by *Pomatomus saltatrix,* a pelagic schooling species distributed in temperate coastal waters of southern Australia, eastern United States, northeastern South America, western and eastern Africa, and the Mediterranean and Black seas (Springer, 1982; Paxton & Hanley, 1989n; Gomon *et al.*, 1994). Tailor are a very important commercial and recreational species worldwide (Kailola *et al.*, 1993; Juanes *et al.*, 1996). Adults (to 1.2 m) are elongate and robust, have a large mouth, and two dorsal fins, the first short and low, the second long and opposite to an equally long anal fin (Kuiter, 1993). Eggs are pelagic and spherical, 0.8–1.2 mm in diameter, and have a single oil globule (Salekhova, 1959; Deuel *et al.*, 1966). Larvae have been described for representatives of the United States east coast population and the Black Sea (Salekhova, 1959; Deuel *et al.*, 1966; Norcross *et al.*, 1974). The weak head spination is the only apparent specialisation of pomatomid larvae to pelagic life.

Meristic characters of the pomatomid species of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Pomatomus saltatrix	(1)	VII–VIII + I, 23–28	I–III, 23–28	16–17	I, 5	17	11 + 15 = 26

Main characters of pomatomid larvae

- 25–27 myomeres
- Body moderate (BD 25–32%)
- Head moderate to large (HL 25–39%), with a large mouth
- Weak head spination, with short preopercular spines
- Gut moderate to long (PAL 43–62%), coiled and voluminous
- Prominent gas bladder over gut
- Moderate gap between anus and origin of anal fin, closed by the postflexion stage
- Pigment dorsally on head from early stages
- Melanophore series along dorsal, lateral and ventral midlines of tail from late preflexion stage
- Pigment dorsally over gas bladder and gut

References to pomatomid larvae

Deuel *et al.* (1966), Norcross *et al.* (1974), Hardy (1978b), Fahay (1983).

Families with similar larvae

Arripidae – Dorsal fin IX, 13–17; body moderately to heavily pigmented; prominent dorsal melanophores along posterior midline of tail; pigment around notochord tip in early stages; 5–6 internal melanophores along nape and anterior of trunk.

Carangidae – Well-developed head spination, including an emergent median supraoccipital crest in most taxa and prominent preopercular spines, spine at angle elongate; first 2 anal-fin spines separated from third; preanal finfold, usually pigmented.

Centrolophidae – No gap between anus and origin of anal fin; moderate head spination, including interopercular spines (head spines absent in *Centrolophus*); body moderately to heavily pigmented, pigment blotches along dorsal and ventral surfaces of tail from preflexion stage.

Cheilodactylidae (early stages) – 34–36 myomeres; no head spines; straight hindgut; no gap between anus and origin of anal fin.

Emmelichthyidae – 24 vertebrae; no teeth; dorsal fin XI–XIV, 9–12; short-based anal fin, III, 9–11; little or no pigment along tail.

Gerreidae – Long ascending premaxillary process; weak head spination; body lightly pigmented, no pigment along dorsal and lateral midlines of tail prior to postflexion stage.

Girellidae – Large, persistent gap between anus and origin of anal fin; body lightly pigmented, with large, widely spaced melanophores along dorsal midline of trunk and tail; pigment around notochord tip in early stages; single dorsal fin with XIII–XVI spines.

Kyphosidae – No gap between anus and origin of anal fin; single dorsal fin, XI, 12–16; body moderately to heavily pigmented, small to large stellate melanophores over trunk and tail in postflexion larvae; pigment along lateral midline of tail from postflexion stage; pigment under notochord tip.

Leptobramidae – 24 myomeres; several small posterior preopercular spines, none on anterior margin of preopercle; dorsal fin IV, 26–30, originates posterior to anal-fin origin; no gap between anus and origin of anal fin; pigment on tips of snout and lower jaw.

Microcanthidae – Moderate head spination, including interopercular spines; single dorsal fin with X–XII spines; pigment along lateral midline of tail from postflexion stage; pigment around notochord tip.

Mullidae – 23–25 myomeres, typically 24; head spines absent in most taxa; prominent gap between anus and origin of anal fin; 2 short, well separated dorsal fins; 3 melanophores in a triangular pattern on midbrain in late preflexion larvae.

Nomeidae (some taxa) – 30–42 myomeres; head deep with rounded snout; XI–XII dorsal-fin spines (*Cubiceps*); early forming, often pigmented pelvic fins (e.g. *Nomeus, Psenes*).

Scombridae – >30 myomeres; head large, usually with an elongate snout; 2 dorsal fins, first with >X spines.

Scorpididae – Moderate head spination, including preopercular and interopercular spines; dorsal fin IX–X, 23–28; body moderately to heavily pigmented, pigment around notochord tip.

Pomatomidae *Pomatomus saltatrix* (Linnaeus, 1766) Tailor

D VII–VIII + 1, 23–28 A I–III, 23–28 P_1 16–17 P_2 I, 5 C 17 V 26

Adults Distributed around southern Australia from Onslow (WA) to Fraser Island (Qld), including Tasmania. Particularly abundant in estuaries and shallow coastal waters on the east and west coasts during winter, less abundant along the southern coast, to a depth of 15 m. Adults have very short spines on the first dorsal fin, and long second dorsal and anal fins almost equal in length. Maximum size 1.2 m (Last *et al.*, 1983; Hutchins & Swainston, 1986; Paxton & Hanley, 1989n; Kailola *et al.*, 1993).

Importance to fisheries Fished commercially mainly with beach seines and used mostly for human consumption. Total annual commercial catch in Australia averages about 400 tonnes. A popular fish among recreational beach fishers (Pollock, 1984; Kailola *et al.*, 1993).

Spawning Eggs of *P. saltatrix* from Northern Hemisphere populations are pelagic and spherical, 0.8–1.2 mm in diameter, and have a single oil globule 0.22–0.30 mm (Salekhova, 1959; Deuel *et al.*, 1966). Large females may produce more than 1 million eggs. Spawning on the east coast of Australia has been reported off Fraser Island during late winter and spring (Pollock, 1984; Zeller *et al.*, 1996). Spawning on the west coast possibly occurs at a similar time in the vicinity of Shark Bay (WA) (Lenanton *et al.*, 1996; R. Steckis, WAFD, pers. comm.). Larvae have been caught in coastal waters off New South Wales from January to May (Miskiewicz *et al.*, 1996).

Diagnostic characters

- 10–11 + 14–17 = 25–27 myomeres
- Internal pigment at nape
- Melanophore series along dorsal midline of tail restricted to dorsal-fin base
- Melanophore series along lateral midline of tail from 3.3 mm, between myomeres 14–24
- Melanophore series along ventral midline of posterior of tail

Description of larvae

Morphology Body moderate (BD 23–32%). Head moderate to large (HL 25–39%). Mouth large, teeth on both jaws by 3.3 mm. One very small anterior preopercular spine from 3.1 mm, up to 4 small posterior preopercular spines from late preflexion stage; 1 additional anterior preopercular spine by 8 mm. Low, smooth supraocular ridge by end of flexion stage. Very low posttemporal ridge in postflexion larvae. One opercular spine by end of flexion stage, a second by 9 mm. Gut moderate to long in preflexion larvae (PAL 43–51%), long in postflexion larvae (PAL 55–62%), coiled and voluminous. Prominent gas bladder over gut. Small gap between anus and origin of anal fin, closed once anal fin is formed. Third anal-fin spine and second dorsal-fin spine transform from soft rays between 5.9 and 8.6 mm. Scales form at about 15 mm.

Size at

Hatching [1]	2.0–2.4 mm
Notochord flexion	3.9–5.3 mm
Transformation	~14.0–16.0 mm
Formation of fins:	

Caudal <3.1–5.6 mm; Dorsal 3.1–6.1 mm; Anal 3.1–6.4 mm; Pelvic 5.0–6.8 mm; Pectoral 5.5–8.2 mm

[1] Salekhova (1959), Deuel *et al.* (1966)

Pigmentation Larvae are moderately pigmented, becoming heavily pigmented during postflexion stage. *External:* 1 to several small melanophores over midbrain and 1 at centre of opercle in late preflexion larvae; melanophores on tip of snout and lower jaw in postflexion larvae. One melanophore may be present on ventral midline of gut. Series of melanophores along dorsal-fin base, extending anteriorly and posteriorly after flexion stage. Series of melanophores along lateral midline of tail by 3.3 mm, between myomeres 14 and 24. Series of melanophores along ventral midline of posterior of tail from preflexion stage, extending along most of anal-fin base from about 8 mm. One or two melanophores on caudal-fin anlage in preflexion larvae. Pigment over dorsolateral surface of head and body, some ventrolaterally on tail, in late postflexion larvae. *Internal:* 1 melanophore below nape and some along cleithrum in preflexion larvae; melanophores at mid- and hindbrain junction from late preflexion stage. Pigment dorsally over gas bladder and gut to anus; melanophores laterally over gut from 6.5 mm. Series of melanophores dorsally along posterior half of notochord from flexion stage, and ventrally after flexion stage, becoming obscured with growth.

Material examined 25 larvae, 3.1–8.4 and 14.7–15.8 mm BL, coastal waters of New South Wales and Lake Macquarie (NSW).

Additional references Pearson (1941), Salekhova (1959), Deuel *et al.* (1966), Norcross *et al.* (1974).

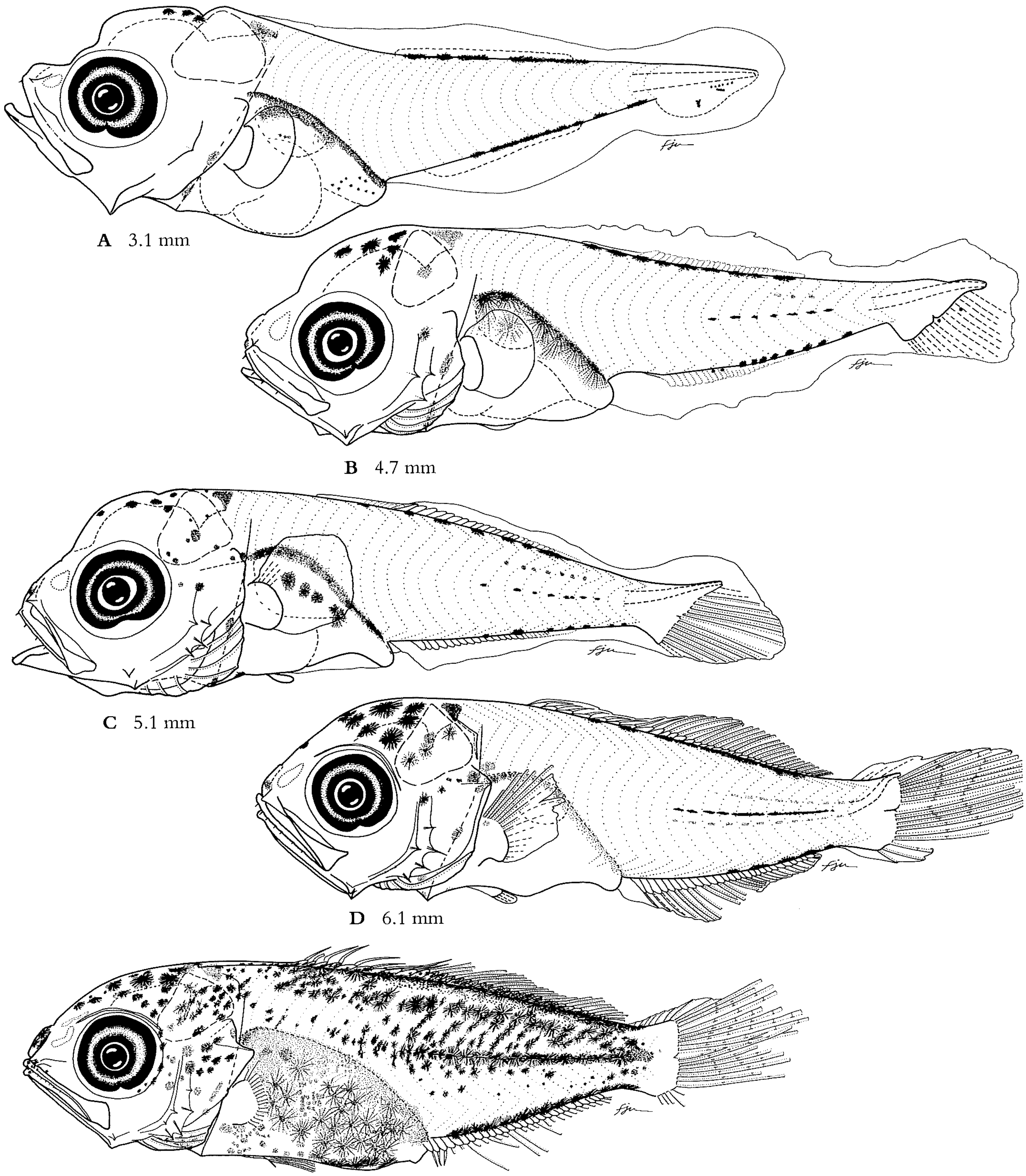


Figure 81 Larvae of *Pomatomus saltatrix*. **A** Preflexion; note developing dorsal, caudal and anal fins. **B** Flexion. **C** Late flexion; note pelvic-fin bud. **D** Early postflexion; note developing pectoral-fin rays. **E** Postflexion; pectoral- and anal-fin rays damaged. A–E from NSW coastal waters. Illustrated by F. J. Neira.

Sciaenidae: Croakers and drums

A.S. Steffe and F. J. Neira

Sciaenids are mostly demersal fishes found in fresh, estuarine and coastal marine waters in subtropical to temperate regions of the Atlantic, Indian and Pacific oceans. The family contains about 50 genera and 210 species worldwide, with 28 species restricted to fresh water (Chao, 1986; Heemstra, 1986; Nelson, 1994). Ten genera have been recorded from Australia, two genera and two species in temperate waters (Hutchins & Swainston, 1986; Gomon *et al.*, 1994; Griffiths & Heemstra, 1995). Many species have considerable commercial and recreational importance. Adults (to 2 m, most <40 cm) are slightly elongate and compressed, have a single, long-based dorsal fin with a deep notch separating the spinous and soft portions, a short-based, posteriorly located anal fin, and a curved lateral line extending to the end of the caudal fin. They also possess large, distinctive otoliths and are well known for their ability to produce drumming and croaking sounds through sonific muscles attached to the gas bladder (Trewavas, 1977; Heemstra, 1986; Griffiths & Heemstra, 1995). Eggs are pelagic and spherical, 0.5–1.7 mm in diameter, and have a single oil globule (Breder & Rosen, 1966; Fahay, 1983; Zhang *et al.*, 1985; Ikeda & Mito, 1988; Ditty & Shaw, 1994). Early larvae are pelagic but become demersal usually during the postflexion stage. Larvae have been described for representatives of many genera, particularly for Northern Hemisphere species (see Ditty & Shaw, 1994, and references therein; see also Montalenti, 1956; Hardy, 1978b; Fahay, 1983; Zhang *et al.*, 1985; Takita & Kinoshita, 1988; Ditty, 1989; Leis & Trnski, 1989; Beckley, 1990; Moser, 1996d). The moderate head spination, excluding the opercular spines which are retained in the adults, is the only apparent specialisation of sciaenid larvae to pelagic life (Leis & Trnski, 1989).

Meristic characters of sciaenid genera of temperate Australia

	(n)	Dorsal*	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Argyrosomus	(1)	XI, 25–30	II, 7	15–19	I, 5	17	11 + 14 = 25
Atractoscion	(1)	XI, 26–31	II, 8–9	17–18	I, 5	17	13–14 + 11–12 = 25

* Dorsal fin is considered as two separate fins by some authors (e.g. Griffiths & Heemstra, 1995).

Main characters of sciaenid larvae

- 24–29 myomeres, typically 25–26
- Body moderate to deep (BD 27–43%), tail slightly narrow
- Head generally deep, with a large, oblique mouth
- Moderate head spination, including early forming, short to moderate preopercular spines, and supraocular, subopercular, interopercular and supracleithral spines; serrate infraorbital, pterotic, low supraoccipital and posttemporal ridges in some taxa
- Gut moderate to long (PAL 40–62%), coiled and compact
- Large gap between anus and origin of anal fin in most taxa, reduced by late postflexion stage
- Dorsal-fin rays at least twice as numerous as anal rays; dorsal spines usually form last
- Length of anal-fin base about 25–35% of dorsal-fin base
- Pigment ventrally on head species-specific, usually including melanophores along dentary and/or midline of gular membrane and along isthmus, and 1 melanophore at angle of lower jaw
- Pigment externally and/or internally at nape, and dorsally over gut and gas bladder
- Pigment usually over anterior surface of gut
- Tail pigment usually restricted to ventral midline, pattern species-specific

References to sciaenid larvae

Montalenti (1956), Watson (1982), Fahay (1983), Moser *et al.* (1983), Takita & Kinoshita (1988), Ditty (1989), Leis & Trnski (1989), Beckley (1990), Battaglene & Talbot (1994), Ditty & Shaw (1994), Moser (1996d).

Families with similar larvae

Apogonidae (early stages) – Typically 24 myomeres; weak to no head spination in most taxa; 2 well separated dorsal fins, first with <X spines; small to no gap between anus and origin of anal fin.

Bramidae – 36–54 myomeres; head large, rounded and deep; no gap between anus and origin of anal fin; early forming pelvic fins; large pectoral fins with early forming rays; single, long-based dorsal fin; long-based, spineless anal fin with >20 rays.

Chandidae – 24–25 myomeres; small preopercular spines; small gap between anus and origin of anal fin; VII–VIII dorsal-fin spines.

Gerreidae – Long ascending premaxillary process; weak head spination; body lightly pigmented; dorsal fin with 9–17 rays.

Haemulidae – Numerous anterior and posterior preopercular spines; moderate opercular and interopercular spines; III anal-fin spines.

Pinguipedidae – 29–34 myomeres; up to 4 small opercular spines; single dorsal fin with IV–V spines; long-based anal fin, I, 17–19; no gap between anus and origin of anal fin; melanophore series ventrally along tail.

Polynemidae (early stages) – Weak head spination; 2 well separated dorsal fins; pelvic fins abdominal, inserted posterior to origin of pectoral fins; pectoral fins move ventrally and split into two portions in most taxa.

Pomacentridae (early stages) – Early forming second dorsal and anal fins; similar number of elements in dorsal and anal fins; pigment dorsally over head in early larvae.

Scombridae – Typically >30 myomeres; head large, usually with an elongate snout; 2 well separated dorsal fins, first with X–XIX spines; dorsal and anal finlets.

Sparidae – Moderate head spination, weak to strong preopercular spines; small to moderate gap between anus and origin of anal fin; dorsal fin X–XIII, 9–15; III anal-fin spines.

Sciaenidae *Argyrosomus japonicus* (Temminck & Schlegel, 1843) Mulloway

D XI, 25–30 A II, 7 P_1 15–17 P_2 I, 5 C 17 V 25

Adults Distributed around southern Australia from North West Cape (WA) to Bundaberg (Qld). Also widely distributed in the Indo-Pacific in southeast Africa, northern Indian Ocean, from Hong Kong to Korea and in Japan. *Argyrosomus hololepidotus* is a junior synonym. Occurs in estuaries, inshore rocky reefs and along ocean beaches. Adults have a single, deeply notched dorsal fin, an anteriorly located anal fin, and are green to blue dorsally and silvery ventrally, with a row of white spots along the lateral line. Maximum size in Australia about 2 m (Hutchins & Swainston, 1986; Kailola *et al.*, 1993; Kuiter, 1993, 1996; Gomon *et al.*, 1994; Griffiths & Heemstra, 1995).

Importance to fisheries Fished commercially with gill and haul nets throughout southern Australia. Also targeted by recreational fishers with hook and line. Total commercial catch in 1990 was 300 tonnes (Kailola *et al.*, 1993).

Spawning Eggs are pelagic and spherical, average 0.9 mm in diameter, and have a single oil globule averaging 0.24 mm. Hatching occurs in 28–30 hours at 23°C (Battaglene & Talbot, 1994). Larvae have been caught entering Lake Macquarie and in coastal waters off Sydney in February and March (Miskiewicz, 1987; Gray, 1995), and in Botany Bay (NSW) from February to April.

Diagnostic characters

- 8–11 + 14–17 = 25–26 myomeres
- 5–7 posterior preopercular spines and 1 posttemporal spine in postflexion larvae
- Posterior end of anal fin 3–5 myomeres ahead of posterior end of dorsal fin
- 1 melanophore on dentary, about midway between tip and angle of lower jaw
- 1 melanophore on nape
- 6–8 melanophores along ventral midline of tail in preflexion larvae, melanophore between myomeres 16–20 enlarged

Description of larvae

Morphology Body moderate (BD 27–37%). Head moderate to large (HL 31–41%). Small teeth along premaxilla from preflexion stage and along dentary from early flexion stage. Two or three anterior preopercular spines in flexion larvae, 4–5 in postflexion larvae, increasing in number in late postflexion larvae. Three posterior preopercular spines in flexion larvae, 5–7 in postflexion larvae. One posttemporal spine in postflexion larvae. Opercular spine from 9 mm. Gut moderate to long (PAL 40–62%), coiled and compact. Prominent, inflated gas bladder over foregut. Large gap between anus and origin of anal fin through to early postflexion stage (VAFL 8–19%), reduced in juveniles (VAFL 2–4%). Posterior end of anal fin 3–5 myomeres ahead of posterior end of dorsal fin. Scales form in juveniles.

Size at

Hatching [1]	2.2–2.3 mm
Notochord flexion	3.9–5.8 mm
Settlement	~12.0 mm

Formation of fins:
Caudal 3.5–5.5 mm; Anal 3.7–7.0 mm; Dorsal 3.7–7.7 mm; Pectoral 5.4–9.2 mm; Pelvic 5.7–8.0 mm

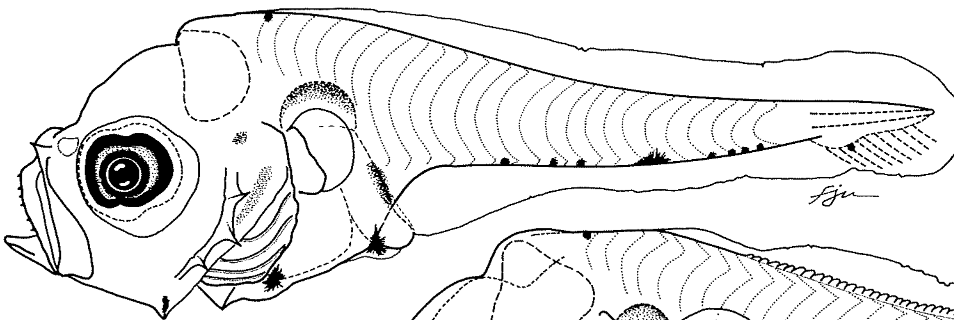
[1] Total length of live, newly-hatched larvae (Battaglene & Talbot, 1994).

Pigmentation Larvae are lightly pigmented. *External:* Usually 1 melanophore on dentary, about midway between tip and angle of lower jaw; 1 at angle of lower jaw. One melanophore on nape. One small melanophore at cleithral symphysis from late preflexion stage. Two melanophores, occasionally up to 4, ventrally on gut. Six to eight melanophores along ventral midline of tail in preflexion larvae, melanophore between myomeres 16 and 20 enlarged; one or two melanophores anterior to enlarged melanophore become internal during flexion stage. One small melanophore behind dorsal edge of pectoral-fin base. One melanophore on margin of lower hypural plate in preflexion larvae, remaining at base of caudal-fin rays in postflexion larvae. Pigment increases on head, body and fins during late postflexion stage, becoming heavy in juveniles. *Internal:* Pigment dorsally over gas bladder. Large melanophores along anterior and dorsal surfaces of gut. One or two melanophores along ventral midline of anterior of tail from flexion stage.

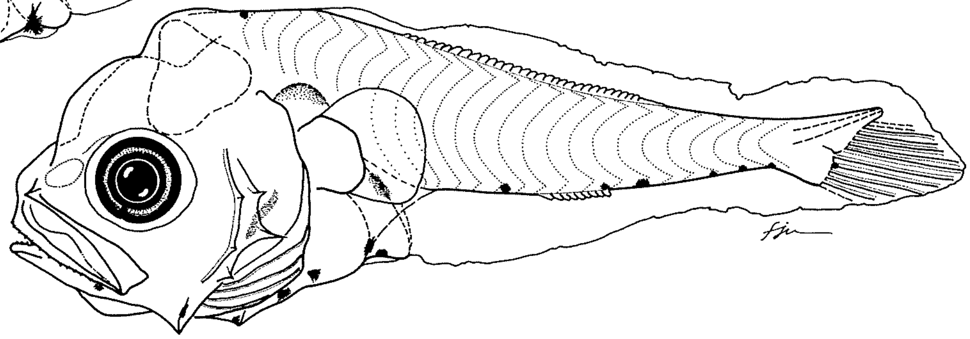
Material examined 67 larvae, 2.8–8.5 mm BL, coastal waters off Lake Macquarie and Sydney, and Botany Bay (NSW); 6 larvae and juveniles, 5.5–20.0 mm BL, reared at the Port Stephens Research Centre (NSW).

Additional references Battaglene & Talbot (1994).

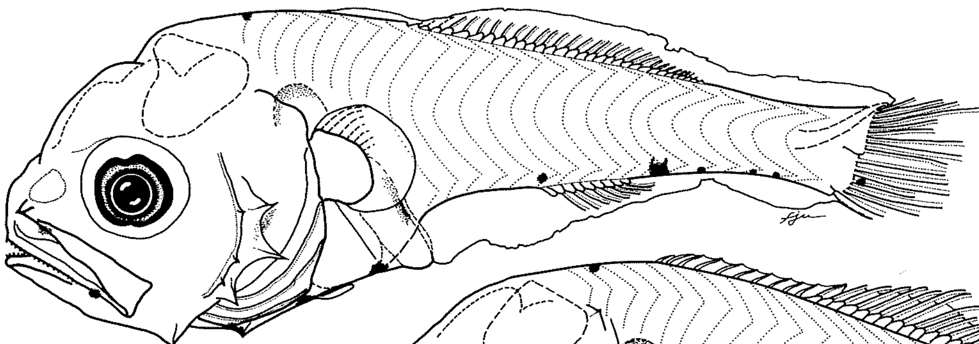
Figure 82 Larvae and juvenile of *Argyrosomus japonicus*. **A** Preflexion. **B** Early flexion; note developing dorsal and anal fins. **C** Late flexion; note pelvic-fin bud. **D** Postflexion. **E** Postflexion. **F** Juvenile; scales omitted. A–D from Botany Bay (NSW); E, F reared at PSRC (NSW). Illustrated by F. J. Neira.



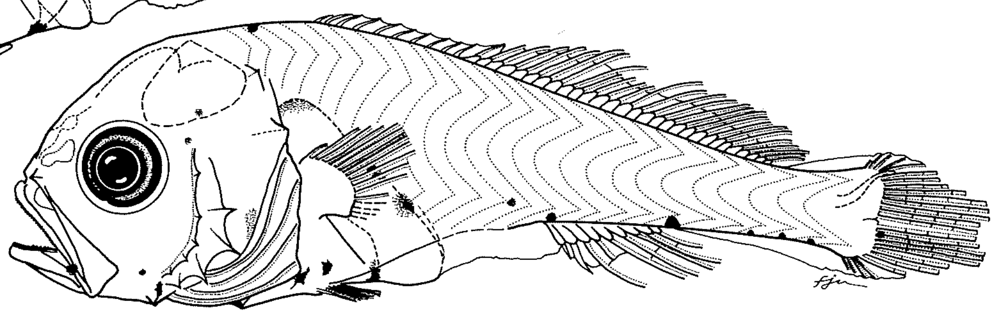
A 3.6 mm



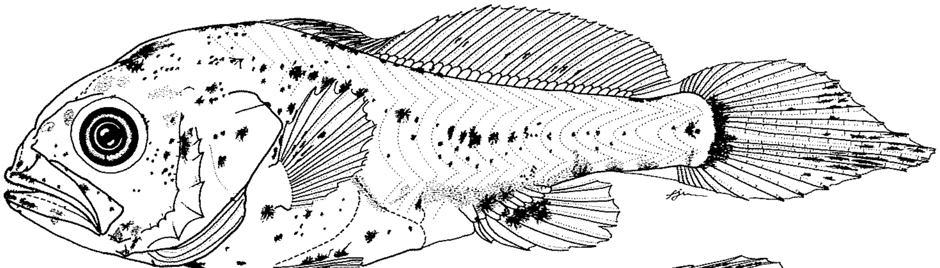
B 4.7 mm



C 5.7 mm



D 9.0 mm



E 11.8 mm

F 20.0 mm

Sciaenidae *Atractoscion aequidens* (Cuvier, 1830) Teraglin

D XI, 26–31 A II, 8–9 P_1 17–18 P_2 I, 5 C 17 V 25

Adults Distributed along eastern Australia from Brisbane (Qld) to Montague Island (NSW). Also widely distributed in the Indo-Pacific and the Atlantic Ocean, including southern and northwest Africa. Occurs in coastal waters, usually associated with gravel and rocky reefs, to a depth of 80 m. Adults have a single, deeply notched dorsal fin, a posteriorly located anal fin, and are green to blue dorsally and silvery ventrally. Maximum size about 1 m (Heemstra, 1986; Hutchins & Swainston, 1986; Kailola *et al.*, 1993).

Importance to fisheries Highly esteemed table fish keenly sought by recreational fishers. Total catch in 1989–90 was 35 tonnes, and there has been a marked decline in the commercial catches in recent years (Kailola *et al.*, 1993).

Spawning Eggs undescribed. Eggs of *A. nobilis* from North America are pelagic and spherical, 1.2–1.3 mm in diameter, and have a single oil globule 0.30–0.36 mm (Moser *et al.*, 1983). Larvae of *A. aequidens* have been caught entering Lake Macquarie (NSW) and in coastal waters off Sydney (NSW) in February (Miskiewicz, 1987; Gray, 1995).

Diagnostic characters

- 24–25 myomeres
- 4 posterior preopercular and 2 interopercular spines in postflexion larvae
- Posterior end of anal fin behind or directly below posterior end of dorsal fin
- Heavy pigment over posterior of head and entire trunk, including pectoral-fin base and membrane, in late preflexion and flexion larvae
- 1 melanophore on posterior region of maxilla

Description of larvae

Morphology Body moderate to deep (BD 33–43%). Head moderate to large (HL 29–40%). Small teeth along premaxilla from preflexion stage and along dentary by early flexion stage. Two small anterior preopercular spines in late preflexion larvae, 1 in postflexion larvae. Three posterior preopercular spines in late preflexion larvae, 4 in postflexion larvae. Two interopercular spines in postflexion larvae. Gut moderate to long (PAL 44–56%), coiled and compact. Prominent gas bladder over foregut, inflated. Large gap between anus and origin of anal fin (VAFL 21–22%). Dorsal-fin spines form before soft rays. Posterior end of anal fin behind or directly below posterior edge of dorsal fin.

Size at

Hatching	<2.1 mm
Notochord flexion	4.4–7.0 mm
Settlement	>7.1 mm

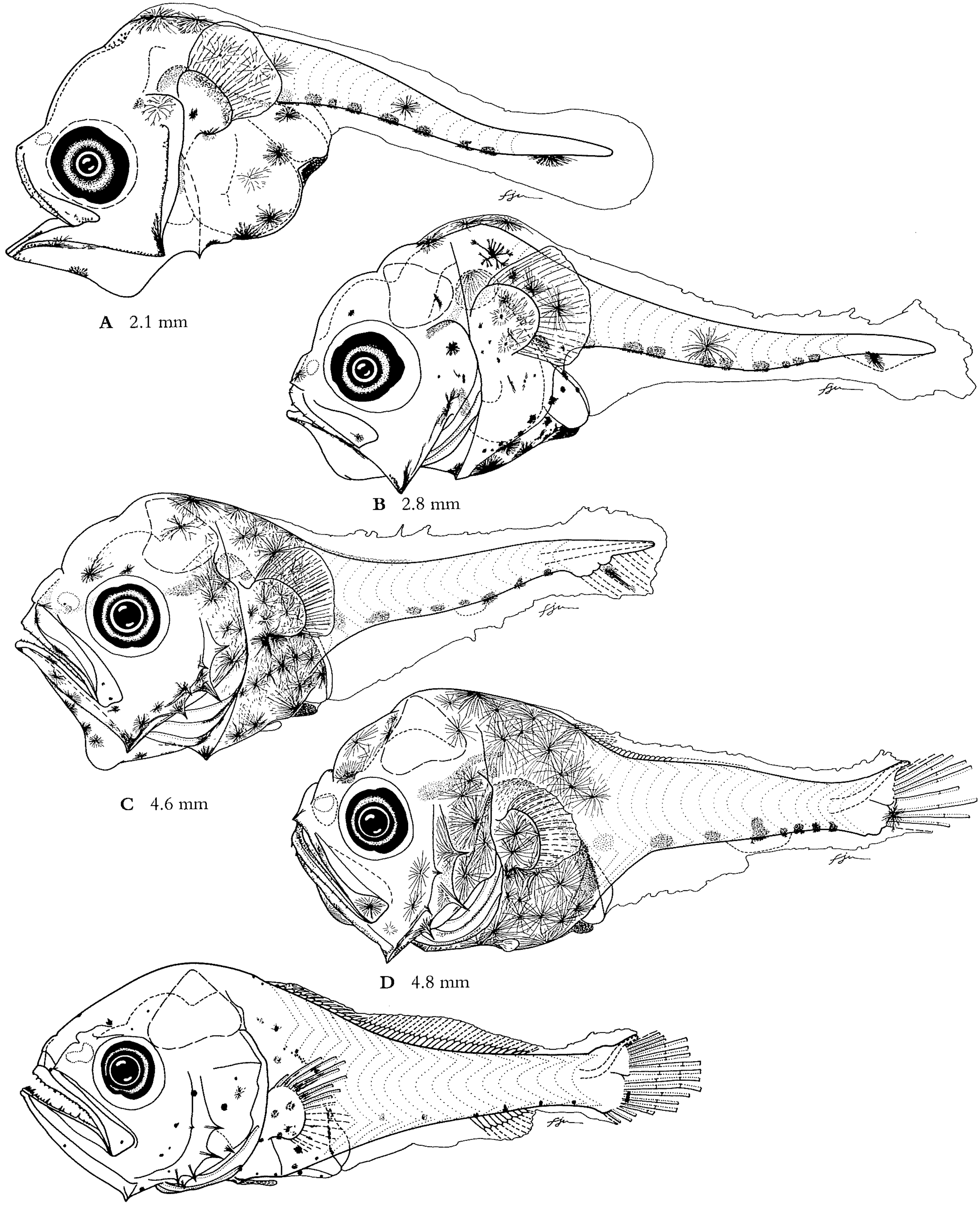
Formation of fins:
Caudal 2.8–>7.1 mm; Dorsal 4.4–>7.1 mm; Anal 4.6–>7.1 mm; Pectoral 4.6–>7.1 mm; Pelvic 4.6–>7.1 mm

Pigmentation Larvae are moderately to heavily pigmented until flexion stage, lightly pigmented in the only postflexion larva available. *External:* Several melanophores along dentary; 1 melanophore on gular membrane in preflexion larvae, 3–4 in flexion larvae. One melanophore at tip of lower jaw, 1 posteriorly on maxilla and 1 at angle of lower jaw. Melanophore in nasal region. One melanophore usually present on cleithral symphysis. Heavy pigment on nape, entire trunk, pectoral-fin base and membrane in preflexion larvae; pigment over posterior of opercle by early flexion stage. Large stellate melanophores along anterior and entire dorsal surfaces of gut. Heavily pigment on preanal membrane until flexion stage. One large melanophore mid-laterally on tail in early preflexion larvae. Seven to ten melanophores along ventral midline of tail in preflexion larvae; anteriormost 4–5 become internal during flexion stage and persist in postflexion larvae; posteriormost remain external along caudal peduncle. One melanophore on lower hypural plate in preflexion larvae, remaining at base of ventral caudal-fin rays in postflexion larvae. *Internal:* One melanophore under each nostril during flexion stage. Heavy pigment under otic capsule. Pigment dorsally over gas bladder. Four to five large melanophores along ventral midline of anterior of tail from flexion stage.

Material examined 11 larvae, 2.1–7.1 mm BL, Lake Macquarie and coastal waters off Sydney (NSW).

Additional references –

Figure 83 Larvae of *Atractoscion aequidens*. **A** Preflexion; stripes on pectoral-fin membrane are pigment and not incipient rays. **B** Preflexion. **C** Late preflexion; note pelvic-fin bud and developing dorsal and anal fins. **D** Late flexion; note developing pectoral-fin rays. **E** Early postflexion; note all fins still developing; anteriormost myomeres not visible. A–E from NSW coastal waters. Illustrated by F. J. Neira.



A 2.1 mm

B 2.8 mm

C 4.6 mm

D 4.8 mm

E 7.1 mm

Scorpididae: Sweeps

D. Rissik, A.G. Miskiewicz and F. J. Neira

Scorpidids are marine fishes mostly found in temperate waters of the Indo-West Pacific, with one species in the Eastern Pacific (California). They occur in schools along rocky shores in coastal waters to a depth of 200 m (Smith, 1986b; Gomon *et al.*, 1994). We follow Johnson (1984) in treating the Scorpididae as a separate family from the Girellidae, Kyphosidae and Microcanthidae, and comprising four genera (*Bathystethus*, *Labracoglossa*, *Medialuna* and *Scorpis*) and about seven species. The monotypic genus *Tilodon*, which is endemic to southern Australian waters, has also been included in the Scorpididae (e.g. Eschmeyer & Bailey, 1990; Gomon *et al.*, 1994), although some authors place it in the Kyphosidae (Nelson, 1994, as *Vinculum*) and Microcanthidae (Johnson, 1980, 1984). Apart from *Scorpis*, the other three scorpidid genera are monotypic and do not occur in Australian waters. Four species of *Scorpis* have been recorded from temperate Australia: *S. aequipinnis* and *S. georgiana* both confined to southwestern and southern Australia, *S. violacea* common in northern New Zealand and rare in New South Wales, and *S. lineolata* confined to southeastern Australia (Kuiter, 1993, 1996; Gomon *et al.*, 1994). Adults (to 60 cm) are deep, laterally compressed and heavily scaled, have abdominal pelvic fins and long-based dorsal and anal fins. Some genera closely resemble butterfly fishes (Family Chaetodontidae) in both shape and coloration (Gomon *et al.*, 1994). Eggs are pelagic but undescribed (Johnson, 1984). Larvae have been described for representatives of *Labracoglossa*, *Medialuna* and *Scorpis* (Hattori, 1964; Konishi, 1988b; Stevens *et al.*, 1989; Watson, 1996j; Neira *et al.*, 1997c). The moderate head spination is the only apparent specialisation of scorpidid larvae to pelagic life.

Meristic characters of the scorpidid genus of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Scorpis	(4)	IX–X, 23–28	III, 25–28	17–18	I, 5	17	10 + 15–16 = 25– 26

Main characters of scorpidid larvae

- 25–26 myomeres
- Body moderate (BD 20–29%), laterally compressed in postflexion larvae
- Moderate head spination, including preopercular, subopercular and interopercular spines
- Gut moderate to long (PAL 36–50%), coiled and compact
- Large gap between anus and origin of anal fin, closed by postflexion stage
- Body moderately to heavily pigmented; melanophore series along dorsal, lateral and ventral midlines of tail, and pigment around notochord tip

References to scorpidid larvae

Hattori (1964), Johnson (1984), Konishi (1988b), Stevens *et al.* (1989), Watson (1996j), Neira *et al.* (1997c).

Families with similar larvae

Arripidae – Dorsal fin IX, 13–17; anal fin III, 9–10; 5–6 internal melanophores along nape and anterior of trunk.

Centrolophidae – Gut long (PAL 51–66%); no gap between anus and origin of anal fin; pigment blotches along dorsal and ventral surfaces of tail from preflexion stage; no pigment around notochord tip in most taxa.

Centropomidae – Gut long (PAL 52–64%); short-based dorsal and anal fins; body moderately to heavily pigmented from early stages; prominent internal pigmented band extending from snout through mideye and to dorsal surface of gut; no pigment around notochord tip.

Cheilodactylidae – 34–36 myomeres; no head spines; no gap between anus and origin of anal fin; hindgut straight and long; no pigment around notochord tip in most taxa.

Girellidae – Weak head spination; large, persistent gap between anus and origin of anal fin; dorsal fin XIII–XVI, 11–15; short-based anal fin, III, 11–12; body lightly pigmented; pigment along lateral midline of tail from flexion stage.

Kyphosidae – No interopercular spines; no gap between anus and origin of anal fin; dorsal fin XI, 12–16; anal fin III, 10–11; small to large stellate melanophores over trunk and tail in postflexion larvae; pigment along lateral midline of tail from postflexion stage; no pigment over notochord tip.

Leptobramidae – 24 myomeres; several small posterior preopercular spines, none on anterior preopercular margin; dorsal fin IV, 26–30, originates posterior to anal-fin origin; no gap between anus and origin of anal fin.

Microcanthidae – Anal fin III, 13–19; none to a few melanophores along dorsal midline of trunk and tail, melanophores widely spaced when present; a few small to large, widely spaced melanophores along ventral midline of tail; pigment along lateral midline of tail from postflexion stage.

Mullidae – Head spines absent in most taxa; 2 short, well separated dorsal fins, first with VII–VIII spines; anal fin I, 6–7; 3 melanophores in a triangular pattern on midbrain in late preflexion larvae.

Pomatomidae – 2 separate dorsal fins, VII–VIII + I, 23–28; body lightly pigmented prior to postflexion stage; no pigment around notochord tip.

Scorpididae *Scorpis (lineolata ?)* Kner, 1865 Silver sweep

D IX, 27 A III, 28 P_1 17–18 P_2 I, 5 C 17 V 25–26

Adults Distributed along southeastern Australia from Noosa Head (Qld) to Port Phillip Bay (Vic), including Tasmania and Lord Howe Island; also in New Zealand. Found in large schools in estuaries, coastal reefs and exposed coastlines to a depth of 30 m. Juveniles are common in rock pools. Adults have a strongly forked caudal fin, and are silver–grey to green–grey dorsally with a black opercular margin. Maximum size 37 cm (Hutchins & Swainston, 1986; Gomon *et al.*, 1994; Kuiter, 1996).

Importance to fisheries Not fished commercially, although its flesh is reported to be firm and of excellent quality (Gomon *et al.*, 1994).

Spawning Eggs undescribed. Larvae have been caught in coastal waters off central New South Wales from May to December (Gray *et al.*, 1992), with peak abundances in August and September (Kingsford *et al.*, 1993).

Diagnostic characters

- 6–10 + 15–19 = 25 myomeres
- 2–8 posterior preopercular spines
- Supraocular ridge and posttemporal, supracleithral and cleithral spines in postflexion larvae
- 2 internal melanophores on nape, followed by an external series of 8–13 melanophores along dorsal midline of trunk and tail in preflexion and flexion larvae
- Up to 13 melanophores along anterior ventral midline of tail in preflexion larvae, becoming internal with growth
- Pigment around notochord tip

Description of larvae

Morphology Body moderate (BD 20–29%). Head moderate in preflexion and flexion larvae (HL 21–29%), moderate to large in postflexion larvae (HL 32–34%). Small teeth along both jaws by late preflexion stage. Two small posterior preopercular spines in late preflexion larvae, 8 in postflexion larvae. Two small anterior preopercular spines in flexion larvae, 1 in postflexion larvae until 8.6 mm. Smooth supraocular ridge, and 3 interopercular, 2 small subopercular, 2 posttemporal, 1 cleithral and 1 supracleithral spine in postflexion larvae. Gut moderate to long (PAL 36–51%), coiled and compact. Small gas bladder above foregut, obscured by heavy pigment in postflexion larvae. Moderate gap between anus and origin of anal fin, reduced by late postflexion stage.

Size at

Hatching	<4.3 mm
Notochord flexion	6.1–7.8 mm
Settlement	>13.3 mm

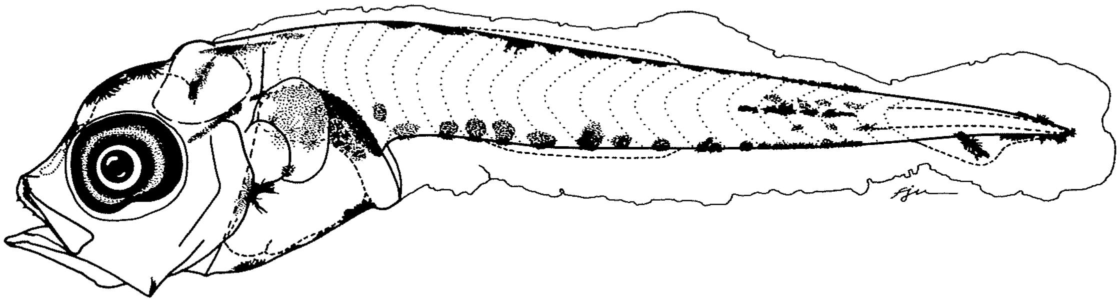
Formation of fins:
Caudal 4.3–8.0 mm; Dorsal 4.6–8.6 mm; Anal 4.6–8.6 mm; Pectoral 6.5–13.3 mm; Pelvic 7.7–<13.3 mm

Pigmentation Larvae are moderately pigmented, becoming heavily pigmented by postflexion stage. *External:* Several melanophores dorsally on head and 1 at tip of snout from preflexion stage; 2–3 ventrally on isthmus from flexion stage; a patch of large, stellate melanophores under eye and several on lower jaw by late flexion stage. Heavy pigment over head by postflexion stage. Three to four melanophores ventrally on gut in preflexion larvae, heavy pigment over entire gut in postflexion larvae. Series of 8–13 closely spaced melanophores along dorsal midline of trunk and tail in preflexion larvae. Melanophore series along lateral midline of tail, extending anteriorly and forming a continuous stripe in postflexion larvae. Up to 13 melanophores along ventral midline of tail in preflexion larvae; anteriormost melanophores expand upwards and become internal during flexion stage, posteriormost melanophores become discrete by early postflexion stage. One elongate melanophore on hypural region in preflexion larvae. Pigment around notochord tip; dorsal pigment disappears during flexion stage, ventral pigment remains along caudal-fin base. Pigment over trunk and tail from late flexion stage, becoming heavy dorsally in postflexion larvae, lighter ventrally. *Internal:* Pigment under midbrain and over hindbrain. Two melanophores on nape. Heavy pigment dorsally over gas bladder and gut. Series of melanophores along ventral midline of anterior of tail during flexion stage. Melanophores dorsally and ventrally along posterior of notochord from preflexion stage, extending anteriorly with growth.

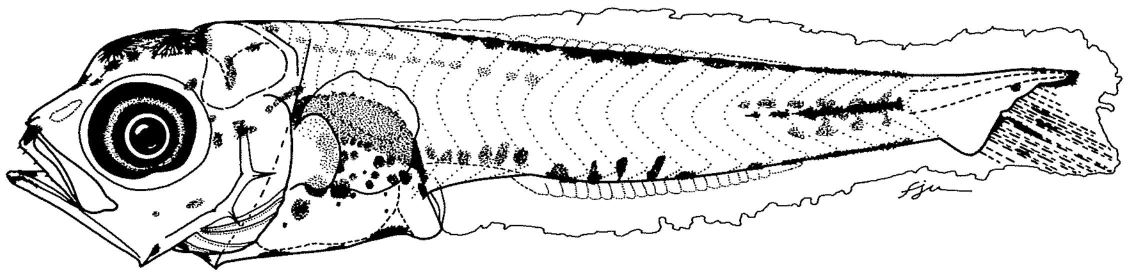
Material examined 28 larvae, 4.3–13.3 mm BL, coastal waters off Terrigal and Greenwell Point (NSW).

Additional references Neira *et al.* (1997c).

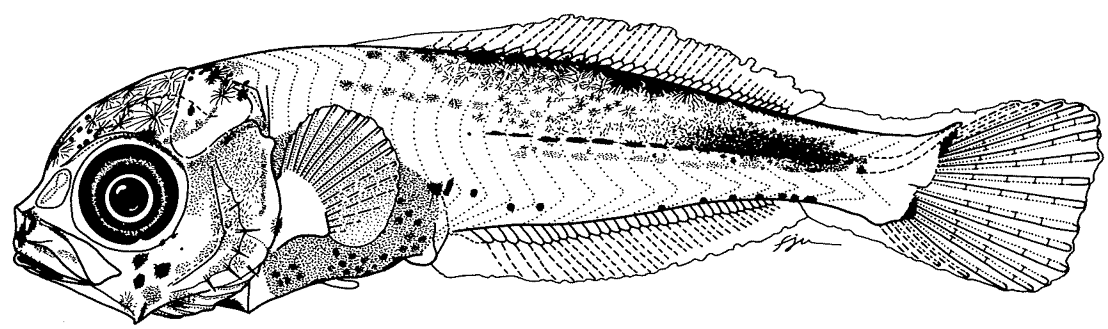
Figure 84 Larvae of *Scorpis* (*lineolata* ?). **A** Preflexion. **B** Early flexion; note developing dorsal and anal fins. **C** Early postflexion; note pelvic-fin bud. **D** Postflexion; myomeres omitted. A–D from NSW coastal waters (from Neira *et al.*, 1997c). Illustrated by F. J. Neira.



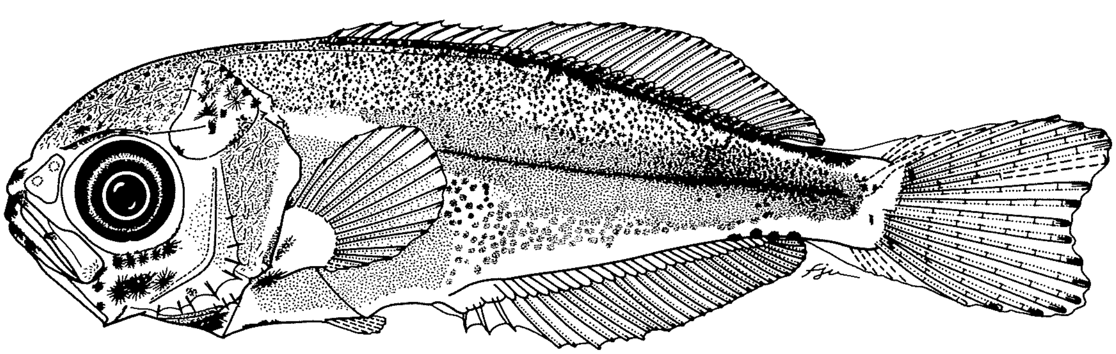
A 5.0 mm



B 6.2 mm



C 7.7 mm



D 8.6 mm

Serranidae (Anthiinae): Sea basses, sea perches, wirrahs

C.C. Baldwin and F. J. Neira

Serranids comprise a large group of marine fishes distributed in tropical to temperate waters worldwide, frequently associated with coral or rocky reefs (Hoese *et al.*, 1989; Randall *et al.*, 1990). Many species are commercially important as food fishes, and others are valuable in the aquarium trade. The family comprises 62 genera and about 450 species (Nelson, 1994). Three subfamilies are usually recognised, the Serraninae, Epinephelinae and Anthiinae, with most temperate Australian species belonging to the last (Heemstra & Randall, 1986; Baldwin & Johnson, 1993). Ten genera and 27 species of anthiine serranids have been recorded from temperate Australia (Hutchins & Swainston, 1986; Hoese *et al.*, 1989; Gomon *et al.*, 1994). Adults (0.03–3.0 m) differ from most other percoids in having three spines on the opercle (Gosline, 1966; Johnson, 1984). Eggs of *Acanthistius*, *Anthias*, *Pseudanthias* and *Sacura* are pelagic and spherical, 0.6–0.9 mm in diameter, and have a single oil globule (Suzuki *et al.*, 1974, 1978; Robertson, 1975a; Brownell, 1979; Kendall, 1984; Ikeda & Mito, 1988). Many New World anthiine serranid larvae have been described (see Kendall, 1984, and references therein; see also Kendall, 1979; Baldwin, 1990; Watson, 1996h), but larvae of few Indo-Pacific species are known. Larvae of many taxa exhibit remarkable morphological adaptations during the pelagic phase (Kendall, 1984; Baldwin, 1990; Baldwin *et al.*, 1991). Identification of anthiine larvae using adult fin-ray counts is difficult because the number of rays often overlap considerably among species. Cladistically, primitive anthiines (e.g. with 17 principal caudal-fin rays; Roberts, 1989; Anderson *et al.*, 1990) for which larvae have been described (e.g. *Acanthistius*, *Hypoplectrodes*, *Plectranthias*) have fewer, less prominent head spines than other anthiines (e.g. *Anthias*, *Hemanthias*, *Pronotogrammus*, *Pseudanthias*; Leis & Rennis, 1983; Kojima, 1988a; Baldwin, 1990; this chapter). Adults of all temperate Australian anthiine genera except for *Pseudanthias* also exhibit primitive anthiine features. The head spines or serrations, and the elongate dorsal-fin spine (second or third), the produced first pelvic-fin ray, and the serrate fin spines and spiny scales in some taxa, constitute specialisations of anthiine serranid larvae to pelagic life (Leis & Rennis, 1983; Kendall, 1984).

Meristic characters of anthiine serranid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Acanthistius	(5)	XIII, 13–15	III, 8	16–18	I, 5	17	10 + 16 = 26
Caesioperca	(2)	X, 19–22	III, 8–10	14–18	I, 5	17	10 + 16 = 26
Caprodon	(2)	X, 19–21	III, 7-9	17–19	I, 5	17	10 + 16 = 26
Epinephelides	(1)	X, 20	III, 8	15	I, 5	17	10 + 17 = 27
Hypoplectrodes	(6)	X, 16–21	III, 7–9	13–17	I, 5	17	10 + 17–18 = 27–28
Lepidoperca	(5)	X, 15–21	III, 7–9	14–18	I, 5	17	10 + 16 = 26
Othos	(1)	X, 18	III, 8	15	I, 5	17	10 + 17 = 27
Plectranthias	(2)	X, 14–15	III, 6–7	14–17	I, 5	17	10 + 16 = 26
Pseudanthias	(2)	X, 16–17	III, 7	16–18	I, 5	15	10 + 16 = 26
Trachypoma	(1)	XII, 13	III, 6	16	I, 5	17	10 + 16 = 26

Main characters of anthiine serranid larvae

- 26–28 myomeres
- Body initially elongate, becoming moderate to deep with development (BD 18–44%)
- Preflexion larvae typically 'hunchbacked'
- Head moderate to large with short snout

- Weak to well developed, extensive head spination, always including prominent preopercular spines and interopercular spines, and, sometimes, spines or serrations on most exposed head bones
- Spiny scales and/or serrate fin spines in some taxa
- Gut moderate to long (PAL 48–69%), coiled early in development
- Second or third dorsal-fin spine elongate in some taxa
- First pelvic-fin ray produced in some taxa
- Anterior dorsal-fin spines and pelvic-fin spine sometimes ossify before other fin elements
- Body lightly to heavily pigmented, pattern species-specific

References to anthiine serranid larvae

Leis & Rennis (1983), Kendall (1984), Kojima (1988a), Baldwin (1990), Baldwin *et al.* (1991), Watson (1996h).

Families with similar larvae

Acropomatidae – 25 myomeres; moderate to well developed head spination, including an emergent median supraoccipital crest in some taxa; 2 separate dorsal fins, IX + I, 10; body lightly pigmented, little or no pigment on tail.

Berycidae – 23–24 myomeres; weak to moderate head spination from late flexion stage; dorsal fin IV–VII, 11–20; anal fin III–IV, 12–30; elongate, early forming pelvic fins, I, 7–13; gut long (PAL 45–60%).

Callanthiidae – 24–25 myomeres; dorsal fin XI, 10–12, third dorsal-fin spine not elongate; body lightly pigmented.

Carangidae – 24–26 myomeres, typically 24–25; median supraoccipital crest in most taxa; two separate dorsal fins, VI–VIII + I, 22–37; long-based anal fin, II + I, 16–29; melanophore series along dorsal and ventral surfaces of trunk and tail, and along lateral midline of tail.

Enoplosidae – 2 dorsal fins, VIII + I, 14–15; anal fin III, 14–15; body moderately to heavily pigmented; pigment on tip of premaxilla and dentary.

Haemulidae – Numerous anterior and posterior preopercular spines; small gap between anus and origin of anal fin; late forming fin spines.

Lutjanidae – 23–25 myomeres, typically 24; slender body; early forming, smooth (unornamented) preopercular spines; early forming dorsal and pelvic fins, second dorsal-fin spine and pelvic-fin spine markedly produced and often finely serrate.

Platycephalidae – Head greatly depressed in postflexion larvae, snout flattened and elongate; large, wing-shaped pectoral fins, with early forming rays; 2 separate dorsal fins, VII–XII + 10–15; anal fin spineless, 10–15 rays; body lightly to moderately pigmented, melanophores usually along ventral midline of tail, and scattered over lateral surfaces of trunk and tail.

Scorpaenidae – Early forming parietal spines, often serrate and prominent; large, fan-shaped pectoral fins with early forming, elongate rays; pigment along pectoral-fin rays and scattered over connecting membranes.

Serranidae (Epinephelinae) – 23–25 myomeres; posterior preopercular spine at angle elongate and serrate; early forming dorsal and pelvic fins, second dorsal- and pelvic-fin spines extremely produced and coarsely serrate; first two anal-fin spines often serrate.

Serranidae *Acanthistius serratus* (Cuvier, 1828) Western wirrah

D XIII, 13–15 A III, 8 P_1 16–18 P_2 I, 5 C 17 V 26

Adults Endemic to southwestern and southern Australia from Shark Bay (WA) to Ceduna (SA). Occurs on exposed coastal reefs to a depth of 40 m, and shelters in caves during the day; juveniles occur in rockpools. Adults have the spinous portion of the dorsal fin longer than the soft portion, 54–55 lateral-line scales, and are pale green to brown–grey, with a variable pattern of spots or blotches over the body, and dusky bands radiating from the eyes. Maximum size 50 cm (Hutchins, 1981; Hutchins & Swainston, 1986; Edgar, 1997).

Importance to fisheries Taken occasionally by anglers although its flesh is not considered good eating (Hutchins & Swainston, 1986; Gomon *et al.*, 1994).

Spawning Eggs undescribed. Eggs of *Acanthistius sebastoides* from South Africa are approximately 0.9 mm in diameter, and have a single oil globule 0.2 mm (Brownell, 1979, as 'Perciform sp. 1'). Larvae described herein were artificially reared from eggs spawned in November.

Diagnostic characters

- 26 myomeres
- Large preopercular spines
- Heavily pigmented pectoral-fin buds
- Body heavily pigmentated by postflexion stage except for a small area of caudal peduncle

Description of larvae

Morphology Body elongate in early preflexion larvae (BD 19%), moderate in late preflexion larvae (BD 27–33%), moderate to deep in flexion and postflexion larvae (BD 34–46%). Head moderate in preflexion larvae (HL 23–33%), large in postflexion larvae (HL 39–46%). Small teeth in both jaws from 8.5 mm. Two small to moderate posterior preopercular spines by flexion stage, 6 by 10 mm, 8 by 23 mm; spine at angle the longest. One small anterior preopercular spine in postflexion larvae. Two small posttemporal spines from late preflexion stage. One small interopercular, 1 small subopercular and 1–2 posteriorly directed supracleithral spines in postflexion larvae. Gut moderate to long (PAL 48–68%), coiled.

Size at

Hatching	<2.8 mm
Notochord flexion	4.1–5.3 mm
Settlement	>10.5–<23.0 mm
Formation of fins:	

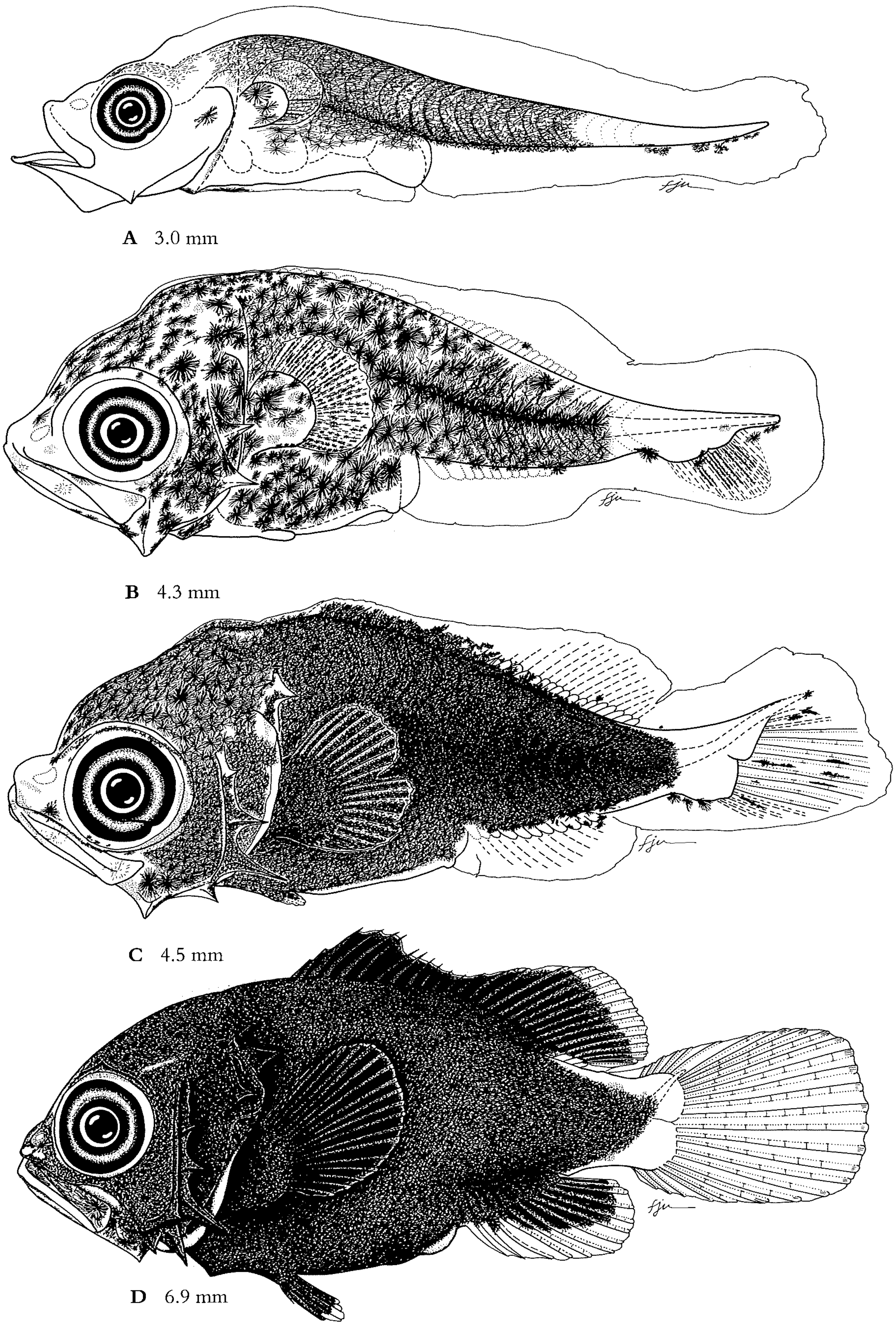
Caudal 4.1–5.3 mm; Dorsal 4.2–4.7 mm; Pelvic 4.2–4.7 mm; Pectoral 4.2–5.3 mm; Anal 4.2–7.5 mm

Pigmentation Larvae are heavily pigmented. *External:* Several melanophores dorsally on head and usually 1 on opercle in preflexion larvae; heavy pigment over head prior to flexion stage. Expanded melanophores over most of anterior of trunk; heavy pigment laterally on gut. Heavy pigment on trunk and tail in postflexion larvae except anteroventral region. No pigment on caudal peduncle. Melanophores under notochord tip in preflexion and flexion larvae, disappearing in postflexion larvae. Several melanophores on base of pectoral-fin bud, heavily pigmented by end of flexion stage. Pectoral-fin base and rays heavily pigmented by flexion stage. Pelvic fin pigmented by end of flexion stage except for distal tip of rays. Spinous dorsal fin heavily pigmented by postflexion stage; soft dorsal-fin rays heavily pigmented proximally in some postflexion larvae, lightly pigmented or unpigmented in others. Pigment on anal-fin spines after flexion stage; pigment on anal-fin rays usually heavier with growth but variously present or absent in postflexion larvae. Juvenile pigment pattern present by 23 mm: head with unpigmented areas and 2 broad postorbital bars of pigment, one from eye to edge of opercle, the other from eye to margin of preopercle near angle. Trunk mostly covered with melanophores, but some unpigmented areas dorsally. *Internal:* Small melanophores on forebrain and pigment dorsally over gut and gas bladder from preflexion stage.

Material examined 44 larvae, 2.8–10.5 mm BL, and 1 juvenile, 23.0 mm BL, reared at the Fremantle Maritime Centre (WA).

Additional references –

Figure 85 Larvae of *Acanthistius serratus*. **A** Preflexion; **B** Late preflexion; note pelvic-fin bud. **C** Flexion. **D** Postflexion. A–D reared at FMC (WA). Illustrated by F. J. Neira.


A 3.0 mm
B 4.3 mm
C 4.5 mm
D 6.9 mm

Serranidae *Hypoplectrodes maccullochi* (Whitley, 1929) Half-banded seaperch

D X, 18–21 A III, 7–9 P_1 15–17 P_2 I, 5 C 17 V 27

Adults Endemic to southeastern Australia from Cape Byron (NSW) to Wilsons Promontory (Vic), including northeastern Tasmania. Found in shallow coastal waters on rocky reefs with abundant sponge and soft coral, to a depth of about 50 m. Adults have 6–7 reddish brown bands on the upper portion of the body. Maximum size 45 cm, usually not >15 cm (Whitley, 1929, as *Ellerkeldia maccullochi*; Hutchins & Swainston, 1986; Gomon *et al.*, 1994).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been collected in coastal waters of northern and central New South Wales in September (A.G. Miskiewicz, pers. comm.).

Diagnostic characters

- 9–10 + 17–18 = 27 myomeres
- Well developed head spination
- Elongate third dorsal-fin spine
- Elongate first pelvic-fin ray, with pigmented sheath distally
- Body lightly pigmented

Description of larvae

Morphology Body moderate to deep (BD 37–43%). Head large (HL 35–44%). Teeth along premaxilla in all larvae, adult teeth in both jaws by 8.4 mm. One supraocular spine; 5 smooth posterior preopercular spines, spine at angle the longest; 2 small anterior preopercular spines. One small subopercular spine and 2 interopercular spines in postflexion larvae, uppermost interopercular spine elongate. Two supracleithral spines, lowermost elongate and posteriorly directed. Two small posttemporal spines. One opercular spine from 7.4 mm. Gut long (PAL 52–60%), coiled. Third dorsal-fin spine elongate. First pelvic-fin soft ray elongate.

Size at

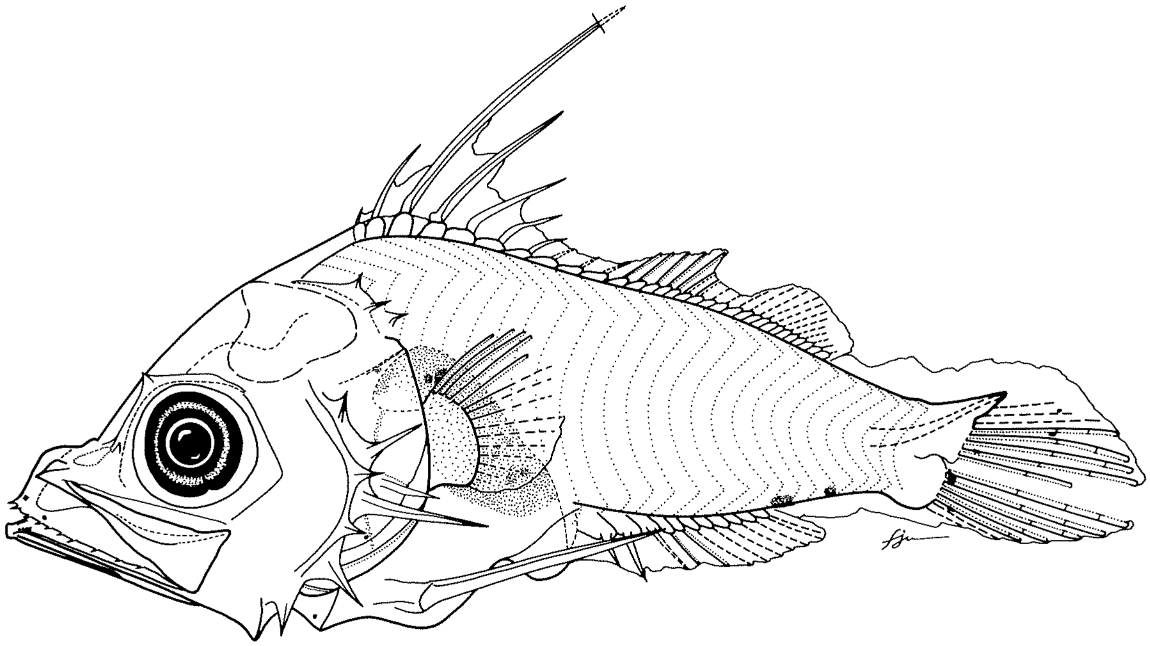
Hatching	—
Notochord flexion	<5.2–5.7 mm
Settlement	>8.4 mm
Formation of fins:	
Caudal <5.2–5.7 mm; Dorsal <5.2–5.7 mm; Anal <5.2–5.7 mm; Pelvic <5.2–5.7 mm; Pectoral <5.2–7.4 mm	

Pigmentation Larvae are lightly pigmented. *External:* A few small melanophores along premaxilla in flexion larvae; a few along dentary in late postflexion larvae. One melanophore on isthmus, just anterior to cleithral symphysis. Large melanophore on ventral midline of tail just posterior to end of anal fin, followed by a smaller melanophore on caudal peduncle. One melanophore on caudal-fin base near junction of hypural plates. Pigmented sheath at tip of elongate first pelvic-fin ray; pigment also present on membranes between second and third pelvic-fin rays in one postflexion larva. *Internal:* 3–4 melanophores on midbrain in larger postflexion larvae. Pigment dorsally over gas bladder, and over anterior and dorsolateral surfaces of gut.

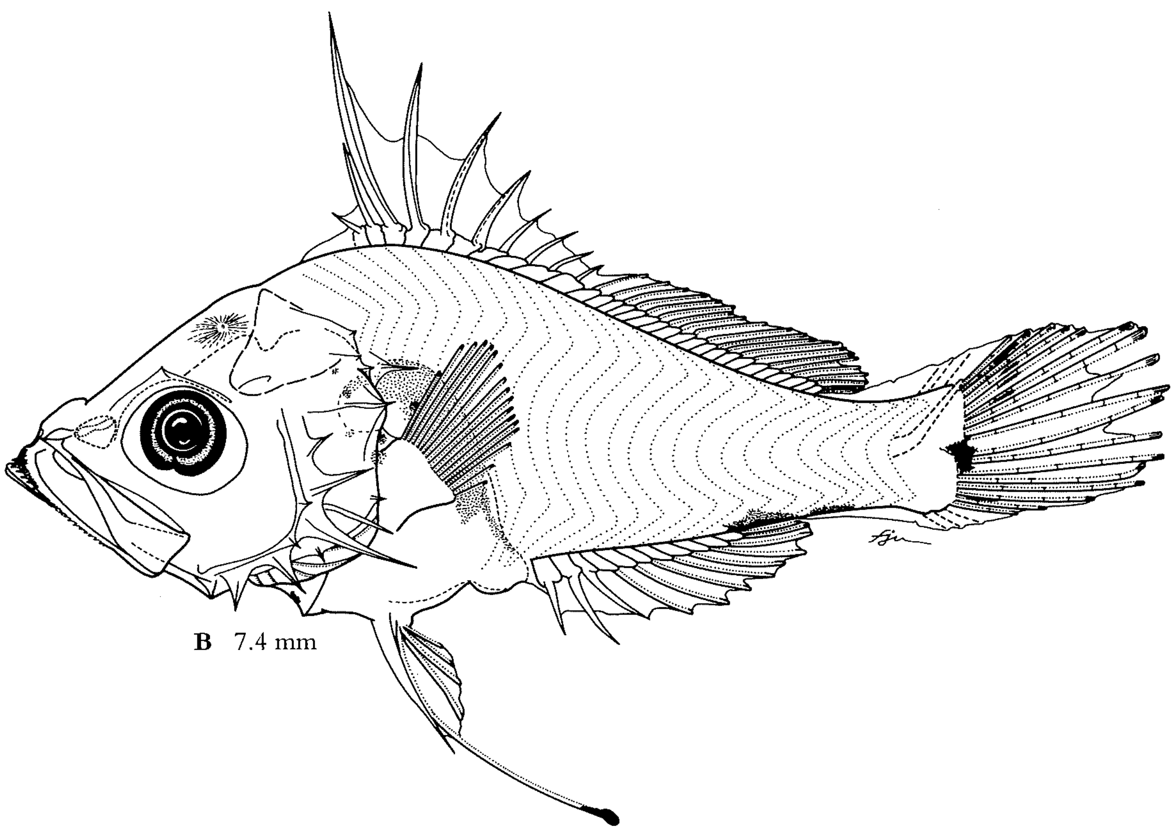
Material examined 7 larvae, 5.2–8.4 mm BL, coastal waters of northern and central New South Wales.

Additional references –

Figure 86 Larvae of *Hypoplectrodes maccullochi*. **A** Late flexion; note elongate pelvic-fin spine. **B** Postflexion; note elongate anteriormost pelvic-fin ray with pigmented sheath at tip. A–B from northern and central NSW coastal waters. Illustrated by F. J. Neira.



A 5.2 mm



B 7.4 mm

Sillaginidae: Whitings, sand smelts

B.D. Bruce and A.G. Miskiewicz

Sillaginids are mostly schooling marine fishes found in estuarine and shallow coastal marine waters in tropical to temperate regions of the Indo-West Pacific (McKay, 1985, 1992). The family comprises the genera *Sillago*, with 29 species, and the monotypic *Sillaginodes* and *Sillaginopsis*. Two genera and 14 species occur in Australia, both genera and 8 species in temperate waters (Hutchins & Swainston, 1986; Paxton & Hanley, 1989m; McKay, 1992; Gomon *et al.*, 1994). Most species have commercial and recreational importance (Kailola *et al.*, 1993). Adults (to 45 cm) are elongate, have a long snout with a small, horseshoe-shaped mouth, two separate but adjacent dorsal fins, and a long-based anal fin. The gas bladder is vestigial or absent in *Sillaginopsis* but is an important taxonomic character in the other two genera, having anterior, lateral and/or posterior extensions in several species (McKay, 1992). Eggs are pelagic and spherical, 0.6–0.9 mm in diameter (Ueno & Fujita, 1954; Ikeda & Mito, 1988; Bruce, 1995). Larvae have been described for the only species of *Sillaginodes* and several representatives of *Sillago* (e.g. Ueno *et al.*, 1958; Kinoshita, 1988d; Leis & Trnski, 1989; Bruce, 1995). Unlike tropical sillaginid larvae (see Leis & Trnski, 1989), larvae of the temperate species described here vary widely in the timing of gut coiling and the anus does not migrate posteriorly. The weak head spination constitutes the only apparent specialisation of sillaginid larvae to pelagic life (Leis & Trnski, 1989).

Meristic characters of sillaginid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Sillaginodes	(1)	XII–XIII + I, 25–27	II, 21–24	13–16	I, 5	17	20–23 + 5–7 + 14–18 = 42–44
Sillago	(7)	X–XII + I, 16–22	II, 15–20	15–17	I, 5	17	12–17 + 5–14 + 7–14 = 32–37

Main characters of sillaginid larvae

- 32–45 myomeres
- Body initially very elongate to elongate, becoming elongate to moderate with development (BD 9–22%)
- Elongate, pointed snout in postflexion larvae
- Very small preopercular spines (absent in *Sillaginodes*); very small posttemporal and supracleithral spines in *Sillago* by late postflexion stage
- Gut moderate to long (PAL 44–64%), initially straight but coils during development; weak striations develop along midgut in most taxa prior to flexion stage
- Prominent gas bladder in larvae caught at night, inconspicuous during day
- Prominent, persistent preanal membrane
- Melanophore at angle of lower jaw
- Melanophore series along dorsal midlines of trunk and tail; in most taxa, these tend to disappear posteriorly during flexion stage and reappear during postflexion stage
- Melanophore series along ventral midline of gut (sometimes they appear to be along preanal membrane), and along entire ventral midline of tail

References to sillaginid larvae

Munro (1945), Gopinath (1946), Uchida *et al.* (1958), Mito (1966), Johnson (1984), Kinoshita (1988d), Leis & Trnski (1989), Oozeki *et al.* (1992), Bruce (1995).

Families with similar larvae

Aplodactylidae (early stages) – Lack striations along midgut; body heavily pigmented from early flexion stage; many small melanophores on caudal finfold and pigment around notochord tip.

Bovichtidae (postflexion *Pseudaphritis*) – No preopercular spines; 2 well separated dorsal fins, first with VII–VIII spines; body lightly pigmented, prominent melanophore at pelvic-fin base.

Cheilodactylidae (early stages) – Head rounded with a blunt snout and no spines; lack striations along midgut; head heavily pigmented by flexion stage; lack pigment ventrally along gut; body heavily pigmented after flexion stage.

Chironemidae (early stages) – 33 myomeres; melanophores over caudal finfold, and pigment around notochord tip.

Clinidae – 42–96 vertebrae; no head spines; little or no pigment on head, and ventrally along gut and dorsal midline of trunk and tail.

Creediidae – 37–59 myomeres; continuous, spineless dorsal fin with 12–27 rays; anal fin spineless, 24–30 rays; pelvic fins jugular; overhanging snout by late postflexion stage; lobed lateral-line scales.

Gobiidae – 24–34 myomeres, typically 25–27; no head spines; 2 short-based dorsal fins; short-based anal fin; lack striations along midgut; prominent gas bladder over midgut; little pigment ventrally along gut in early stages.

Latridae – No head spines; continuous dorsal fin, XVII–XXIII, 23–40; anal fin III, 18–35; little pigment ventrally along gut in early stages; body heavily pigmented after flexion stage.

Ophidiidae – 48–87 myomeres; elongate body with tapered tail; lower jaw angle ventrally directed and pronounced; dorsal and anal fins long, spineless, and confluent with caudal fin; pelvic fins jugular; little pigment ventrally along gut in early stages.

Plesiopidae (*Trachinops*) – 37–40 myomeres; body lightly pigmented, 1 internal melanophore above anus; lack pigment along ventral midline of trunk and tail.

Terapontidae – 25–26 myomeres; weak to well developed head spination; gut coiled and compact from early stages; 1–2 large melanophores ventrally along gut; little or no pigment along dorsal midline of tail in early larvae.

Tripterygiidae (early stages) – No head spines; moderate ascending premaxillary process; little or no pigment ventrally along gut and along dorsal midlines of trunk and tail in most taxa.

Sillaginidae *Sillaginodes punctata* (Cuvier, 1829) King George whiting

D XII–XIII + I, 25–27 A II, 21–24 P_1 13–16 P_2 I, 5 C 17 V 42–44

Adults Endemic to southern Australia from Jurien Bay (WA) to Sydney (NSW), including northern Tasmania. Inhabits estuaries, bays and shallow coastal marine waters to a depth of 25 m. Juveniles occur in tidal creeks and estuaries, and shallow waters of low energy coasts, often among seagrass beds. Adults have numerous small brown spots over the upper body. Maximum size 72 cm, the largest species in the family (Robertson, 1977; McKay, 1985, 1992; Jones *et al.*, 1990; Kailola *et al.*, 1993; Gomon *et al.*, 1994).

Importance to fisheries Fished commercially with beach seines and gill nets in estuaries, bays and coastal waters. Main commercial fishery operates in South Australia (600–800 tonnes annually), with smaller fisheries in Western Australia and Victoria (100–200 tonnes). Also targeted by recreational fishers with handlines (Kailola *et al.*, 1993).

Spawning Eggs are pelagic and spherical, 0.84–0.94 mm in diameter, and have a smooth chorion, an unsegmented yolk, and a single oil globule 0.25–0.26 mm (Bruce, 1995). Spawning has been reported in South Australia between late February and late June, and in Victoria between May and July (Gilmour, 1969; Jones *et al.*, 1990; McKay, 1992). Larvae have been caught in South Australia from March to September. Pre-settlement larvae and post-settlement recruits have been caught just inside the entrance of Port Phillip Bay (Vic) from late August until late November (Jenkins & Black, 1994; Jenkins & May, 1994; Hamer & Jenkins, 1996).

Diagnostic characters

- 16–21 + 23–27 = 42–45 myomeres
- No head spines
- Gut coils after settlement (21–24 mm)
- Melanophore series along dorsal midline of trunk and tail disappear by end of flexion stage except melanophores between myomeres 31–40 which become prominent
- 4–6 discrete pigment patches dorsally along trunk and tail in postflexion larvae, each comprising 3–4 pairs of stellate melanophores
- 0–3 melanophores, usually 1–2, above and 2–4 below notochord tip in preflexion larvae

Description of larvae

Morphology Body elongate in early preflexion stage (BD 10–16%), very elongate from late postflexion stage (BD 9–10%). Head small to moderate (HL 16–24%), without spines. Small villiform teeth along premaxilla from flexion stage. Gut moderate to long (PAL 45–55%), initially straight, coiled after settlement by 21–24 mm; midgut striated from late preflexion stage. Gas bladder visible from 3.5 mm, inflated and prominent in larvae caught at night. Yolk sac is resorbed by 3.9 mm. Scales form by 32 mm.

Size at

Hatching	2.0–2.2 mm
Notochord flexion	5.7–7.0 mm
Settlement	15.0–18.0 mm
Formation of fins:	

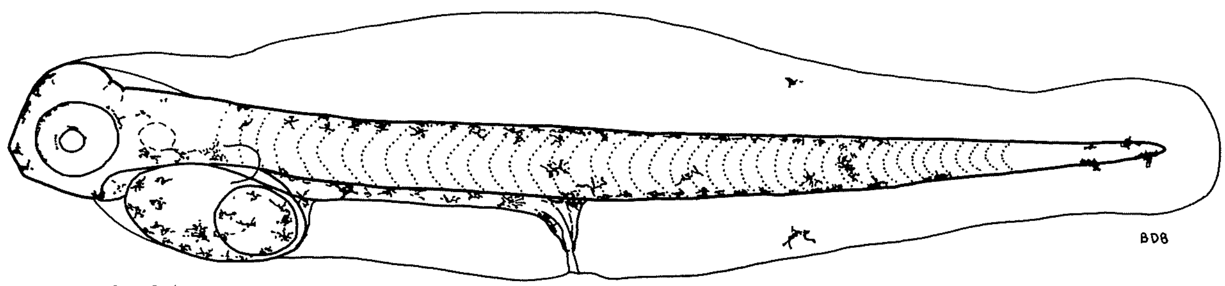
Caudal 5.6–7.0 mm; Anal 5.8–13.0 mm; Dorsal 5.8–13.1 mm; Pectoral 9.2–11.5 mm; Pelvic 9.2–21.5 mm

Pigmentation Larvae are lightly pigmented. *External:* Scattered melanophores over entire surface of body in newly hatched larvae. Melanophores at angle of lower jaw, on gular membrane, and sometimes on lower jaw. Single melanophore series along dorsal midline of trunk and tail in preflexion and flexion larvae; dorsal melanophores disappear by end of flexion stage except for a few which remain between myomeres 31 and 40 and become prominent; dorsal pigment on trunk and tail reappears during postflexion stage as 4–6 discrete pigment blotches, each comprising 3–4 pairs of stellate melanophores. Melanophore series ventrally along body in early preflexion larvae, from isthmus to caudal peduncle; series ventrally along tail paired by 8.5 mm, with about 1 pair per myomere by settlement. Melanophores along lateral midline of posterior of tail in postflexion larvae. None to three melanophores dorsally, usually 1–2, and 2–4 ventrally along notochord tip in preflexion larvae; ventral melanophores remain along caudal-fin base in postflexion larvae. *Internal:* Pigment at base of otic capsule and dorsally over gas bladder and gut.

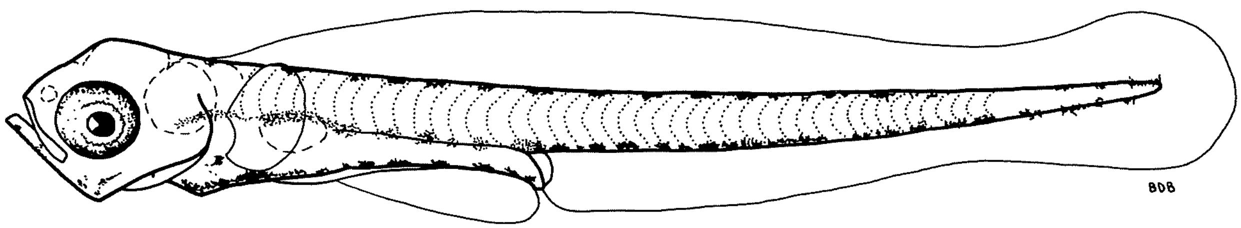
Material examined 65 larvae, 2.0–18.0 mm BL, and 10 juveniles, 18.7–35.0 mm BL, incorporating both larvae reared at the South Australian Research and Development Institute (SA), and field-collected specimens from Spencer Gulf and Gulf St Vincent (SA).

Additional references Bruce (1995).

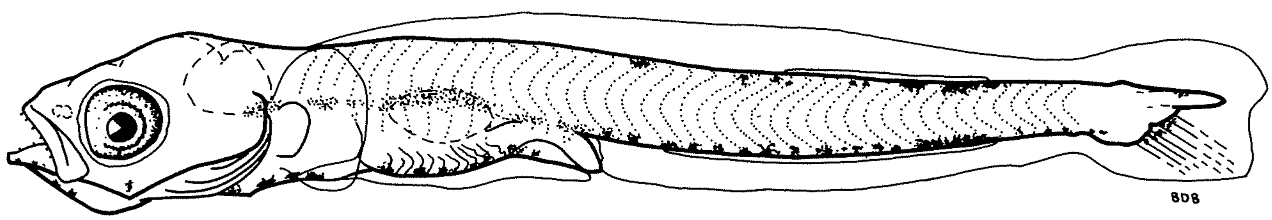
Figure 87 Larvae and settlement stage of *Sillaginodes punctata*. **A** Preflexion, yolk sac. **B** Preflexion. **C** Flexion; note developing dorsal and anal fins. **D** Postflexion; note striated gut. **E** Settlement stage. A–D reared at SARDI (SA); E from Spencer Gulf (SA) (from Bruce, 1995). Illustrated by B.D. Bruce.



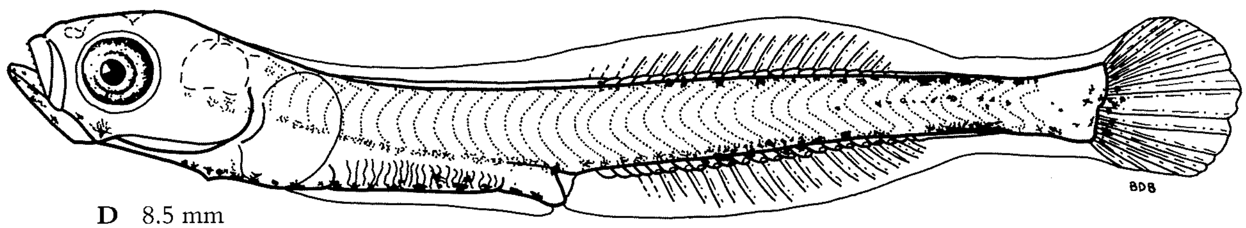
A 3.1 mm



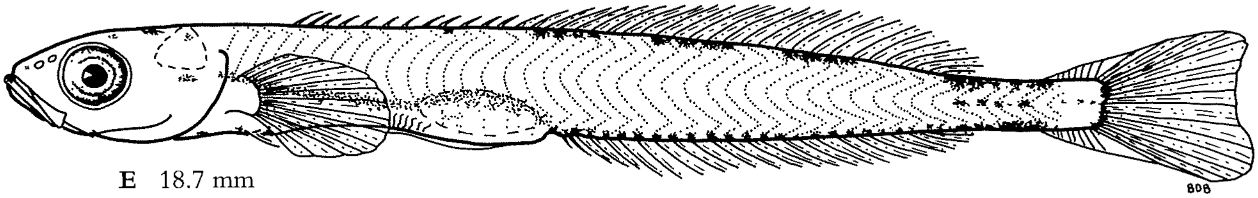
B 4.2 mm



C 6.5 mm



D 8.5 mm



E 18.7 mm

Sillaginidae *Sillago bassensis* Cuvier, 1829 Western school whiting

D X–XII + I, 16–19 A II, 18–20 P_1 15–16 P_2 I, 5 C 17 V 33–35

Adults Endemic to southern Australia from Geraldton (WA) to western Victoria. Found in protected bays, surf zones and coastal marine waters to a depth of 55 m. Juveniles occur in shallow waters off sandy beaches, sometimes in association with accumulations of drift algae. Adults have a row of narrow, rusty–brown oblique stripes along the body. Maximum size 36 cm (Lenanton *et al.*, 1982; McKay, 1985, 1992; Hutchins & Swainston, 1986).

Importance to fisheries Commercial by-catch of prawn and scallop fisheries in Western Australia and South Australia. Total commercial catch in 1988–89 was 18 tonnes. Also targeted by recreational fishers (Kailola *et al.*, 1993).

Spawning Eggs undescribed. Spawning has been reported on the lower west coast of Australia between September and November, and in March and April, with peak activity from December to March (Hyndes & Potter, 1996). Larvae have been caught in coastal waters of South Australia from January to April.

Diagnostic characters

- 11–15 + 19–23 = 32–35 myomeres
- Gut coils in preflexion larvae by 4.1 mm
- 1 minute posterior preopercular spine in early postflexion larvae by 7.8 mm, not visible after settlement
- Melanophores along dorsal midline of trunk and tail reduced to 0–3 posterior to dorsal-fin base by early flexion stage; pigment reappears after settlement as a series of discrete pigment patches each comprising 3–6 pairs of stellate melanophores
- 1–2 melanophores under notochord tip in preflexion larvae

Description of larvae

Morphology Body elongate to moderate (BD 14–21%). Head small to moderate (HL 19–31%). Small villiform teeth along premaxilla prior to flexion stage. One minute posterior preopercular spine by early postflexion stage (7.8 mm), disappearing after settlement. One small posttemporal and 1 small supracleithral spine in late postflexion larvae. Single opercular spine by 12.7 mm, retained in juveniles. Gut moderate to long (PAL 44–56%), initially straight, coiled by late preflexion stage; midgut striated in larvae from 3 mm. Gas bladder visible from 3.1 mm, inflated and prominent in larvae caught at night. Scales form by 16 mm.

Size at

Hatching	<2.3 mm
Notochord flexion	4.8–7.3 mm
Settlement	12.0–13.0 mm
Formation of fins:	

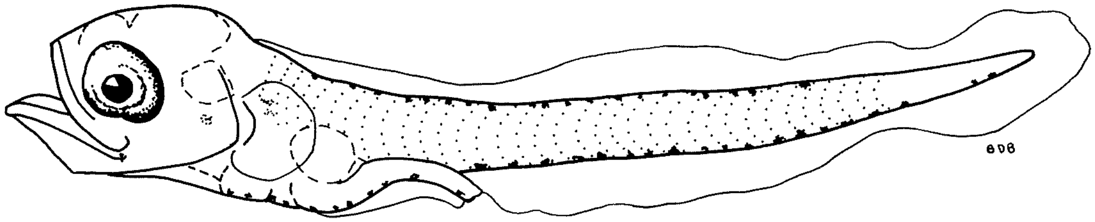
Caudal 4.4–7.3 mm; Anal 5.9–10.5 mm; Dorsal 5.9–10.5 mm; Pectoral 7.0–10.0 mm; Pelvic 7.0–12.5 mm

Pigmentation Larvae are lightly pigmented. *External:* Melanophore at angle of lower jaw and some usually on gular membrane. Single melanophore series along dorsal midline of trunk and tail through to early flexion stage, reduced to 0–3 melanophores remaining at posterior of dorsal-fin base from late flexion stage; dorsal pigment reappears after settlement as a series of discrete patches, each comprising 3–6 pairs of stellate melanophores. Melanophore series ventrally along body in preflexion and flexion larvae, from isthmus to end of caudal peduncle; series ventrally along midline of tail paired along anal-fin base in postflexion larvae, with about 1 pair per myomere by settlement; 1–2 melanophores below pectoral fin on either side of ventral midline series, forming a diamond pattern when viewed ventrally. One or two melanophores under notochord tip in preflexion larvae, remaining at base of lower caudal-fin rays. Melanophores along lateral midline of tail anterior to caudal peduncle after settlement, extending anteriorly with growth. *Internal:* Pigment at base of otic capsule and dorsally over gas bladder. Pigment may be present dorsally over posterior caudal vertebrae in late postflexion larvae.

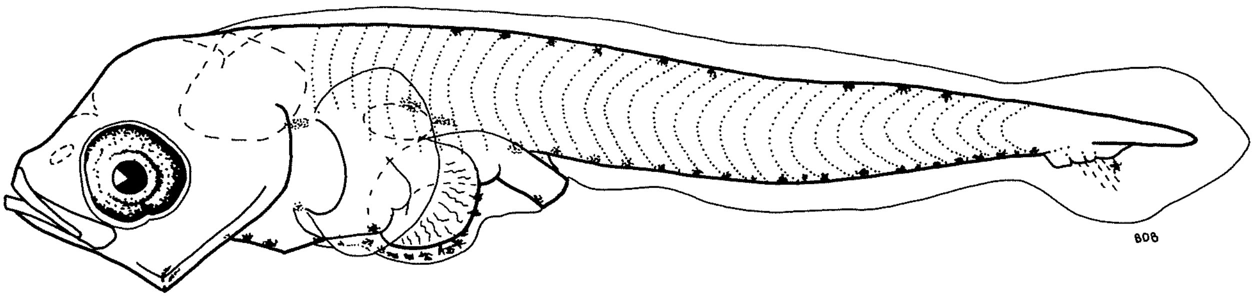
Material examined 36 larvae, 2.3–11.9 mm BL, and 4 juveniles, 12.3–17.2 mm BL, Spencer Gulf and Gulf St Vincent (SA).

Additional references Bruce (1995).

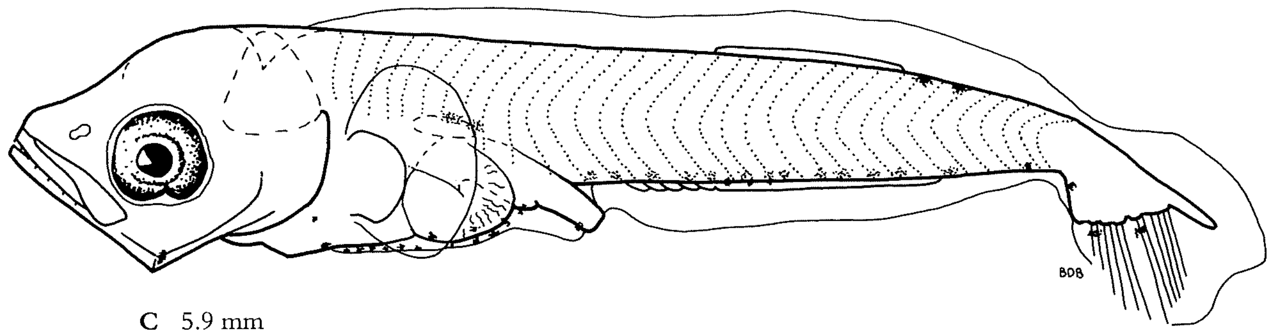
Figure 88 Larvae and settlement stage of *Sillago bassensis*. **A** Preflexion. **B** Late preflexion; note coiling gut. **C** Late flexion. **D** Early postflexion; note pelvic-fin bud. **E** Settlement stage. A–D from SA coastal waters; E from Noarlunga Reef (SA) (from Bruce, 1995). Illustrated by B.D. Bruce.



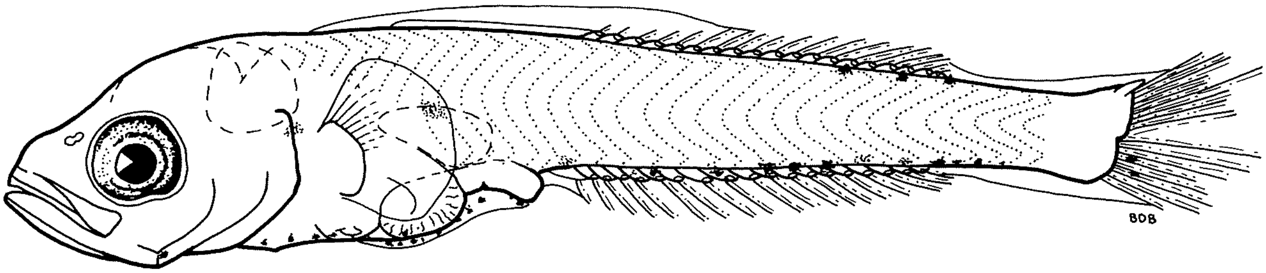
A 3.7 mm



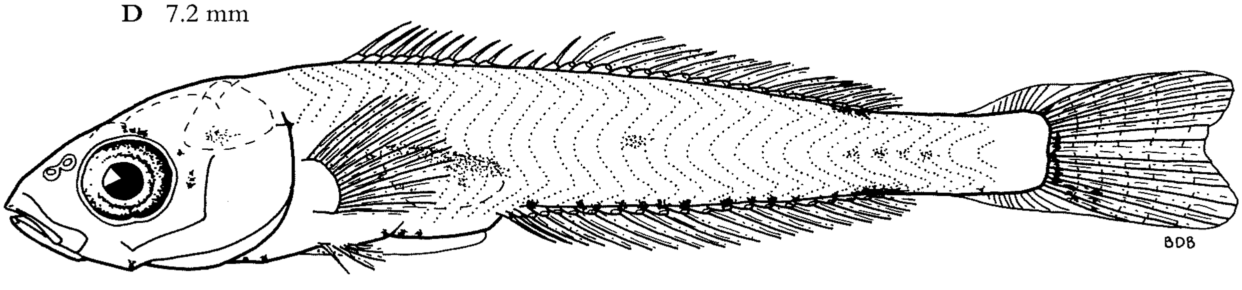
B 4.8 mm



C 5.9 mm



D 7.2 mm



E 12.7 mm

Sillaginidae *Sillago ciliata* Cuvier, 1829 Sand whiting

D XI + I, 16–18 A II, 15–17 P_1 15–17 P_2 I, 5 C 17 V 32–34

Adults Distributed in eastern Australia from Cape York (Qld) to eastern Victoria, including eastern Tasmania; also in Lord Howe Island and New Caledonia. Found on sandflats in estuaries and on sandbars and surf zones in coastal beaches. Juveniles occur in seagrass beds in estuaries and on sandy beaches. Adults have a dark spot at the base of the pectoral fin, and a uniform body coloration without dark bars or blotches. Maximum size 51 cm (McKay, 1985, 1992; Burchmore *et al.*, 1988).

Importance to fisheries Fished commercially with beach seines in estuaries and nearshore coastal waters of southern Queensland and New South Wales. Combined annual commercial catches of *S. ciliata* and *S. maculata* range from 400 to 600 tonnes. Also targeted by recreational fishers (McKay, 1985, 1992; Burchmore *et al.*, 1988; Kailola *et al.*, 1993).

Spawning Eggs are pelagic and spherical, 0.7 mm in diameter, and have a single oil globule (Tosh, 1902). Spawning has been reported in Moreton Bay (Qld) between September and February (Tosh, 1902), and in Botany Bay (NSW) between December and April, with peak activity in February (Burchmore *et al.*, 1988). In New South Wales, larvae have been caught entering Lake Macquarie from November to May, with peak abundances between January and March (Miskiewicz, 1987), entering Tuggerah Lakes in February and March (Marsden, 1986), and in coastal waters off Sydney from September to May (Gray, 1995).

Diagnostic characters

- 11–14 + 19–22 = 32–34 myomeres
- Weak head spination
- Melanophores along gular membrane
- Melanophores along dorsal midline of trunk and tail in preflexion and flexion larvae retained in postflexion larvae; 3 pigment patches in late postflexion larvae
- 2–4 melanophores under notochord tip in preflexion larvae

Description of larvae

Morphology Body elongate (BD 15–20%). Head small to moderate in preflexion larvae (HL 17–23%), moderate in flexion and postflexion larvae (HL 26–29%). Small villiform teeth along both jaws from early flexion stage. One small anterior preopercular spine in late flexion larvae; 2 small anterior preopercular spines and 1 posterior preopercular, 1 posttemporal and 1 supracleithral spine in late postflexion larvae. Gut moderate in preflexion larvae (PAL 46–50%), long in flexion and postflexion larvae (PAL 50–57%), initially straight, coiled in early preflexion larvae by 2.6 mm; midgut striated from 3 mm. Gas bladder inflated only in larvae caught at night.

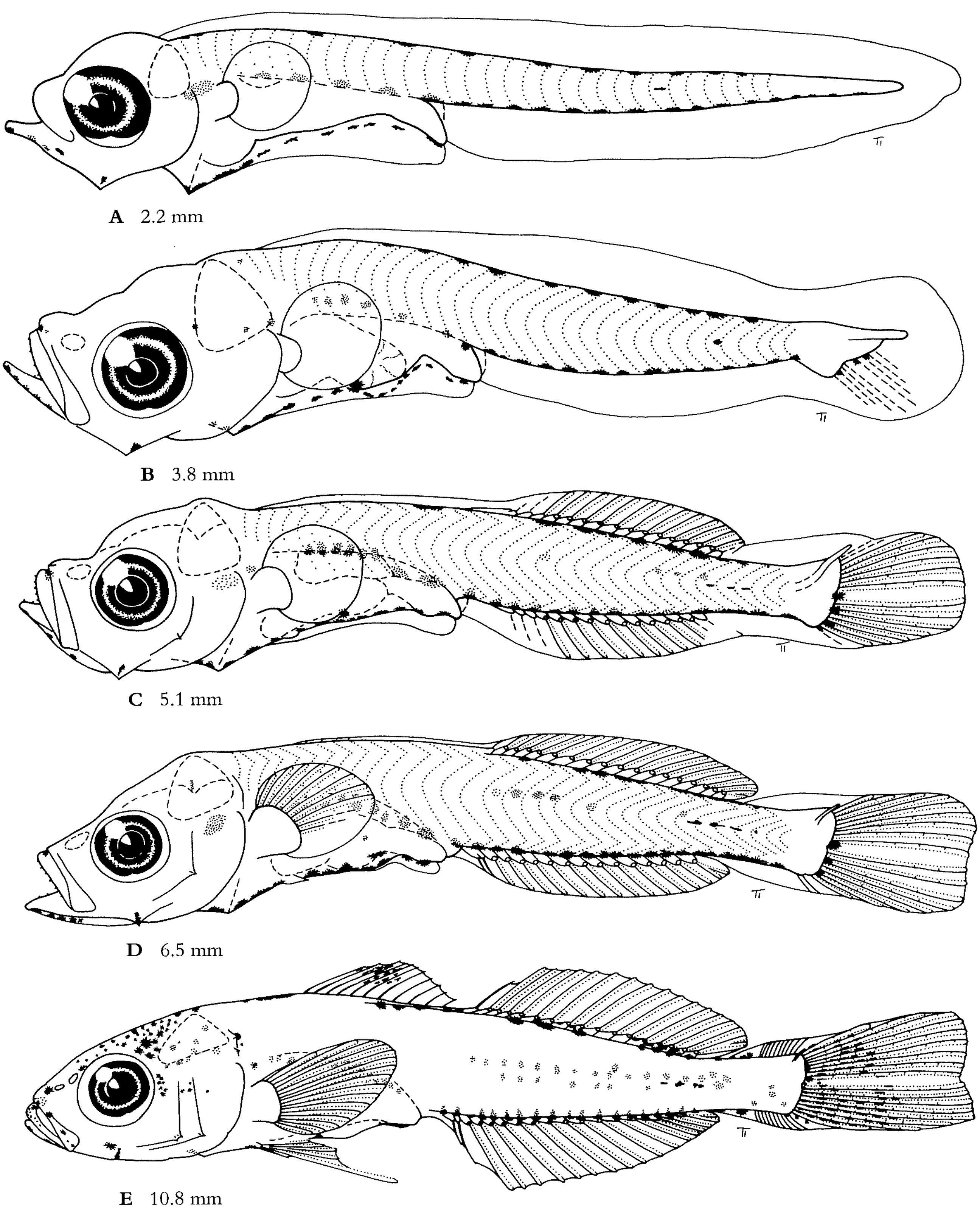
Size at	
Hatching	<2.1 mm
Notochord flexion	3.8–5.6 mm
Settlement	11.0–13.5 mm
Formation of fins:	
Caudal 3.6–6.5 mm; Anal 4.4–6.5 mm; Dorsal 4.4–7.4 mm; Pelvic 5.1–9.5 mm; Pectoral 5.3–9.5 mm	

Pigmentation Larvae are lightly pigmented. *External:* One melanophore at angle of lower jaw and up to 5 along gular membrane. One pair of melanophores on tip of snout and 1 at tip of upper jaw from flexion stage. Additional melanophores on snout, on opercle behind orbit and several over mid- and hindbrain in postflexion larvae. Single melanophore series along dorsal midline of trunk and tail in preflexion and flexion larvae; 3 pigment patches in late postflexion larvae. Melanophore series ventrally along body in preflexion and flexion larvae, from isthmus to end of caudal peduncle; melanophores along preanal membrane in early larvae. Melanophores along lateral midline of posterior of tail in late preflexion larvae, extending anteriorly with growth. Two to four melanophores ventrally along notochord tip in preflexion larvae, remaining along caudal-fin base in postflexion larvae. Pigment on first dorsal fin by 9.7 mm. *Internal:* Pigment along base of otic capsule and 1 melanophore over hindbrain. Pigment dorsally over gas bladder and a series of melanophores dorsally along gut. Pigment dorsally over posterior caudal vertebrae in late flexion larvae, extending to all caudal vertebrae in late postflexion larvae.

Material examined 25 larvae, 2.1–11.0 mm BL, reared at the Port Stephens Research Centre (NSW); 5 juveniles, 13.5–14.8 mm BL, coastal waters of New South Wales.

Additional references Tosh (1902), Munro (1945), Miskiewicz (1987).

Figure 89 Larvae of *Sillago ciliata*. **A** Preflexion, 6 days old. **B** Late preflexion, 18 days old. **C** Late flexion, 23 days old; note pelvic-fin bud. **D** Postflexion, 26 days old; note four incipient dorsal-fin spines; specimen has fewer anal-fin rays than published meristic values. **E** Postflexion, 30 days old; myomeres omitted. A–E reared at PSRC (NSW). Illustrated by T. Trnski.



A 2.2 mm

B 3.8 mm

C 5.1 mm

D 6.5 mm

E 10.8 mm

Sillaginidae *Sillago maculata* Quoy & Gaimard, 1824 Trumpeter whiting

D XI–XII + I, 19–21 A II, 19–20 P_1 15–17 P_2 I, 5 C 17 V 34–36

Adults Endemic to eastern Australia from north Queensland to Narooma (NSW). Found on silty and muddy substrates in estuaries and deeper portions of bays, to a depth of 50 m. Juveniles occur in seagrass beds in estuaries and on sandy beaches. Adults have a dark spot at the pectoral-fin base and dark blotches dorsolaterally along the body. Maximum size 30 cm (McKay, 1985, 1992; Burchmore *et al.*, 1988).

Importance to fisheries Fished commercially with beach seines and otter trawls in estuaries and nearshore coastal waters of southern Queensland and New South Wales. Combined annual commercial catches of *S. ciliata* and *S. maculata* range between 400 and 600 tonnes. Also targeted by recreational fishers (Weng, 1983; Burchmore *et al.*, 1988; McKay, 1992; Kailola *et al.*, 1993).

Spawning Eggs undescribed. Spawning has been reported in Botany Bay (NSW) between October and April, with peak activity in December and February (Burchmore *et al.*, 1988). Larvae have been caught in Lake Macquarie (NSW) from October to May, with peak abundances between December and March (Miskiewicz, 1987), and in coastal waters off Sydney in November and February (Gray, 1995).

Diagnostic characters

- 11–15 + 21–24 = 34–36 myomeres
- Gut coils in preflexion larvae by 3.2 mm
- About 8 melanophores along dorsal midline of posterior of tail in preflexion larvae, 3–5 remaining adjacent to posterior of dorsal fin in early postflexion larvae; 3 pigment patches along dorsal-fin base in late postflexion larvae
- 2–7 melanophores under notochord tip in preflexion larvae

Description of larvae

Morphology Body elongate to moderate (BD 13–21%). Head small to moderate in preflexion larvae (HL 13–25%), moderate in flexion and postflexion larvae (HL 22–31%). Small villiform teeth along premaxilla by 3.9 mm. One small anterior preopercular spine in flexion larvae, absent from 10 mm. One posttemporal and 1 small supracleithral spine in late postflexion larvae. Low pterotic ridge by settlement. Gut moderate to long (PAL 44–56%), initially straight, coiled from preflexion stage; midgut weakly striated from 3.2 mm until end of preflexion stage. Small gas bladder over foregut. Scales form at settlement.

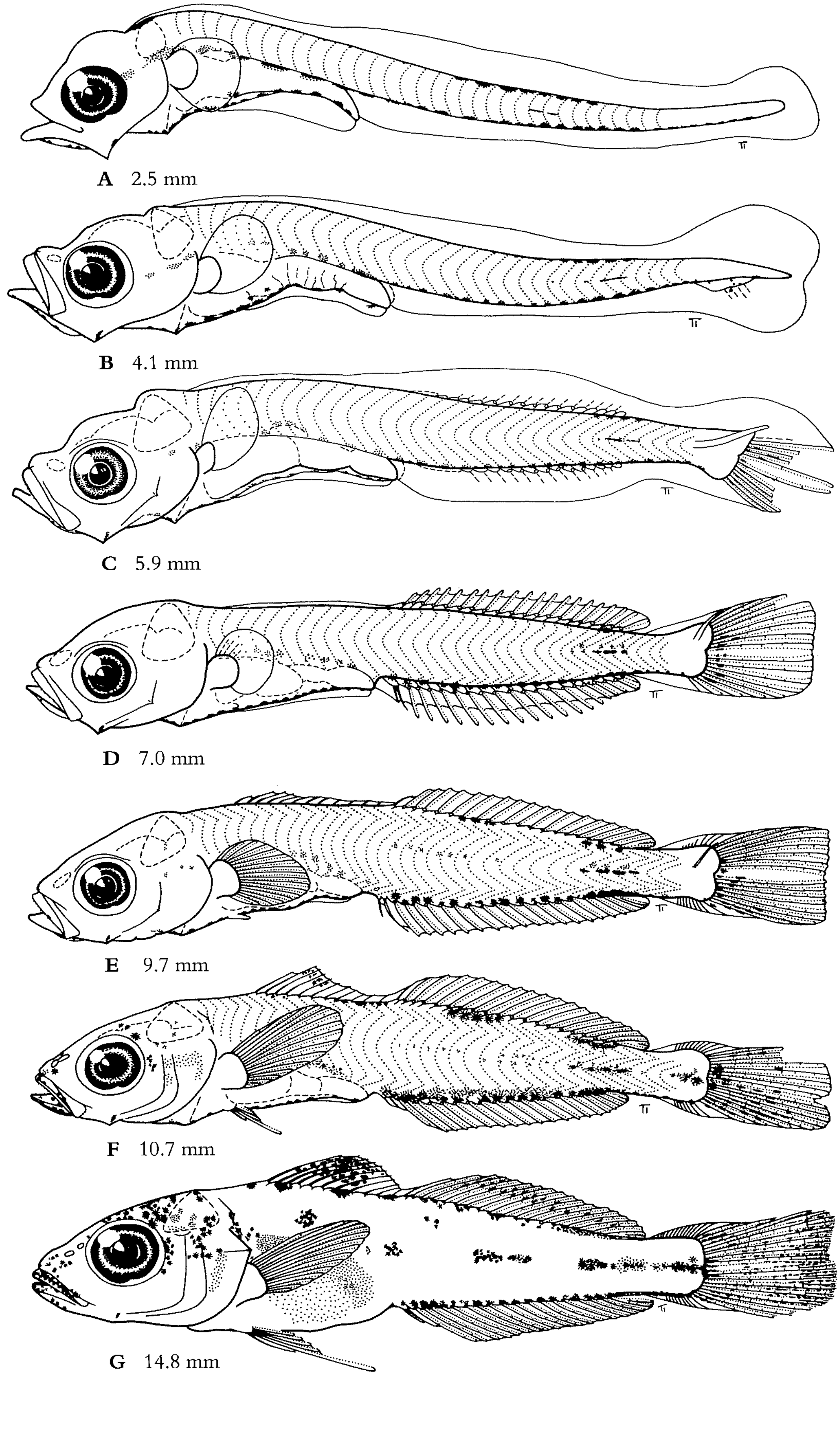
Size at	
Hatching	<2.1 mm
Notochord flexion	4.6–6.6 mm
Settlement	~14.0–15.5 mm
Formation of fins:	
Caudal 3.9–6.8 mm; Anal 4.6–8.6 mm; Dorsal 4.6–8.8 mm; Pectoral 6.8–9.5 mm; Pelvic 6.8–10.8 mm	

Pigmentation Larvae are lightly pigmented. *External:* Melanophore at angle of lower jaw, and up to 4 along gular membrane. Melanophores on snout, around jaws, over brain and on opercle in late postflexion larvae. Single series of about 8 melanophores along dorsal midline of posterior of tail in preflexion larvae, 3–5 remaining adjacent to posterior of dorsal fin by end of flexion stage; 3 pigment patches along dorsal-fin base in late postflexion larvae, increasing in number prior to settlement. Melanophores along lateral midline of posterior of tail in preflexion larvae, extending anteriorly with growth. Melanophore series ventrally along body through to postflexion larvae, from isthmus to end of caudal peduncle. Two to seven melanophores under notochord tip in preflexion larvae, remaining along caudal-fin base in postflexion larvae. *Internal:* Pigment under base of otic capsule and on hindbrain. Pigment dorsally over gas bladder, and a series of melanophores dorsally along gut. Pigment over posterior caudal vertebrae in postflexion larvae, extending over trunk vertebrae with growth.

Material examined 44 larvae, 2.1–15.5 mm BL, reared at the Port Stephens Research Centre (NSW).

Additional references Miskiewicz (1987).

Figure 90 Larvae and settlement stage of *Sillago maculata*.
A Preflexion, 8 days old. **B** Preflexion, 16 days old. **C** Flexion, 22 days old. **D** Postflexion, 28 days old. **E** Postflexion, 30 days old. **F** Postflexion, 34 days old. **G** Settlement stage, 44 days old; scales and myomeres omitted; specimen has fewer dorsal- and anal-fin rays than published meristic values. A–G reared at PSRC (NSW). Illustrated by T. Trnski.



A 2.5 mm

B 4.1 mm

C 5.9 mm

D 7.0 mm

E 9.7 mm

F 10.7 mm

G 14.8 mm

Sillaginidae *Sillago schomburgkii* Peters, 1864 Yellowfin whiting

D X–XII + I, 19–22 A II, 17–20 P_1 15–16 P_2 I, 5 C 17 V 37

Adults Endemic to southern Australia from Shark Bay (WA) to Gulf St Vincent (SA). Occur in estuaries, sometimes penetrating into brackish waters, and on sandy areas in coastal marine waters to a depth of 30 m. Juveniles are found in mangrove creeks and in shallow waters of protected bays. Adults have yellow–orange pelvic and anal fins, and lack a dark blotch on the pectoral-fin base. Maximum size 42 cm (Lenanton, 1982; Hutchins & Swainston, 1986; Jones *et al.*, 1990; McKay, 1992; Gomon *et al.*, 1994).

Importance to fisheries Fished commercially mainly with beach seines and bottom-set gill nets across its distributional range. Major fisheries operate in Shark Bay (WA), and Spencer Gulf and Gulf St Vincent (SA). Total annual commercial catch up to 800 tonnes. Also targeted by recreational fishers (Kailola *et al.*, 1993).

Spawning Eggs undescribed. Spawning has been reported in Shark Bay (WA) between September and January (Lenanton, 1969), and in South Australia between December and February (Jones, 1980). Larvae have been caught in coastal waters of South Australia from January to March.

Diagnostic characters

- 14–17 + 20–23 = 36–38 myomeres
- 1–2 small posttemporal spines from 10.1 mm; small preopercular spines by settlement
- Gut initially straight, coiled by early flexion stage
- Melanophores along dorsal midline of trunk and tail reduce in number by flexion stage; pigment reappears by 10.1 mm as 3 discrete pigment patches, each consisting of 3–5 stellate melanophores
- Melanophore series along lateral midline of tail from early preflexion stage
- 1–3 melanophores under notochord tip in preflexion larvae

Description of larvae

Morphology Body elongate (BD 14–18%). Head moderate (HL 20–30%). Small villiform teeth along premaxilla by late preflexion stage. One small posttemporal spine and 1 small supracliththral spine from 10.1 mm. One to two posterior preopercular spines, and 1 opercular spine after settlement; latter is retained in adults. Gut moderate to long (PAL 49–54%), initially straight, coiled by early flexion stage; midgut striated in preflexion larvae from 4.4 mm. Gas bladder visible from 2.7 mm, inflated and prominent only in larvae caught at night. Scales form by 17.2 mm.

Size at

Hatching	<2.7 mm
Notochord flexion	4.8–<10.1 mm
Settlement	~13.0 mm
Formation of fins:	

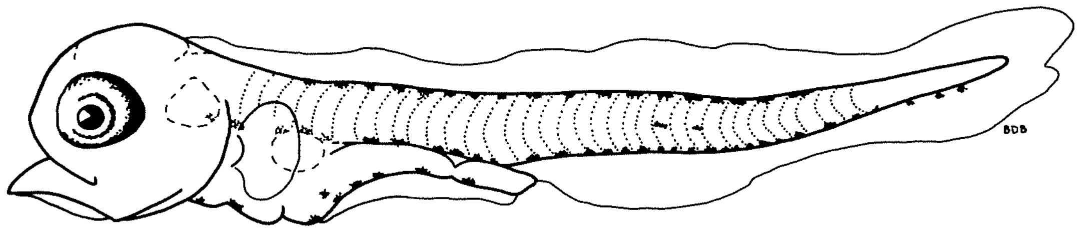
Caudal 4.8–<10.1 mm; Anal 5.0–<10.1 mm; Dorsal 5.0–<10.1 mm; Pectoral <10.1–12.7 mm; Pelvic <10.1–12.7 mm

Pigmentation Larvae are lightly pigmented. *External:* Melanophore at angle of lower jaw and several along gular membrane by late preflexion stage; additional melanophores on tip of snout, several scattered laterally over head, and a cap of pigment over mid- and hindbrain in postflexion larvae. Single melanophore series along dorsal midline of trunk and tail in preflexion larvae, reducing in number in early flexion larvae; pigment reappears by 10.1 mm as 3 discrete pigment patches, each consisting of 3–5 stellate melanophores. Melanophore series along lateral midline of tail until end of flexion stage, extending anteriorly during postflexion stage. Melanophore series ventrally along body in preflexion and flexion larvae, from isthmus to end of caudal peduncle; series ventrally along tail paired in postflexion larvae, with about 1 pair per myomere by settlement. One to three melanophores under notochord tip in preflexion larvae, remaining along caudal-fin base. *Internal:* Pigment at base of otic capsule, and dorsally over gas bladder and gut. Melanophores over trunk and caudal vertebrae from 10.1 mm.

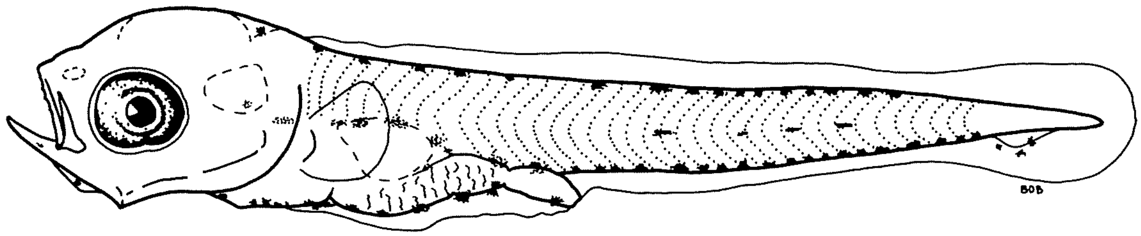
Material examined 14 larvae, 2.7–5.0 and 10.1 mm BL, and 2 juveniles, 13.0–17.2 mm BL, Spencer Gulf (SA).

Additional references Bruce (1995).

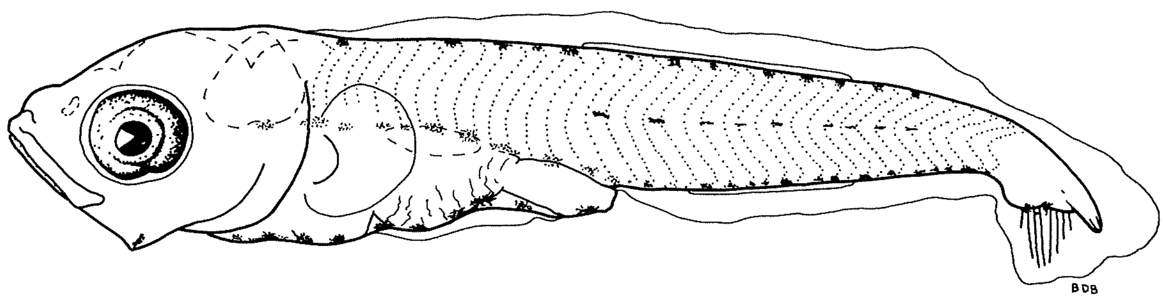
Figure 91 Larvae and settlement stage of *Sillago schomburgkii*. **A** Preflexion. **B** Late preflexion. **C** Flexion; note developing dorsal and anal fins. **D** Postflexion; note pelvic-fin bud. **E** Settlement stage. A–E from the Spencer Gulf (SA) (from Bruce, 1995). Illustrated by B.D. Bruce.



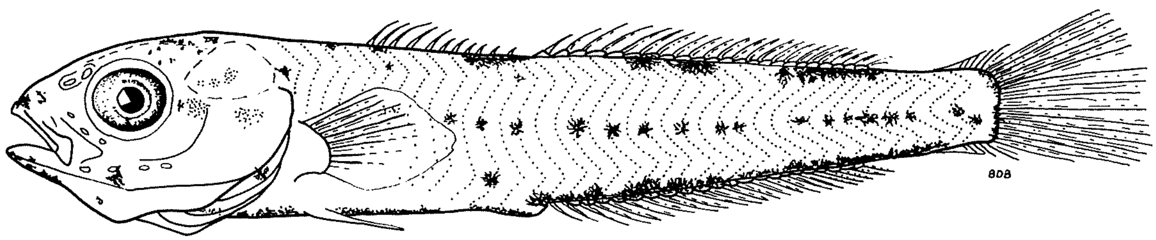
A 2.7 mm



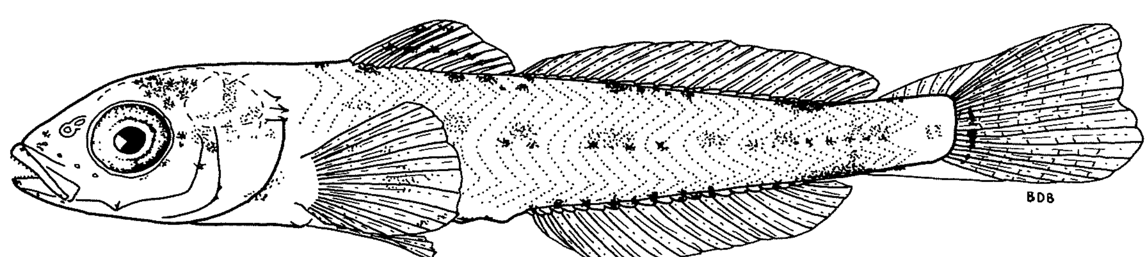
B 4.9 mm



C 5.0 mm



D 10.1 mm



E 13.0 mm

Sparidae: Breams, snappers

A.G. Miskiewicz and F. J. Neira

Sparids are primarily marine fishes found in estuarine and coastal marine waters of the Indo-Pacific, Atlantic Ocean and Mediterranean Sea. They frequently occur over seagrass beds, soft substrates and rocky reefs. The family contains 29 genera and about 100 species worldwide, with the highest diversity in South African waters (Bauchot & Smith, 1984; Smith & Smith, 1986; Nelson, 1994). Three genera and 4 species have been recorded from temperate Australia (Kuiter, 1993, 1996; Gomon *et al.*, 1994). Many species have considerable recreational and commercial importance (Crossland, 1981b; Davy, 1990; Kailola *et al.*, 1993). Adults (to 1.2 m) are robust, deep and laterally compressed, have a moderate to large head with a gently rounded to steep dorsal profile, and a continuous dorsal fin. Eggs of *Acanthopagrus*, *Evynnis*, *Pagrus*, *Rhabdosargus* and *Sparidentex* are pelagic and spherical, 0.6–1.2 mm in diameter, and have a single oil globule (Cassie, 1956; Mito, 1963; Hussain *et al.*, 1981; Tsukashima & Kitajima, 1982; Zhang *et al.*, 1985; Ikeda & Mito, 1988). Larvae have been described for representatives of various genera including *Acanthopagrus*, *Argyrops*, *Calamus*, *Dentex*, *Pagrus*, *Rhabdosargus* and *Sparus* (Munro, 1945; Cassie, 1956; Crossland, 1981a; Hussain *et al.*, 1981; Zahang *et al.*, 1985; Kinoshita, 1986, 1988i; Leis & Trnski, 1989; Watson & Sandknop, 1996f). The moderately to well developed, extensive head spination is the only apparent specialisation of sparid larvae to pellagic life (Leis & Trnski, 1989).

Meristic characters of sparid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Acanthopagrus	(2)	X–XIII, 10–13	III, 8–10	14–16	I, 5	17	10 + 14 = 24
Pagrus	(1)	XII, 9–10	III, 8–9	15–16	I, 5	17	10 + 14 = 24
Rhabdosargus	(1)	XI, 13–15	III, 11–12	13–15	I, 5	17	10 + 14 = 24

Main characters of sparid larvae

- 24–25 myomeres
- Body moderate to deep (BD 21–44%)
- Moderately to well developed, extensive head spination, including short to long anterior and posterior preopercular spines, and an opercular spine; subopercular, interopercular, posttemporal and cleithral spines, and a second opercular spine may also form depending on taxa; supraocular and supracleithral ridges, if present, smooth or with spines depending on taxon
- Gut moderate to long (PAL 41–63%), coiled and compact
- Small to moderate gap between anus and origin of anal fin, closed by postflexion stage
- Body initially lightly pigmented, usually heavily pigmented at settlement
- None to a few melanophores over head in preflexion larvae; rarely any pigment dorsally along trunk or tail before postflexion stage
- Pigment dorsally over gas bladder and gut
- Melanophores ventrally along gut and midline of tail
- Small melanophores under notochord tip in preflexion larvae

References to sparid larvae

Kinoshita (1988i), Leis & Trnski (1989), Watson & Sandknop (1996f).

Families with similar larvae

Chandidae – Head moderate to large with small preopercular spines; short-based dorsal fin, VII–VIII, 7–11; internal pigment over anterior surface of gut.

Gerreidae – Long ascending premaxillary process; weak head spination; body elongate to moderate (BD 19–28%); IX–X dorsal-fin spines; body lightly pigmented.

Haemulidae – 26–28 myomeres; numerous anterior and posterior preopercular spines in most taxa; gut long, extending from midbody to 74% BL.

Kuhliidae – Weak, late forming preopercular spines, never elongate; prominent gap between anus and origin of anal fin; body lightly pigmented; distinct cluster of melanophores over hypural complex; pigment ventrally along tail after flexion stage.

Microcanthidae – None to a few, widely spaced melanophores along dorsal midline of trunk and tail; a few small to large, widely spaced melanophores along ventral midline of tail; 15–21 dorsal-fin rays.

Mullidae – Head spines absent in most taxa; 2 well separated dorsal fins, first with VII–VIII spines; short-based anal fin, I, 6–7; prominent gap between anus and origin of anal fin; 3 melanophores in a triangular pattern on midbrain in late preflexion larvae.

Nemipteridae – 22–24 myomeres; no head spines except for small posterior preopercular spines in some taxa by postflexion stage (e.g. *Scolopsis*); dorsal fin X, 9.

Plesiopidae – 24–40 myomeres, 24–35 in most taxa; weak preopercular spines in most taxa; no gap between anus and origin of anal fin; pelvic fin I, 2 or I, 4; caudal peduncle laterally compressed and deep in postflexion larvae.

Pomacentridae – 26–27 myomeres, typically 26; small, late forming preopercular spines; lack subopercular and interopercular spines; anal fin II, 10–18, similar number of dorsal-fin elements.

Sciaenidae – Long-based dorsal fin, XI, 25–31; short-based, posteriorly located anal fin, II, 7–9; prominent gap between anus and origin of anal fin.

Terapontidae – 25–26 myomeres; body elongate to moderate (BD 16–35%); prominent gap between anus and origin of anal fin.

Sparidae *Acanthopagrus australis* (Günther, 1859) Yellowfin bream, silver bream

D X–XII, 10–13   A III, 8–10 P_1 14–16 P_2 I, 5   C 17   V 24

Adults Endemic to eastern Australia from Townsville (Qld) to the Gippsland Lakes (Vic). A schooling species common in estuarine and shallow coastal marine waters to a depth of 30 m. Adults have the second anal-fin spine longer and stronger than the third spine, 43–46 lateral-line scales, yellowish pelvic and anal fins, and a small black spot on the pectoral-fin axil. Body colour varies from grey in estuaries to silver in coastal marine waters. Hybrids of *A. australis* and *A. butcheri* have been recorded in landlocked estuarine lakes in southern New South Wales (Rowland, 1984b). Maximum size 66 cm (Munro, 1949; Hutchins & Swainston, 1986; Kuiter, 1993, 1996; Edgar, 1997).

Importance to fisheries Fished commercially mostly with gill, seine and tunnel nets throughout its distributional range. Total annual commercial catch in 1989–90 was 750 tonnes. Also targeted by recreational fishers with handlines (Kailola *et al.*, 1993).

Spawning Eggs are pelagic and spherical, 0.7–0.8 mm in diameter, and have a single oil globule (Munro, 1944). They spawn at the entrance of estuaries and over a protracted period, with peak activity between late autumn and winter (Munro, 1944, 1945; State Pollution Control Commission, 1981; Pollock, 1982; Pollock *et al.*, 1983; Edgar, 1997). In New South Wales, larvae have been caught entering Lake Macquarie in all months except November, with peak abundances between January and July (Miskiewicz, 1986, 1987), entering Tuggerah Lakes from January to May and in September and October (Marsden, 1986), and in coastal waters off Sydney from November to July (Gray *et al.*, 1992; Gray, 1993).

Diagnostic characters

- 7–10 + 14–17 = 24 myomeres
- Small anterior and posterior preopercular spines
- Smooth supracleithral ridge from late flexion stage
- 2 large melanophores on ventral surface of gut in preflexion and flexion larvae
- 1–3 small melanophores under notochord tip

Description of larvae

Morphology Body elongate to moderate in preflexion larvae (BD 18–23%), moderate in flexion and postflexion larvae (BD 21–34%). Head moderate (HL 22–32%), dorsal profile gently rounded by postflexion stage. Small teeth in both jaws by mid-flexion stage. Small anterior preopercular and posterior preopercular spines in late preflexion larvae, increasing in number in postflexion larvae. One small interopercular spine and a smooth supracleithral ridge by late flexion stage, former absent by 9.1 mm. One opercular spine in late postflexion larvae. Gut moderate (PAL 32–50%), coiled and compact. Small gas bladder above foregut. Large gap between anus and origin of anal fin, reduced by settlement stage. Scales form at settlement.

Size at

Hatching [1]	~1.7 mm
Notochord flexion	4.6–6.0 mm
Settlement	10.0–12.0 mm
Formation of fins:	
Caudal 3.4–6.3 mm; Dorsal 4.2–7.9 mm; Anal 4.2–7.9 mm; Pectoral 5.8–8.3 mm; Pelvic 5.8–8.6 mm	

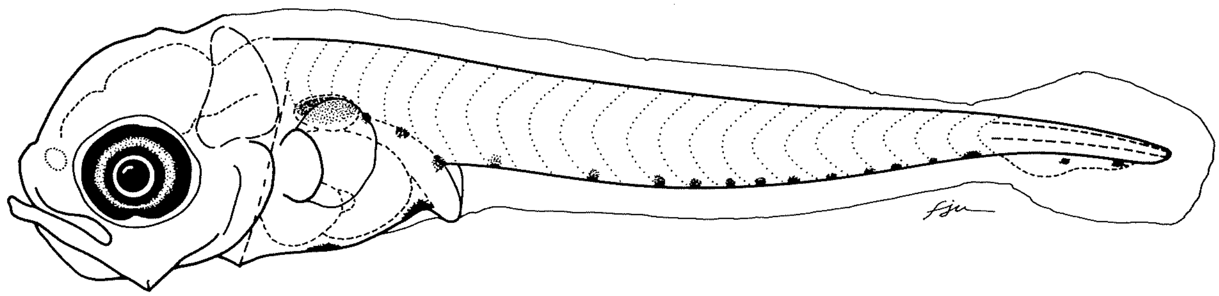
[1] Munro (1944)

Pigmentation Larvae are lightly pigmented. *External:* A pair of melanophores over midbrain by flexion stage; several over head and jaws by 8.8 mm. Two large melanophores ventrally on gut in early preflexion larvae; 1–2 on isthmus and 2–4 ventrally on gut in postflexion larvae. Up to 14 melanophores along ventral midline of tail in early preflexion larvae, 4–8 in late preflexion and flexion larvae; additional melanophores along anal-fin base and ventral midline of caudal peduncle in postflexion larvae. Pigment on membrane between dorsal-fin spines and on dorsal-fin base from 8.8 mm. One to two melanophores laterally on caudal-fin anlage from late preflexion stage. One to three melanophores under notochord tip in preflexion larvae, remaining along caudal-fin base in postflexion larvae. One melanophore dorsally on caudal peduncle by 7.9 mm. Additional pigment on caudal-fin base in postflexion larvae. Broad vertical bands of pigment laterally on trunk and tail just prior to settlement. *Internal:* Melanophore on lateral surface of hindbrain by 7.9 mm. Heavy pigment dorsally over gas bladder and several melanophores dorsally along hindgut. Melanophore series dorsally over caudal vertebrae from 8.8 mm.

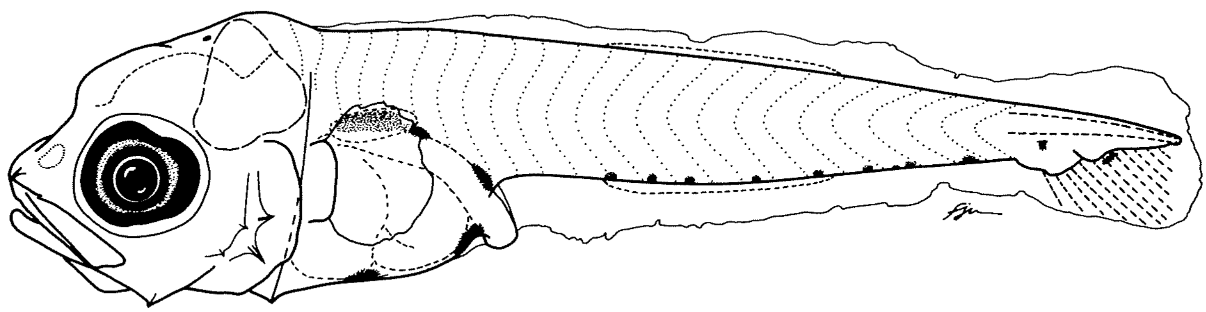
Material examined 25 larvae, 3.0–10.4 mm BL, and 6 juveniles, 10.3–13.9 mm BL, Richmond River (near Yamba), Lake Macquarie, Broken Bay and Botany Bay (NSW).

Additional references Munro (1944, 1945), Miskiewicz (1987), Kinoshita (1988i).

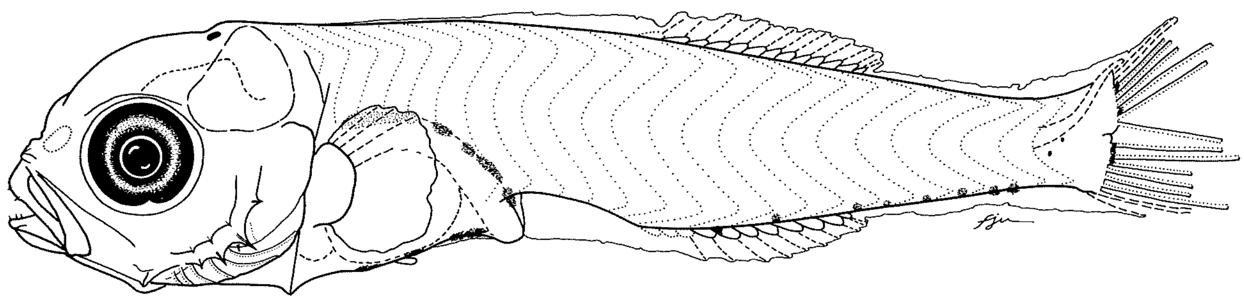
Figure 92 Larvae of *Acanthopagrus australis*. **A** Preflexion. **B** Late preflexion; note developing dorsal and anal fins. **C** Late flexion; note pelvic-fin bud and developing pectoral-fin rays. **D** Postflexion. A–D from Lake Macquarie (NSW). Illustrated by F. J. Neira.



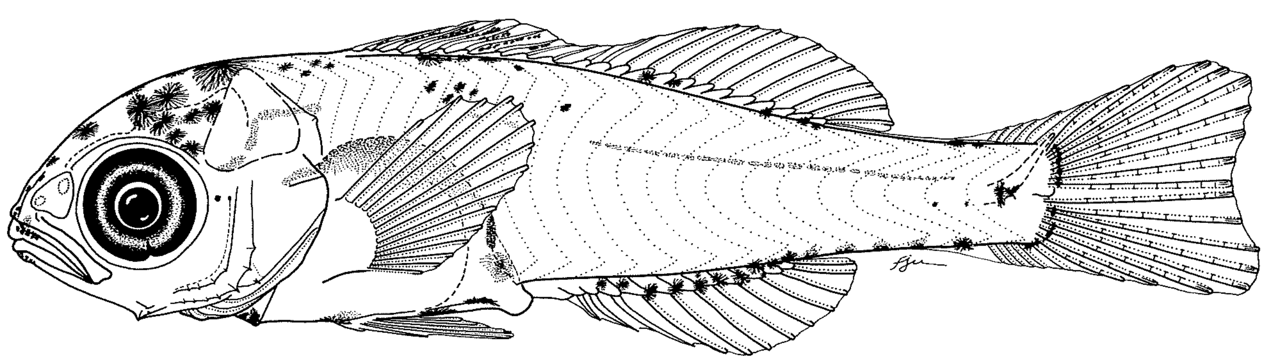
A 3.4 mm



B 4.2 mm



C 5.8 mm



D 8.8 mm

Sparidae *Acanthopagrus butcheri* (Munro, 1949) Black bream

D X–XIII, 10–13 A III, 8–10 P_1 14–16 P_2 I, 5 C 17 V 24

Adults Endemic to southern Australia from Shark Bay (WA) to southern New South Wales, including Tasmania. Occurs in upper reaches of rivers, brackish waters and estuaries, occasionally in coastal marine waters, to a depth of 15 m. Adults have 52–58 lateral-line scales, and are golden-brown or bronze with brownish to dusky anal and pelvic fins. Hybrids of *A. australis* and *A. butcheri* have been recorded in landlocked estuarine lakes in southern New South Wales (Rowland, 1984b). Maximum size 60 cm (Munro, 1949; Last *et al.*, 1983; Kuiter, 1993; Gomon *et al.*, 1994; Edgar, 1997; Neira *et al.*, 1997a).

Importance to fisheries Fished commercially mostly with gill and seine nets along southern Australia, particularly in the Gippsland Lakes (Vic), where it has supported a commercial fishery since 1914. Total annual commercial catch varies from 250 to 550 tonnes. Also targeted by recreational fishers (Hobday & Moran, 1983; Hall & MacDonald, 1986; Kailola *et al.*, 1993; Neira *et al.*, 1997a).

Spawning Eggs are pelagic and spherical, 0.7–0.8 mm in diameter, and have a single oil globule (Munro, 1944). Reported to spawn in brackish waters (Munro, 1949). Serial spawner, at least in the Gippsland Lakes (Vic). Only late postflexion larvae and early juveniles have been caught in estuaries, including the Gippsland Lakes (Ramm, 1986).

Diagnostic characters

- 10 + 14–15 = 24–25 myomeres
- Small anterior and posterior preopercular spines
- Smooth supraocular and supracleithral ridges from early postflexion stage
- Large melanophores dorsally on head

Description of larvae

Morphology Body moderate (BD 22–37%). Head moderate to large (HL 28–39%), dorsal profile steep in early juveniles. Small teeth along both jaws in postflexion larvae. Small anterior preopercular and posterior preopercular spines, increasing in number with growth. Smooth supraocular and supracleithral ridges from early postflexion stage. One opercular spine by 9.1 mm, and 2 very small interopercular spines in early juveniles. Gut moderate to long (PAL 49–63%), coiled and compact. Conspicuous gas bladder above foregut. Small gap between anus and origin of anal fin in postflexion larvae. Scales form by settlement.

Size at

Hatching [1]	1.7 mm
Notochord flexion	<7.1–7.3 mm
Settlement	~11.7 mm
Formation of fins:	

Caudal –<7.1 mm; Dorsal <7.1–7.4 mm; Pectoral <7.1–7.4 mm; Pelvic <7.1–9.0 mm; Anal <7.1–10.9 mm

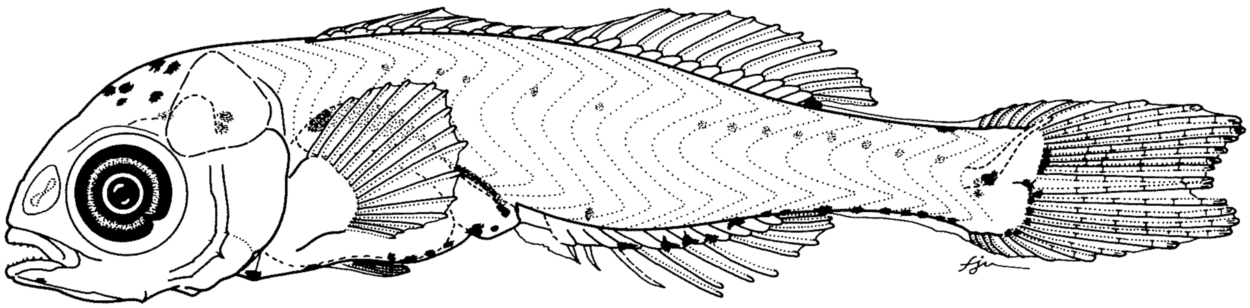
[1] Munro (1944)

Pigmentation Postflexion larvae are initially lightly pigmented, becoming heavily pigmented with growth. *External:* Melanophores over midbrain and on dentary; over hindbrain, on snout and opercle by 9.1 mm. Two or three melanophores along isthmus and several along ventral surface of gut. Melanophores along anal-fin base and ventral midline of caudal peduncle. Large melanophore patches along dorsal-fin base and pigment on distal portion of fin membrane between dorsal-fin spines by 9.1 mm. Melanophores laterally on caudal peduncle and along caudal-fin base. Scattered melanophores ventrally along tail and on caudal-fin rays in postflexion larvae, extending over entire trunk and tail and medial fins in juveniles. *Internal:* Melanophores at junction of mid- and hindbrain, over hindbrain and under opercle. Heavy pigment dorsally over gas bladder and gut. Melanophores dorsally over vertebrae and several in caudal peduncle from 7.4 mm.

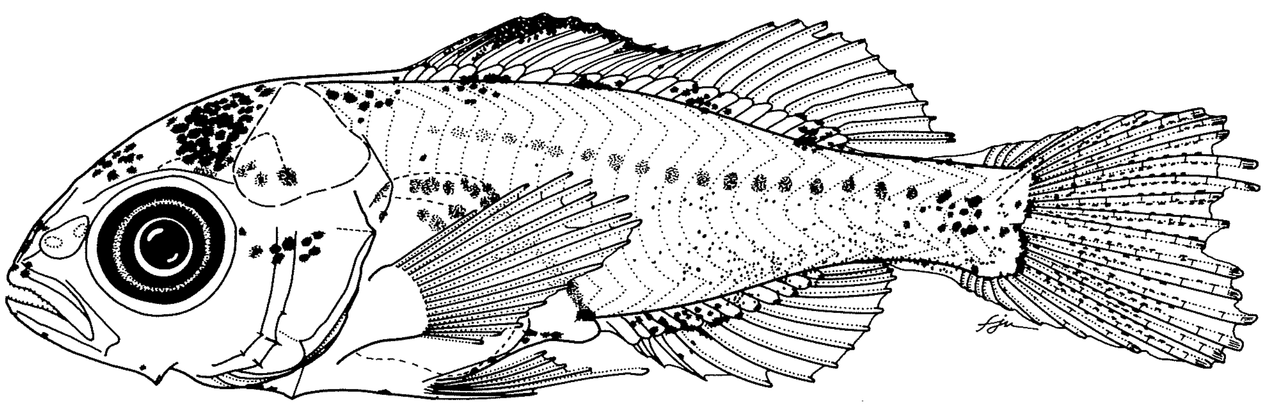
Material examined 9 larvae, 7.1–11.7 mm BL, reared at the Fremantle Maritime Centre (WA).

Additional references Munro (1944).

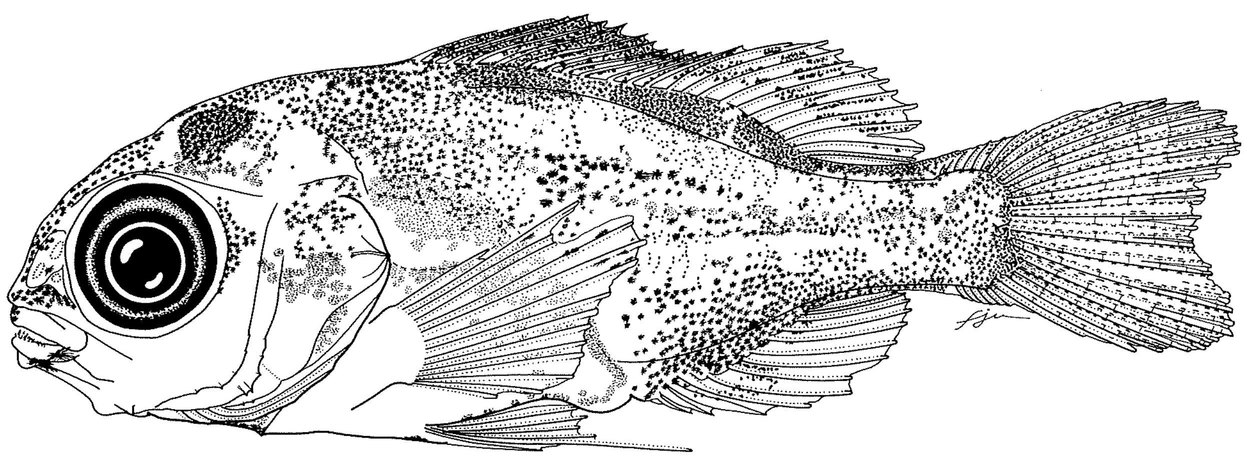
Figure 93 Larvae and early juvenile of *Acanthopagrus butcheri*. **A** Early postflexion, 28 days old. **B** Postflexion, 41 days old. **C** Early juvenile, 58 days old; myomeres and scales omitted. A–C reared at FMC (WA). Illustrated by F. J. Neira.



A 7.4 mm



B 9.5 mm



C 11.6 mm

Sparidae *Pagrus auratus* (Foster, 1801) Snapper

D XII, 9–10 A III, 8–9 P_1 15–16 P_2 I, 5 C 17 V 24

Adults Distributed around southern Australia from North West Cape (WA) to Townsville (Qld), including northern Tasmania, Lord Howe and Norfolk islands. Also in New Zealand and Japan. Juveniles and small adults occur in estuaries and bays while large adults are found around coastal rocky reefs to a depth of 300 m, but more frequently to 35 m. Adults are pink dorsally and silver–white ventrally, with bright blue spots scattered on the upper half of the body; blue spots are most prominent in juveniles. Large males develop fleshy bulges on the snout and a prominent bony hump on the forehead. Maximum size 1.3 m (Hutchins & Swainston, 1986; Paulin, 1990; Kuiter, 1993, 1996; Gomon *et al.*, 1994; Williams *et al.*, 1996).

Importance to fisheries One of the most important commercial and recreational coastal species in southern Australia, caught mainly with traps, bottom-set longlines, and hook and line. Total annual catches vary between 1400 and 2400 tonnes. It also supports large commercial and recreational fisheries in New Zealand and Japan (Crossland, 1981b; Davy, 1990; Hall & MacDonald, 1986; Kailola *et al.*, 1993; Neira *et al.*, 1997a).

Spawning Eggs are pelagic and spherical, 0.7–1.0 mm in diameter, and have a smooth chorion, an unsegmented yolk, and one oil globule 0.25 mm (Cassie, 1956; Robertson, 1975a; Crossland, 1981a,b; Pankhurst *et al.*, 1991; Battaglene & Talbot, 1992). Serial spawner, at least in Port Phillip Bay (Vic). Larvae have been caught in Western Australia entering Wilson Inlet in December and January (Neira & Potter, 1992a); in Victoria in Port Phillip Bay from December to March (Jenkins, 1986b); and in New South Wales entering Lake Macquarie in all months with a peak abundance in September (Miskiewicz, 1986, 1987), entering Tuggerah Lakes from August to October (Marsden, 1986), and in coastal waters off Sydney throughout the year (Gray, 1995).

Diagnostic characters

- 8–10 + 14–17 = 24–25 myomeres
- Elongate posterior preopercular spines in preflexion and flexion larvae; supracleithral and interopercular spines in flexion larvae
- 1 large internal melanophore over nape
- 2 large melanophores ventrally on gut
- 1–3 small melanophores under notochord tip

Description of larvae

Morphology Body moderately deep (BD 24–34%). Head moderate in preflexion and flexion larvae (HL 25–32%), moderate to large in postflexion larvae (HL 30–36%), dorsal profile steep. Small teeth along both jaws from early flexion stage. Small anterior preopercular and elongate posterior preopercular spines in preflexion and flexion larvae; 1 small interopercular spine in late preflexion larvae, and a smooth supraocular ridge and 1 supracleithral spine in early flexion larvae; all spines increase in number with growth. One posttemporal spine by 7.7 mm and 1–2 subopercular spines by 9.2 mm, latter increasing in number in early juveniles; supracleithral and posttemporal serrate in early juveniles. One opercular and 1 cleithral spine from 11.3 mm. Gut moderate in preflexion and flexion larvae (PAL 42–47%), long in postflexion larvae (PAL 53–59%), coiled and compact. Small gas bladder above foregut. Small gap between anus and origin of anal fin during flexion stage, closed by postflexion stage. Scales form at about 9.5 mm.

Size at

Hatching [1]	2.1–3.1 mm
Notochord flexion	5.0–6.6 mm
Settlement	~12.0–13.3 mm
Formation of fins:	
Caudal 4.5– ~7.0 mm; Pelvic 5.0–8.8 mm; Anal 5.0–10.1 mm; Dorsal 5.0–10.4 mm; Pectoral 5.9–10.4 mm	

[1] Battaglene & Talbot (1992)

Pigmentation Larvae are lightly pigmented prior to settlement. *External:* 0–3 melanophores over midbrain in preflexion larvae, several by settlement. One melanophore on isthmus and 2 large melanophores ventrally on gut and in preflexion larvae; a few additional melanophores ventrally on gut in postflexion larvae, absent in early juveniles. Series of 7–17 melanophores along ventral midline of tail in early preflexion larvae; additional melanophores along anal-fin base and ventral midline of caudal peduncle from 7.7 mm. Melanophores on membrane between dorsal-fin spines and along dorsal-fin base from 9.2 mm. Broad vertical bands of pigment laterally on trunk and tail in larvae near settlement. One to three melanophores under notochord tip in preflexion larvae, remaining along lower portion of caudal-fin base in postflexion larvae. *Internal:* Pigment under and laterally on hindbrain. One large melanophore over nape, gradually obscured by muscle tissue with growth. Pigment over gas bladder and dorsally over hindgut.

Material examined 25 larvae, 3.0–13.3 mm BL, Lake Macquarie and Botany Bay (NSW); 1 larva, 10.1 mm, Wilson Inlet (WA).

Additional references Crossland (1981a,b), Miskiewicz (1987), Kinoshita (1988i).

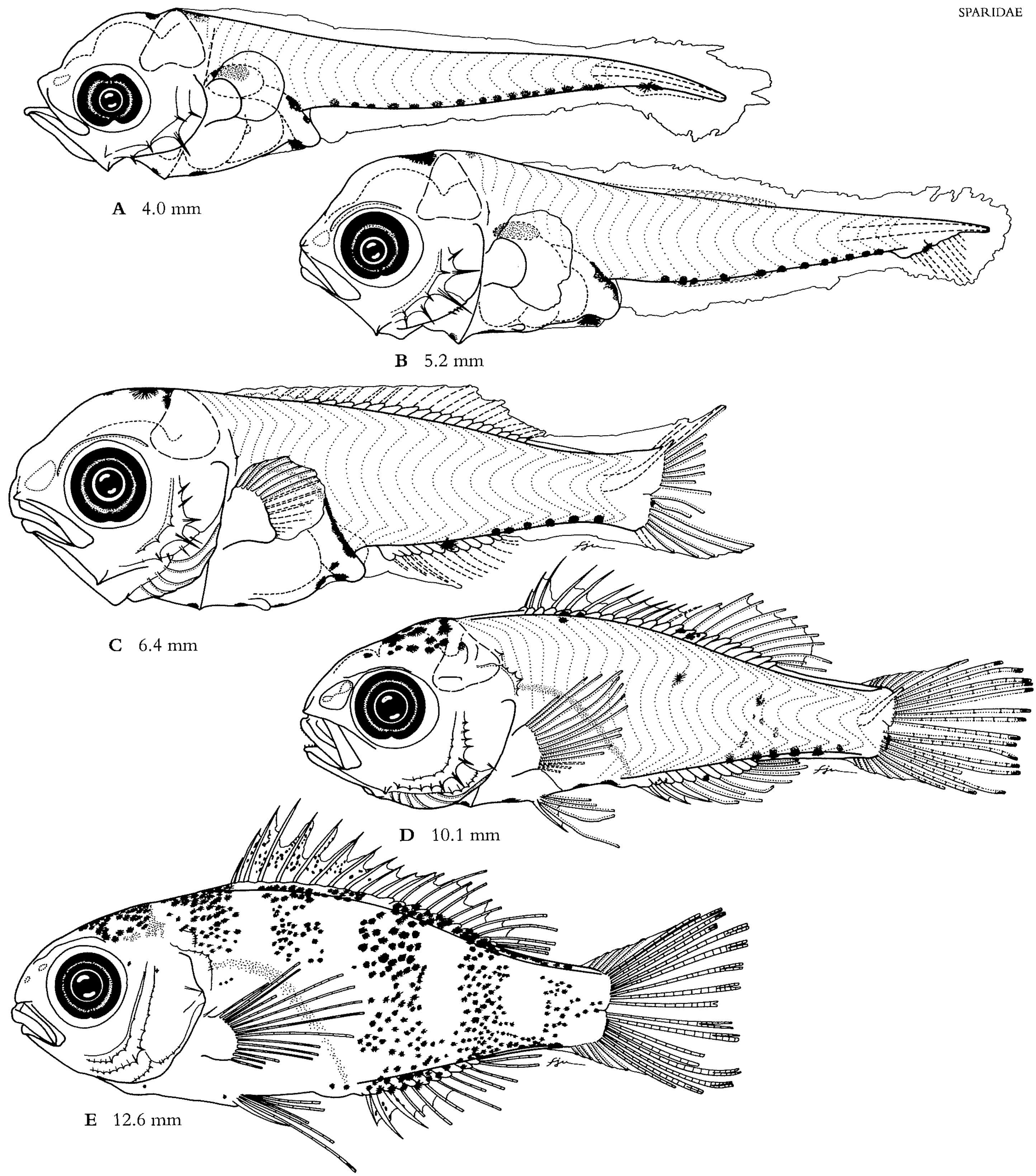


Figure 94 Larvae and early juvenile of *Pagrus auratus*. **A** Preflexion; note elongate preopercular spines and internal melanophore at nape. **B** Early flexion; note pelvic-fin bud. **C** Late flexion. **D** Postflexion; developing scales omitted. **E** Early juvenile; myomeres and scales omitted. A–C from northern NSW coastal waters; D from entrance channel of Wilson Inlet (WA); E from Lake Macquarie (NSW). Illustrated by F. J. Neira.

Sparidae *Rhabdosargus sarba* (Försskål, 1775) Tarwhine

D XI, 13–15 A III, 11–12 P_1 13–15 P_2 I, 5 C 17 V 24

Adults Distributed along western Australia from Shark Bay to Albany (WA), and along eastern Australia from Townsville (Qld) to the Gippsland Lakes (Vic). Also widely distributed in subtropical waters of the Indo-Pacific region, including Japan and South Africa. Found in schools in estuarine and coastal marine waters to a depth of 60 m. Adults have the second anal-fin spine equal in length to the third spine, and golden lines along the side of the body. Maximum size 45 cm (Munro, 1949; Masuda *et al.*, 1984; Hutchins & Swainston, 1986; Smith & Smith, 1986; Kuiter, 1986).

Importance to fisheries A by-catch species of yellowfin and black bream fisheries, with catches of approximately 35 tonnes per year (Kailola *et al.*, 1993).

Spawning Eggs of the Japanese populations (as *Sparus sarba*) are pelagic and spherical, 0.95–1.04 mm in diameter, and have a single oil globule (Tsukashima & Kitajima, 1982; Kinoshita, 1988i; Leu, 1994). Larvae have been caught in Western Australia entering Wilson Inlet in December and January (Neira & Potter, 1992a); in New South Wales entering Lake Macquarie from May to December, with a peak abundance in June (Miskiewicz, 1986, 1987), entering Tuggerah Lakes from May to October (Marsden, 1986), and in coastal waters off Sydney (NSW) from April to December (Gray *et al.*, 1992); and in southern Queensland in estuaries during winter (Munro, 1945).

Diagnostic characters

- 7–10 + 14–18 = 24–25 myomeres
- Small anterior and posterior preopercular spines, spine at angle moderate; posterior preopercular spines remain in postflexion larvae
- 1–2 small supracleithral spines in postflexion larvae
- Internal melanophore under hindbrain
- 2 large melanophores ventrally on gut, up to 4 from flexion stage
- 4–8 small melanophores under notochord tip

Description of larvae

Morphology Body moderate (BD 21–33%). Head moderate to large (HL 24–35%), dorsal profile gently rounded in postflexion larvae. Small teeth along both jaws from early flexion stage. Small anterior preopercular and posterior preopercular spines, spine at angle moderate; anterior preopercular spines disappear by settlement, posterior spines increase in number and remain in early juveniles. One or two supracleithral spines, and 1 interopercular spine by 6.2 mm; latter disappears at settlement. Smooth supraocular ridge and 1 weak opercular spine in early juveniles. Gut moderate to long (PAL 42–59%), coiled and compact. Small gas bladder above foregut. Large gap between anus and origin of anal fin, closed by late postflexion stage. Scales form at about 11.5 mm.

Size at

Hatching	<3.0 mm
Notochord flexion	4.4–7.0 mm
Settlement	10.5–12.5 mm
Formation of fins:	

Caudal 3.5–6.2 mm; Dorsal 4.9–9.5 mm; Anal 4.9–9.5 mm; Pectoral 6.2–9.1 mm; Pelvic 6.2–9.8 mm

Pigmentation Larvae are lightly pigmented prior to settlement. *External:* 2 melanophores over midbrain from late flexion stage, increasing in number with growth. Additional melanophores over forebrain and several on jaws in late postflexion larvae; heavy pigment on head in early juveniles. One melanophore at cleithral symphysis and 2 large melanophores ventrally on gut in preflexion larvae; 1–2 along isthmus and 2–4 ventrally on gut in flexion larvae. Series of 11–13 melanophores along ventral midline of tail in early preflexion larvae, 7–11 in late preflexion and flexion larvae. Additional melanophores along anal-fin base and ventral midline of caudal peduncle in postflexion larvae. One melanophore dorsally on caudal peduncle by 6.2 mm, up to 4 in postflexion larvae. Four to eight small melanophores under notochord tip in preflexion larvae, remaining along caudal-fin base in postflexion larvae. Additional pigment on caudal-fin rays from 11 mm. Broad vertical bands of pigment laterally along trunk and tail, pigment on membrane between dorsal- and anal-fin spines, and along soft rays of all fins in juveniles. *Internal:* 1 melanophore usually under hindbrain in preflexion larvae, and 1 laterally on hindbrain in late postflexion larvae. Pigment over gas bladder and melanophores dorsally along hindgut. Melanophores dorsally over vertebrae from early postflexion stage.

Material examined 22 larvae, 3.0–11.5 mm BL, and 12 juveniles, 10.5–12.5 mm BL, Richmond River (near Yamba), Lake Macquarie and Tuggerah Lakes (NSW).

Additional references Munro (1945), Miskiewicz (1987), Kinoshita (1986, 1988i), Leu (1994).

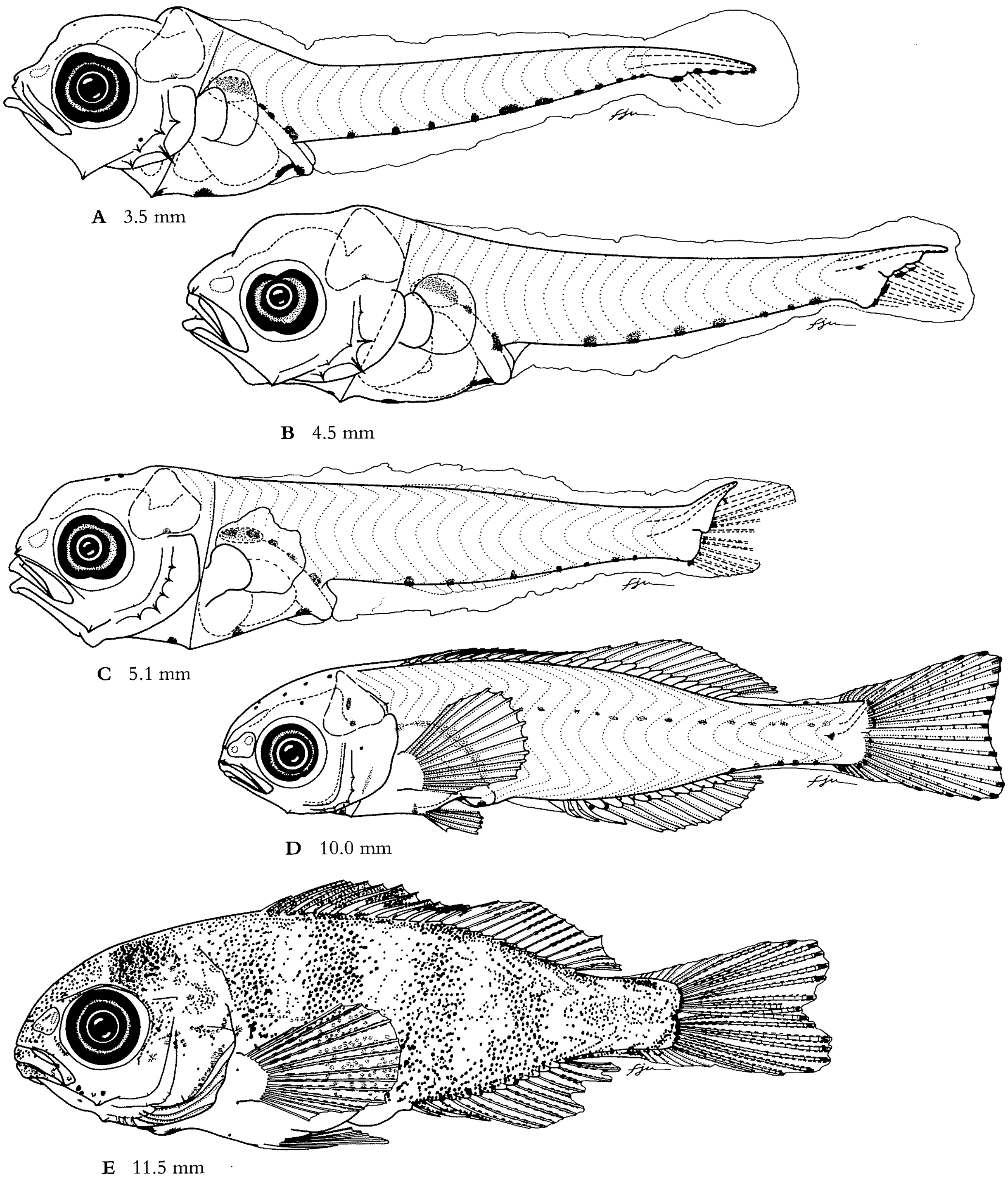


Figure 95 Larvae and early juvenile of *Rhabdosargus sarba*. **A** Preflexion. **B** Early flexion. **C** Late flexion; note developing dorsal and anal fins. **D** Postflexion. **E** Early juvenile; myomeres and scales omitted. A–C from Lake Macquarie (NSW); D from Tuggerah Lakes (NSW); E from Richmond River (NSW). Illustrated by F. J. Neira.

Terapontidae: Trumpeters, grunters

T. Trnski and F. J. Neira

Terapontids are mostly schooling fishes found in fresh, estuarine and coastal marine waters throughout the Indo-West Pacific. The family comprises 16 genera and 46 species, 35 of which are freshwater (Nelson, 1994). Twelve genera and about 30 species have been recorded from Australia, 4 genera and 6 species (two freshwater) in temperate regions (Vari, 1978; Hutchins & Swainston, 1986; Allen & Cross, 1989c; Gomon *et al.*, 1994; Kuiter, 1996; Merrick, 1996). Adults (most 20–40 cm) are oblong to ovate and moderately deep, have two opercular spines, a single, usually notched dorsal fin, and thoracic pelvic fins (Gomon *et al.*, 1994; Nelson, 1994). Eggs are pelagic, or demersal and non-adhesive as in some freshwater species, and spherical, 0.6–2.8 mm in diameter (Zvjagina, 1965; Lake, 1967b; Llewellyn, 1973; Merrick & Schmida, 1984). Larvae have been described for representatives of *Amniataba*, *Bidyanus*, *Pelates*, *Leiopotherapon*, *Terapon* and *Rhyncopelates* (Munro, 1945; Zvjagina, 1965; Lake, 1967b; Llewellyn, 1973; Zhang *et al.*, 1985; Kinoshita, 1988h; Leis & Trnski, 1989; Potter *et al.*, 1994). The weak to well developed head spination, which is sometimes retained in a modified form in adults, is the only obvious specialisation of terapontid larvae to pelagic life (Leis & Trnski, 1989).

Meristic characters of terapontid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Amniataba	(1)	XII–XIII, 8–10	III, 8–9	13–17	I, 5	17	10 + 15 = 25
Bidyanus	(2)	XII–XIII, 11–13	III, 7–9	14–17	I, 5	17	11 + 14 = 25
Pelates	(2)	XI–XIII, 9–11	III, 9–11	13–17	I, 5	17	10 + 15 = 25
Pelsartia	(1)	XII–XIII, 11	III, 10	14–15	I, 5	17	10 + 15 = 25

Main characters of terapontid larvae

- 25–26 myomeres, typically 25
- Body elongate to moderate (BD 16–35%)
- Weak to well developed head spination, often including preopercular, opercular, cleithral and interopercular spines, and low, smooth supraocular and supracleithral ridges; supracleithral and subopercular spines, and a serrate infraorbital in some taxa
- Gut moderate in preflexion through to postflexion larvae (PAL 30–47%), long in larvae near settlement (PAL to 65%), coiled and compact
- Moderate to large gap between anus and origin of anal fin, closed by late postflexion stage; conspicuous postanal membrane along gap
- Small gas bladder, pigmented
- Body initially lightly pigmented, heavily pigmented near settlement
- One or two large melanophores ventrally along gut in early stages
- Melanophore series along ventral midline of tail

References to terapontid larvae

Uchida *et al.* (1958), Zvjagina (1965), Zhang *et al.* (1985), Kinoshita (1988h), Leis & Trnski (1989).

Families with similar larvae

Chandidae – Head moderate to large, with small preopercular spines; small to moderate gap between anus and origin of anal fin; VII–VIII dorsal-fin spines; internal pigment over anterior surface of gut.

Gerreidae – Long ascending premaxillary process; IX–X dorsal-fin spines.

Haemulidae – 26–28 myomeres; numerous anterior and posterior preopercular spines in most taxa; gut long, extending from midbody to 74% BL.

Kuhliidae – Weak, late forming preopercular spines, never elongate; X dorsal-fin spines; body lightly pigmented; distinct cluster of melanophores over hypural complex; pigment ventrally along tail after flexion stage.

Mullidae – Head spines absent in most taxa; 2 well separated dorsal fins, first with VII–VIII spines; short-based anal fin, I, 6–7; 3 melanophores in a triangular pattern on midbrain in late preflexion larvae.

Pomacentridae – 26–27 myomeres, typically 26; no subopercular or interopercular spines; anal fin II, 10–18; melanophores dorsally over head from preflexion stage.

Sillaginidae – 32–45 myomeres; elongate snout in postflexion larvae; late forming, very small preopercular spines in most taxa; long-based anal fin, II, 15–24; body lightly pigmented in postflexion larvae; melanophore series ventrally along gut.

Sparidae – Body moderate to deep (BD 21–44%); small to moderate gap between anus and origin of anal fin.

Terapontidae *Amniataba caudavittata* (Richardson, 1845) Yellowtail trumpeter

D XII–XIII, 8–10 A III, 8–9 P_1 13–17 P_2 I, 5 C 17 V 25

Adults Distributed around northern Australia from Cape Leeuwin (WA) to Bowen (Qld); also in southern New Guinea. Common in estuaries but also in fully fresh water as well as hypersaline habitats (e.g. Shark Bay). Adults are silver to yellowish and have a large transverse black blotch on each lobe of the yellowish caudal fin. Maximum size 28.5 cm (Vari, 1978; Hutchins & Swainston, 1986; Allen & Cross, 1989c; Potter *et al.*, 1994).

Importance to fisheries Targeted by recreational fishers with handlines in the Swan Estuary (WA) and used mostly for bait.

Spawning Eggs undescribed. Mature oocytes average 0.56 mm in diameter. Population in the Swan Estuary (WA) spawns in the upper reaches between November and March. Fecundity ranges from 50 000 to 705 000 eggs (Potter *et al.*, 1994). Larvae have been caught in the upper Swan Estuary from November to March (Neira *et al.*, 1992).

Diagnostic characters

- 6–10 + 15–19 = 25 myomeres
- Small posterior preopercular spines; no anterior preopercular spines
- Series of melanophores along lateral midline of posterior of tail in postflexion larvae
- Up to 40 melanophores along ventral midline of tail in early preflexion larvae

Description of larvae

Morphology Body elongate to moderate (BD 16–23%), laterally compressed in postflexion larvae. Head small to moderate in preflexion and flexion larvae (HL 18–20%), moderate in postflexion larvae (HL 21–30%). Small villiform teeth along upper jaw by flexion stage, along lower jaw by postflexion stage. Two to three small posterior preopercular spines by flexion stage, 5–7 by postflexion stage. One opercular, 1 cleithral and 1 supracleithral spine, and a very small interopercular spine by postflexion stage. Gut moderate (PAL 30–47%), tightly coiled and compact. Small gas bladder over foregut. Large gap between anus and origin of anal fin (VAFL 12–15%). Postanal membrane present through to postflexion larvae.

Size at

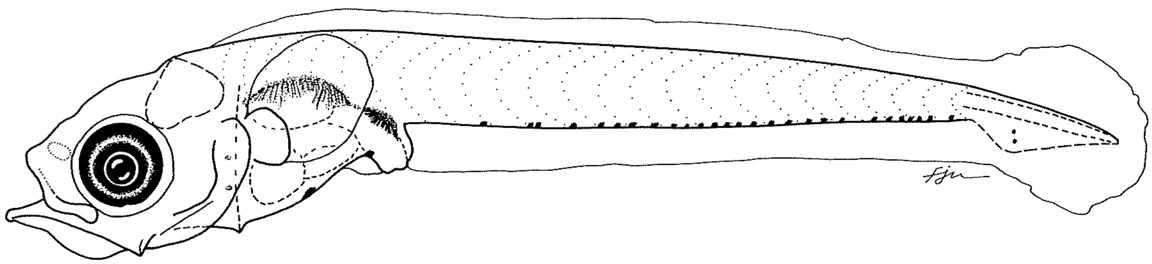
Hatching	<2.4 mm
Notochord flexion	4.3–5.2 mm
Settlement	>7.8 mm
Formation of fins:	
Caudal 3.9–5.2 mm; Dorsal 4.3–6.6 mm; Anal 4.3–6.6 mm; Pectoral 5.0–6.6 mm; Pelvic 5.1–6.6 mm	

Pigmentation Larvae are lightly pigmented. *External:* Rarely 1 melanophore dorsally on head prior to flexion stage, a few on midbrain from flexion stage, and on snout, tip of lower jaw, angle of lower jaw and opercle in postflexion larvae by 6.6 mm. One melanophore may be present at pelvic-fin origin, and 1 ventrally on gut anterior to anus; additional melanophores ventrally along gut in late postflexion larvae. Single series of up to 40 melanophores along ventral midline of tail in early preflexion larvae, reduced to about 10 in late flexion larvae. A few melanophores along anal-fin base and 4–6 along ventral midline of caudal peduncle; 1 melanophore on each anal-fin pterygiophore by 6.6 mm. Series of melanophores along dorsal midline of trunk and tail and lateral midline of posterior of tail in late postflexion larvae. One or two melanophores under notochord tip in preflexion larvae; pigment along caudal-fin base in postflexion larvae. *Internal:* 1 melanophore at nape, and a few along cleithrum from early postflexion stage. Melanophores dorsally over gas bladder and gut; 1 above anus.

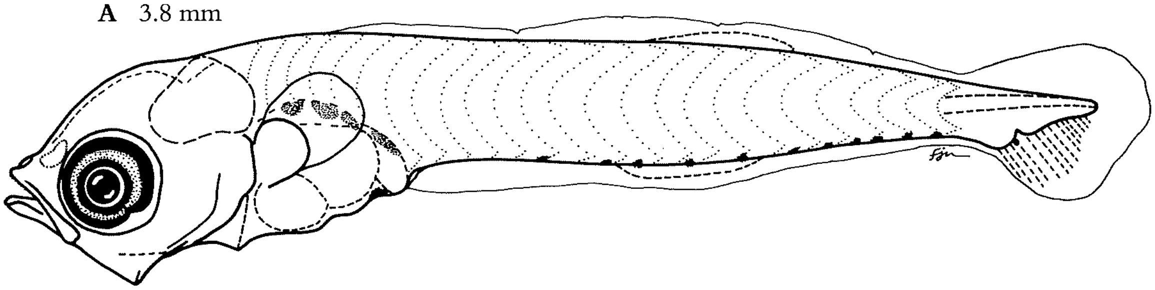
Material examined 17 larvae, 2.4–7.8 mm BL, upper Swan Estuary (WA).

Additional references Neira (1988), Potter *et al.* (1994).

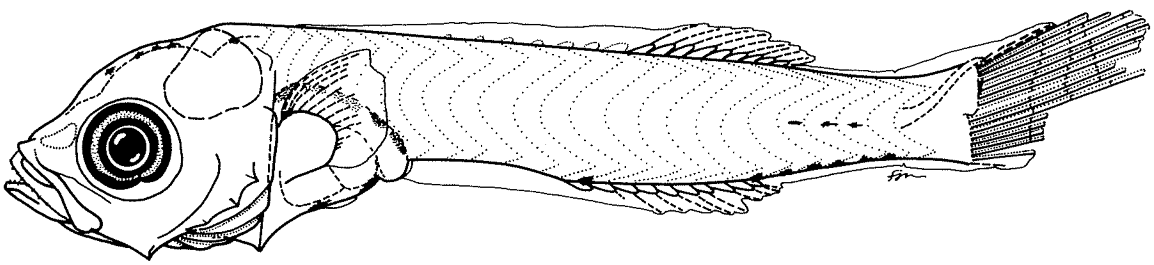
Figure 96 Larvae of *Amniataba caudavittata*. **A** Preflexion. **B** Preflexion; note developing dorsal and anal fins. **C** Early postflexion; note pelvic-fin bud. **D** Postflexion. **E** Postflexion; note prominent gap between anus and origin of anal fin, and the postanal membrane. A–E from upper Swan Estuary (WA) (modified from Potter *et al.*, 1994). Illustrated by F. J. Neira.



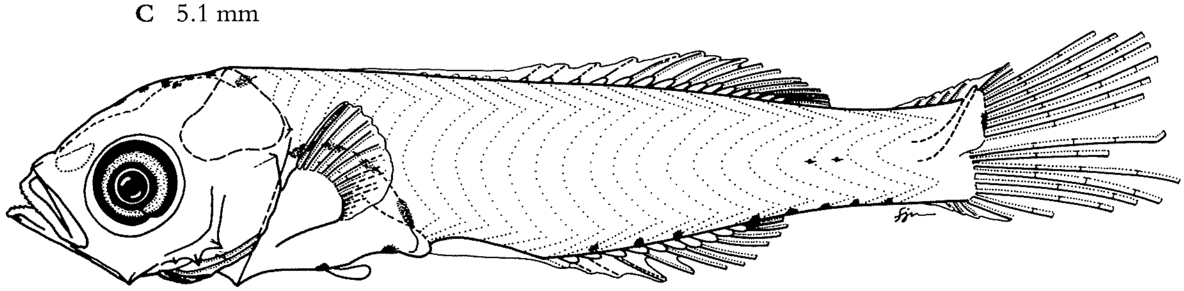
A 3.8 mm



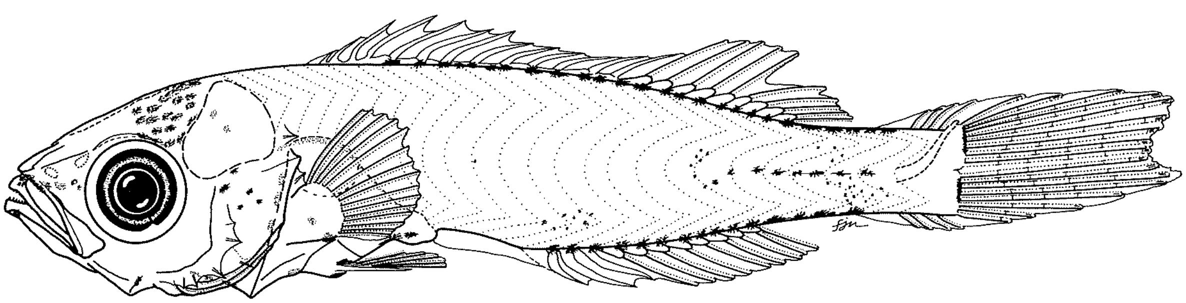
B 4.1 mm



C 5.1 mm



D 5.6 mm



E 6.6 mm

Terapontidae *Pelates octolineatus* (Jenyns, 1840) Western striped trumpeter

D XI–XII, 9–11 A III, 9–11 P_1 15–16 P_2 I, 5 C 17 V 25

Adults Endemic to western and southern Australia from Broome (WA) to Kangaroo Island (SA). Occurs over sand and weed bottoms in estuaries and coastal bays. *Helotes sexlineatus* is a synonym (e.g. in Kuiter, 1993, as *Helotus sexlineatus*). Adults have a small head (HL 24–30%), rows of tricuspid teeth, 5–8 longitudinal dark stripes along the body, and a prominent blotch laterally on the nape from 35 mm SL. Maximum size 28 cm (Vari, 1978; Hutchins & Swainston, 1986, as *P. sexlineatus*; Gomon *et al.*, 1994; Kuiter, 1996).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in the lower Swan and the Nornalup–Walpole estuaries (WA) from November to April (Neira *et al.*, 1992; Neira & Potter, 1994), and in the Spencer Gulf and Gulf St Vincent (SA) from January to March (B.D. Bruce, pers. comm.).

Diagnostic characters

- 5–9 + 16–20 = 25–26 myomeres
- Series of melanophores along lateral midline of tail by end of flexion stage
- 14–19 melanophores along ventral midline of tail in early preflexion larvae
- 2 melanophores, occasionally 1, ventrally on gut
- Usually 2 or more melanophores under tip of notochord in preflexion and flexion larvae
- Series of internal melanophores dorsally along posterior of notochord from flexion stage

Description of larvae

Morphology Body elongate to moderate (BD 17–21%), moderate in postflexion larvae from 9.5 mm (BD 21–28%). Head small in early preflexion larvae (HL 18–20%), moderate to large thereafter (HL 24–34%). Minute teeth along both jaws by end of flexion stage. One small posterior preopercular spine by 2.7 mm; up to 4 small posterior preopercular and 2–4 very small anterior preopercular spines from flexion stage. Anterior preopercular spines very weak after 7 mm, posterior preopercular spines increase in number from 9 mm. Low supracleithral ridge in early flexion larvae, with a small spine from 8.5 mm and 2 short spines in late postflexion larvae. Low supraocular ridge in postflexion larvae. One opercular spine by end of flexion stage, and a second by 9.5 mm. Cleithral spine in late postflexion larvae. Low pterotic ridge and 1 small interopercular spine from 10 mm. Gut moderate (PAL 31–40%), moderate to long in early juveniles from 9.6 mm (PAL 48–63%), tightly coiled and compact. Small gas bladder over foregut in all stages, often large after 10 mm. Large gap between anus and origin of anal fin (VAFL 14–25%), reduced as gut lengthens after 9.6 mm (VAFL 2–9%). Scales form between 10–14 mm.

Size at

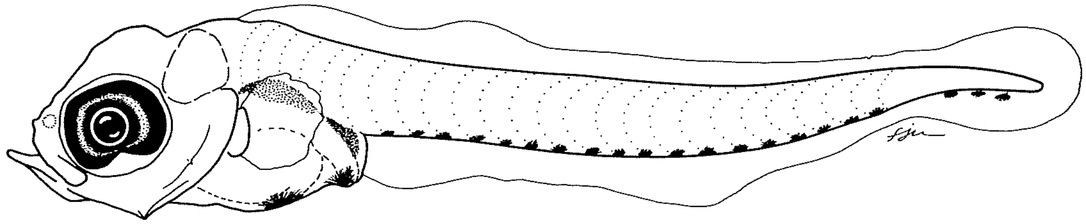
Hatching	<2.3mm
Notochord flexion	4.2–6.3 mm
Settlement	9.0–10.0 mm
Formation of fins:	
Caudal 2.9–6.7 mm; Anal 4.2–8.5 mm; Dorsal 4.2–9.0 mm; Pelvic 4.8–8.5 mm; Pectoral 4.8–9.1 mm	

Pigmentation Larvae are initially lightly pigmented, becoming heavily pigmented prior to settlement. *External:* A few melanophores over midbrain in some preflexion larvae, always present in flexion and postflexion larvae. Small melanophores on tip of snout, tip of lower jaw and on opercle by 8.4 mm. One or two melanophores ventrally on gut, first at pelvic-fin origin in 75% of larvae, second anterior to anus. Series of 14–19 melanophores along ventral midline of tail in early preflexion larvae, about 1 per myomere, reduced to about 14 in late flexion larvae; series of melanophores along anal-fin base and 5–7 ventrally along caudal peduncle once anal fin is formed. Series of melanophores along dorsal and lateral midlines of tail by end of flexion stage. Usually 2 or more melanophores, occasionally 1, under notochord tip, remaining along caudal-fin base from 7.5 mm. Pigment over most of body and medial fin membranes from 9 mm. *Internal:* 1 melanophore at nape in late flexion and early postflexion larvae. Pigment dorsally over gas bladder and hindgut. Series of melanophores dorsally along posterior of notochord from flexion stage, extending anteriorly to above anus by early postflexion stage.

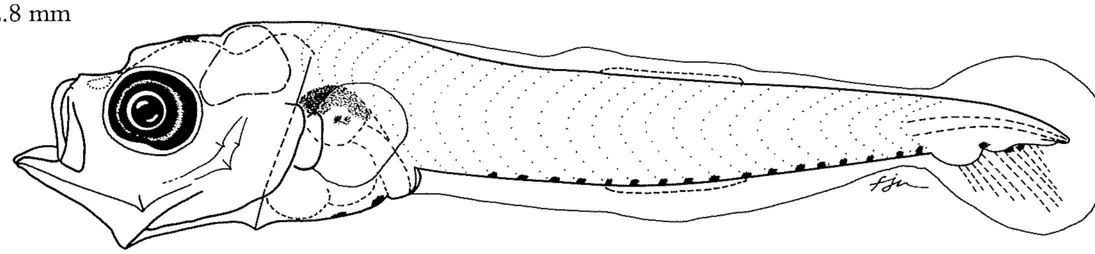
Material examined 203 larvae, 2.3–9.0 mm BL, and 3 juveniles, 9.1–14.0 mm BL, lower Swan Estuary and Cockburn Sound (WA); 1 larva, 8.0 mm BL, and 3 juveniles, 9.6–14.1 mm BL, upper Spencer Gulf (SA).

Additional references –

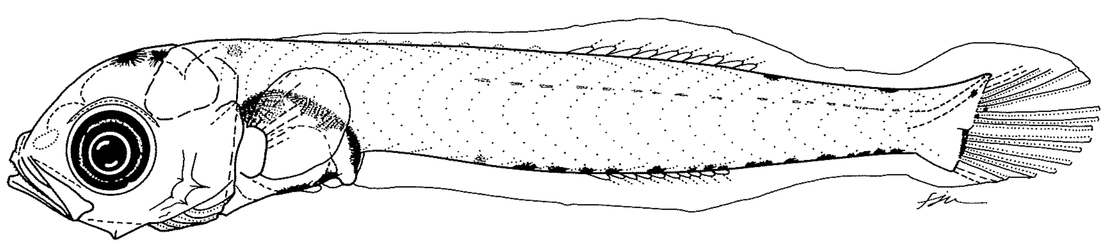
Figure 97 Larvae and settlement stage of *Pelates octolineatus*. **A** Preflexion. **B** Late preflexion; note developing dorsal and anal fins. **C** Late flexion; note pelvic-fin bud. **D** Early postflexion. **E** Postflexion. **F** Settlement stage; note juvenile pigmentation; almost fully formed scales omitted. A–C from lower Swan Estuary (WA); D–F from Cockburn Sound (WA). Illustrated by F.J. Neira.



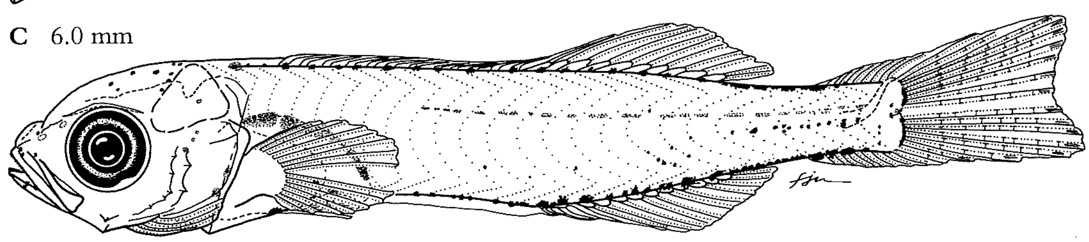
A 2.8 mm



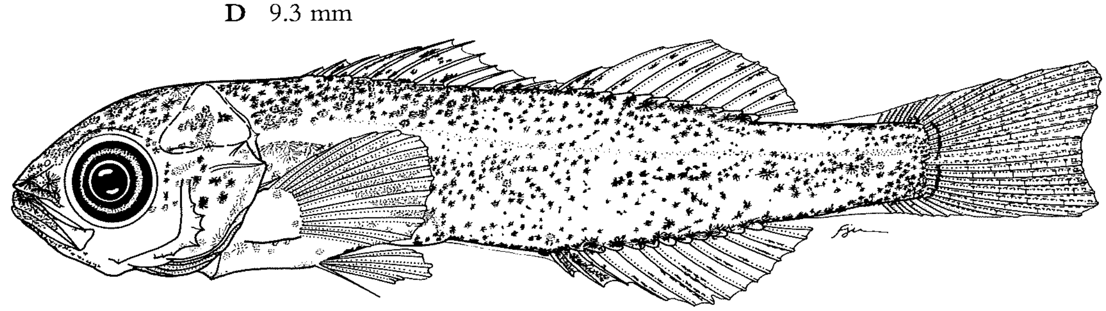
B 4.3 mm



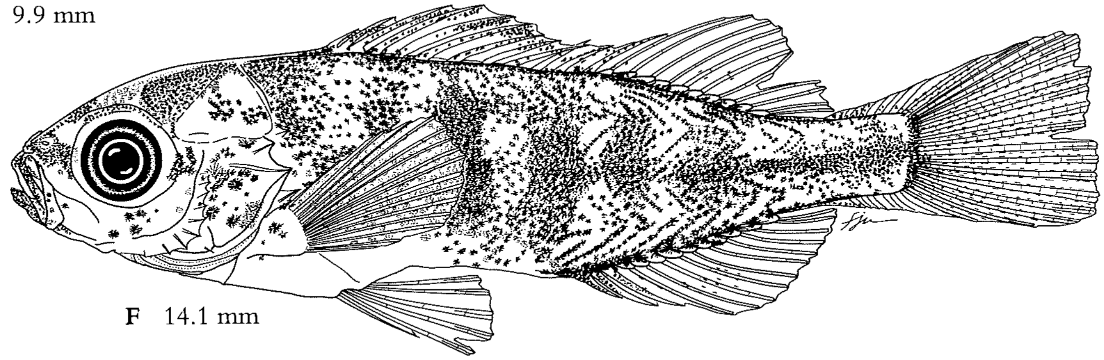
C 6.0 mm



D 9.3 mm



E 9.9 mm



F 14.1 mm

Terapontidae *Pelates sexlineatus* (Quoy & Gaimard, 1824) Six-lined trumpeter

D XII–XIII, 9–11 A III, 9–10 P_1 13–17 P_2 I, 5 C 17 V 25

Adults Endemic to eastern Australia from southern Queensland to Green Cape (NSW). Found in estuaries and coastal bays to a depth of 30 m. Adults have a moderately large head (HL 29–36%), rows of peg-like, unicuspid teeth, 5–6 longitudinal dark stripes along the body and, in juveniles <65 mm SL, a dark spot on the caudal-fin base. Maximum size 20 cm (Vari, 1978; Allen & Cross, 1989c; Kuiter, 1993, 1996).

Importance to fisheries –

Spawning Eggs undescribed although probably pelagic (Munro, 1945). Spawning in southern Queensland appears to take place close to river mouths between late summer and late winter (Munro, 1945). In New South Wales, larvae have been caught entering Lake Macquarie in most months (Miskiewicz, 1987), and in coastal waters off Sydney from August to May (Gray, 1995).

Diagnostic characters

- 4–10 + 15–21 = 25–26 myomeres
- Series of melanophores along lateral midline of tail in late postflexion larvae
- 10–15 melanophores along ventral midline of tail in early preflexion larvae
- 1 melanophore, occasionally 2, ventrally on gut
- 0–2 melanophores, usually 1, under tip of notochord in preflexion and flexion larvae
- Series of internal melanophores dorsally along posterior of notochord from late flexion stage

Description of larvae

Morphology Body elongate to moderate (BD 17–23%), deeper near settlement (BD to 28%). Head moderate to large (HL 23–35%). Minute teeth along both jaws by end of flexion stage. One small posterior preopercular spine by 2.8 mm; 3–5 small posterior preopercular and 2–3 very small anterior preopercular spines by flexion stage. Anterior preopercular spines very weak after 7 mm; posterior preopercular spines increase in number after 11 mm. Low supracleithral ridge in flexion larvae, with a small spine by 9.3 mm, sometimes a second spine by settlement. Low supraocular ridge in postflexion larvae. One opercular spine by end of flexion stage, a second by late postflexion stage. One cleithral and 1 very small interopercular spine, and 1 low pterotic and 2 pairs of low tabular ridges in late postflexion larvae. Gut moderate through to early postflexion larvae (PAL 35–47%), long by settlement (PAL to 56%), tightly coiled and compact. Gas bladder always small and inconspicuous. Large gap between anus and origin of anal fin (VAFL 11–15%), reduced by settlement. Scales form between 12–14 mm.

Size at

Hatching	<2.8 mm
Notochord flexion	4.0–5.9 mm
Settlement	11.9–14.0 mm
Formation of fins:	

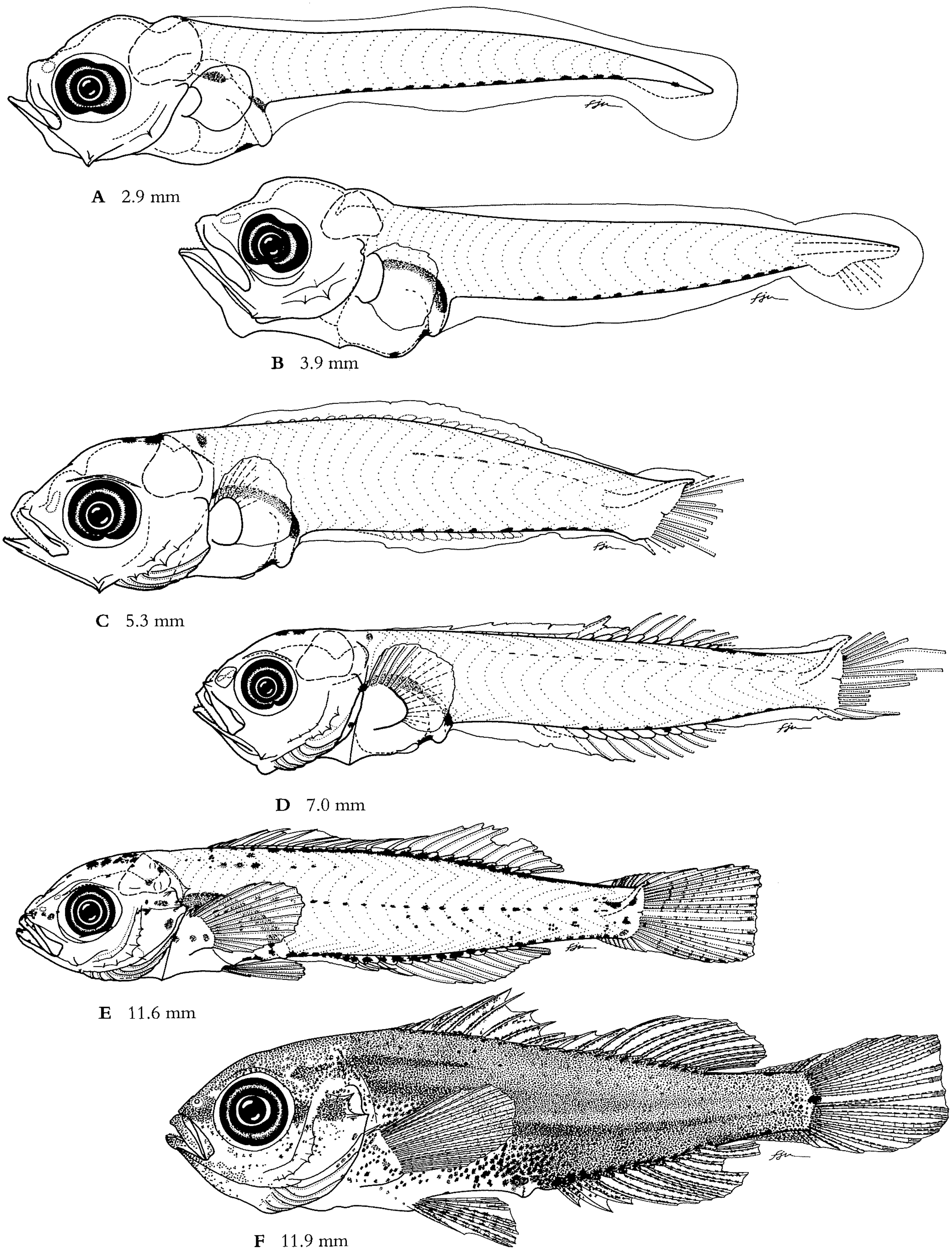
Caudal 2.8–6.0 mm; Anal 4.1–10.7 mm; Dorsal 4.1–11.0 mm; Pelvic 4.9–9.3 mm; Pectoral 5.3–9.3 mm

Pigmentation Larvae are initially lightly pigmented, becoming heavily pigmented prior to settlement. *External:* A few melanophores over midbrain in some preflexion larvae, always present from flexion stage. Several melanophores on tip of snout, tip of lower jaw and on opercle by 9.3 mm. One melanophore on ventral midline of gut at pelvic-fin origin in 20% of larvae, and a second melanophore anterior to anus. Series of 10–15 melanophores along ventral midline of tail in early preflexion larvae, about 1 per myomere, reduced to about 4 in late flexion larvae; series of melanophores along anal-fin base and 3–8 ventrally along caudal peduncle once anal fin is formed. Series of melanophores along dorsal and lateral midlines of tail in late postflexion larvae. One melanophore, rarely 0 or 2, under tip of notochord or on caudal-fin base. Pigment over almost entire body and along all fin elements by settlement. *Internal:* Usually 1 melanophore below nape in mid-flexion to early postflexion larvae. Pigment dorsally over gas bladder and hindgut. Series of melanophores dorsally along posterior of notochord from late flexion stage, extending anteriorly to above anus by 10.7 mm. Pigment around urostyle in late postflexion larvae.

Material examined 41 larvae, 2.8–11.8 mm BL, and 2 juveniles, 11.9–14.4 mm BL, Richmond River (near Yamba) and Lake Macquarie (NSW).

Additional references Munro (1945), Miskiewicz (1987).

Figure 98 Larvae and settlement stage of *Pelates sexlineatus*. **A** Preflexion. **B** Late preflexion; note developing caudal-fin rays. **C** Late flexion; note pelvic-fin bud. **D** Early postflexion. **E** Postflexion. **F** Settlement stage; note juvenile pigmentation; developing scales omitted. A–E from coastal waters off Lake Macquarie (NSW); F from Richmond River (NSW). Illustrated by F. J. Neira.


A 2.9 mm
B 3.9 mm
C 5.3 mm
D 7.0 mm
E 11.6 mm
F 11.9 mm

Labroidei

The Labroidei is the second largest suborder of perciform fishes, with 6 families, about 219 genera and approximately 2230 species found in fresh, estuarine and coastal marine waters, including coral reefs, in tropical and temperate regions worldwide (Nelson, 1994). Families comprise the Cichlidae (cichlids), Embiotocidae (surfperches), Labridae (wrasses), Odacidae (weed whitings), Pomacentridae (damselfishes) and Scaridae (parrotfishes). The Cichlidae, Embiotocidae and Pomacentridae were transferred from Percoidei to Labroidei (Kaufmann & Liem, 1982) although some authors still retain the three families in the former suborder (e.g. Eschmeyer & Bailey, 1990). The Odacidae and Scaridae were included within the Labridae by Kaufmann & Liem (1982), but the three families are still maintained as separate families by most authors (e.g. Richards & Leis, 1984; Nelson, 1994). The Cichlidae, which contains only freshwater and brackish water species, makes up 58% of all species in the suborder (~1270 species), and constitutes the third largest teleost fish family after the Cyprinidae and Gobiidae, while the Labridae is the second largest marine family in the suborder (Nelson, 1994). Adult labroids show extreme intraspecific variation in body shape and coloration associated with ontogeny, social structure and sex. Females of almost all labrid and scarid species change sex and become males (protogynia).

Various reproductive modes are found within labroids. Cichlids exhibit a high level of parental care, from mouth brooding to guarding and incubating eggs adhered to the substrate. Embiotocids are viviparous. Most labrids and all known scarids spawn pelagic eggs, with some temperate eastern Atlantic labrids having demersal eggs, while pomacentrids produce demersal, adhesive eggs that are guarded and incubated by the male (Breder & Rosen, 1966; Russell, 1976; Leis & Rennis, 1983; Richards & Leis, 1984). Larvae have been described mostly for labrids, pomacentrids and scarids (see review of early life history stages by Richards & Leis, 1984; see also Miller *et al.*, 1979; Leis & Rennis, 1983; Kinoshita, 1988j,k; Kojima, 1988c,d; Watson, 1996k,l). Descriptions of cichlid larvae are rare as many species develop directly from larvae to juveniles (Richards & Leis, 1984; Kinoshita, 1988j). Odacid larvae were virtually unknown prior to this study.

Family and species included here

ODACIDAE
Haletta semifasciata
Odax acroptilus
Odax cyanomelas
Siphonognathus argyrophanes

Odacidae: Weed whitings, rainbow fishes

F. J. Neira

Odacids are colourful marine fishes commonly found in shallow rocky, seagrass and seaweed areas of temperate waters of Australia and New Zealand. The family contains 4 genera (*Haletta*, *Neoodax*, *Odax* and *Siphonognathus*) and 12 species (Gomon & Paxton, 1985; Gomon *et al.*, 1994). The 4 genera are represented in southern Australia by 10 endemic species, while the remaining 2 species (*O. cyanoallix* and *O. pullus*) are endemic to New Zealand. Weed whitings are morphologically diverse and generally resemble fishes of the Labridae to which the group is closely related. Adults (12–52 cm) are elongate, have a single dorsal fin with a high number of spines (XIV–XXVII), a snout long and tubular in many taxa, a mouth with the jaw teeth fused into beak-like plates, and pelvic fins, if present, with I, 4 elements. Adults of all species except *S. argyrophanes* are sexually dichromic. Like most labrids, odacids also change sex from female to male, with males usually being the largest individuals (Gomon & Paxton, 1985; Gomon *et al.*, 1994). Little is known of the reproductive biology of members of this family (Richards & Leis, 1984; Gomon & Paxton, 1985). Eggs of *O. pullus* are pelagic and spherical, 1.9–2.1 mm in diameter, and have no oil globule (Robertson, 1975a). Some larval stages have been described for *O. pullus* and *Neoodax* sp. (Regan, 1916; Crossland, 1982). The relatively large, nearly vertical mouth, which becomes horizontal after settlement and opens at the end of a tubular snout in adults of many taxa, constitutes the only apparent specialisation of odacid larvae to pelagic life.

Meristic characters of odacid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal*	Vertebrae*
Haletta	(1)	XVII–XVIII, 12–14	III, 10–12	14–16	I, 4	14	21 + 17–18 = 38–39
Neoodax	(1)	XV–XVII, 11–14	II–III, 11–14	13–16	I, 4	14	18 + 17–18 = 35–37
Odax	(2)	XIV–XVIII, 8–14	II–III, 9–12	12–15	I, 4	14	14–21 + 17–20 = 31–41
Siphonognathus	(6)	XV–XXVII, 10–22	0–III, 7–13	11–15	0–I, 0–4	11–14	17–33 + 17–22 = 34–54

* Most common counts; full range of caudal-fin rays (segmented and branched) and vertebral counts are given in Gomon & Paxton (1985).

Main characters of odacid larvae

- 30–54 myomeres, 30–42 in most taxa
- Body elongate to moderate (BD 10–20%), laterally compressed
- Head moderate, with no spines (preopercle serrate in early juveniles)
- Mouth relatively large and nearly vertical in most stages; angle of lower jaw ventrally directed and pronounced
- Gut long to very long (PAL 54–74%), initially straight and tubular but becoming coiled by flexion stage
- Gas bladder above foregut, pigmented in some taxa
- Persistent, low preanal membrane
- Very little or no pigment during development, except in larvae of *Odax pullus* and *Siphonognathus argyrophanes*

References to odacid larvae

Richards & Leis (1984).

Families with similar larvae

Aulostomidae (early stages) – 61–65 myomeres; body very elongate and laterally compressed; 2 continuous, parallel stripes of tiny melanophores ventrally along tail; small melanophores on caudal finfold and around notochord tip.

Clupeidae (early stages) – Myomeres with muscle fibres in a cross-hatched pattern in most taxa, more evident in preflexion and flexion larvae; weakly to strongly striated hindgut.

Engraulidae (early stages) – Myomeres with muscle fibres in a cross-hatched pattern, more evident in preflexion and flexion larvae; striated hindgut.

Labridae – 23–28 myomeres; body laterally compressed with a deep caudal peduncle; mouth small and horizontal; eyes ovoid, round, or squarish, often with a mass of choroid tissue ventrally; dorsal fin with <XIII spines; pelvic fins I, 5.

Ophidiidae (early stages) – 48–87 myomeres; body elongate with tapered tail; dorsal and anal fins spineless, confluent with caudal fin; when present, pelvic fins jugular, with 1–2 rays; body moderately pigmented.

Plesiopidae – 24–40 myomeres, 24–35 in most taxa; weak to moderate head spination, small to moderate preopercular spines; mouth large, reaching below middle to posterior of eye; gut moderate to long (PAL 48–65%), coiled and moderately compact; body lightly to heavily pigmented.

Pseudochromidae (early stages) – 26–35 myomeres, 26–29 in most taxa; weak head spination; gut anteriorly coiled and striated in preflexion larvae >3 mm; melanophores along dorsal surface of tail in some taxa; long-based dorsal fin, I–III spines and >19 rays.

Scaridae (early stages) – 25 myomeres; body laterally compressed, deep caudal peduncle; mouth small and horizontal; eyes initially ovoid to squarish, rounded by late postflexion stage or, in some species, narrow and with a mass of choroid tissue ventrally; midgut striated; X dorsal-fin spines; pelvic fins I, 5.

Odacidae *Haletta semifasciata* (Valenciennes, 1840) Blue weed whiting

D XVII–XVIII, 12–14 A III, 10–12 P_1 14–16 P_2 I, 4 C 14 V 38–39

Adults Endemic to southern Australia from Houtman Abrolhos Islands (WA) to Sydney (NSW), including northern Tasmania. Often found in large schools in sandy and seagrass areas of estuaries and sheltered coastal waters, to a depth of 15 m. Adults are sexually dichromic: males are blue–green with a dark blotch at the rear end of the dorsal fin; females have six irregular, dark brown vertical bars on the body. Maximum size 41 cm (Gomon & Paxton, 1985; Hutchins & Swainston, 1986; Kuiter, 1993, 1996; Gomon *et al.*, 1994).

Importance to fisheries Occasionally caught by recreational fishers and sold in fish markets, although flesh is not considered of high quality (Gomon *et al.*, 1994; Kuiter, 1996).

Spawning Eggs undescribed, although probably pelagic (Richards & Leis, 1984). Based on larval occurrence, spawning occurs in late winter in coastal waters near Perth (WA), and in early summer along the south coast of Western Australia. Larvae have been caught on flood tides at the entrance of Wilson Inlet (WA) between November and January (Neira & Potter, 1992a), and newly settled juveniles in seagrass beds in Cockburn Sound (WA) from September to November (Jonker, 1993).

Diagnostic characters

- 20–21 + 17–18 = 38 myomeres
- Small melanophores on dentary and premaxilla
- Melanophore on ventral edge of pectoral-fin base
- Pigment along first 3–4 anal-fin elements from early postflexion stage
- Conspicuous melanophore on posterior end of anal-fin base from 5.7 mm

Description of larvae

Morphology Body elongate in postflexion larvae (BD 14–19%), laterally compressed. Head moderate in postflexion larvae (HL 24–33%). Preopercular spines in settlement-stage larvae from 16 mm. Gut long to very long (PAL 62–73%), initially straight with a slight constriction before anus, coiled by 7 mm. Short preanal membrane in postflexion larvae examined. Scales develop from 16 mm.

Size at

Hatching	—
Notochord flexion	<5.0 mm
Settlement	14.0–18.0 mm

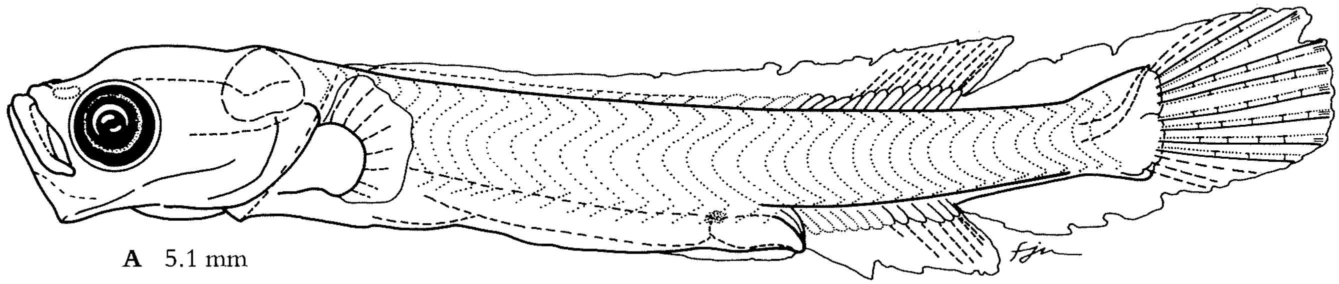
Formation of fins:
Caudal <5.0–6.9 mm; Dorsal <5.0–7.0 mm; Anal <5.0–7.0 mm; Pectoral 5.0–7.0 mm; Pelvic 7.0–14.0 mm

Pigmentation Postflexion larvae are lightly pigmented. *External:* Tiny melanophores along dentary and upper jaw, melanophores at angle of lower jaw and cleithral symphysis; 1 melanophore on ventral edge of pectoral-fin base and several on pectoral-fin membrane, some ventrally just before anus, several along first 3-4 anal-fin elements, and 1 melanophore at posterior end of anal-fin base in early postflexion larvae. Small melanophores dorsally and laterally over midbrain, several posteriorly on dorsal- and anal-fin membranes from 7 mm. One large melanophore on ventral caudal-fin rays, up to 4 along anterior ventral midline of trunk, 1 on ventral surface of gut posterior to insertion of pelvic fin, small melanophores anteriorly on preanal membrane, and 1 melanophore at posterior end of dorsal-fin base in larvae near settlement. Juveniles have up to 7 pigment blotches along lateral midline of trunk and tail, small melanophores on dorsal and anal fins, a patch at pelvic-fin base, and 1 dorsally and medially on caudal-fin base. *Internal:* 1 patch above hindgut constriction, obscured by muscle tissue in larvae near settlement.

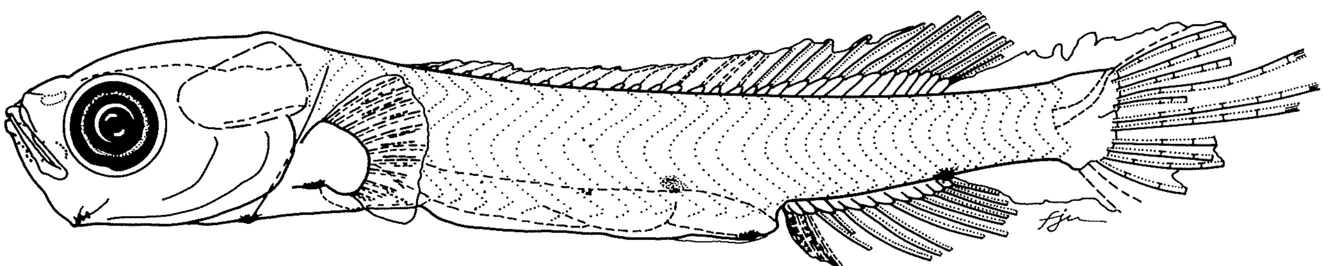
Material examined 16 postflexion larvae and juveniles, 5.0–18.3 mm BL, Cockburn Sound and Wilson Inlet (WA).

Additional references –

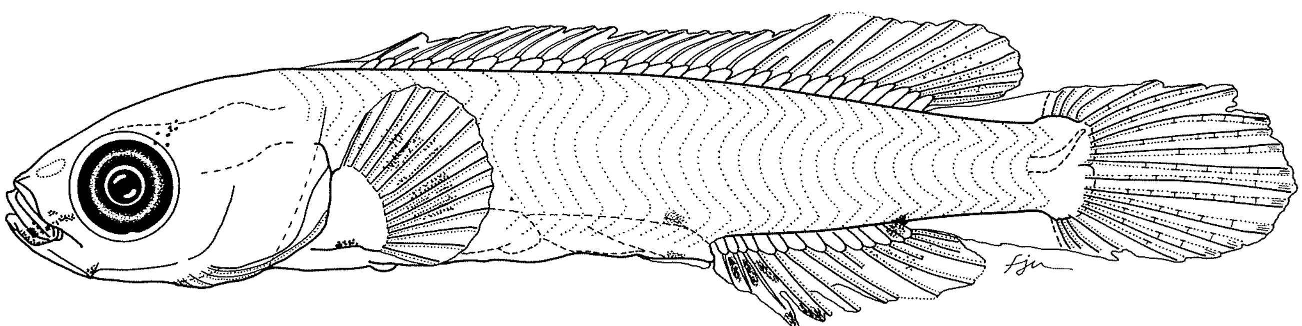
Figure 99 Larvae and settlement stage of *Haletta semifasciata*. **A** Early postflexion; note developing pectoral-fin rays. **B** Postflexion. **C** Postflexion; note pelvic-fin bud. **D** Settlement stage. A–D from Cockburn Sound (WA). Illustrated by F. J. Neira.



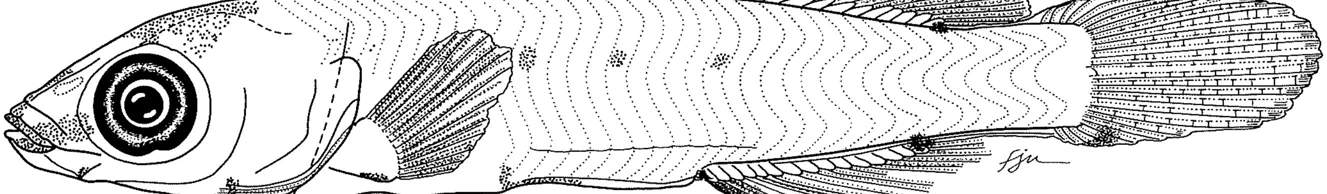
A 5.1 mm



B 5.7 mm



C 7.1 mm



D 14.2 mm

Odacidae *Odax acroptilus* (Richardson, 1846) Rainbow cale

D XIV–XVI, 8–10 A III, 11–12 P_1 14–15 P_2 I, 4 C 14 V 31–33

Adults Endemic to southern Australia from Kalbarri (WA) to Coffs Harbour (NSW), including northern Tasmania. Occurs in exposed rocky reef areas with abundant algae and among seagrass beds, to a depth of 25 m. One of the most colourful marine temperate fishes, they resemble parrotfishes (Family Scaridae) in body shape and in having teeth fused in a parrot-like beak. Adults are sexually dichromic: males have elongate anterior dorsal-fin spines and irridescent blue markings on the head and fins; females have six irregular, dark brown vertical bars on the body. Maximum size 30 cm (Gomon & Paxton, 1985; Hutchins & Swainston, 1986; Gomon *et al.*, 1994; Kuiter, 1996).

Importance to fisheries Occasionally taken with fishing lines (Gomon *et al.*, 1994).

Spawning Eggs undescribed. Eggs of *Odax pullus* are pelagic (Robertson, 1975a). Larvae have been caught in coastal waters off Perth (WA) from September to November, on flood tides at the entrance of Wilson Inlet (WA) from November to January (Neira & Potter, 1992a), and in Botany Bay (NSW) in March (A.S. Steffe, pers. comm.). Newly settled juveniles have been caught among seagrass in Cockburn Sound (Jonker, 1993).

Diagnostic characters

- 14–16 + 15–18 = 31–32 myomeres
- Early forming villiform teeth along premaxilla
- 4–5 internal melanophores (sometimes coalesced) on hindgut above anus

Description of larvae

Morphology Body elongate (BD 14–20%), laterally compressed; body enclosed in a dermal sac in early preflexion larvae except for anterior portion of gut. Head moderate (HL 20–30%), lower-jaw angle prominent. Small villiform teeth along premaxilla in preflexion larvae from 3.4 mm. Gut long (PAL 54–63%), initially straight and with a constriction anterior to anus, coiled at hindgut in postflexion larvae from 5 mm. Preanal membrane in all stages. Gas bladder over foregut, inflated in some larvae.

Size at

Hatching	<2.1 mm
Notochord flexion	4.5–5.2 mm
Settlement	>5.6 mm

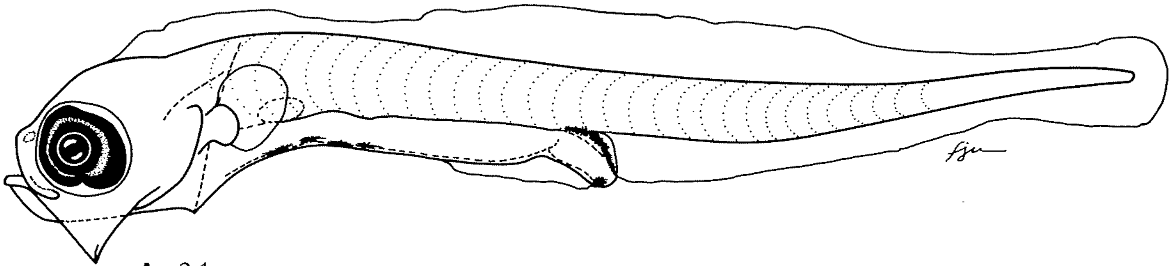
Formation of fins:
Caudal 3.9–5.6 mm; Dorsal 4.2–>5.6 mm; Anal 4.2–>5.6 mm; Pectoral 4.3–5.6 mm; Pelvic 5.6– – mm

Pigmentation Larvae are very lightly pigmented. *External:* 4 melanophores along ventral midline of foregut and 1–2 ventrally at anus, disappearing by late preflexion stage. *Internal:* 4–5 melanophores dorsally on hindgut over anus, sometimes coalesced.

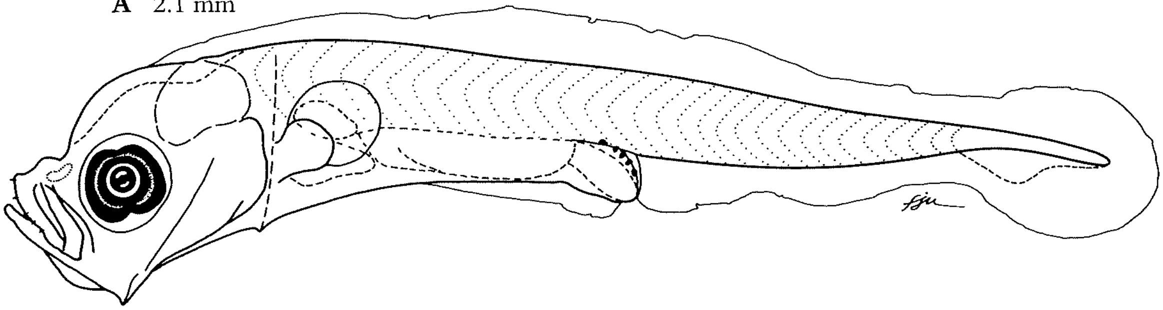
Material examined 17 larvae, 2.1–5.6 mm BL, coastal waters off Perth, Cockburn Sound and in the entrance channel of Wilson Inlet (WA), and in Botany Bay (NSW).

Additional references –

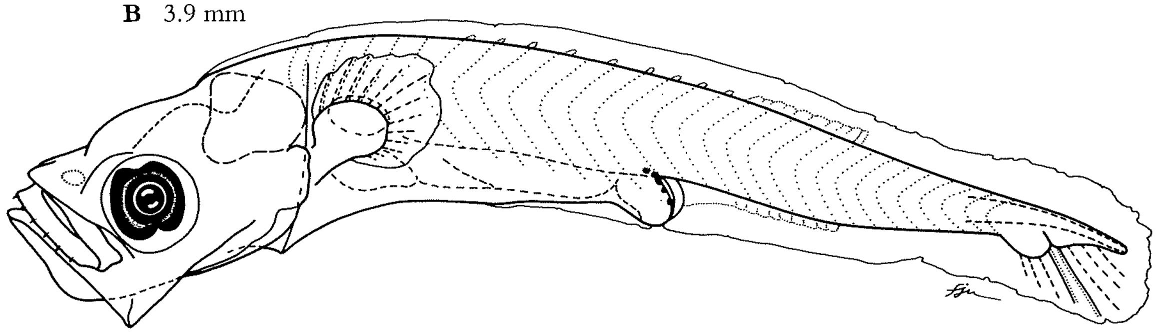
Figure 100 Larvae of *Odax acroptilus*. **A** Preflexion. **B** Preflexion; note developing caudal fin. **C** Late preflexion; note developing pectoral-fin rays, and dorsal and anal fins. **D** Flexion. **E** Postflexion; note pelvic-fin bud. A–D from entrance channel of Wilson Inlet (WA); E from Botany Bay (NSW). Illustrated by F. J. Neira.



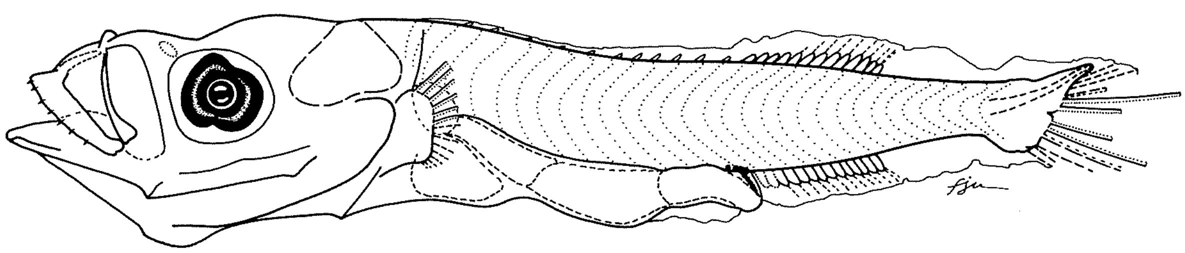
A 2.1 mm



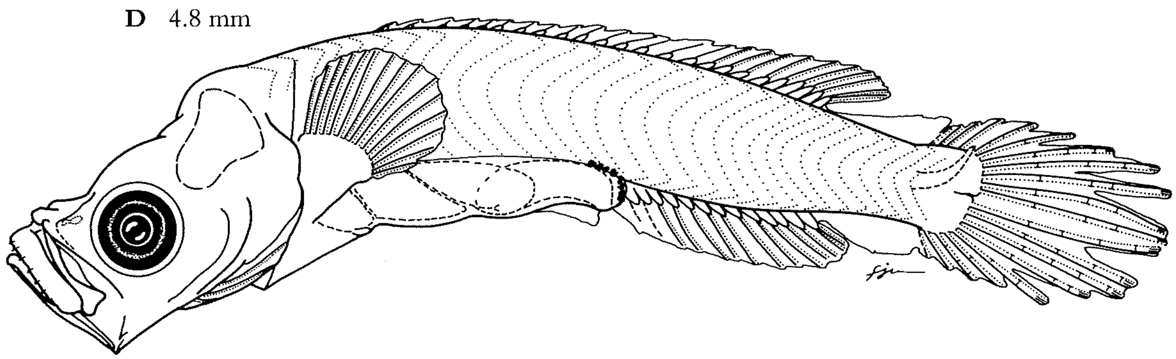
B 3.9 mm



C 4.5 mm



D 4.8 mm



E 5.6 mm

Odacidae *Odax cyanomelas* (Richardson, 1850) Herring cale

D XVI–XVIII, 9–11 A II–III, 9–11 P_1 12–13 P_2 I, 4 C 14 V 39–41

Adults Endemic to southern Australia from Houtman Abrolhos Islands (WA) to Coffs Harbour (NSW), including Tasmania. Found along exposed rocky shores, especially with abundant macroalgae, to a depth of 30 m. Adults are sexually dichromic: males are pale blue to nearly black; females are brown with wavy blue lines on the head and fins. Most fish caught are females. Maximum size 51 cm (Gomon & Paxton, 1985; Hutchins & Swainston, 1986; Gomon *et al.*, 1994).

Importance to fisheries Not targeted by fishers because its diet of broad-leaved algae taints the flesh (Gomon *et al.*, 1994).

Spawning Eggs undescribed. Eggs of *Odax pullus* are pelagic (Robertson, 1975a). Larvae of *O. cyanomelas* have been caught in Botany Bay (NSW) in March (A.S. Steffe, pers. comm.).

Diagnostic characters

- 20–22 + 19–21 = 40–42 myomeres
- Early forming villiform teeth along premaxilla
- Up to 5 small melanophores at tip of lower jaw
- Up to 4 small melanophores on either side of hindgut in preflexion larvae, becoming internal during flexion stage

Description of larvae

Morphology Body elongate (BD 14–19%), laterally compressed. Head moderate (HL 20–30%), lower-jaw angle prominent. Small villiform teeth on premaxilla in preflexion larvae from 3.7 mm. Gut long in preflexion larvae (PAL 60–64%), long to very long in flexion and postflexion larvae (PAL 62–74%); initially straight and with a constriction anterior to anus, coiled at hindgut in postflexion larvae from 6 mm. Gas bladder over foregut, inflated in some larvae. Long preanal membrane in all stages.

Size at

Hatching	<3.5 mm
Notochord flexion	4.5–5.2 mm
Settlement	>6.1 mm
Formation of fins:	

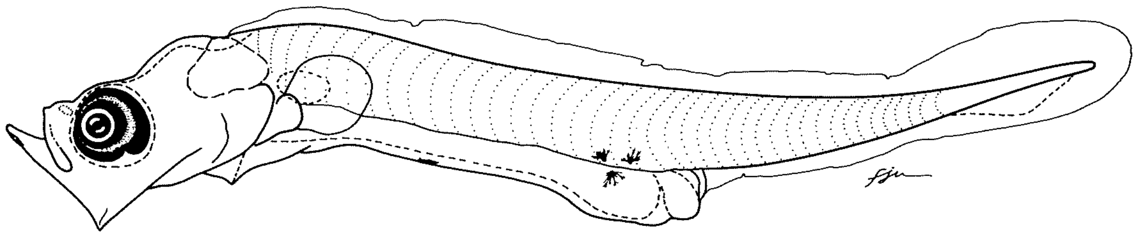
Caudal 3.5–6.0 mm; Dorsal 4.2–>6.1 mm; Anal 4.5–>6.1 mm; Pectoral 4.6–6.1 mm; Pelvic >6.1 mm

Pigmentation Larvae are very lightly pigmented. *External:* Up to 5 small melanophores at tip of lower jaw. One or two melanophores on preanal membrane below midgut until flexion stage. Up to 4 small melanophores on either side of hindgut near constriction in preflexion larvae, becoming internal in flexion larvae and disappearing in postflexion larvae. *Internal:* Melanophores over hindgut during flexion stage.

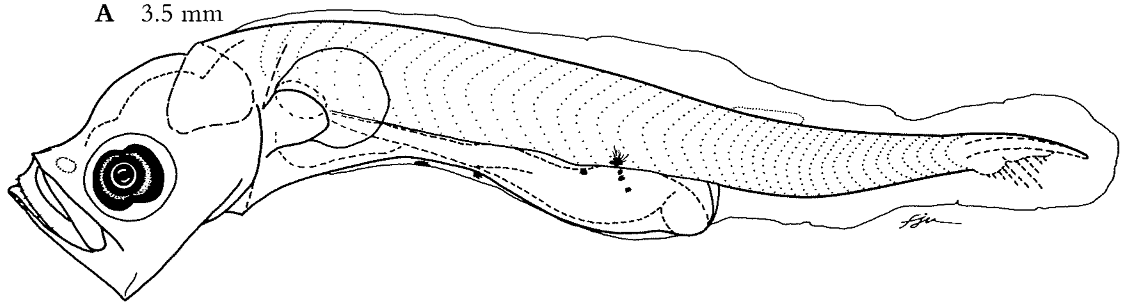
Material examined 13 larvae, 3.5–6.1 mm BL, Botany Bay (NSW).

Additional references –

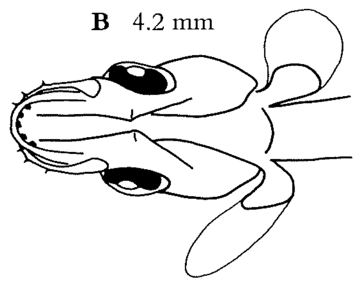
Figure 101 Larvae of *Odax cyanomelas*. **A** Preflexion. **B** Late preflexion; note developing dorsal and caudal fins. **C** Ventral view of head of larva in B; note teeth along premaxilla and melanophores around tip of lower jaw. **D** Flexion; note developing pectoral-fin rays and anal-fin anlage. **E** Late flexion. **F** Postflexion; note single coil of hindgut. A–F from Botany Bay (NSW). Illustrated by F. J. Neira.



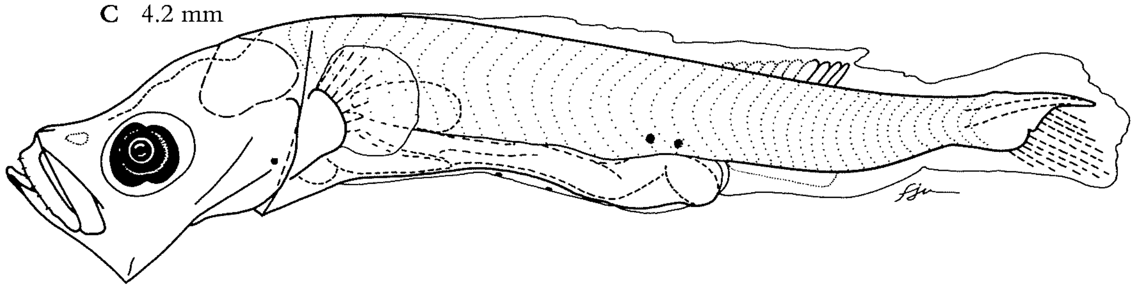
A 3.5 mm



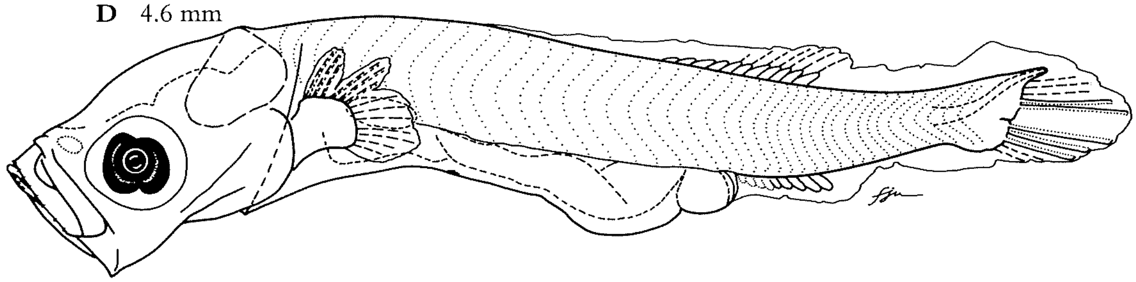
B 4.2 mm



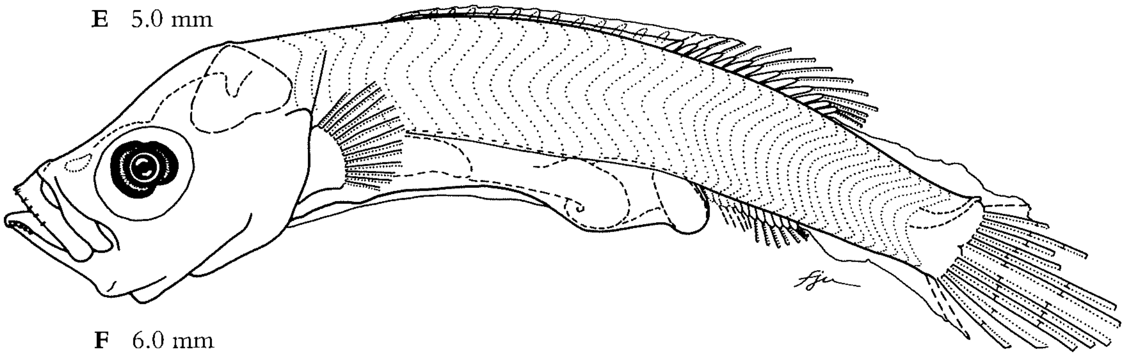
C 4.2 mm



D 4.6 mm



E 5.0 mm



F 6.0 mm

Odacidae *Siphonognathus argyrophanes* Richardson, 1858 Tubemouth

D XXII–XXVII, 19–22   A 0–II, 11–13 P_1 11–13 P_2 0   C 12–13   V 51–54

Adults Endemic to southern Australia from Lancelin (WA) to Wilsons Promontory (Vic) and Flinders Island (Bass Strait), excluding Tasmania. Occurs in shallow, sheltered coastal waters among seagrass and large brown algae. Adults have an elongate, slender body, an extremely elongate snout with a long, fleshy filament extending forward from the upper lip, a high number of dorsal-fin spines and no pelvic fins. This is the only odacid species which is not sexually dichromic. Most large specimens caught are females. Maximum size 52 cm (Gomon & Paxton, 1985; Hutchins & Swainston, 1986; Gomon *et al.*, 1994).

Importance to fisheries Occasionally caught by trawlers in weedy areas (Gomon *et al.*, 1994).

Spawning Eggs undescribed, although probably pelagic (Richards & Leis, 1984). Larvae have been caught in the lower reaches of the Swan Estuary (WA) in September, November and December (Neira *et al.*, 1992).

Diagnostic characters

- 32 + 21–22 = 53–54 myomeres
- 4–7 melanophores ventrally along dentary
- Internal melanophore series from roof of mouth to under brain, continuing dorsally over entire gut and ventrally along caudal peduncle before becoming external
- 1 melanophore on posterior end of dorsal-fin anlage by 4.8 mm
- Pigment around notochord tip and laterally on caudal peduncle

Description of larvae

Morphology Body elongate (BD 10–12%). Head small in early preflexion larva (HL 17%), moderate in late preflexion and flexion larvae (HL 22–25%); angle of lower jaw prominent. Gut long (PAL 63–69%), straight. Long preanal membrane. All three larvae examined were caught at night and each has an inflated gas bladder over foregut.

Size at

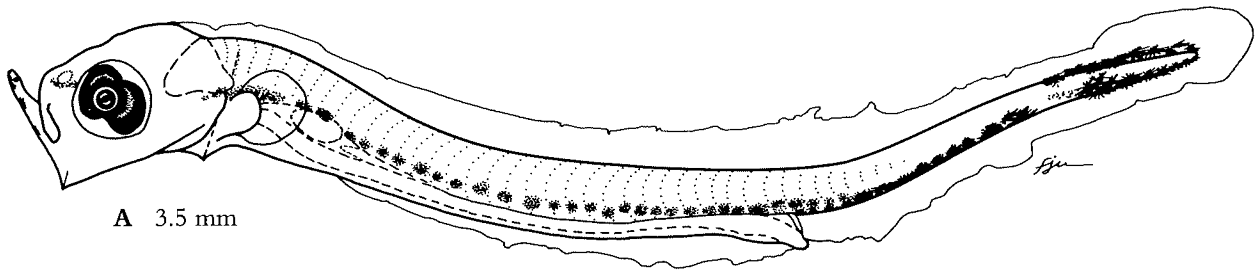
Hatching	<3.5 mm
Notochord flexion	5.0– – mm
Settlement	–
Formation of fins:	
Caudal ~4.8–>5.0 mm; Dorsal 4.8–>5.0 mm; Anal 4.8–>5.0 mm; Pectoral >5.0 mm	

Pigmentation Larvae are moderately pigmented; most pigment is internal. *External:* A few small melanophores on tip of lower jaw and 4-7 ventrally along dentary. Series of melanophores along ventral midline of tail and caudal peduncle, and pigment around notochord tip. One melanophore on posterior end of dorsal-fin anlage by late preflexion stage. Melanophores on lateral midline of trunk above anus and on lateral midline of caudal peduncle by late preflexion stage. *Internal:* Melanophore series along roof of mouth to under brain, continuing dorsally along entire gut and ventrally along caudal peduncle; another series along floor of mouth in 5.0 mm flexion larva. Pigment dorsally over gas bladder.

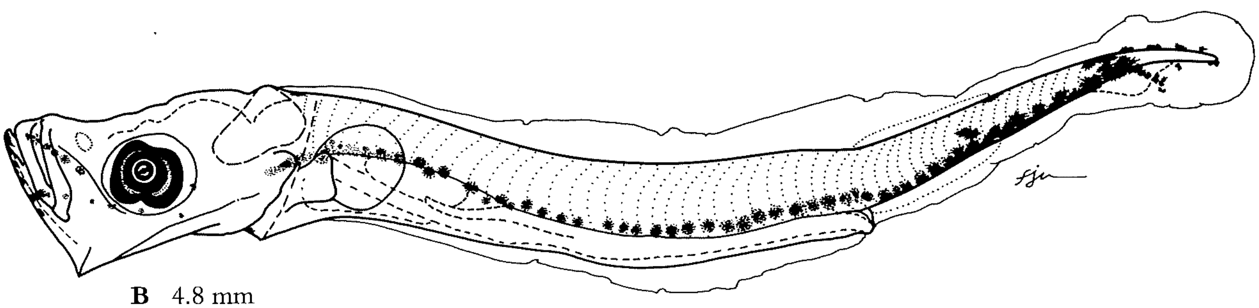
Material examined 3 larvae, 3.5–5.0 mm BL, lower Swan Estuary (WA).

Additional references –

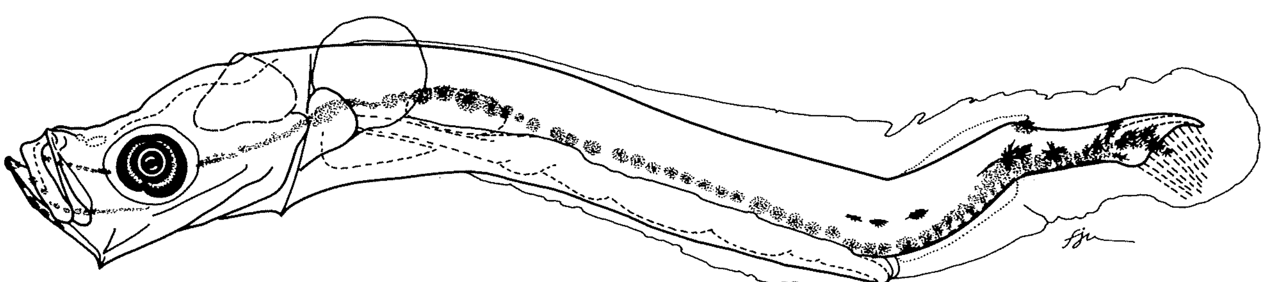
Figure 102 Larvae of *Siphonognathus argyrophanes*. **A** Preflexion; posterior myomeres not distinguishable. **B** Late preflexion; note caudal- dorsal- and anal-fin anlagen. **C** Flexion; myomeres omitted. A–C from lower Swan Estuary (WA). Illustrated by F. J. Neira.



A 3.5 mm



B 4.8 mm



C 5.0 mm

Notothenioidei

The Notothenioidei is a small perciform suborder of mostly marine, demersal fishes (some pelagic) found in temperate to polar regions of the Southern Hemisphere. Many species occur at various depths in sub-zero waters of Antarctica, with some living under the ice (cryopelagic). The suborder contains 6 families, 41 genera and about 122 species (Gon & Heemstra, 1990; Nelson, 1994). Families comprise the Artedidraconidae (plunderfishes), Bathydraconidae (dragonfishes), Bovichtidae (thornfishes), Channichthyidae (crocodile icefishes), Harpagiferidae (spiny plunderfishes) and Nototheniidae (Antarctic rock cods). Notothenioid fishes have three platelike pectoral-fin radials, jugular pelvic fins with one spine and five branched rays, usually one (bovichtids) or three lateral lines, and no gas bladder (Nelson, 1994). Larvae have been described for representatives of all families except the Bovichtidae which are described here for the first time (see review of early life history stages by Stevens *et al.*, 1984; see also Efremenko, 1983).

Family and species included here

BOVICHTIDAE
Bovichtus angustifrons
Pseudaphritis urvillii

Bovichtidae: Thornfishes

C.A. Sutton and B.D. Bruce

Bovichtids are predominantly marine fishes restricted to the Southern Hemisphere, with most representatives found in temperate to Antarctic waters (Nelson, 1994). The family contains 3 genera and about 11 species (Nelson, 1994). Two genera and 3 species have been recorded from temperate Australia: *Bovichtus angustifrons*, recently separated from the New Zealand *B. variegatus*, and two species of *Pseudaphritis* (Kuiter, 1993, 1996). *Pseudaphritis urvillii* occurs in estuaries and sometimes fresh water in southeastern Australia and Tasmania (Last *et al.*, 1983; Kuiter, 1993; Gomon *et al.*, 1994; Andrews, 1996). Adults (to 36 cm) are elongate, have a depressed head with dorsolateral eyes, two separate dorsal fins, the first short-based, and jugular pelvic fins (Last *et al.*, 1983; Gomon *et al.*, 1994). Eggs are unknown. The only known previous account of early stages is an illustration of a pelagic juvenile of *B. variegatus* (Robertson & Mito, 1979). Bovichtid larvae are diverse in appearance and the large size attained prior to settlement is their only apparent specialisation to pelagic life.

Meristic characters of bovichtid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Bovichtus	(1)	VIII + 18–19	12–18	15–16	I, 5	13–14	14–15 + 22–23 = 37–38
Pseudaphritis	(2)	VII–VIII + 19–26	II, 21–25	15–18	I, 5	14	40–42

Main characters of bovichtid larvae

- 37–42 myomeres
- Body very elongate to moderate (BD 9–33%)
- Head moderate and slender to almost triangular
- Late forming upper opercular spine, long in *Bovichtus*
- Gut moderate to long (PAL 44–57%), either straight or coiled but not compact
- 2 separate dorsal fins
- Pelvic fins jugular, originating anterior to cleithral symphysis
- Lightly to heavily pigmented body

References to bovichtid larvae

Stevens *et al.* (1984).

Families with similar larvae

Aplodactylidae (cf. *Bovichtus*) – 35 myomeres; no head spines; single, long-based dorsal fin, XVI–XVIII, 16–21; anal fin II–III, 6–8; pelvic fins abdominal; many small melanophores on caudal finfold and pigment around notochord tip.

Chironemidae (cf. *Bovichtus*) – 33 myomeres; no head spines; single, long-based dorsal fin, XIV–XVI, 14–20; anal fin III, 6–8; pelvic fins abdominal; melanophore series along lateral midline of tail; melanophores on caudal finfold and pigment around notochord tip.

Creediidae (cf. postflexion *Pseudaphritis*) – Single, spineless dorsal fin, 12–27; long-based, spineless anal fin, 24–30; gut with striations; body moderately pigmented, melanophore clusters along dorsal and ventral midlines of trunk and tail; lobed lateral-line scales from 8 mm.

Latridae (cf. *Bovichtus*) – No head spines; single, long-based dorsal fin, XVII–XXIII, 23–40; long-based anal fin, III, 18–35; pelvic fins slightly abdominal.

Microdesmidae (cf. postflexion *Pseudaphritis*) – 44–66 myomeres; no head spines; body extremely elongate; single, long-based dorsal fin, X–XXVIII, 28–66 (Microdesminae), or 2 dorsal fins, IV–VI + I, 9–37 (Ptereleotrinae); long-based anal fin, 23–61 rays (Microdesminae) or I, 9–36 (Ptereleotrinae).

Scomberesocidae (cf. *Bovichtus*) – 62–70 myomeres; dorsal and anal finlets.

Sillaginidae (cf. postflexion *Pseudaphritis*) – 32–35 myomeres in most taxa, 42–45 in *Sillaginodes*; late forming, very small preopercular spines in most taxa; gut long in postflexion larvae (PAL >55%), with weak striations along midgut.

Trichonotidae (cf. postflexion *Pseudaphritis*) – No head spines; gut long (PAL 50–70%), straight; small gas bladder above midgut, moves posteriorly with growth; >45 dorsal-fin elements; >35 anal-fin elements.

Bovichtidae *Bovichtus angustifrons* (Regan, 1913) Thornfish, dragonet

D VIII + 18–19 A 12–18 P_1 15–16 P_2 I, 5 C 13–14 V 37–38

Adults Endemic to southeastern Australia from the eastern Great Australian Bight (SA) to Eden (NSW), including Tasmania. Occurs in intertidal rock pools and on rocky reefs, to a depth of 15 m. Adults have a moderately elongate body, a triangular head with the mouth extending to below the anterior margin of the eye, a large, sharp spine on the upper opercular margin, and no scales. Maximum size 30 cm (Last *et al.*, 1983; Kuiter, 1993, 1996; Gomon *et al.*, 1994).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in coastal waters of Tasmania from July to November. Juveniles are common in rock pools in autumn (Last *et al.*, 1983).

Diagnostic characters

- 14–17 + 21–23 = 37–38 myomeres
- Large size at notochord flexion (7.7–10.6 mm)
- Long, sharp upper opercular spine in postflexion larvae
- Gut moderate to long (PAL 46–57%), loosely coiled
- Prominent preanal membrane until end of flexion stage
- Body heavily pigmented
- No pigment posterior to last 3–4 postanal myomeres until postflexion stage

Description of larvae

Morphology Body elongate in preflexion and flexion larvae (BD 17–20%), moderate in postflexion larvae >13 mm (BD 28–33%). Head moderate (HL 24–33%). Long, sharp upper opercular spine from postflexion stage, retained in adults. Gut moderate to long (PAL 46–57%), loosely coiled. Prominent preanal membrane in preflexion and flexion larvae.

Size at

Hatching	<6.1 mm
Notochord flexion	7.7–10.6 mm
Settlement	>30.1 mm

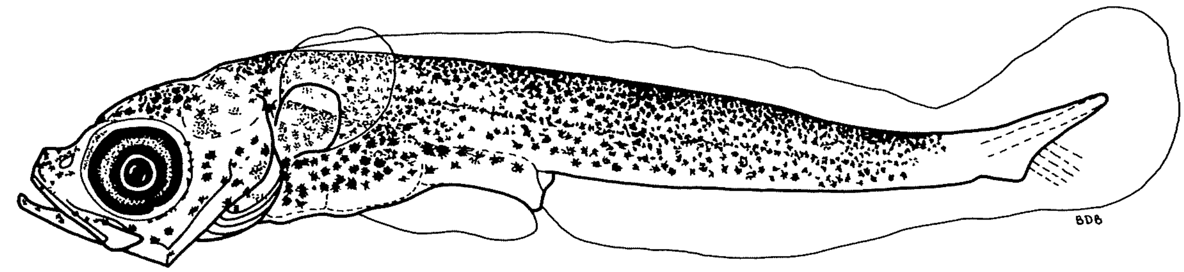
Formation of fins:
Caudal 7.6–10.6 mm; Pelvic 8.6–12.5 mm; Dorsal 9.8–12.5 mm; Anal 9.8–12.5 mm; Pectoral 10.4–12.5 mm

Pigmentation Larvae are heavily pigmented from flexion stage. *External:* Melanophores scattered over snout and nape; 1–2 melanophores on preopercular margin posterior to eye until late preflexion stage. Additional pigment around isthmus, and dorsally and laterally on head in all larvae from late preflexion stage. Pigment over entire body, except ventral surface of gut and tail and last 3–4 myomeres including notochord tip, by end of flexion stage. Large, stellate melanophores over anterior of gut in flexion and postflexion larvae; pigment progressively denser and darker, extending over entire gut and posteriorly to caudal peduncle and caudal-fin base by late postflexion stage. No pigment on preanal membrane. *Internal:* Scattered pigment above and anterior to otic capsule, and at base of hindbrain. Melanophores scattered on snout and dorsally along gut.

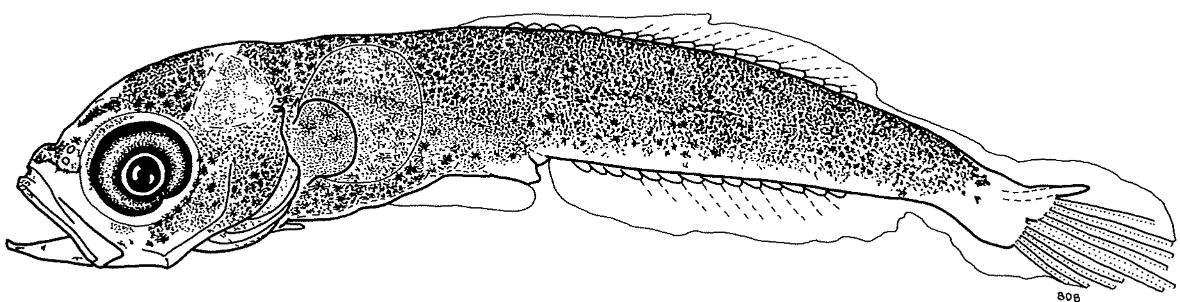
Material examined 22 larvae, 6.1–30.1 mm BL, Storm Bay and Southport (Tas), and coastal waters of eastern and western Tasmania.

Additional references –

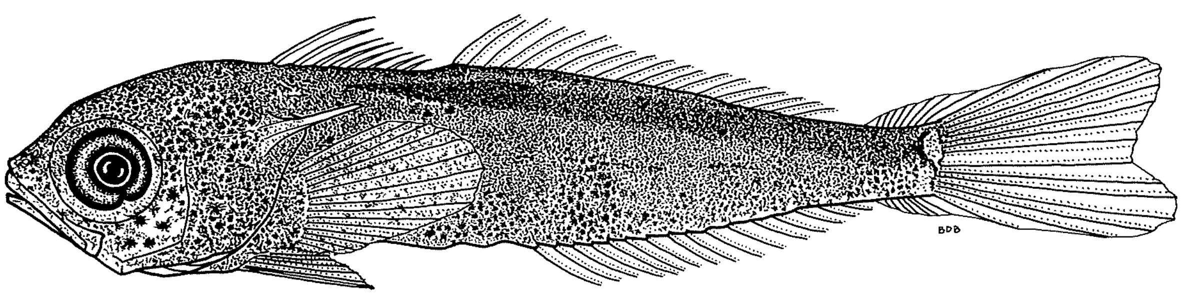
Figure 103 Larvae of *Bovichtus angustifrons*. **A** Early flexion. **B** Late flexion; note pelvic-fin bud. **C** Postflexion. Myomeres omitted in A–C. A–C from southern Tas coastal waters. Illustrated by B.D. Bruce.



A 8.5 mm



B 10.2 mm



C 17.3 mm

Bovichtidae *Pseudaphritis urvillii* (Valenciennes, 1831) Congolli

D VII–VIII + 19–22   A II, 21–25 P_1 18 P_2 I, 5   C 14   V 40–42

Adults Endemic to southern Australia from Streaky Bay (SA) to Bega (NSW), including Tasmania. Found in estuaries and lower portions of rivers, and occasionally in coastal waters, to a depth of 4 m; it prefers slow-flowing streams, where it is often partially buried amongst leaf litter. Adults have a shallow, elongate body covered with ctenoid scales, a moderately large, slightly depressed head, a large mouth with the lower jaw longer than the upper jaw, and a small, inconspicuous flattened spine near the upper opercular margin. Maximum size 36 cm (Last *et al.*, 1983; Gomon *et al.*, 1994; Andrews, 1996; Edgar, 1997).

Importance to fisheries Occasionally caught by recreational anglers, but of no commercial importance. Adapts well to aquaria (Andrews, 1996).

Spawning Eggs undescribed. Little is known on the breeding biology of this species other than it spawns in estuaries (Gomon *et al.*, 1994). Late postflexion larvae have been caught in Barker Inlet (near Adelaide, SA) from July to September. Settlement larvae have been caught in Gippsland Lakes (Vic) in November (F.J. Neira, pers. comm.).

Diagnostic characters

- 12–13 + 27–28 = 39–40 myomeres
- Body very elongate (BD 9–10%)
- No pigment on head, and dorsal and lateral surfaces of trunk and tail
- Prominent stellate melanophore at pelvic-fin base
- Series of stellate melanophores laterally along gut
- Series of melanophores along anal-fin base, about 1 per anal-fin pterygiophore

Description of larvae

Morphology Body very elongate (BD 9–10%), caudal peduncle relatively deep. Head moderate (HL 23–25%), without spines. Lower jaw protrudes beyond upper jaw. Minute villiform teeth along premaxilla and dentary. Upper margin of opercle elongate. Gut moderate (PAL 44–46%), straight.

Size at

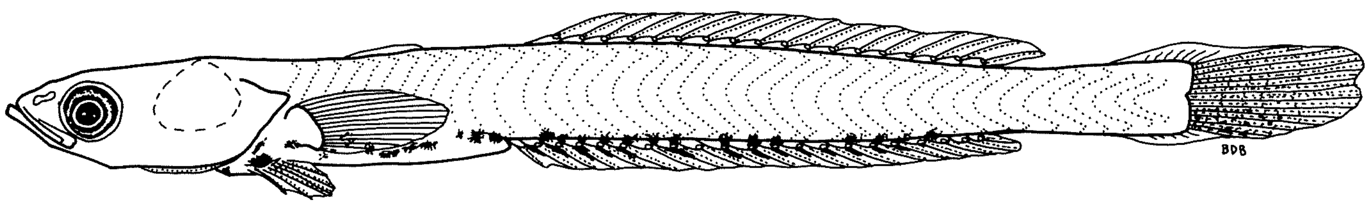
Hatching	–
Notochord flexion	<14.1 mm
Settlement	>15.9 mm
Formation of fins:	
Caudal <14.1 mm; Dorsal <14.1–>15.9 mm; Anal <14.1–>15.9 mm; Pectoral <14.1–>15.9 mm; Pelvic <14.1 mm	

Pigmentation Postflexion larvae are lightly pigmented; pigment is restricted to ventral surface of body. *External:* 2 elongate melanophores on isthmus, just anterior to cleithral symphysis; 1 prominent melanophore at pelvic-fin base. A small melanophore may be present on ventral margin of pectoral-fin base. Series of melanophores laterally along gut, and along anal-fin base, about 1 per anal-fin pterygiophore. Elongate melanophores along anal-fin rays. Small, scattered melanophores over lower caudal-fin rays. *Internal:* No visible pigment.

Material examined 5 larvae, 14.1–15.9 mm BL, Barker Inlet (near Adelaide, SA).

Additional references –

Figure 104 Postflexion larva of *Pseudaphritis urvillii*. From Barker Inlet (SA). Illustrated by B.D. Bruce.



15.9 mm

Trachinoidei

The Trachinoidei is a small, morphologically diverse perciform suborder of predominantly marine, demersal fishes found in tropical regions of most oceans, and occasionally in cold temperate regions (Watson *et al.*, 1984; Pietsch, 1989; Nelson, 1994). The interrelationships of the various taxa within the group remain uncertain despite recent studies (e.g. Pietsch, 1989; Johnson, 1993; Nelson, 1994). According to Nelson (1994), the suborder comprises 13 families, 51 genera and about 212 species. Families include the Ammodytidae (sand lances), Champsodontidae (gapers), Cheimarrichthyidae, Creediidae (sand burrowers), Leptoscopidae (sandfishes), Percophidae (duckbills), Pinguipedidae (sandperches, grubfishes), Trichonotidae (sand divers) and Uranoscopidae (stargazers). Larvae have been described for representatives of most families except the monotypic freshwater Cheimarrichthyidae (see review of early life history stages by Watson *et al.*, 1984; see also Kojima, 1988e; Kojima & Mori, 1988; Mori, 1988a,b; Neira & Gaughan, 1989; Trnski *et al.*, 1989; Watson, 1989, 1996m).

Families and species included here

CREEDIIDAE
Creedia haswelli
Limnichthys fasciatus
Schizochirus insolens

LEPTOSCOPIDAE
Lesueurina platycephala

PERCOPHIDAE
Enigmapercis reducta

PINGUIPEDIDAE
Parapercis haackei

Creediidae: Tommyfishes, sand divers

S.E. Reader and F. J. Neira

Creediids are small, demersal and burrowing marine fishes found in sand and gravel substrates in coastal waters of tropical to temperate regions of the Indian and Pacific oceans. The family contains 7 genera and about 16 species (Nelson, 1978, 1983, 1985, 1994; Nelson & Randall, 1985). Three genera and 5 species have been recorded from temperate Australia (Kuiter, 1993; Gomon *et al.*, 1994). Adults (to 8 cm) are elongate, have a slightly subterminal mouth with a row of cirri bordering the lower jaw, spineless dorsal and anal fins, jugular pelvic fins, fully or partially scaled bodies, and lateral line scales often with trilobed posterior extensions (Nelson, 1994). Eggs of *Limnichthys donaldsoni* and *Crystallodytes cookei* are pelagic and spherical, 0.7–1.1 mm in diameter (Leis, 1982). Larvae have been described for the above two species, and for *L. fasciatus* (Leis, 1982; Leis & Rennis, 1983; Mori, 1988b) and *Tewara cranwelli* (postflexion larva; Crossland, 1982). The preopercular spination is the only apparent specialisation of creediid larvae to pelagic life (Leis & Rennis, 1983).

Meristic characters of the creediid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Creedia	(3)	12–16	24–28	8–13	I, 3–5	11	42–47
Limnichthys	(1)	24–27	26–30	11–13	I, 5	10	40–42
Schizochirus	(1)	18–20	28–29	16–17	I, 5	11	40*

* AMS cleared and stained specimen

Main characters of creediid larvae

- 37–59 myomeres
- Body very elongate to elongate (BD 8–19%)
- Snout elongate by flexion stage, with an overhanging snout by late postflexion stage
- Small posterior preopercular spines from 3–5 mm, disappearing from 9 mm
- Lateral-line scales with posterior lobes from 8 mm
- Gut moderate to long (PAL 44–62%), with striations, and either initially straight and coiled by end of flexion stage or remaining straight throughout development
- Gas bladder absent in most taxa (present in *Schizochirus*)
- Long-based, spineless anal fin
- Pelvic fins short and jugular, originating slightly anterior to pectoral-fin bases
- Body moderately pigmented; numerous small melanophores, in series or clusters, along dorsal and ventral midlines of trunk and tail

References to creediid larvae

Leis (1982), Leis & Rennis (1983), Mori (1988b).

Families with similar larvae

Ammodytidae – 51–69 myomeres; very small preopercular spines between 10 and 16 mm; gut long (PAL 59–70%) and straight, without striations; long-based dorsal fin, 40–69 rays.

Bovichtidae (postflexion *Pseudaphritis*) – 2 dorsal fins, first with VII–VIII spines; anal fin II, 21–25; no striations along gut; scales not lobed; body lightly pigmented, prominent melanophore at pelvic-fin base.

Chanidae, **Clupeidae**, **Engraulidae**, **Gonorynchidae** – No head spines; gut long to very long in most taxa (PAL 60–94%; *Coilia* = 48–74%); striated hindgut; pelvic fins abdominal and spineless.

Gonostomatidae (Gonostomatinae, e.g. *Cyclothone*, *Gonostoma*) – 28–42 myomeres; no head spines; series of separate photophores ventrally along body from about 10 mm; pectoral fins pedunculate.

Microdesmidae – No head spines; body extremely elongate; single, long-based dorsal fin, X–XXVIII, 28–66 (Microdesminae), or 2 dorsal fins, IV–VI + I, 9–37 (Ptereleotrinae); long-based anal fin, 23–61 (Microdesminae) or I, 9–36 (Ptereleotrinae).

Percophidae – 32–34 myomeres; no head spines; early forming, elongate pelvic-fin rays in some taxa.

Sillaginidae – 32–35 myomeres in most taxa, 42–45 in *Sillaginodes*; gut long (PAL >55%); 2 separate dorsal fins; long-based anal fin, II, 15–24; lateral-line scales not lobed; melanophore series ventrally along gut.

Synodontidae (early stages) – 46–65 myomeres; no head spines; gut long to very long (PAL 66–92%); prominent pigment blotches along dorsolateral surface of gut.

Trichonotidae – No head spines; gut long and straight (PAL 50–70%), without striations; small gas bladder above midgut, moves posteriorly with growth; >45 dorsal-fin elements; >35 anal-fin elements.

Creediidae *Creedia haswelli* (Ramsay, 1881) Slender sand diver

D 13–15 A 24–28 P_1 8–9 P_2 I, 4 C 11 V 42–45

Adults Endemic to southern Australia from Cape Leeuwin (WA) to Newcastle (NSW), including northeastern Tasmania. Occurs in coastal areas, and burrows in sand or gravel substrates in depths from 27 to 55 m. Adults are very elongate with a pointed snout, and have small dorsally positioned eyes and a translucent body with darker pigment dorsally and mid-laterally. Maximum size 7.5 cm (Nelson, 1983; Kuiter, 1993; Gomon *et al.*, 1994).

Importance to fisheries –

Spawning Eggs undescribed but probably spherical and pelagic (Leis, 1982). Larvae have been caught in coastal waters off Perth (WA) from March to May and September to December, in Botany Bay (NSW) in March (A.S. Steffe, pers. comm.), and in coastal waters of central New South Wales in May, July and September to December (A.G. Miskiewicz, pers. comm.).

Diagnostic characters

- 14–21 + 24–29 = 41–45 myomeres
- Gut initially straight, with a single coil and striations from 4 mm
- 1–6 posterior preopercular spines
- Melanophore series along dorsal midline of trunk and tail; series along dorsal-fin base paired from flexion stage, series along trunk disappears from early postflexion stage

Description of larvae

Morphology Body very elongate to elongate (BD 8–14%), laterally compressed. Head moderate (HL 22–29%), snout elongate and flattened by end of flexion stage. Small villiform teeth along both jaws by early preflexion stage. One to six posterior preopercular spines from late preflexion stage, 2 remaining by 11.4 mm. Gut moderate to long (PAL 46–58%), initially straight, with a single coil posteriorly from late preflexion stage; striations along gut in flexion and postflexion larvae. Very small gas bladder over midgut. Anus migrates anteriorly by 4–6 myomeres during flexion stage. Lobed lateral-line scales first appear in 10–11 mm larvae.

Size at

Hatching	<3.0 mm
Notochord flexion	5.0–7.5 mm
Settlement	11.4–16.3 mm
Formation of fins:	

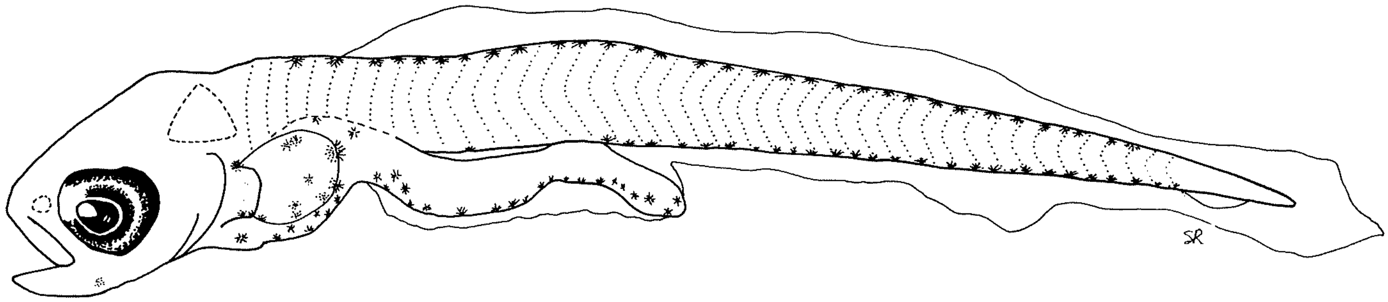
Caudal 4.6–7.5 mm; Dorsal 5.4–7.5 mm; Anal 5.4–7.5 mm; Pelvic 6.5–>11.4 mm; Pectoral 7.0–>11.4 mm

Pigmentation Larvae are lightly pigmented. *External:* 1 melanophore at angle of lower jaw; numerous scattered on isthmus, and along ventral and ventrolateral surfaces of entire gut. Series of melanophores along dorsal midline of trunk, and dorsal and ventral midlines of tail; series along dorsal- and anal-fin bases paired from flexion stage, dorsal trunk series gradually disappears from early postflexion stage. Series of melanophores along anal-fin rays in early postflexion larvae. Two to four melanophores ventrally on caudal-fin membrane and along lower caudal-fin base by early postflexion stage; additional melanophores extend to upper caudal-fin rays with growth. One to three melanophores on ventral edge of pectoral-fin base or membrane; 1–3 behind pectoral-fin base, and 1 at upper pectoral axil. Additional melanophores may be present on branchiostegal rays and laterally on body. *Internal:* No visible pigment.

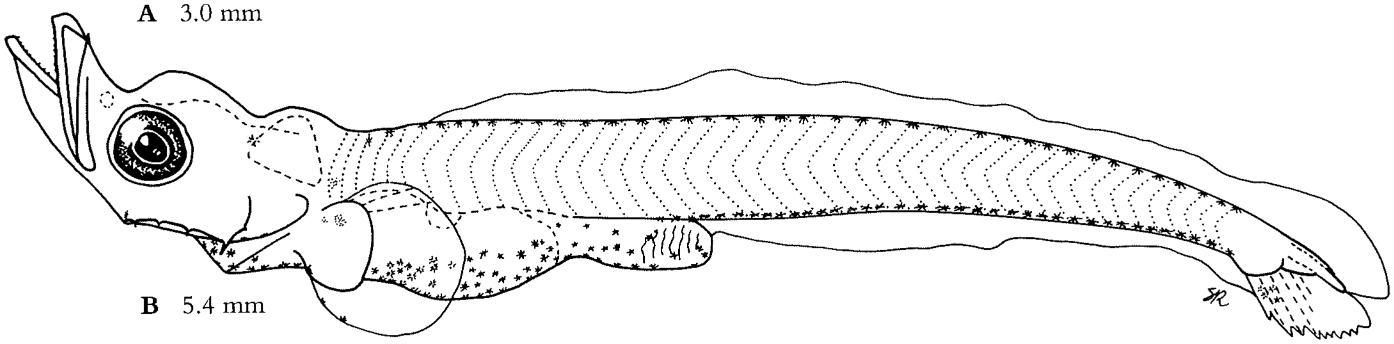
Material examined 30 larvae, 3.0–11.4 mm BL, and 1 juvenile, 16.3 mm BL, Sydney Harbour and Botany Bay (NSW), and coastal waters of central New South Wales.

Additional references –

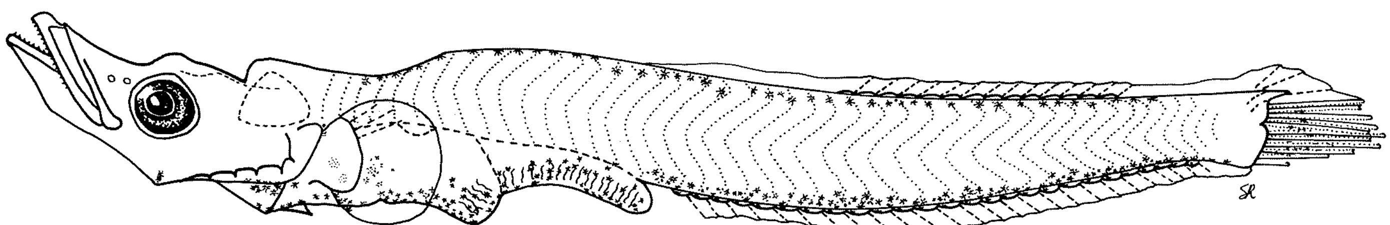
Figure 105 Larvae of *Creedia haswelli*. **A** Preflexion. **B** Early flexion; note preopercular spines and coiled gut striated posteriorly. **C** Early postflexion; note pelvic-fin bud. **D** Postflexion; note lobed lateral-line scales. A–C from Sydney coastal waters (NSW); D from Botany Bay (NSW). Illustrated by S.E. Reader.



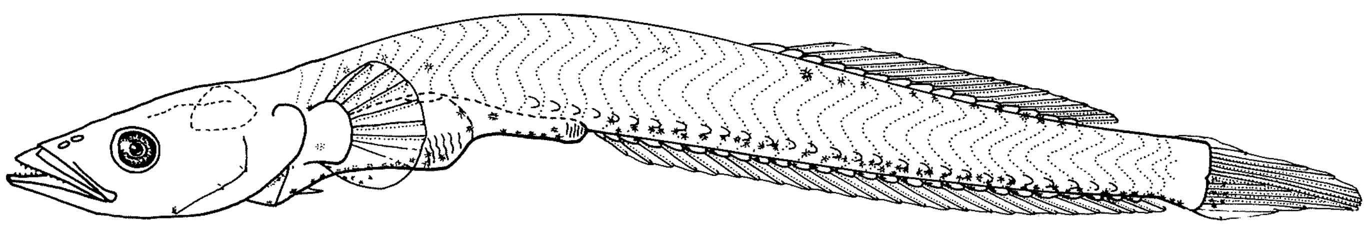
A 3.0 mm



B 5.4 mm



C 7.3 mm



D 11.4 mm

Creediidae *Limnichthys fasciatus* Waite, 1904 Tommyfish

D 24–27 A 26–30 P_1 11–13 P_2 I, 5 C 10 V 40–42

Adults Distributed in Australia from the Dampier Archipelago to the Recherche Archipelago (WA) on the west coast, and from northern Queensland to Bermagui (NSW) on the east coast. Also widespread in the western Pacific and eastern Indian oceans, including Lord Howe and Norfolk islands, New Zealand, Japan and Taiwan. The only representative of the genus in Australia. Occurs in small to large aggregations in shallow waters on sandy bottoms near boulder reefs, where they bury in the sand with only their eyes exposed. Adults are very elongate, have a pointed snout and small dorsally positioned eyes, and a creamy body with about eight dark blotches laterally along the body. Maximum size 6 cm (Nelson, 1978; Allen & Swainston, 1988; Kuiter, 1993; Gomon *et al.*, 1994).

Importance to fisheries –

Spawning Eggs undescribed. Eggs of *L. donaldsoni* are pelagic and spherical, about 0.8 mm in diameter, and have clusters of small oil globules (Leis, 1982). Larvae of *L. fasciatus* have been caught in Wilson Inlet (WA) in November (Neira & Potter, 1992b), in coastal waters off Sydney (NSW) from March to May (Gray, 1995), and in Botany Bay (NSW) in March (A.S. Steffe, pers. comm.).

Diagnostic characters

- 14–19 + 21–27 = 40–42 myomeres
- 7–17 small posterior preopercular spines, absent from 11 mm
- Up to 6 evenly spaced melanophore clusters along dorsal midline of trunk and tail
- 3 evenly spaced melanophore clusters along ventral midline of tail, opposite to dorsal clusters

Description of larvae

Morphology Body elongate (BD 10–15%), laterally compressed. Head moderate (HL 21–31%), snout elongate and flattened by end of flexion stage. Small villiform teeth along both jaws. Eyes migrate dorsolaterally during flexion stage. Seven small posterior preopercular spines in smallest larva, up to 17 small spines by postflexion stage, all disappearing by 11 mm. Gut moderate to long (PAL 47–62%), straight and striated; striations obscured by 10 mm. Lateral-line scales by 10 mm, bilobed by 11 mm.

Size at

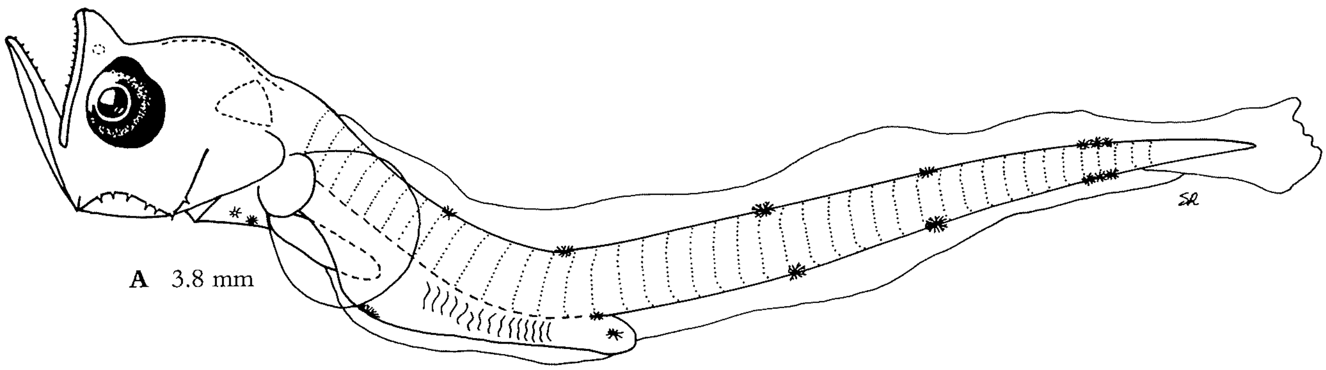
Hatching	<3.7 mm
Notochord flexion	4.0–6.0 mm
Settlement	11.0–14.0 mm
Formation of fins:	
Caudal 4.9–7.0 mm; Dorsal 4.9–7.0 mm; Anal 4.9–7.0 mm; Pelvic 4.9–8.0 mm; Pectoral 8.0–12.1 mm	

Pigmentation Larvae are lightly pigmented. *External:* A few expanded melanophores ventrally and laterally just posterior to cleithral symphysis, 1 remaining in postflexion larvae. One to three stellate melanophores ventrally on gut and at anus. Four to six evenly spaced melanophores along dorsal midline of trunk and tail in preflexion larvae, becoming clusters each with up to 4 melanophores and increasing to up to 6 clusters in postflexion larvae. Three evenly spaced melanophores along ventral midline of tail, opposite dorsal midline clusters, becoming clusters in postflexion larvae. *Internal:* No visible pigment.

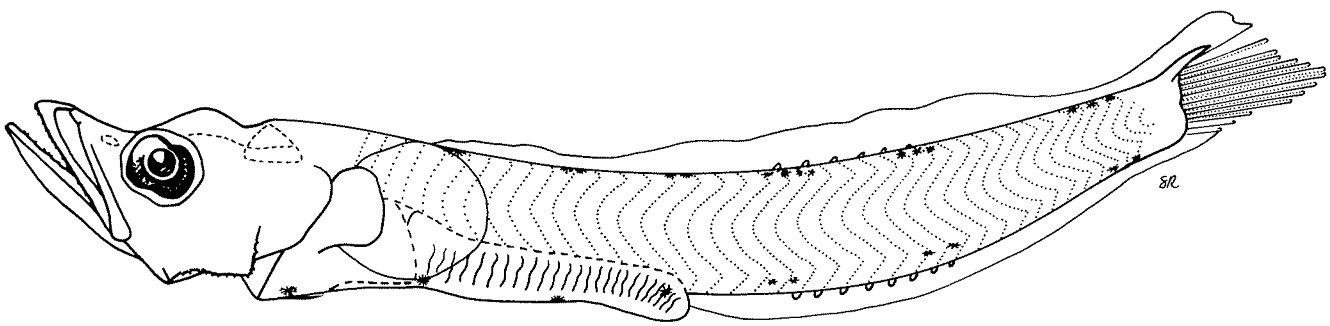
Material examined 16 larvae, 3.7–11.0 mm BL, Wilson Inlet (WA), and Botany Bay and coastal waters off Sydney (NSW); 9 juveniles, 12.1–18.6 mm BL, Lizard Island (north of Cairns, Qld), and Lord Howe Island.

Additional references Note: the larvae illustrated by Mori (1988b) are most likely *L. donaldsoni* and not *L. fasciatus*.

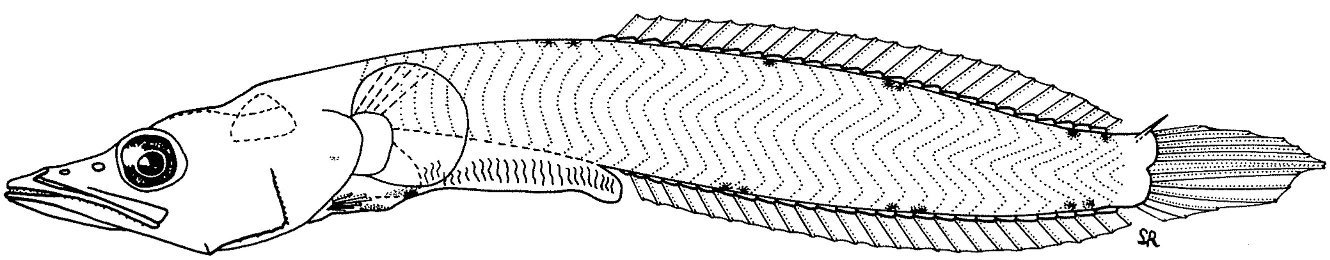
Figure 106 Larvae of *Limnichthys fasciatus*. **A** Preflexion; note small preopercular spines and striated gut. **B** Late flexion; note pelvic-fin bud. **C** Postflexion. **D** Postflexion; note lobed lateral-line scales. A–C from Sydney coastal waters (NSW); D from Wilson Inlet (WA). Illustrated by S.E. Reader.



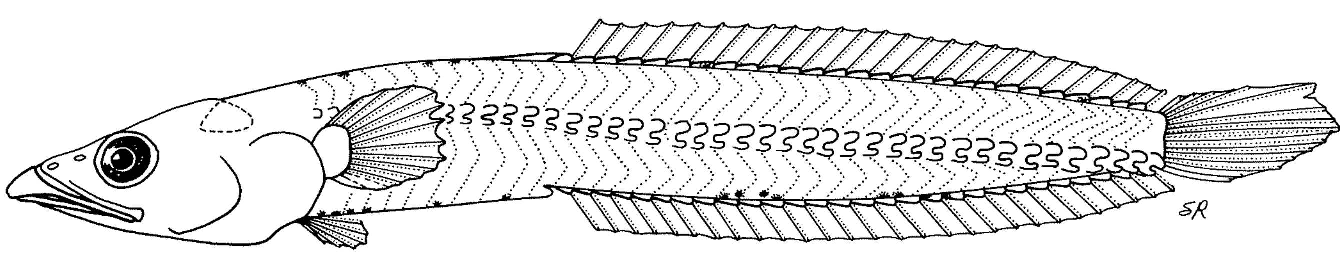
A 3.8 mm



B 5.9 mm



C 8.4 mm



D 11.0 mm

Creediidae *Schizochirus insolens* Waite, 1904 Sand diver

D 18–20 A 28–29 P_1 16–17 P_2 I, 5 C 11 V* 40
* From AMS cleared and stained specimen

Adults Endemic to eastern Australia from Rockhampton (Qld) to Sydney (NSW), and known only from a few specimens. Small demersal species found in bays and coastal waters. Adults have branched anal-, pectoral- and most pelvic-fin rays, and lack dorsal saddles of pigment. Maximum size 5.3 cm (Nelson, 1978, 1985; AMS records).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in coastal waters of central New South Wales in April, May and September (A.G. Miskiewicz, pers. comm.), and in Botany Bay (NSW) in March (A.S. Steffe, pers. comm.).

Diagnostic characters

- 10–14 + 24–29 = 37–40 myomeres
- Up to 6 posterior preopercular spines from late preflexion stage
- Melanophore series along dorsal midline of trunk and tail to caudal peduncle
- Melanophore series along lateral midline of trunk and tail, about 1 per myomere
- Melanophore series along ventral midline of tail

Description of larvae

Morphology Body elongate (BD 13–19%), laterally compressed. Head moderate to large (HL 28–38%), snout elongate and flattened by end of flexion stage. Mouth large with small villiform teeth along both jaws. Three small posterior preopercular spines by 3.6 mm, up to 6 by postflexion stage, disappearing from 10 mm; one spine remains at angle of preopercle by 12 mm. Gut moderate to long (PAL 44–61%), initially straight, with a single coil by 3.6 mm; striations visible from flexion stage but obscured by postflexion stage. Anus migrates anteriorly by about 4 myomeres during flexion stage. Conspicuous gas bladder over gut, not always inflated. Lobed scales form by 8 mm; a single, well developed row of scales by 11.8 mm, extending from lower caudal peduncle to pectoral-fin base, and a second row of round scales dorsal to the first, developing from posterior to anterior.

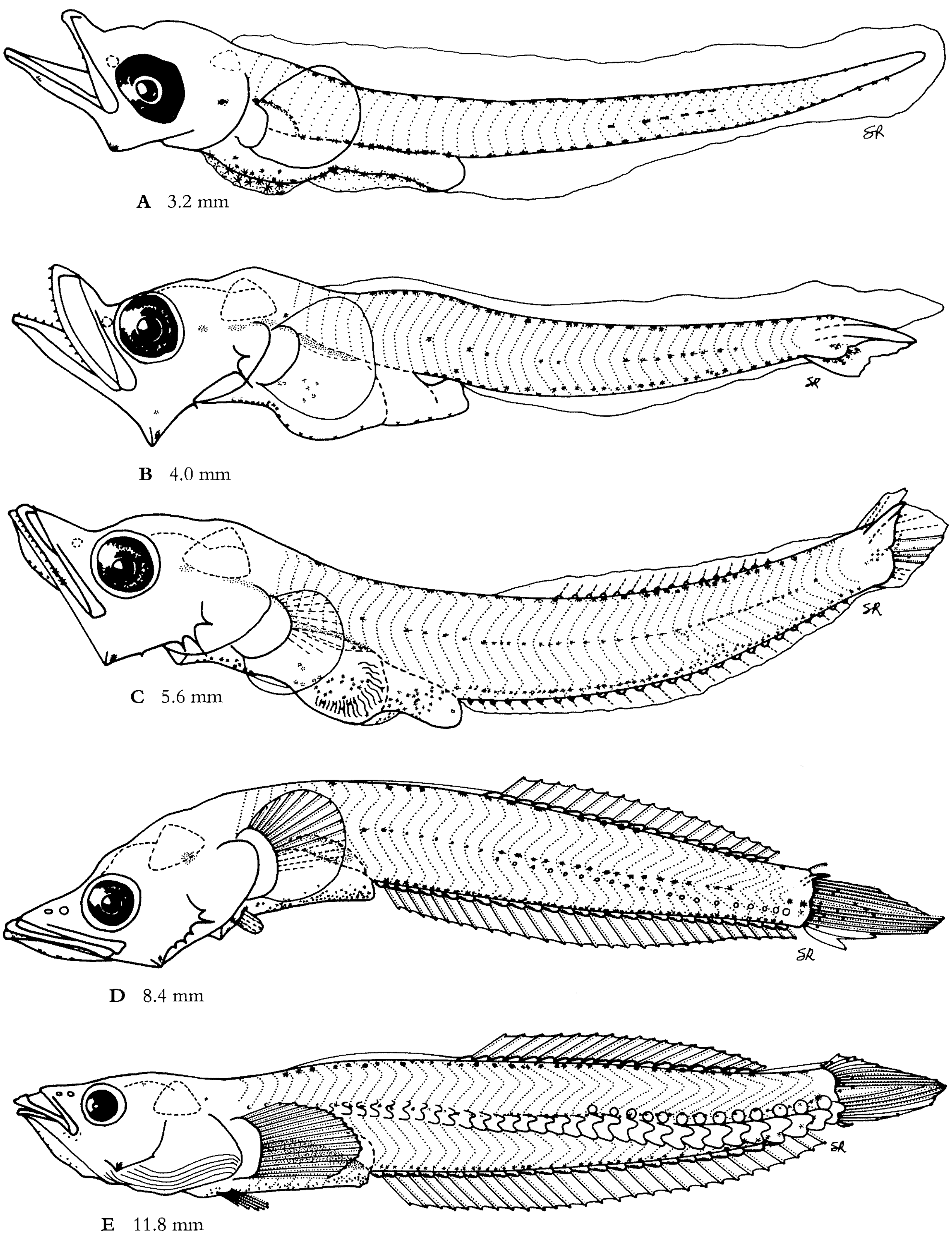
Size at	
Hatching	<3.2 mm
Notochord flexion	4.1–5.8 mm
Settlement	>12.0 mm
Formation of fins:	
Caudal 3.6–6.0 mm; Dorsal 4.8–5.8 mm; Anal 4.8–5.9 mm; Pectoral 4.8–9.0 mm; Pelvic 6.0–9.0 mm	

Pigmentation Larvae are lightly pigmented. *External:* 1 melanophore at angle of lower jaw; some may be present on premaxilla and along dentary; series of melanophores along gular membrane in most larvae. Numerous fine melanophores around cleithral symphysis, and ventral and lateral surfaces of gut. Melanophore series along dorsal midline of trunk and tail, single from just posterior of nape to dorsal-fin origin, paired along dorsal-fin base and single along caudal peduncle. Melanophore series along lateral midline by flexion stage, extending from above gut to anterior of caudal peduncle, about 1 per myomere. Melanophore series along ventral midline of tail in preflexion larvae, paired along anal-fin base in postflexion larvae. Pigment on ventral surface of caudal peduncle in preflexion larvae, extending over caudal-fin base and posteriorly onto caudal-fin rays in postflexion larvae. *Internal:* 1–2 melanophores laterally on midbrain, and pigment under hindbrain by late preflexion stage. Light pigment dorsally over gas bladder and gut.

Material examined 24 larvae, 3.2–12.0 mm BL, Lake Macquarie, Botany Bay and coastal waters off Sydney (NSW).

Additional references –

Figure 107 Larvae of *Schizochirus insolens*. **A** Preflexion; note coiled gut. **B** Preflexion. **C** Late flexion; note striations on gut. **D** Postflexion; note developing pelvic fin. **E** Postflexion; note row of lobed and round scales along trunk and tail. A from Lake Macquarie (NSW); B, C from coastal waters off Botany Bay (NSW); D from coastal waters off Port Macquarie (NSW); E from coastal waters off Ballina (NSW). Illustrated by S.E. Reader.


A 3.2 mm
B 4.0 mm
C 5.6 mm
D 8.4 mm
E 11.8 mm

Leptoscopidae: Sandfishes

F. J. Neira

Leptoscopids are marine fishes endemic to Australia and New Zealand, most of which are found buried in soft substrates along surf zones off exposed beaches. The New Zealand species *Leptoscopus macropygus* has also been recorded in the lower reaches of rivers (McDowall, 1990). The family comprises three genera with approximately five species. Two genera and at least three species have been recorded from temperate Australia (Last *et al.*, 1983; Last & Edgar, 1987; Kuiter, 1993; Gomon *et al.*, 1994). Adults (to 12 cm) are elongate, have small, dorsally positioned eyes, a wide mouth with dense fringes of cirri in both jaws, jugular pelvic fins, and long-based, spineless dorsal and anal fins, the anal-fin base slightly longer (Scott *et al.*, 1980; Last *et al.*, 1983; Last & Edgar, 1987; Gomon *et al.*, 1994). Eggs of *Crapatalus angusticeps* are pelagic and spherical, 0.65-0.72 mm in diameter, and have a single oil globule (Robertson, 1975a). Larvae have only been described for *Lesueurina platycephala* (as *Lesueurina* sp., Neira & Gaughan, 1989). The laterally positioned eyes, which become dorsal at settlement, constitute the only apparent specialisation of leptoscopid larvae to pelagic life (Neira & Gaughan, 1989).

Meristic characters of leptoscopid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal (segmented)	Vertebrae
Crapatalus	(2)	35–38	36–38	20–23	I, 5	12	–
Lesueurina	(1)	31–37	34–37	17–21	I, 5	12	10 + 35 = 45

Main characters of leptoscopid larvae

- 42–48 myomeres
- Body elongate (BD 12–18%), laterally compressed
- Eyes laterally positioned in *Lesueurina* larvae prior to settlement, becoming dorsal during settlement
- No head spines
- Gut short (PAL 20–29%), coiled and compact
- Pelvic fins jugular
- Dorsal and anal fins spineless; anal-fin base slightly longer than dorsal-fin base
- Body lightly pigmented
- Large, conspicuous melanophore ventrally along posterior region of tail in *Lesueurina* larvae

References to leptoscopid larvae

Watson *et al.* (1984), Neira & Gaughan (1989).

Families with similar larvae

Atherinidae – 2 short-based, well separated dorsal fins, second located posteriorly on body; posteriorly located, short-based anal fin; pelvic fins abdominal; pigment over midbrain and along lateral midline of tail; pigment often along dorsal midline of tail.

Blenniidae – Typically 30–40 myomeres; weak to well developed preopercular spines; often large canine teeth; dorsal-fin base longer than anal-fin base, dorsal fin with spinuous portion.

Carapidae (early stages) – >82 myomeres; body extremely elongate with filamentous tail; vexillum present; lack pelvic and caudal fins; melanophores around notochord tip.

Notocheiridae (= Isonidae) – 35–38 myomeres; 2 well separated dorsal fins, second located posteriorly; one large stellate melanophore over midbrain, followed by 1–2 smaller melanophores over hindbrain; melanophore series along dorsal midline of tail.

Leptoscopidae *Lesueurina platycephala* Fowler, 1908 Common sandfish

D 32–37 A 34–37 P_1 17–21 P_2 I, 5 C 12 V 45

Adults Distributed along southern Australia from Geraldton (WA) to Moreton Bay (Qld), including Tasmania. Occurs in shallow sandy substrates in protected marine embayments and off exposed coastal beaches. *Crapatalus arenarius* is a synonym. Adults have a depressed head, eyes located dorsally, a lower jaw that projects beyond the snout, and cirri on both upper and lower lips. Maximum size 11 cm (Last *et al.*, 1983; Gomon *et al.*, 1994).

Importance to fisheries –

Spawning Eggs undescribed, although probably small and pelagic as in most other trachinoids (Watson *et al.*, 1984). Adults from Tasmania have running ripe gonads between November and December (P.R. Last, CSIRO, Hobart, pers. comm.). Larvae have been collected in the lower Swan Estuary (WA) from June to November (Neira & Gaughan, 1989; Neira *et al.*, 1992). Settlement larvae have been caught at Noarlunga Reef, Gulf St Vincent (SA), in November (B.D. Bruce, pers. comm.).

Diagnostic characters

- 4–7 + 37–44 = 42–48 myomeres
- Large internal melanophore over peritoneum
- Large, conspicuous ventral melanophore on posterior region of tail, between myomeres 29–35
- Pigment on inner surface of pectoral-fin base, extending onto lower pectoral-fin rays during postflexion stage
- No pigment dorsally along body prior to settlement

Description of larvae

Morphology Body elongate (BD 12–18%). Dermal sac encloses most of body in early preflexion larvae. Head small to moderate (HL 15–24%), round. Eyes lateral in all larval stages, dorsally positioned by settlement. Small villiform teeth on both jaws by flexion stage; fringe of cirri form before settlement. Gut short (PAL 20–29%), coiled and compact. Gas bladder visible over gut. Dorsal- and anal-fin rays develop from posterior to anterior.

Size at

Hatching	<2.9 mm
Notochord flexion	6.0–8.5 mm
Settlement	~14.0 mm
Formation of fins:	

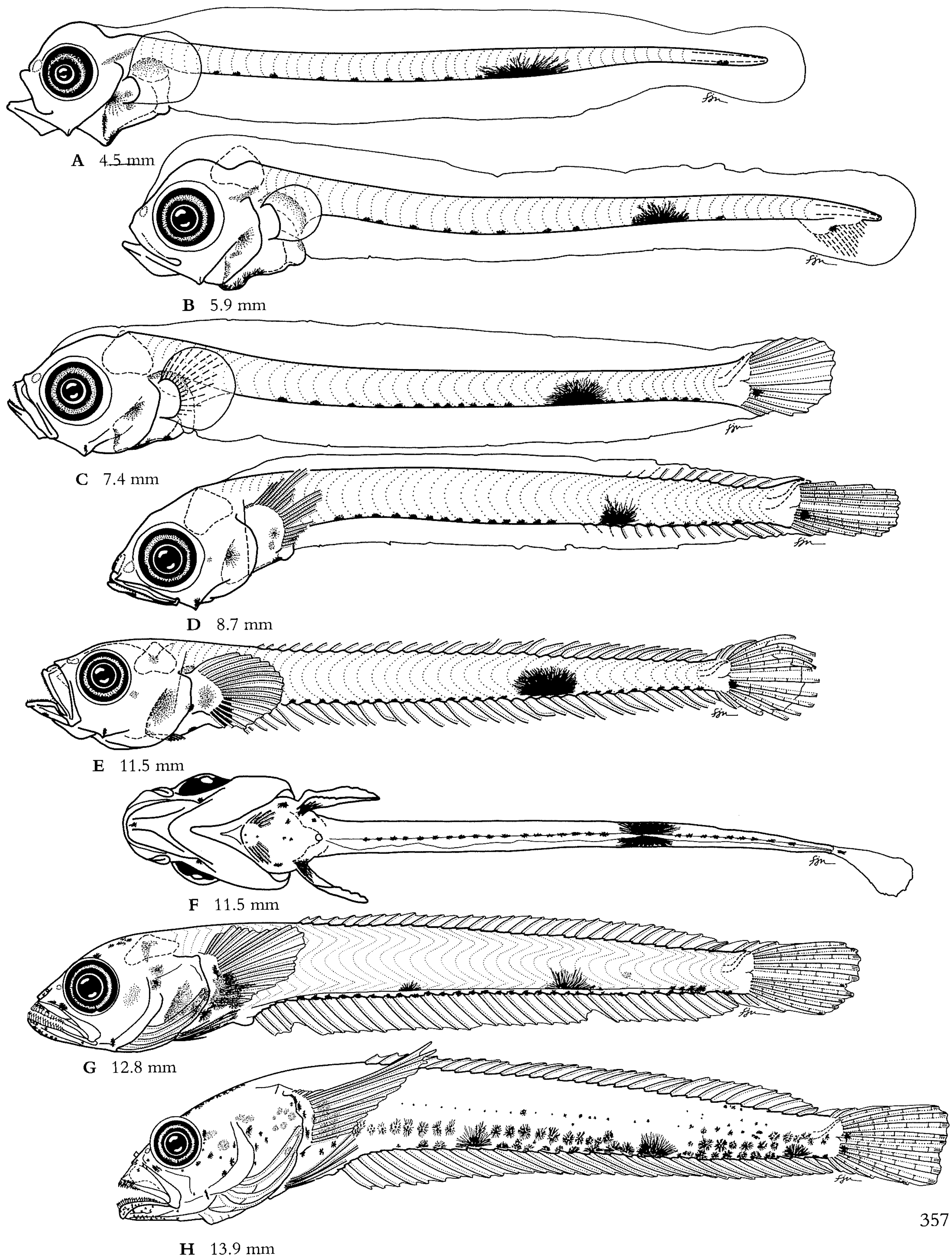
Caudal 5.8–7.0 mm; Pectoral 7.0–8.2 mm; Dorsal 8.3–11.0 mm; Anal 8.3–11.0 mm; Pelvic 9.0–11.0 mm

Pigmentation Larvae are lightly pigmented. *External:* 1 melanophore anteriorly on gular membrane and 1 at angle of lower jaw by flexion stage. A few scattered melanophores ventrally on gut. Series of 7–15 evenly spaced melanophores along ventral midline of tail in preflexion larvae, increasing to about 1 per myomere in postflexion larvae; 1 very large, stellate ventral melanophore on posterior region of tail, between myomeres 29 and 35. Pigment on inner surface of lower half of pectoral-fin base in flexion larvae, extending to lower 6 pectoral-fin rays in postflexion larvae. Pigment on snout, dorsally on head and laterally on opercle, 2 additional large melanophores along ventral surface of tail, and a row of melanophores along ventrolateral surface of trunk and tail in settlement larvae. *Internal:* 1 large stellate melanophore on the anterior surface of peritoneum, and pigment dorsally over gas bladder and gut.

Material examined 55 larvae, 2.9–14.0 mm BL, lower Swan Estuary (WA) and Noarlunga Reef, Gulf St Vincent (SA); 1 juvenile, 26.0 mm BL, surf beach off Perth (WA).

Additional references Neira & Gaughan (1989, as *Lesueurina* sp.).

Figure 108 Larvae and settlement stage of *Lesueurina platycephala*. **A** Preflexion. **B** Late preflexion. **C** Late flexion. **D** Postflexion. **E** Postflexion; note developing pelvic fin. **F** Ventral view of larva in E. **G** Postflexion. **H** Settlement stage; uppermost pectoral-fin rays folded inward; note fringe of cirri in mouth of this and larva in G. A–E from lower Swan Estuary (WA); G, H from Noarlunga Reef (SA). A–G from Neira & Gaughan (1989). Illustrated by F.J. Neira.


A 4.5 mm
B 5.9 mm
C 7.4 mm
D 8.7 mm
E 11.5 mm
F 11.5 mm
G 12.8 mm
H 13.9 mm

Percophidae: Sandfishes, duckbills

S.E. Reader and F. J. Neira

Percophids are benthic, marine fishes found in coastal waters in tropical to temperate regions of the Atlantic, Indo-West Pacific and southeastern Pacific. The family contains 13 genera and about 40 species worldwide, some undescribed (Nelson, 1994). Four genera and 6 species have been recorded from Australia, one species in temperate waters (Kuiter, 1993; Gomon *et al.*, 1994). Adults (10 cm) are elongate, have a depressed head with ovate eyes separated by a narrow interorbital space, jugular pelvic fins with a wide interpelvic space, a spinous dorsal fin, if present, well separated from the soft portion, and an anal fin with or without a single spine (Nelson, 1994). They often burrow in sandy bottoms where they expose only the eyes and adopt a body coloration similar to that of their surroundings. There is no information on the reproductive biology of percophids and the eggs are unknown (Breder & Rosen, 1966; Watson *et al.*, 1984). Larvae have been described for representatives of *Hemerocoetes* and *Spinapsaron* (Crossland, 1982; Mori, 1988a). The large mouth with prominent teeth and, in some taxa, the early forming, elongate pelvic-fin rays, are the only apparent specialisations of percophid larvae to pelagic life.

Meristic characters of the percophid genus of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Enigmapercis	(1)	II, 18	24	16	I, 5	9	–

Main characters of percophid larvae

- 32–34 myomeres
- Body elongate to moderate (BD 15–26%)
- No head spines
- Mouth large, with teeth along premaxilla and dentary in early larvae
- Gut moderate to long (PAL 48–64%), loosely coiled
- Usually 2 separate dorsal fins, first short-based and second long-based
- Pelvic fins jugular; early forming, elongate pelvic-fin rays in some taxa (e.g. early preflexion larvae of *Enigmapercis*)
- Body lightly pigmented
- Melanophores along dorsal and/or ventral midlines of tail, single or in clusters

References to percophid larvae

Mori (1988a).

Families with similar larvae

Bregmacerotidae – >40 myomeres, 43–59 vertebrae; 2 dorsal fins, first consisting of an elongate, early forming occipital ray on nape; second dorsal and anal fins long-based and strongly lobed.

Creediidae – 37–59 myomeres; small posterior preopercular spines from 3–5 mm; lack elongate, early forming pelvic-fin rays; gut with striations.

Platycephalidae – 25–28 myomeres; well developed head spination, including long preopercular spines; lack elongate, early forming pelvic-fin rays.

Trichonotidae – 50–58 myomeres; body slender and elongate; gut long and straight (PAL 50–70%); lack elongate, early forming pelvic-fin rays.

Triglidae – Head moderate to large, with deeply concave snout profile; weak to well developed head spination, often with prominent posttemporal spines; large, fan-shaped pectoral fins with early forming rays; lack elongate, early forming pelvic-fin rays.

Percophidae *Enigmapercis reducta* Whitley, 1936 Broad sandfish

D II, 18 A 24 P_1 16 P_2 I, 5 C 9 V –

Adults A monotypic genus endemic to southeastern Australia from Port Lincoln (SA) to Sydney (NSW); larvae caught in coastal waters off southwestern Western Australia suggest a wider distribution. Bottom-dwelling species found on sandy bottoms in coastal waters, often near rocky reefs, in depths from 5 to at least 130 m. Adults are elongate and have a depressed head with a pointed snout and close-set, dorsally located eyes, and body colour which matches the sand in which they bury. Rarely collected due to their small size and cryptic habits. Maximum size 9 cm (Kuiter 1993; Gomon *et al.*, 1994).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in the lower Swan Estuary (WA) from September to April, and in coastal waters off Sydney (NSW) in April and May (Gray, 1995).

Diagnostic characters

- 9–17 + 17–24 = 32–34 myomeres
- Moderately elongate, flattened snout
- Elongate, early forming pelvic fins, pigmented in postflexion larvae
- 1 melanophore on pelvic-fin base
- Melanophore series along ventral midline of tail

Description of larvae

Morphology Body moderate to elongate (BD 15–27%). Head moderate to large (HL 22–37%); snout elongate and flattened by end of preflexion stage. Mouth large with teeth along both jaws; teeth absent by 8 mm. Gut moderate to long (PAL 48–69%), coiled by 3 mm. Small gas bladder above midgut. Early forming pelvic fins; pelvic-fin rays long, reaching past anus in postflexion larvae.

Size at

Hatching	<1.9 mm
Notochord flexion	4.0–6.8 mm
Settlement	>8.0 mm

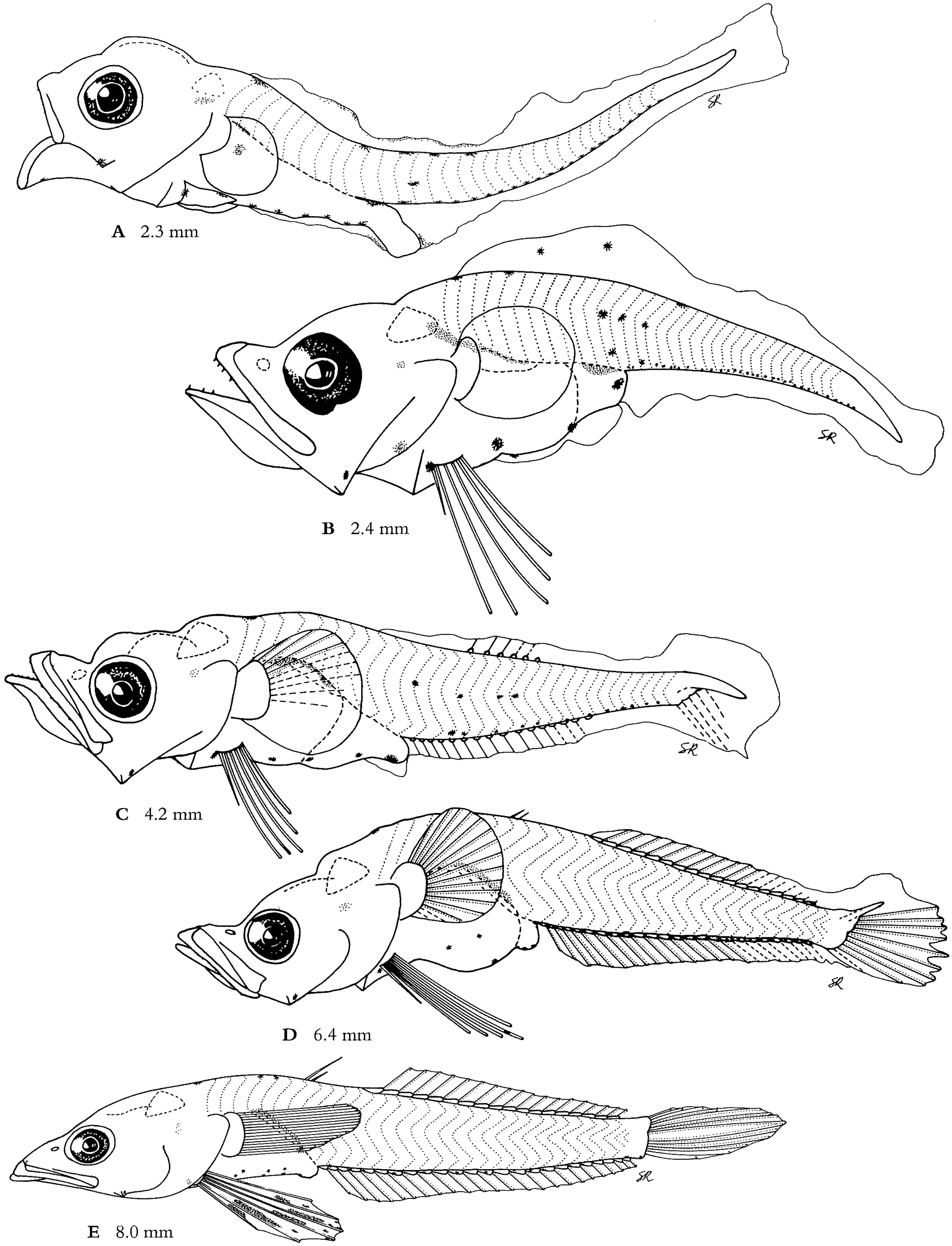
Formation of fins:
Pelvic 1.9–3.4 mm; Pectoral 3.4–7.0 mm; Anal 3.8–8.0 mm; Caudal 4.0–6.8 mm; Dorsal 4.2–8.0 mm

Pigmentation Larvae are lightly pigmented. *External:* 1 melanophore at angle of lower jaw; 1 on nape and, in some larvae, 1 on hindbrain. Four to sixteen melanophores laterally and ventrally on gut. Melanophore series along ventral midline of tail, from just posterior to anus to caudal peduncle, remaining along anal-fin base once anal fin forms, about 1 per pterygiophore. None to four melanophores along dorsal midline of trunk and tail; 1–3 anterior to first dorsal fin from about 7 mm. A few sparse melanophores may be present laterally on trunk and tail in preflexion larvae. One to three melanophores on anterior portion of dorsal finfold by 2.4 mm. Pigment on preanal membrane in early preflexion larvae. One prominent melanophore, occasionally 2, just anterior to pelvic-fin base; 1 on each pectoral-fin base in most larvae. Light pigment distally on pelvic-fin rays and associated membrane, heavy from early postflexion stage. *Internal:* Light pigment below hindbrain and dorsally over gas bladder and gut.

Material examined 15 larvae, 2.3–8.0 mm BL, Lake Macquarie and Botany Bay (NSW); 8 larvae, 1.9–8.0 mm BL, Swan Estuary (WA).

Additional references –

Figure 109 Larvae of *Enigmapercis reducta*. **A** Preflexion; note pelvic-fin buds. **B** Preflexion; note elongate pelvic-fin rays. **C** Early flexion. **D** Flexion. **E** Postflexion, near settlement. A from Lake Macquarie (NSW); B, C from lower Swan Estuary (WA); D from coastal waters east of Rottnest Island (WA); E from Botany Bay (NSW). Illustrated by S.E. Reader.


A 2.3 mm
B 2.4 mm
C 4.2 mm
D 6.4 mm
E 8.0 mm

Pinguipedidae: Sandperches, grubfishes

F. J. Neira

Pinguipedids are demersal marine fishes found in coastal waters, often near coral reefs, along the Atlantic coasts of South America and Africa, the Indo-Pacific (to New Zealand and Hawaii), and Chile. The family (formerly Mugiloididae) contains 4 genera and about 50 species (Nelson, 1994). *Parapercis* is the only genus recorded from Australia, with 3 of the 10 Australian species occurring in temperate waters (Kuiter, 1993; Gomon *et al.*, 1994). Adults (to 60 cm, most 15–25 cm) are elongate and subcylindrical, have a long-based dorsal fin with four to five short spines either joined to or well separated from the longer soft portion, a long-based anal fin with one or two spine-like rays, and thoracic pelvic fins (Scott *et al.*, 1980; Last *et al.*, 1983; Gomon *et al.*, 1994). Eggs of *Parapercis* are pelagic and spherical, 0.8–1.3 mm in diameter, and have a single oil globule (Robertson, 1975a; Ikeda & Mito, 1988). Larvae have only been described for representatives of *Parapercis* (Leis & Rennis, 1983; Kojima & Mori, 1988). The moderate head spination, most of which is lost in the adults (except for one opercular spine), is the only apparent specialisation of pinguipedid larvae to pelagic life (Leis & Rennis, 1983).

Meristic characters of the pinguipedid genus of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Parapercis	(3)	IV–V, 21–25	I, 17–19	13–22	I, 5	17	28–33

Main characters of pinguipedid larvae

- 29–34 myomeres
- Body moderate (BD 24–40%)
- Head short and round before flexion stage, elongate and depressed at settlement
- Moderate head spination, including 3–4 small to moderate posterior preopercular spines and 1–4 small opercular spines
- Gut moderate to long (PAL 31–56%), coiled and compact
- Pelvic fins thoracic, inserted slightly anterior to pectoral-fin bases; pelvic-fin rays usually form before or during flexion stage
- Body lightly pigmented
- Melanophore at angle of lower jaw
- Single melanophore series along ventral midline of tail in preflexion and flexion larvae, about 1 melanophore per anal pterygiophore in postflexion larvae; series disappears at settlement
- Expanded ventral melanophore on posterior region of tail, prominent in preflexion through to early postflexion larvae

References to pinguipedid larvae

Leis & Rennis (1983), Watson *et al.* (1984), Kojima & Mori (1988).

Families with similar larvae

Chandidae – 24–25 myomeres; short-based dorsal and anal fins, VII–VIII, 7–11 and III, 7–11 respectively; large gap between anus and origin of anal fin; large internal melanophore at nape.

Blenniidae – Typically 30–40 myomeres; moderate to large pectoral fins, usually with pigment over membrane and underside of fin base; large canine teeth in some taxa; 0–4 pelvic-fin rays; pigment over midbrain in early preflexion larvae; gut heavily pigmented.

Nemipteridae – 22–24 myomeres; no preopercular spines except for small posterior preopercular spines in some taxa after flexion stage (e.g. *Scolopsis*); dorsal fin X, 9; anal fin III, 7; small to moderate gap between anus and origin of anal fin; pelvic fins inserted posterior to origin of pectoral-fin base; lack expanded ventral melanophore on posterior region of tail.

Opistognathidae – Typically 25–28 myomeres; prominent lower-jaw angle and large mouth; large pectoral fins with early forming rays in some taxa; a few melanophores ventrally along tail.

Polynemidae (early stages) – 24–27 myomeres; weak head spination; 2 separate dorsal fins; pelvic fins abdominal; pectoral fins move ventrally and split into two portions in most taxa; moderate gap between anus and origin of anal fin; a few large melanophores ventrally along tail.

Pomacentridae – 26–27 myomeres; pigment dorsally on head from early stages; a few melanophores ventrally along tail in most taxa, lack expanded ventral melanophore; anal fin II, 10–18.

Sciaenidae – 24–29 myomeres; XI dorsal-fin spines; prominent gap between anus and origin of anal fin; short-based, posteriorly located anal fin.

Scombridae – 30–66 myomeres; 2 dorsal fins, first with X–XIX spines; moderate to large gap between anus and origin of anal fin; pigment over midbrain in early preflexion larvae.

Pinguipedidae *Parapercis haackei* (Steindachner, 1884) Wavy grubfish

D IV–V, 21–24 A I, 18–19 P_1 13–15 P_2 I, 5 C 17 V –

Adults Endemic to southern Australia from Point Quobba (WA) to Kangaroo Island (SA). Found in estuaries, rock pools and protected inshore sandy and rocky bottoms, to a depth of 35 m. Adults are elongate and have a pointed snout, the spinous portion of the dorsal fin almost completely separate from the soft portion, and the upper side of the body with wavy brown to black stripes. Maximum size about 11 cm (Scott *et al.*, 1980; Hutchins & Swainston, 1986; May & Maxwell, 1986; Gomon *et al.*, 1994; Kuiter, 1996).

Importance to fisheries –

Spawning Eggs undescribed. Eggs of *Parapercis colias* and *P. gilliesii* (New Zealand), and *P. sexfasciatus* (Japan) are pelagic and spherical, 0.8–1.3 mm in diameter, and have a smooth chorion, an unsegmented yolk, and a single oil globule 0.23–0.30 mm (Robertson, 1975a; Ikeda & Mito, 1988). Larvae have been caught in the lower Swan Estuary (WA) from November to April, with a peak abundance in January (Gaughan *et al.*, 1990; Neira *et al.*, 1992), and in coastal waters off Port Lincoln (SA) in January (B.D. Bruce, pers. comm.).

Diagnostic characters

- 8–10 + 21–22 = 30–32 myomeres
- 2–3 small posterior preopercular and up to 4 small opercular spines
- Series of small melanophores along ventral midline of tail
- Expanded ventral melanophore on tail between myomeres 23–25, visible until late postflexion stage
- No pigment along dorsal and lateral surfaces of body prior to settlement

Description of larvae

Morphology Body moderate (BD 24–34%). Head moderate to large (HL 20–35%), deep and laterally compressed in preflexion and flexion larvae, depressed and slightly elongate in juveniles. Two posterior preopercular spines in preflexion larvae, 3 in flexion larvae, becoming very small prior to settlement. Two to four small opercular spines from flexion stage; 2 small, flat spines remain at settlement. Gut moderate to long (PAL 35–53%), coiled and compact. Gas bladder over gut. Pelvic-fin buds thoracic, initially anterior to pectoral-fin base, located under pectoral-fin base from postflexion stage; pelvic-fin rays reach beyond anus in late postflexion larvae.

Size at

Hatching	<2.5 mm
Notochord flexion	3.7–4.4 mm
Settlement	>9.6 mm
Formation of fins:	

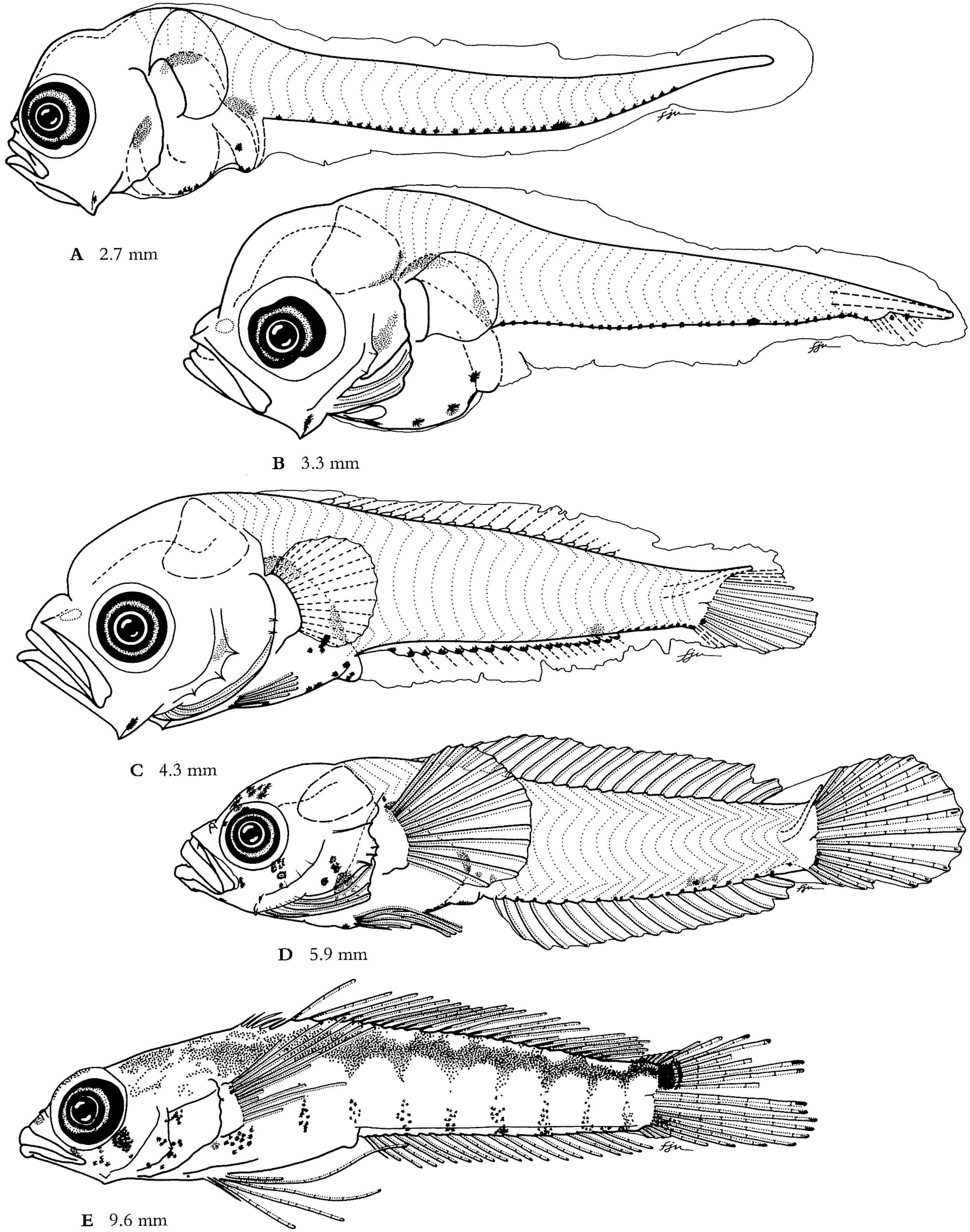
Pelvic 3.2–4.5 mm; Caudal 3.3–5.9 mm; Pectoral 3.9–4.5 mm; Dorsal 4.3–9.6 mm; Anal 4.3–9.6 mm

Pigmentation Larvae are lightly pigmented. *External:* 1 melanophore at angle of lower jaw. Scattered melanophores dorsally on head, laterally on opercle and a patch below eye in postflexion larvae. Scattered melanophores ventrally on gut; 1 small melanophore above anus. Series of up to 30 small melanophores along ventral midline of tail in preflexion and flexion larvae, about 1 per anal-fin pterygiophore in postflexion larvae; ventral melanophores disappear by settlement. Expanded ventral melanophore on posterior region of tail between myomeres 23 and 25, becoming internal during flexion stage. One or two melanophores on lower hypural plate. Pigment on dorsolateral surface of trunk and tail, with 9 uniformly spaced vertical bars of scattered melanophores extending between just below lateral line and ventral body surface in settlement larvae. *Internal:* Pigment over peritoneum, and dorsally over gas bladder and hindgut; gut pigment obscured in postflexion larvae.

Material examined 24 larvae, 2.5–9.6 mm BL, Swan Estuary and Cockburn Sound (WA), and coastal waters off Port Lincoln (SA).

Additional references –

Figure 110 Larvae and settlement stage of *Parapercis haackei*. **A** Preflexion. **B** Preflexion; note pelvic-fin bud. **C** Flexion. **D** Postflexion; note opercular spines. **E** Settlement stage; myomeres and scales omitted. A, B, E from Port Lincoln (SA); C, D from Cockburn Sound (WA). Illustrated by F. J. Neira.



A 2.7 mm

B 3.3 mm

C 4.3 mm

D 5.9 mm

E 9.6 mm

Blennioidei

The Blennioidei is a relatively large perciform suborder of marine, benthic fishes found mostly in tropical to temperate regions worldwide (Matarese *et al.*, 1984; Springer, 1993). The suborder contains 6 families, 127 genera and about 732 species (Nelson, 1994). Families comprise the Blenniidae (combtooth blennies), Clinidae (clinids), Chaenopsidae (pike blennies), Dactyloscopidae (sand stargazers), Labrisomidae (labrisomids) and Tripterygiidae (threefin blennies). Monophyly of the Blennioidei is based on the presence in all taxa of five specialised character complexes including an anal fin with none to two spines and all soft rays simple (Springer, 1993). Larvae have been described for representatives of all families (see review of early life history stages by Matarese *et al.*, 1984; see also Miller *et al.*, 1979; Leis & Rennis, 1983; Watson, 1983, 1996n,o; Kojima & Shiogaki, 1988; Shiogaki, 1988).

Family and species included here

BLENNIIDAE
Omobranchus anolius
Omobranchus rotundiceps
Parablennius intermedius
Parablennius postoculomaculatus
Parablennius tasmanianus
Petroscirtes lupus

Blenniidae: Blennies

W. Watson and A.G. Miskiewicz

Blenniids are demersal or semi-demersal, marine fishes found in estuarine and coastal waters in tropical and temperate regions worldwide, with a few species in brackish waters. Most species are residents of reefs, oyster beds, tidepools and fouling communities. The family comprises 53 genera with about 345 species in 6 tribes (Nelson, 1994). Although 5 of the 6 tribes are represented in Australia, only 8 species belonging to the tribes Nemophini (1 species), Omobranchini (3), Parablenniini (3) and Salariini (1) have been recorded from temperate waters (Springer & Gomon, 1975; Smith-Vaniz, 1976; Bath, 1977; Bath & Hutchins, 1986; Hutchins & Swainston, 1986; Springer & Williams, 1994). Adults (most <20 cm) are elongate, have a blunt head usually with a fleshy medial crest, long-based dorsal and anal fins, thoracic pelvic fins, and no scales in most taxa. Eggs are demersal and ovoid to nearly spherical, 0.4–0.9 × 0.6–1.1 mm, and are attached to a nest surface by a bundle of short adhesive filaments arising from the basal pole. Eggs are deposited in clusters and are tended by one or both parents (Munro, 1955; Dotsu & Moriuchi, 1980; Matarese *et al.*, 1984). Larvae have been described for representatives of all tribes except Phenablenniini (e.g. Munro, 1955; Watson, 1983, 1996o; Matarese *et al.*, 1984; Kojima & Shiogaki, 1988; Olivar & Fortuño, 1991). Blenniid larvae develop directly except those of some species of the Salariini which pass through a specialised 'ophioblennius' pelagic stage. Morphological specialisations of blenniid larvae to pelagic life vary markedly among the tribes and include large hooked teeth, small to large preopercular spines, large, early forming pectoral fins, and a relatively small gas bladder (Watson, 1983).

Meristic characters of blenniid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Cirripectes	(1)	XIII, 13–14	II, 15–16	14–16	I, 4	9–11	10 + 19–22 = 29–32
Omobranchus	(3)	XI–XIII, 17–24	II, 19–26	12–13	I, 2	12–13	10–12 + 26–33 = 36-43
Parablennius	(3)	XII, 15–19	II, 16–20	14	I, 3	13	10 + 24–28 = 34–38
Petroscirtes	(1)	X–XI, 19–21	II, 18–20	13–15	I, 3	11	11–13 + 19–25 = 30–37

Main characters of blenniid larvae

- 28–135 myomeres, typically 30–40
- Body typically elongate to moderate (BD 15–27%), very elongate to moderate in Nemophini (BD 3–40%)
- Head spination absent or limited to preopercular spines, depending on tribe: none in Nemophini; none to few in Salariini, generally small when present; few in Omobranchini, the one at angle of preopercle broad and long; and several in Parablenniini, none to few moderately large
- Large canine teeth present depending on tribe
- Gut typically moderate to long (PAL 33–57%), coiled and compact
- Pectoral fins moderate to large; early forming, elongate pectoral-fin rays in some taxa (e.g. *Omobranchus*)
- Pigment mainly restricted to head, dorsally over gut and ventral midline of tail
- Pectoral fins often with pigment over membrane and underside of fin base
- Internal pigment usually on roof of mouth

References to blenniid larvae

Watson (1983, 1996o), Matarese *et al.* (1984), Kojima & Shiogaki (1988), Olivar & Fortuño (1991).

Families with similar larvae

Atherinidae – No head spines; 2 short, well separated dorsal fins, second located posteriorly on body; short-based, posteriorly located anal fin; pigment along lateral midline of tail and often along dorsal midline of tail.

Clinidae – 13–35 + 25–63 vertebrae, 48–96 in Ophiclinini, 40–58 in Myxodini; no head spines; gut moderate, coiled anteriorly and straight posteriorly; single long-based dorsal fin with more spines than rays; first 3 dorsal-fin spines separated from remaining spines by small notch in Clinini; body lightly pigmented; no pigment over head in early stages.

Leptoscopidae – 42–48 myomeres; body elongate and laterally compressed by postflexion stage; no head spines; dorsal and anal fin spineless; anal-fin base slightly longer than dorsal-fin base.

Phycidae (early stages) – 38–55 myomeres; body moderate and stocky; pterotic spines in some taxa, no preopercular spines; elongate, early forming pelvic-fin rays; 2–3 dorsal fins, close together; usually 1–2 pigmented bands along tail; pelvic fins heavily pigmented early in development.

Pinguipedidae – 29–34 myomeres; 1–4 small opercular spines; early forming pelvic fins; expanded ventral melanophore on posterior region of tail; pectoral fins not pigmented; no pigment over head prior to postflexion stage.

Tripterygiidae – No head spines; 3 dorsal fins; gut moderate, straight in preflexion larvae; small gas bladder over foregut; lack large canine teeth; body typically lightly pigmented.

Blenniidae *Omobranchus anolius* (Valenciennes, 1836) Oyster blenny

D XI–XIII, 17–19 A II, 19–22 P_1 12–13 P_2 I, 2 C 12–13 V 36–38

Adults Endemic to eastern Australia from the Gulf of Carpentaria (NT, Qld) to Spencer Gulf (SA). Occurs in oyster beds and shell substrates in estuaries, and intertidal and shallow subtidal zones of bays. Adults have 2–5 longitudinal rows of small black spots and are sexually dimorphic, with males having a large, fleshy cranial crest and elongate posterior dorsal-fin rays. Maximum size about 9 cm (Springer & Gomon, 1975; Gomon *et al.*, 1994).

Importance to fisheries –

Spawning Eggs are demersal and hemispherical, approximately 0.5–0.8 mm, flattened at their basal poles, and have no oil globule. They are attached in a single layer in a nest shell and are tended by the male parent (Thomson & Bennett, 1953). In New South Wales, larvae have been caught in Lake Macquarie and adjacent coastal waters from October to May, with peak abundances between December and April (Miskiewicz, 1987), entering Tuggerah Lakes in January, February and October (Marsden, 1986), and in coastal waters off Sydney from November to May (Gray *et al.*, 1992); and in Victoria in Port Phillip Bay in January (Jenkins, 1986b).

Diagnostic characters

- 5–11 + 25–32 = 35–37 myomeres
- Lowermost posterior preopercular spine long and broad from flexion stage
- Early forming, elongate pectoral-fin rays; fin heavily pigmented from flexion stage
- Internal pigment on snout in all stages

Description of larvae

Morphology Body elongate to moderate (BD 17–23%). Head moderate (HL 24–30%). Mouth inferior until end of flexion stage. Two or three posterior preopercular spines in early preflexion larvae; upper 1–2 disappear by late preflexion stage, remaining lower spine long and broad by postflexion stage. Supraocular ridge in all larvae, initially smooth, with small serrations from flexion stage. Small spinules on frontal, dentary, articular, and preopercle in preflexion larvae (not illustrated). Gut moderate (PAL 37–44%), coiled and compact. Gas bladder small and discernible only in early preflexion larvae. Yolk sac is resorbed within two days, by 3.5–3.7 mm (Thomson & Bennett, 1953). Pectoral fin almost completely developed at hatching.

Size at

Hatching [1]	~3.2 mm
Notochord flexion	5.3–6.2 mm
Settlement	12.7–17.2 mm

Formation of fins:
Pectoral [1] 3.2 mm; Caudal 3.8–6.1 mm; Dorsal 5.8–8.1 mm; Anal 5.8–8.1 mm; Pelvic 7.5–8.1 mm

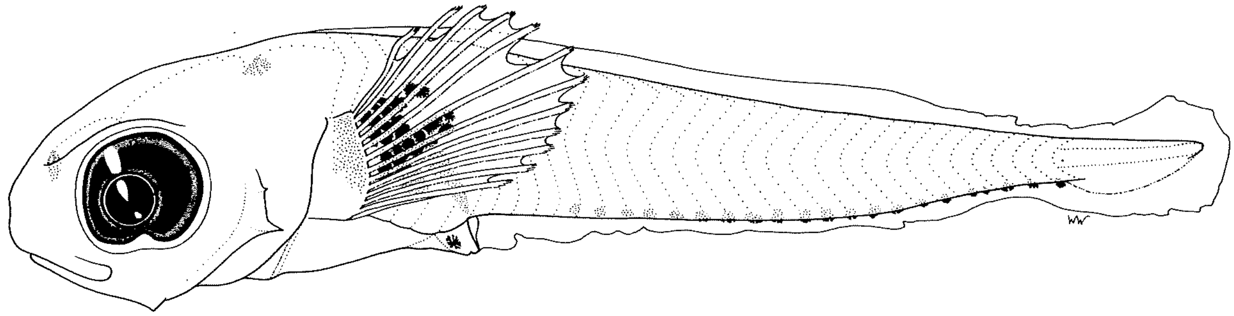
[1] Thomson & Bennett (1953)

Pigmentation Larvae are lightly pigmented. *External:* 2–4 melanophores over midbrain during flexion stage, occasionally by late preflexion stage, increasing in number with growth. Several melanophores on opercle in postflexion larvae. Pigmented bars on snout and below eye before settlement. Rarely 1 melanophore ventrally at anus. Series of 15–22 melanophores along ventral midline of tail, extending from postanal myomere 5–9 to anterior of notochord tip; last 2–3 melanophores remain along hypural margin during flexion stage and increase from 4 to 8 in postflexion larvae. Heavy pigment on inner surface of pectoral-fin base and on inner surfaces of membranes between all (usually) except upper 3–5 rays. *Internal:* 1–2 melanophores on anterior margin of forebrain, 2–4 on anterior margin of midbrain and 2 on posterior margin of midbrain in preflexion larvae; pigment around brain increases with growth. Pigment under upper end of preopercle, spreading to under opercle in postflexion larvae. Heavy pigment dorsally over gas bladder and gut and on pharyngobranchials. Pigment spreads ventrally over entire gut in postflexion larvae.

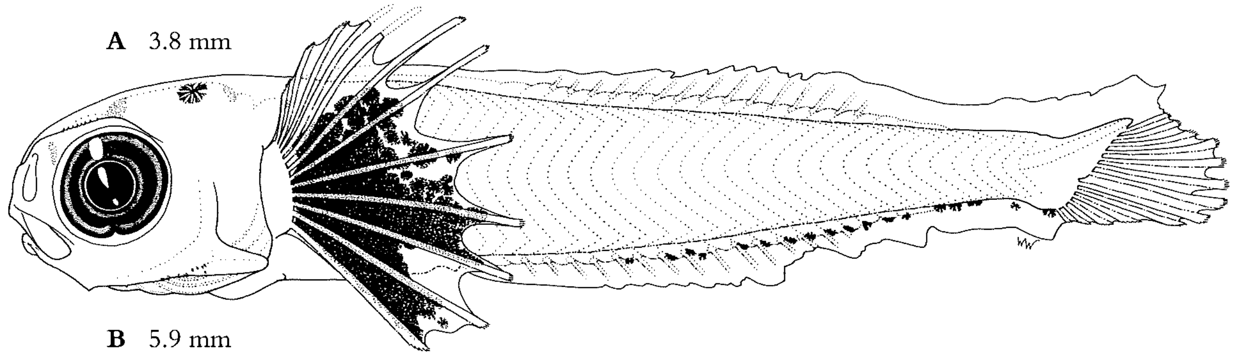
Material examined 32 larvae, 3.2–12.7 mm BL, and 1 juvenile, 17.2 mm BL, Lake Macquarie (NSW).

Additional references Thomson & Bennett (1953), Miskiewicz (1987).

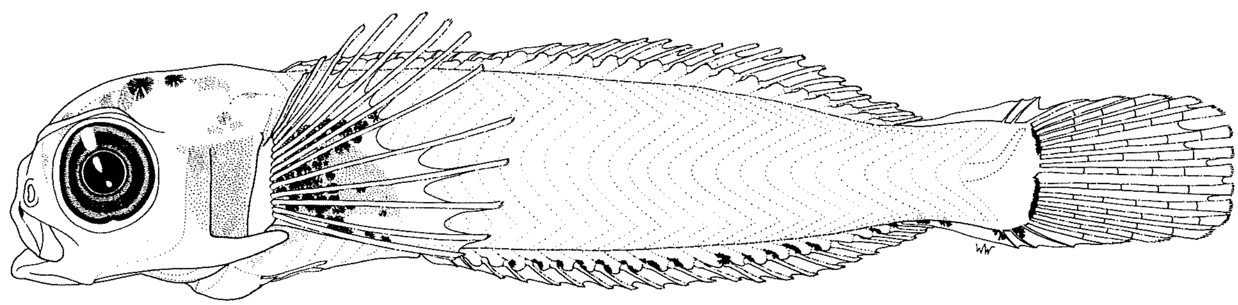
Figure 111 Larvae of *Omobranchus anolius*. **A** Preflexion. **B** Flexion; note finely serrate supraocular. **C** Postflexion. **D** Postflexion. **E** Postflexion. A–E from central NSW coastal waters. Illustrated by W. Watson.



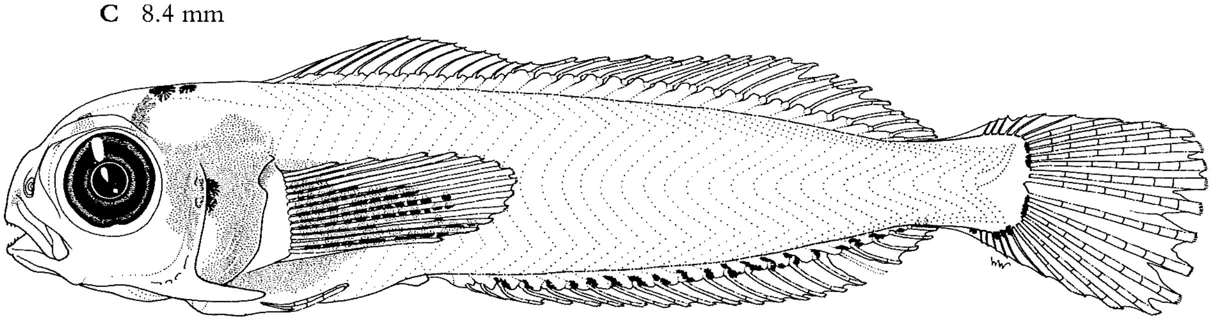
A 3.8 mm



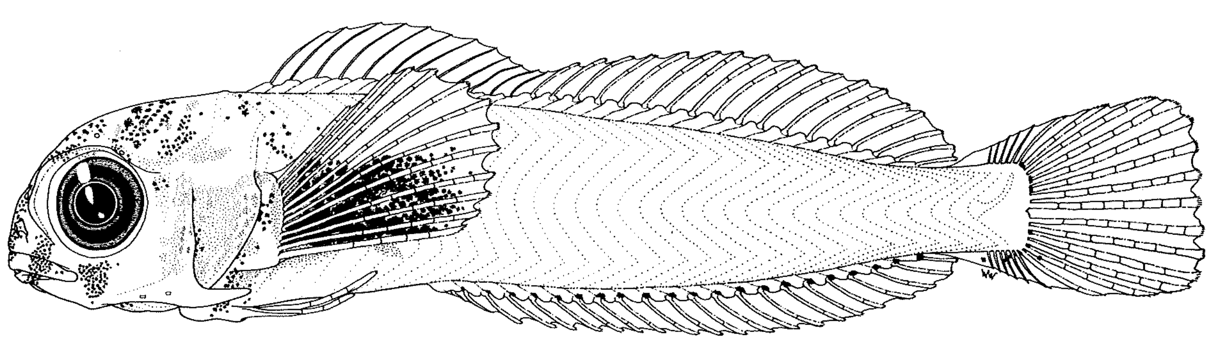
B 5.9 mm



C 8.4 mm



D 10.9 mm



E 11.4 mm

Blenniidae *Omobranchus rotundiceps* (Macleay, 1881) Blenny

D XI–XIII, 18–24 A II, 20–26 P_1 12–13 P_2 I, 2 C 12–13 V 37–43

Adults Endemic to northern Australia from Perth (WA) to Sydney (NSW). Occurs in estuaries, and on rocky and coral reefs in shallow coastal waters. Adults have a large, dark spot behind the orbit, and 10–12 broad, ventrally tapering dark bands laterally along the body. Maximum size about 8 cm (Springer & Gomon, 1975).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in Lake Macquarie (NSW) from September to May, with peak abundances between November and March (Miskiewicz, 1987).

Diagnostic characters

- 7–10 + 30–33 = 39–41 myomeres
- 5-8 posterior preopercular spines, spine at angle long and slender from flexion stage
- Pterygiophores of dorsal- and anal-fin rays each with a prominent spine
- Early forming, elongate pectoral-fin rays; fin moderately to heavily pigmented
- 17–28 melanophores, usually 24–26, along ventral midline of tail

Description of larvae

Morphology Body elongate to moderate (BD 15–22%). Head moderate (HL 21–27%). Mouth inferior until end of flexion stage. Small teeth along lower jaw. Two or three small anterior preopercular spines in preflexion stage, disappearing by end of flexion stage; 5–8 posterior preopercular spines, spine at angle long and slender by flexion stage. Smooth supraocular ridge and small spinules on frontal, supraocular, dentary, and preopercle in preflexion larvae (not illustrated); dentary spinules prominent in flexion larvae. Gut moderate (PAL 33–39%), coiled and compact. Small gas bladder anteriorly, usually not visible. Yolk sac is resorbed in preflexion larvae by 3.4 mm. A prominent spine on proximal radial of each dorsal- and anal-fin pterygiophore from flexion stage; these spines are largest in late flexion and early postflexion larvae, then shorten and disappear before settlement (in *O. obliquus*; older larvae of *O. rotundiceps* were unavailable).

Size at

Hatching	<2.5 mm
Notochord flexion	4.9–6.8 mm
Settlement	>7.5 mm
Formation of fins:	

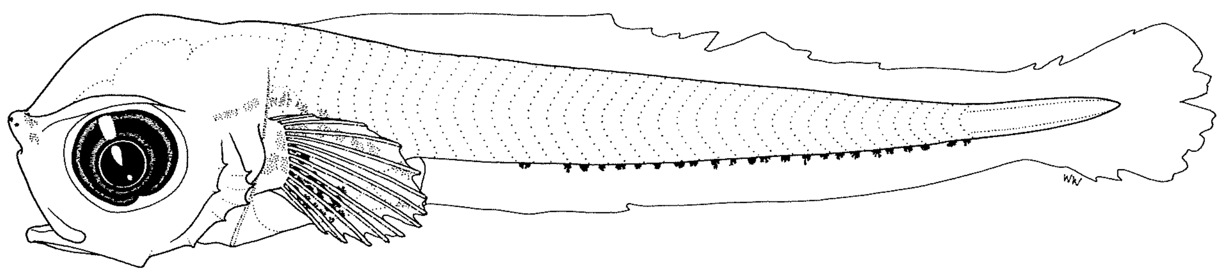
Pectoral <2.5 mm; Caudal 4.5–7.5 mm; Dorsal 4.9–>7.5 mm; Anal 4.9–>7.5 mm; Pelvic 5.2–>7.5 mm

Pigmentation Larvae are lightly pigmented. *External:* 0–2 melanophores near tip of snout, usually absent after 3 mm; a few over midbrain in late flexion larvae. Occasionally 1 melanophore ventrally at anus. Series of 17–28, usually 24–26, irregularly spaced melanophores along ventral midline of tail, extending from postanal myomeres 3–8 to anterior of notochord tip, usually with 1–2 per myomere in preflexion larvae and 1 per pterygiophore when anal fin is formed; last 2–3 melanophores remain along hypural margin in flexion larvae. Light to moderate pigment on inner surface of pectoral-fin base, and moderate to heavy, occasionally light, on inner surface of pectoral-fin rays and membranes. Sparse or no pigment on exterior surface of pectoral-fin base in late flexion larvae. *Internal:* 1–2 melanophores at anterior margin of forebrain; 2, rarely 0, on anterior margin of midbrain. Some melanophores on dorsal surface of hindbrain in late flexion larvae. Heavy pigment dorsally over gas bladder and gut, spreading laterally during flexion stage and to most of gut by early postflexion stage.

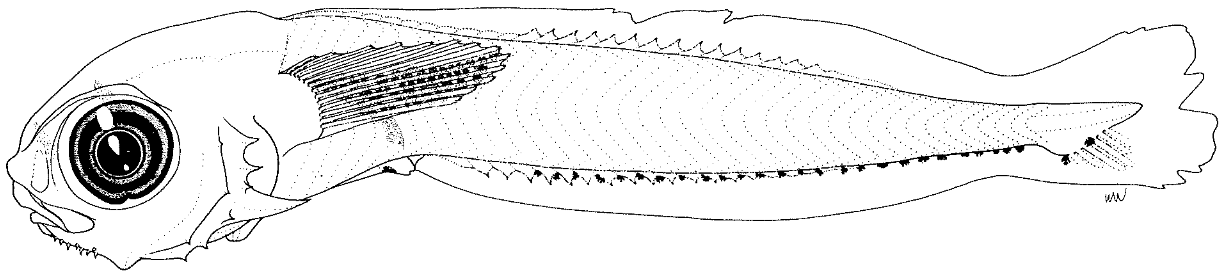
Material examined 30 larvae, 2.5–7.5 mm BL, Lake Macquarie (NSW).

Additional references Miskiewicz (1987).

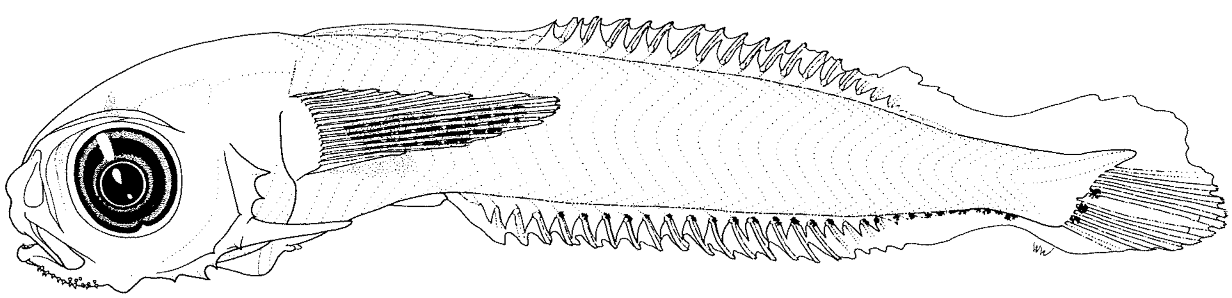
Figure 112 Larvae of *Omobranchus rotundiceps*. **A** Preflexion. **B** Early flexion. **C** Late flexion. **D** Postflexion. A–D from central NSW coastal waters. Illustrated by W. Watson.



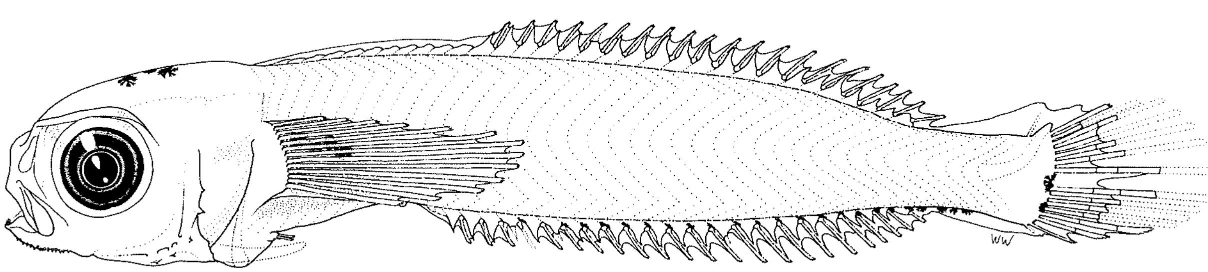
A 2.5 mm



B 4.9 mm



C 5.2 mm



D 7.5 mm

Blenniidae *Parablennius intermedius* (Ogilby, 1915) False Tasmanian blenny

D XII, 16–18 A II, 17–19 P_1 13–14 P_2 I, 3 C 13 V 34–36

Adults Endemic to eastern Australia from Cape York (Qld) to Cape Conran (Vic). Occurs in reef and sponge communities in shallow coastal waters. Adults are pale to dark brown, with reddish brown to black spots on the head, and a series of dark spots along the upper side of the body. They are sexually dimorphic, with males having a long, fringed tentacle above the eye. Hybrids are reported to occur where *P. tasmanianus* and *P. intermedius* are sympatric. Maximum size about 13 cm (Bath & Hutchins, 1986; Kuiter, 1993, 1996).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in Lake Macquarie (NSW) and adjacent coastal waters from February to June, with peak abundances in April and between September and November (Miskiewicz, 1987), and in coastal waters off Sydney (NSW) from September to May (Gray, 1995).

Diagnostic characters

- 7–9 + 26–29 = 34–37 myomeres
- Up to 9 small posterior preopercular spines, spine at angle slightly longer
- Large melanophore, occasionally absent, on inner surface of pectoral-fin base from preflexion stage
- 3–6 melanophores along ventral midline of tail restricted to last few myomeres

Description of larvae

Morphology Body elongate to moderate (BD 17–24%). Head moderate (HL 22–28%). Teeth along both jaws from early preflexion stage; anterior teeth anteriorly directed until end of flexion stage. Small posterior preopercular spines in early preflexion larvae, up to 9, usually 5–7, in postflexion larvae; spine at angle slightly longer. Up to 3 small anterior preopercular spines from 3.5 mm until early flexion stage. Smooth supraocular ridge from flexion stage. Gut moderate (PAL 34–42%), coiled and compact. Small gas bladder, usually only visible in preflexion larvae.

Size at

Hatching	<2.5 mm
Notochord flexion	5.3–6.2 mm
Settlement	14.0–17.0 mm
Formation of fins:	

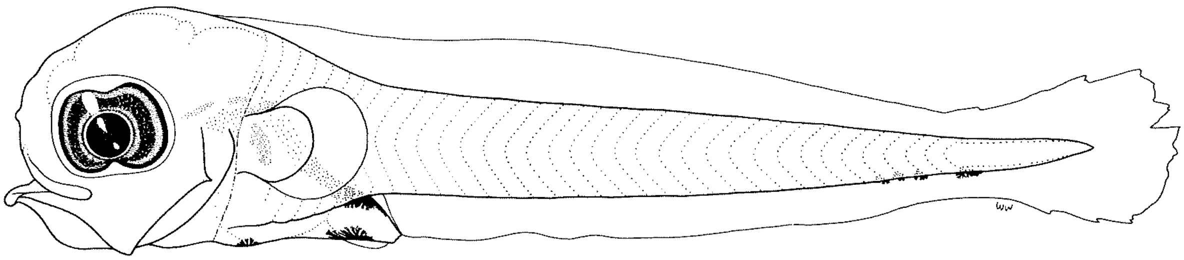
Caudal 3.5–5.9 mm; Pectoral 5.2–7.9 mm; Dorsal 5.9–9.7 mm; Anal 5.9–9.7 mm; Pelvic 5.3–9.7 mm

Pigmentation Larvae are lightly pigmented. *External:* A few melanophores over midbrain by mid-flexion stage, increasing in number by postflexion stage. Pigment over forebrain and near premaxillary symphysis in late postflexion larvae. Several small melanophores may be present along ventral midline of gut, with 1 usually at anus. A few melanophores on some dorsal fin-ray bases by late postflexion stage. Series of 3–6 melanophores along ventral midline of tail, restricted to last few myomeres in preflexion and early flexion larvae, increasing in number and extending from base of first anal-fin ray to caudal peduncle in postflexion larvae; last 1–3 melanophores remain along hypural margin in flexion larvae, and increase in number in postflexion larvae. Sparse pigment, occasionally absent, on inner surface of pectoral-fin base, and a few melanophores on membranes between lower pectoral-fin rays in late postflexion larvae. *Internal:* 1–2 melanophores on anterior margin of forebrain and 1 on dorsal surface of hindbrain by early preflexion stage. Pigment on pharyngobranchials and ventral surface of brain by start of flexion stage. Pigment on inner surface of opercle in postflexion larvae from 9.1 mm. One or two melanophores near tip of premaxilla in postflexion larvae. Pigment dorsally over gut, spreading laterally over entire gut by about 14 mm. Melanophore series dorsally along vertebrae by about 14 mm.

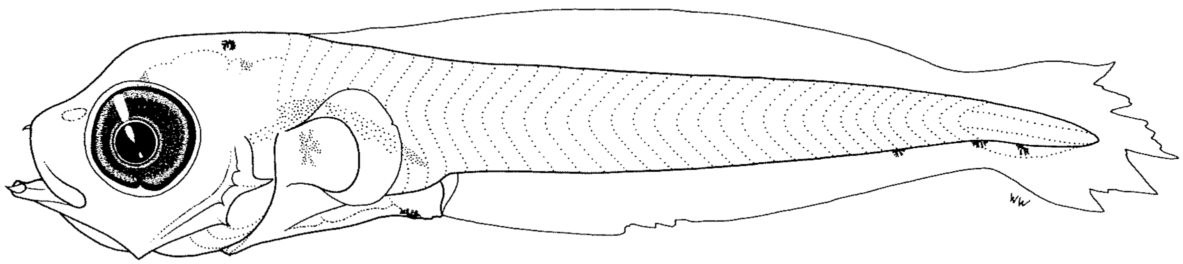
Material examined 22 larvae, 2.5–15.4 mm BL, Lake Macquarie (NSW); 8 juveniles, 14.0–17.0 mm BL, Shoalwater Bay (north of Rockhampton, Qld) and coastal waters off Yamba (NSW).

Additional references Miskiewicz (1987).

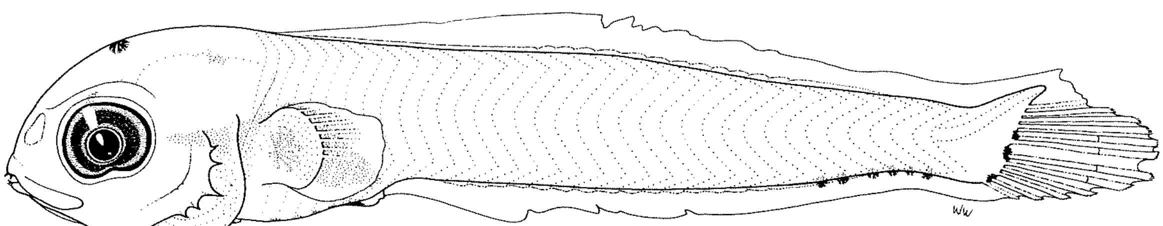
Figure 113 Larvae of *Parablennius intermedius*. **A** Preflexion. **B** Preflexion. **C** Flexion; note pelvic-fin bud behind branchiostegal membrane. **D** Early postflexion. **E** Postflexion. A–E from central NSW coastal waters. Illustrated by W. Watson.



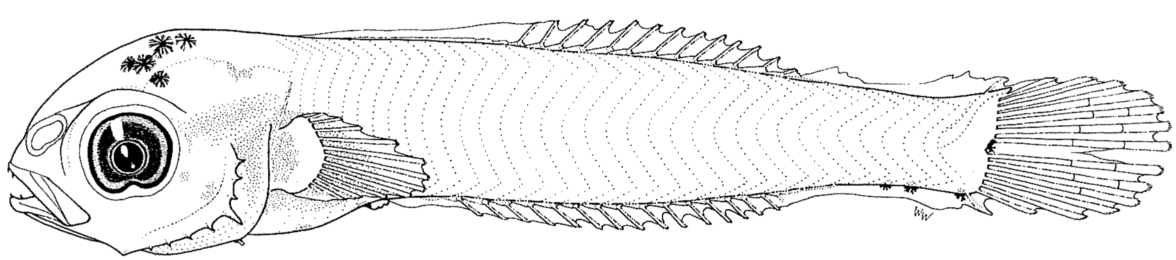
A 2.7 mm



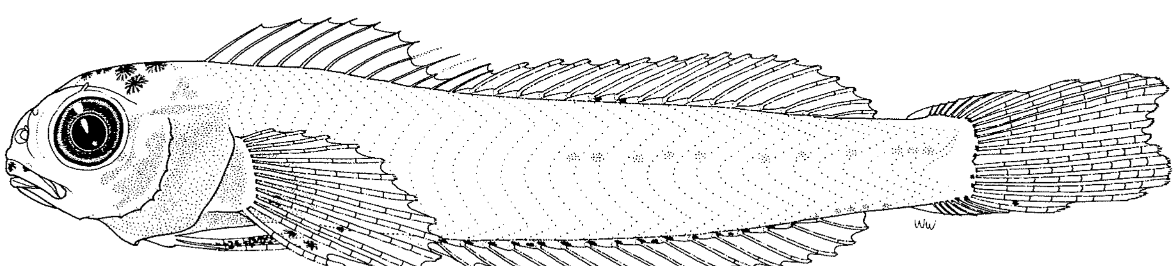
B 3.5 mm



C 6.1 mm



D 6.5 mm



E 15.4 mm

Blenniidae *Parablennius postoculomaculatus* Bath & Hutchins, 1986

Western blenny

D XII, 15–17 A II, 16–18 P_1 13–14 P_2 I, 3 C 13 V 35–36

Adults Endemic to Western Australia from North West Cape to Two Peoples Bay. Occurs in reef and sponge communities in coastal waters. Adults have red–brown to black spots on the head and pectoral-fin base, and a series of vertical dark bars laterally on the body. They are sexually dimorphic, with males having a long, fringed tentacle above the eye. Maximum size about 13 cm (Hutchins & Thompson, 1983; Bath & Hutchins, 1986).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been collected in the Swan Estuary (WA) from September to May, with peak abundances in November and January (Gaughan *et al.*, 1990; Neira *et al.*, 1992), and in the Wilson Inlet and Nornalup–Walpole Estuary (WA) from October to April, with peak abundances in December and January (Neira & Potter, 1992b, 1994).

Diagnostic characters

- 7–9 + 26–29 = 34–37 myomeres
- Up to 11 small posterior preopercular spines
- Several melanophores on inner surface of pectoral-fin base and on pectoral finfold in preflexion and flexion larvae, and on membrane between lower pectoral-fin rays in postflexion larvae
- Melanophores along most of ventral midline of tail in all stages

Description of larvae

Morphology Body elongate to moderate (BD 17–22%). Head small to moderate (HL 19–28%). Teeth along both jaws from late preflexion stage; anterior teeth anteriorly directed until end of flexion stage. Small posterior preopercular spines in preflexion larvae from 3.3 mm, up to 11, usually 5–7, in postflexion larvae. Up to 3 very small anterior preopercular spines in preflexion larvae from about 4 mm, absent by settlement. Low supraocular ridge from late preflexion stage. Gut moderate (PAL 33–40%), coiled and compact. Small gas bladder, visible in some early postflexion larvae. Yolk sac is resorbed in preflexion larvae by 3.3 mm.

Size at

Hatching	<2.8 mm
Notochord flexion	5.6–6.9 mm
Settlement	>13.2 mm

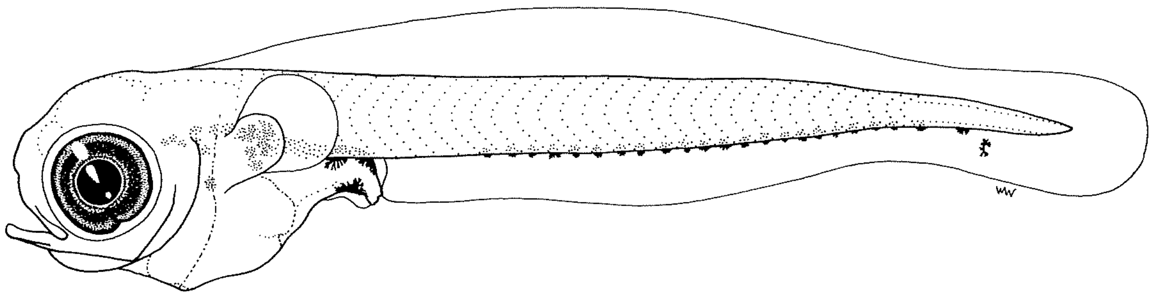
Formation of fins:
Caudal 4.8–6.8 mm; Pectoral 5.5–6.8 mm; Pelvic 5.8–11.3 mm; Dorsal 6.7–11.3 mm; Anal 6.7–11.3 mm

Pigmentation Larvae are lightly pigmented. *External:* None to a few melanophores over midbrain, always more than 1 after yolk-sac resorption, increasing in number in postflexion larvae. Melanophores over forebrain and near tip of upper jaw in late postflexion larvae; heavy pigment over entire head from 11.3 mm. Some melanophores may be present along ventral midline of gut, with 1 usually at anus. Dorsolateral pigment patches along dorsal-fin base and several mid-lateral clusters of pigment on tail in late postflexion larvae. Melanophore series along ventral midline of tail, extending from postanal myomeres 3–7 to anterior of notochord tip; last 1–3 melanophores remain along hypural margin in flexion larvae. Several melanophores on inner surface of pectoral-fin base and on pectoral finfold in preflexion and flexion larvae, and on membrane between lower pectoral-fin rays in early postflexion larvae. *Internal:* 1–2 melanophores on anterior margin of forebrain after yolk-sac resorption; 1 dorsally on hindbrain by early preflexion stage. One or two melanophores near tip of premaxilla in postflexion larvae. Melanophores on pharyngobranchials and ventral surface of brain; on inner surface of opercle by flexion stage. Pigment dorsally over gut, spreading laterally over entire gut by about 11.3 mm. Melanophore series dorsally along vertebrae by early postflexion stage.

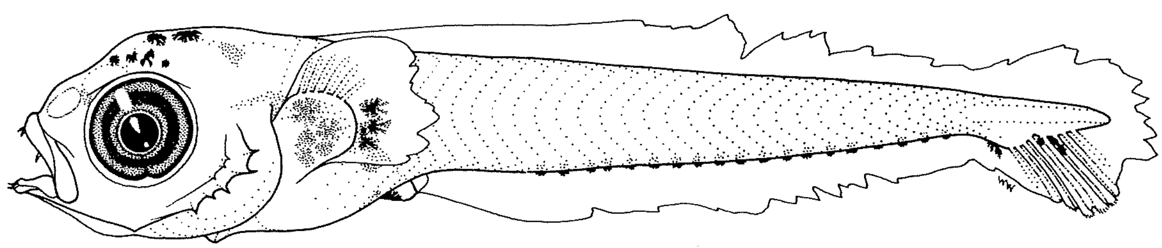
Material examined 25 larvae, 2.8–8.9 and 11.3–13.2 mm BL, Swan Estuary and Wilson Inlet (WA).

Additional references –

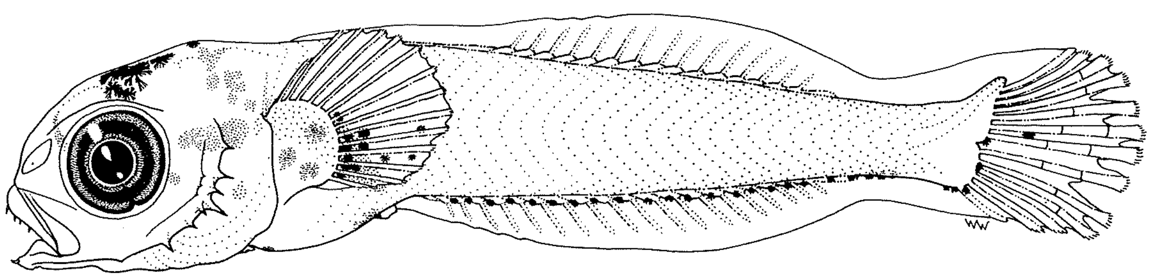
Figure 114 Larvae of *Parablennius postoculomaculatus*. **A** Preflexion. **B** Late preflexion. **C** Late flexion. **D** Postflexion. **E** Postflexion. A–E from Swan Estuary (WA). Illustrated by W. Watson.



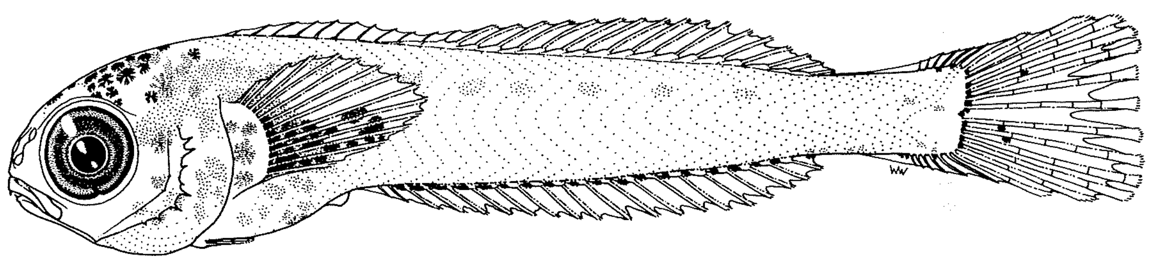
A 3.1 mm



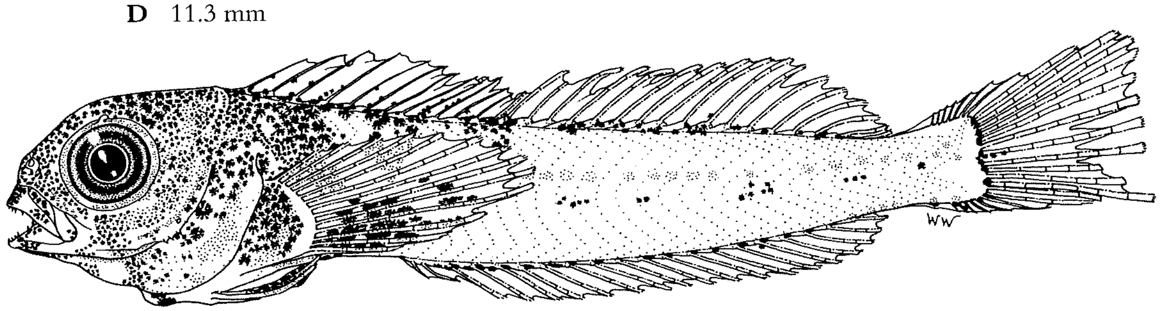
B 5.6 mm



C 6.8 mm



D 11.3 mm



E 13.2 mm

Blenniidae *Parablennius tasmanianus* (Richardson, 1842) Tasmanian blenny

D XII, 16–19 A II, 19–20 P_1 14 P_2 I, 3 C 13 V 36–38

Adults Endemic to southeastern Australia from Ceduna (SA) to central New South Wales, including Tasmania. Occurs in reef and sponge communities in shallow coastal waters. Adults have a pale to ash–grey body covered with small dark spots. They are sexually dimorphic, with males having a long, fringed tentacle above the eye. Hybrids are reported to occur where *P. tasmanianus* and *P. intermedius* are sympatric. Maximum size about 13 cm (Bath & Hutchins, 1986; Kuiter, 1996).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in Port Phillip Bay (Vic) from October to April (Jenkins, 1986b), coastal waters near Hobart (Tas) in November and December (B.D. Bruce, pers. comm.), coastal waters off Port Hacking from October to April (Bruce, 1982), and Lake Macquarie (NSW) from January to April (Miskiewicz, 1987).

Diagnostic characters

- 8–10 + 26–29 = 34–37 myomeres
- Up to 9 small posterior preopercular spines by postflexion stage, spine at angle, and occasionally upper spine, slightly longer
- 1–2 small melanophores on inner surface of pectoral-fin base from preflexion stage, and several on membranes between lower pectoral-fin rays by postflexion stage, occasionally by flexion stage
- Melanophores along most of ventral midline of tail in all stages

Description of larvae

Morphology Body elongate to moderate (BD 18–26%). Head moderate (HL 20–31%). Mouth slightly inferior until early postflexion stage. Small teeth along both jaws by early preflexion stage; anterior teeth project anteriorly until mid-preflexion stage. One small posterior preopercular spine in preflexion larvae, up to 9, usually 5–7, in postflexion larvae; spine at angle, and occasionally upper spine, slightly longer. One to three small anterior preopercular spines by late preflexion stage, absent by 15 mm. Smooth supraocular ridge from flexion stage. Gut moderate (PAL 35–45%), coiled and compact. Small gas bladder, occasionally visible in early postflexion larvae.

Size at

Hatching	<3.2 mm
Notochord flexion	4.5–6.7 mm
Settlement	>17.4 mm
Formation of fins:	

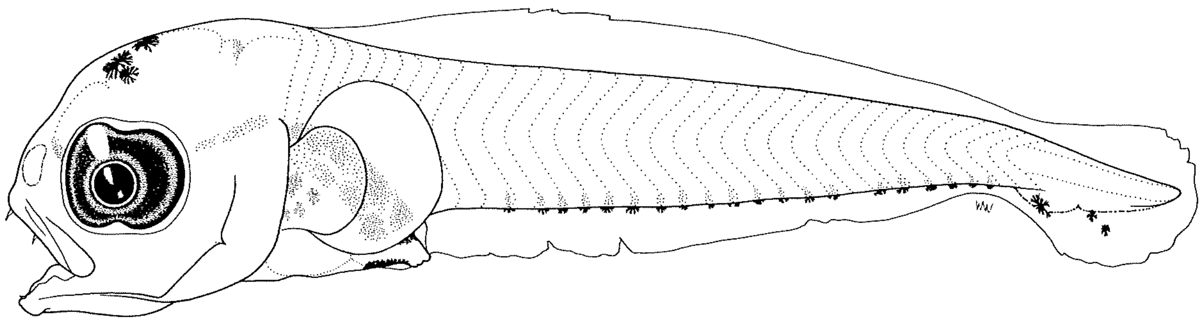
Caudal 3.8–8.3 mm; Pectoral 4.3–8.3 mm; Pelvic 4.4–9.8 mm; Dorsal 4.6–9.8 mm; Anal 4.6–9.8 mm

Pigmentation Larvae are lightly pigmented. *External:* 2 to several melanophores over midbrain, increasing in number in postflexion larvae. Pigment over forebrain, at nape, and near tip of upper jaw in late postflexion larvae. Usually 1 melanophore ventrally on gut, just anterior to anus. Dorsolateral melanophores adjacent to dorsal-fin base in late postflexion larvae from about 14 mm, from first dorsal-fin spine and spreading caudally. Melanophore series along ventral midline of tail, extending from postanal myomeres 3–12, usually 3–7, to anterior of notochord tip; last 1–3 melanophores remain along hypural margin in flexion larvae, and increase in number in postflexion larvae. Sparse pigment on inner surface of pectoral-fin base from preflexion stage, with a few melanophores on membranes between lower pectoral-fin rays by postflexion stage, occasionally by flexion stage. *Internal:* 1 melanophore on anterior margin of forebrain, 1 dorsally on hindbrain, and pigment on pharyngobranchials and ventral surface of brain in preflexion larvae by 3.9 mm. One or two melanophores near tip of premaxillary in postflexion larvae. Pigment on opercle in early postflexion larvae, beginning at centre and spreading ventrally. Pigment dorsally over gut, spreading laterally over entire gut by 9.8 mm. Melanophore series dorsally along vertebrae by 9.8 mm.

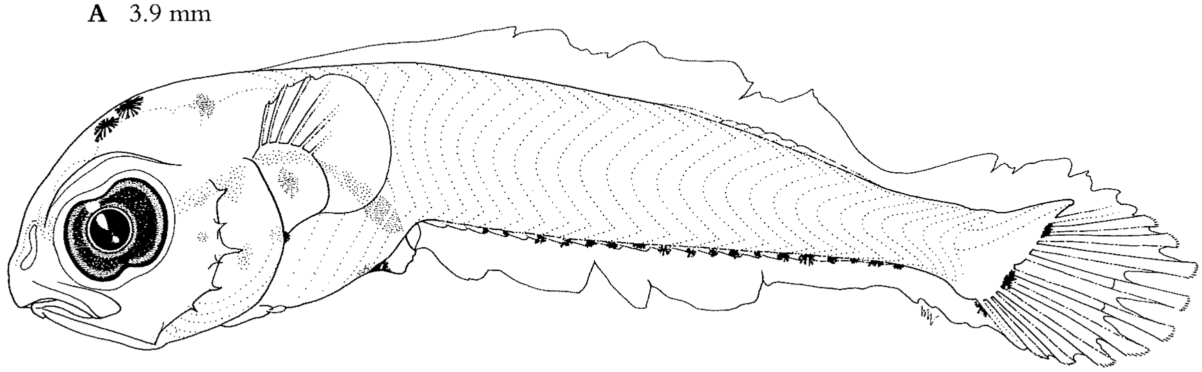
Material examined 15 larvae, 3.2–17.4 mm BL, Lake Macquarie and Port Hacking (NSW); 10 larvae, 3.8–14.0 mm BL, Hobart (Tas).

Additional references Miskiewicz (1987).

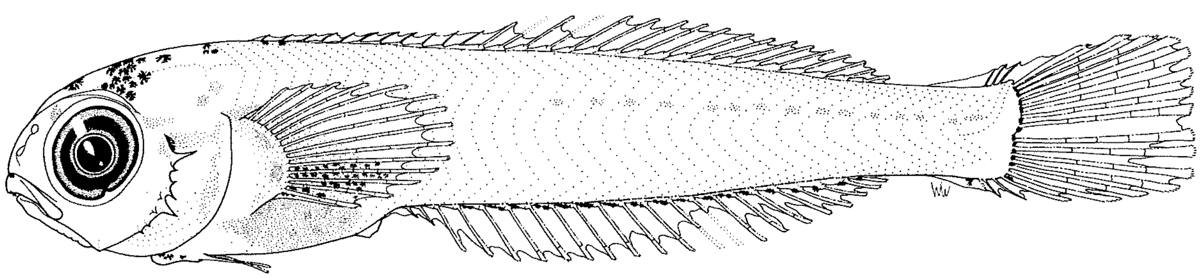
Figure 115 Larvae of *Parablennius tasmanianus*. **A** Late preflexion. **B** Flexion. **C** Postflexion. **D** Postflexion; note small preopercular spines. A–D from Sydney coastal waters (NSW). Illustrated by W. Watson.



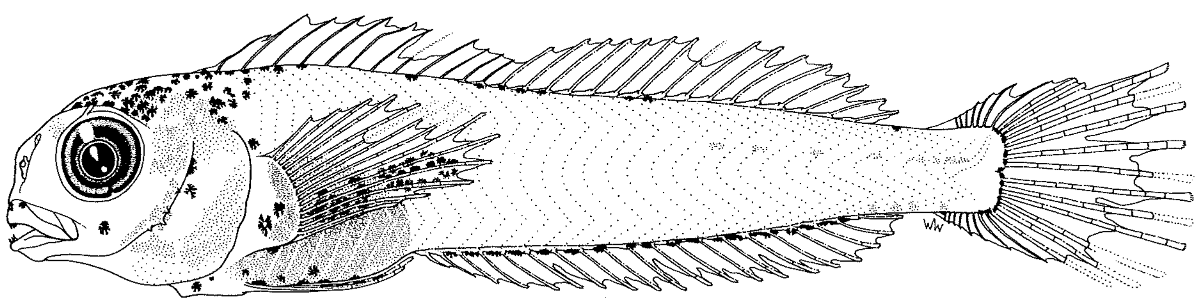
A 3.9 mm



B 4.6 mm



C 11.6 mm



D 17.4 mm

Blenniidae *Petroscirtes lupus* (De Vis, 1886) Sabre-toothed oyster blenny

D X–XI, 19–21 A II, 18–20 P_1 13–15 P_2 I, 3 C 11 V 35–36

Adults Distributed along eastern Australia from Bowen (Qld) to Merimbula (NSW); also in Lord Howe Island and New Caledonia. Occur in oyster shell substrates near seagrass beds in intertidal estuarine and shallow coastal waters to a depth of 10 m. Often observed in empty bottles and cans, and associated with floating rafts of seaweed. Adults have long, recurved canine teeth, and a brownish body with a broad lateral stripe of 6–8 dark blotches. Maximum size about 13 cm (Smith-Vaniz, 1976; Hutchins & Swainston, 1986; Edgar, 1997).

Importance to fisheries –

Spawning Eggs are demersal and nearly spherical, 0.7 × 0.9 mm, flattened at their basal poles, and have segmented yolk; they are attached in a single layer in a nest shell and are tended by the male parent (Munro, 1955). Larvae have been caught in coastal waters off northern and central New South Wales and in Lake Macquarie (NSW) from September to May, with peak abundances in October and between January and March (Miskiewicz, 1987), and in coastal waters off Sydney (NSW) from October to May (Gray, 1995).

Diagnostic characters

- 6–12 + 24–30 = 34–37 myomeres
- Pair of large dentary canine teeth from early preflexion stage
- No preopercular spines
- Internal pigment on forebrain in preflexion larvae
- Melanophores along lateral midline of tail from late flexion stage, spreading laterally over entire tail by postflexion stage
- No melanophores on pectoral-fin membrane

Description of larvae

Morphology Body elongate to moderate in preflexion larvae (BD 17–26%), moderate in flexion and postflexion larvae (BD 24–31%). Head moderate to large (HL 22–36%). Enlarged dentary canine teeth by 2.7 mm. Smooth supraocular ridge from flexion stage. Gut moderate in preflexion and flexion larvae (PAL 34–42%), moderate to long in postflexion larvae (PAL 49–55%), coiled and compact. Small gas bladder, rarely visible. Yolk sac is resorbed in preflexion larvae by 3 mm.

Size at	
Hatching [1]	~2.1–2.9 mm
Notochord flexion	4.3–6.4 mm
Settlement	13.0–17.0 mm
Formation of fins:	
Pectoral 3.1–4.9 mm; Caudal 3.1–4.9 mm; Anal 4.9–6.4 mm; Pelvic 4.9–8.7 mm; Dorsal 4.9–10.0 mm	

[1] Munro (1955)

Pigmentation Larvae initially lightly pigmented, becoming heavily pigmented during postflexion stage. *External:* 1–2 melanophores over midbrain in preflexion larvae by 3.1 mm; pigment dorsally over entire head, and on snout and upper lip in postflexion larvae by 8.7 mm. A few melanophores on opercle and branchiostegal membrane during flexion stage, spreading onto dentary by postflexion stage. Series of 10–18 melanophores along ventral midline of tail, extending from postanal myomeres 2–8 to anterior of notochord tip, about 1 per myomere. Often a few melanophores along hypural margin during flexion stage. Series of melanophores along lateral midline of posterior of tail from flexion stage, spreading from postflexion stage; pigment over entire trunk and tail by settlement. Melanophores on inner surface of pectoral-fin base, and occasionally 1–2 on outer surface in flexion larvae, increasing in number in postflexion larvae. Six to eight pigmented bars on dorsal- and anal-fin rays and membranes in late postflexion larvae. *Internal:* 1–2 large melanophores on anterior margin of forebrain, several under mid- and hindbrain, on floor of otic capsule, on pharyngobranchials, and 1–2 under middle of opercle in preflexion larvae by 3.1 mm; latter increase in number and spread under branchiostegal membrane during flexion stage. Heavy pigment dorsally and anteriorly over gut, spreading ventrally over entire gut at level of pelvic fins by 8.7 mm. Melanophore series dorsally along vertebrae by early postflexion stage, from postanal myomeres 8–18 and spreading anteriorly and posteriorly with growth; series ventrally along vertebrae from about 8.7 mm.

Material examined 34 larvae and pelagic juveniles, 2.1–17.0 mm BL, Lake Macquarie and coastal waters off Port Hacking (NSW).

Additional references Munro (1955), Miskiewicz (1987).

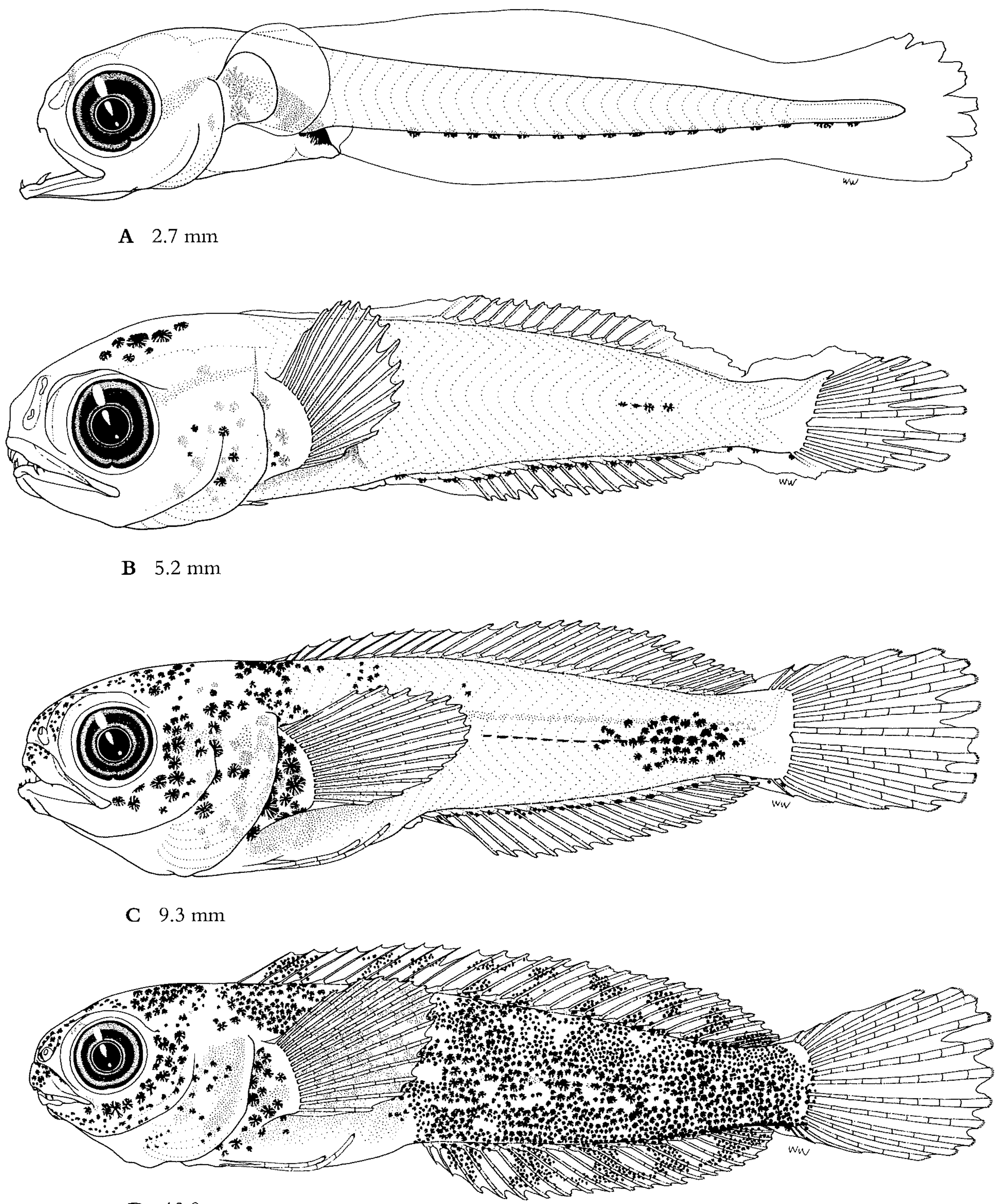


Figure 116 Larvae and early juvenile of *Petroscirtes lupus*. **A** Preflexion. **B** Late flexion. **C** Postflexion. **D** Early juvenile. A–D from central NSW coastal waters. Illustrated by W. Watson.

Gobioidei

The Gobioidei is the third largest suborder of perciform fishes, with 8 families, about 270 genera and some 2120 species found in fresh, estuarine and coastal marine waters throughout tropical and temperate regions worldwide (Nelson, 1994). Families comprise the Eleotridae (sleepers), Gobiidae (gobies), Kraemeriidae (sand darts), Microdesmidae (wormfishes), Odontobutidae, Rhyacichthyidae (loach gobies), Schindleriidae (Schindler's fishes) and Xenisthmidae (toothpick gobies) (Hoese, 1984; Hoese & Gill, 1993; Johnson & Brothers, 1993; Nelson, 1994). The Gobiidae is the second largest perciform family and contains the largest number of marine species of any teleost family (Nelson, 1994). Larvae have been described for members of all families except the Odontobutidae, Kraemeriidae and Rhyacichthyidae (see review of early life history stages by Ruple, 1984; see also Leis & Rennis, 1983; Dotsu *et al.*, 1988; Leis & Trnski, 1989; Leis *et al.*, 1993; Watson, 1996p,q,r).

Families and species included here

ELEOTRIDAE
Hypseleotris sp.

GOBIIDAE
Afurcagobius suppositus
Arenigobius bifrenatus
Favonigobius lateralis
Gobiid sp. 1
Gobiopterus semivestita
Papillogobius punctatus
Pseudogobius olorum
Redigobius macrostoma

Eleotridae: Gudgeons, sleepers

P.C. Gehrke and F. J. Neira

Eleotrids are mostly benthic fishes found in fresh, estuarine and coastal marine waters in tropical to subtropical regions worldwide, with only a few species in temperate regions (McDowall, 1975; Nelson, 1994). They are frequently found in habitats with abundant aquatic vegetation or woody debris. The taxonomic status of the Eleotridae is unclear and some authors regard it as a subfamily of the Gobiidae (Hoese & Gill, 1993; Larson & Hoese, 1996a). We follow Nelson (1994) in treating it as a separate family and containing 2 subfamilies, 35 genera and 150 species. Eight genera and approximately 40 species occur in Australia, most of which are restricted to tropical freshwater and mangrove areas. Five genera and about 14 species have been recorded from temperate Australia (Allen, 1982, 1989; Gomon *et al.*, 1994; Larson & Hoese, 1996a). Adults (up to 60 cm, most <17 cm) have a rounded to moderately depressed head, a large, slightly superior mouth, six branchiostegal rays, two separate dorsal fins, pelvic fins widely separate although the bases may be united or close together, and a lateral-line system reduced to pores and papillae on the head (Hoese, 1984; Gomon *et al.*, 1994). Adults of most species are sexually dimorphic. Eggs are demersal, adhesive and ovoid, 0.4–0.5 × 0.3–0.6 mm, and are attached to the substrate by a series of filaments arising from the basal pole (e.g. *Eleotris oxycephala*, *Hypseleotris cyprinoides*; Dotsu & Fujita, 1959; Dotsu *et al.*, 1988), or by an adhesive, smooth chorion without filaments (e.g. *Hypseleotris klunzingeri*; Lake, 1967b). Larvae have been described for representatives of *Dormitator*, *Eleotris*, *Erotelis*, *Hypseleotris*, *Odontobutis* and *Philypnodon* (see Ruple, 1984, and references therein; see also Lake, 1967b; Dotsu *et al.*, 1988; Watson, 1996p). The prominent gas bladder, which is lost in many species at settlement, is the only apparent specialisation of eleotrid larvae to pelagic life (Ruple, 1984).

Meristic characters of eleotrid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal (segmented)	Vertebrae
Gobiomorphus	(2)	VI–VIII + I, 8–9	I, 7–9	14–19	I, 5	15	12–13 + 16–17 = 28–29
Hypseleotris	(5)	VI–IX + I, 8–13	I, 9–13	13–17	I, 5	15	27–32
Mogurnda	(4)	VI–IX + I, 10–14	I, 10–13	14–16	I, 5	15	14–15 + 16–19 = 31–34
Philypnodon	(2)	VI–VIII + I, 8–10	I, 7–10	15–20	I, 5	15	12–14 + 17–20 = 29–32
Thalasseleotris	(1)	V–VII + I, 9–10	I, 8–9	17–21	I, 5	15–17	10 + 17 = 27

Main characters of eleotrid larvae

- 25–34 myomeres
- Body slender and very elongate to elongate (BD 7–20%), with a long caudal peduncle
- Head small to moderate, without spines; 6 branchiostegal rays
- Prominent gas bladder midway along gut, present in all larval stages but lost in many taxa at settlement
- Gut moderate to long (PAL 45–60%), initially straight but becoming coiled after flexion stage
- 2 separate dorsal fins, second develops prior to first and originates directly above anus
- Separate pelvic fins
- Body lightly pigmented
- Pigment along isthmus and cleithral symphysis, and along ventral midline of tail

References to eleotrid larvae

Lake (1967b), Anderson *et al.* (1971), Auty (1978), Hoese (1984), Ruple (1984), Dotsu *et al.* (1988), Watson (1996p).

Families with similar larvae

Gobiidae – Body elongate to moderate; 5 branchiostegal rays; comparatively short caudal peduncle; mostly estuarine and coastal species.

Eleotridae *Hypseleotris* sp. Carp gudgeon

D VI–IX + I, 10–13 A I, 10–13 P_1 14–17 P_2 I, 5 C 15 V 29–31

Adults Undescribed species found in freshwater coastal drainages from central Queensland to northern New South Wales, and throughout the Murray–Darling river system. Prefers still waters such as lakes and billabongs, but also occurs in flowing streams; usually associated with aquatic plants and muddy bottoms. Adults have 31–36 lateral scale rows and small cycloid scales dorsally on the head. Mature adults are sexually dimorphic, with males generally larger and stockier than females, and developing a dorsal hump on the head during the breeding season. Maximum size 6 cm (Hoese *et al.*, 1980; Larson & Hoese, 1996a).

Importance to fisheries Attractive aquarium species that breeds easily in captivity (Hoese *et al.*, 1980; Larson & Hoese, 1996a).

Spawning Eggs undescribed. Eggs of *H. galii* and *H. klunzingeri* are demersal and adhesive, slightly ovoid, 0.5–0.9 × 0.4–0.6 mm, and have a smooth chorion, a small to large perivitelline space, and up to 5 oil globules 0.04–0.18 mm (Lake, 1967b, as *Carassiops klunzingeri*; Anderson *et al.*, 1971). Breeds in spring and summer in southern and inland habitats, and deposits adhesive eggs on aquatic vegetation in shallow water. Flooding is not a requirement for spawning (Gehrke, 1992).

Diagnostic characters

- 10–12 + 17–21 = 29–31 myomeres
- Pigment along myosepta posterior to anus until early postflexion stage
- Paired series of 8–10 melanophores along anal-fin base, followed by a single series ventrally along caudal peduncle
- No melanophores along dorsal midline of trunk and tail before postflexion stage

Description of larvae

Morphology Body very elongate in preflexion larvae (BD 7–9%), elongate in postflexion larvae (BD 13–20%). Head small in preflexion larvae (HL 13–18%), moderate in postflexion larvae (HL 23–33%). Mass of pigmented tissue ventrally on eye in preflexion and flexion larvae, merging with eye in late flexion larvae. Gut moderate to long (PAL 45–60%), with a single coil from flexion stage. Large gas bladder over hindgut in all stages. Long preanal membrane until late postflexion stage. Scales form by 12 mm.

Size at

Hatching	<2.1 mm
Notochord flexion	5.5–6.5 mm
Settlement	~15.0 mm

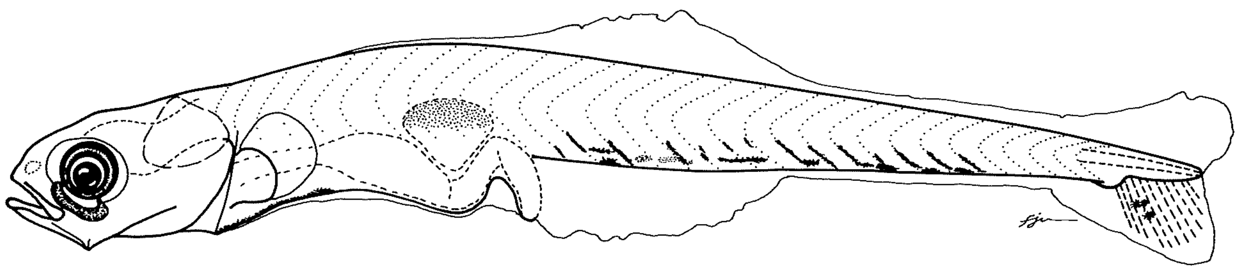
Formation of fins:
Caudal 4.8–7.5 mm; Second dorsal 5.2–9.0 mm; Anal 5.2–9.0 mm; Pectoral 7.5–9.0 mm; First dorsal 7.5–9.2 mm; Pelvic 7.5–10.3 mm

Pigmentation Larvae are lightly pigmented. *External:* Melanophores dorsally on head, 1 at angle of lower jaw and anterior to cleithral symphysis by postflexion stage. Pigment ventrally along foregut. Series of 8–10 paired melanophores along anal-fin base, followed by a single series ventrally along caudal peduncle; latter may coalesce to form a stripe by late postflexion stage. Several melanophores dorsally over trunk and tail, along lateral midline of tail, and along caudal-fin rays by postflexion stage. Melanophores along caudal myosepta until early postflexion stage. *Internal:* Several melanophores at junction of mid- and hindbrain, and in otic region in late postflexion larvae. Pigment dorsally over gas bladder. One melanophore above anus in late postflexion larvae.

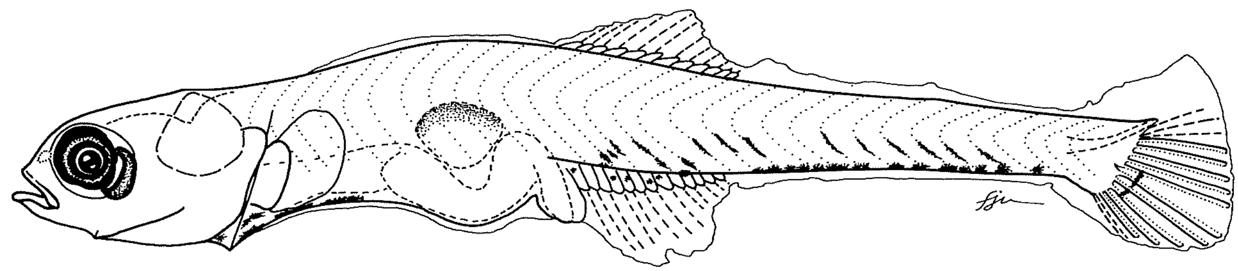
Material examined 43 larvae and juveniles, 2.1–20.0 mm BL, Horseshoe Lagoon near Gulpa Creek, Murray–Darling drainage (southwestern NSW).

Additional references –

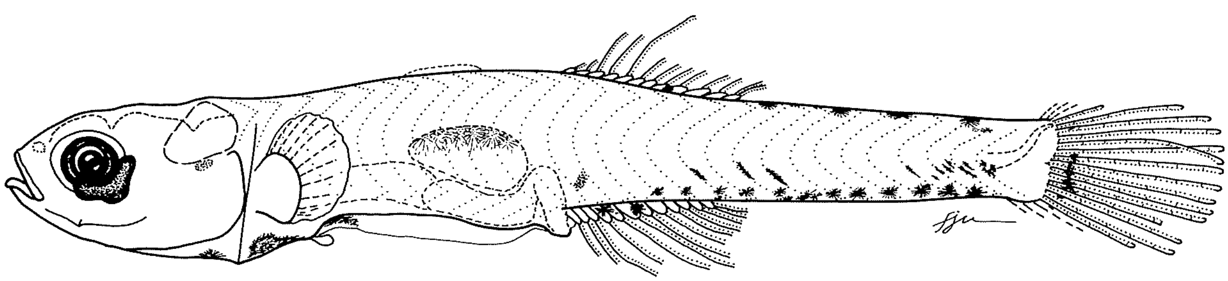
Figure 117 Larvae of *Hypseleotris* sp. **A** Preflexion. **B** Flexion. **C** Early postflexion; note pelvic-fin bud. **D** Postflexion; note tissue below and behind eye in A–D. **E** Postflexion; scales omitted. A–E from near Gulpa Creek, Murray River (NSW). Illustrated by F. J. Neira.



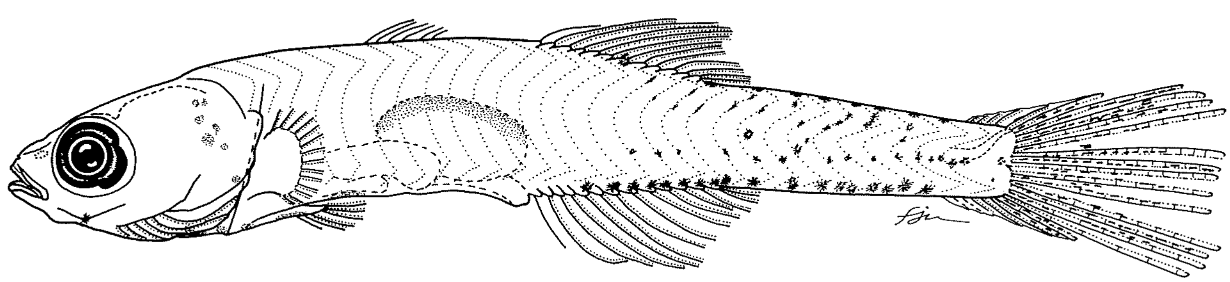
A 5.0 mm



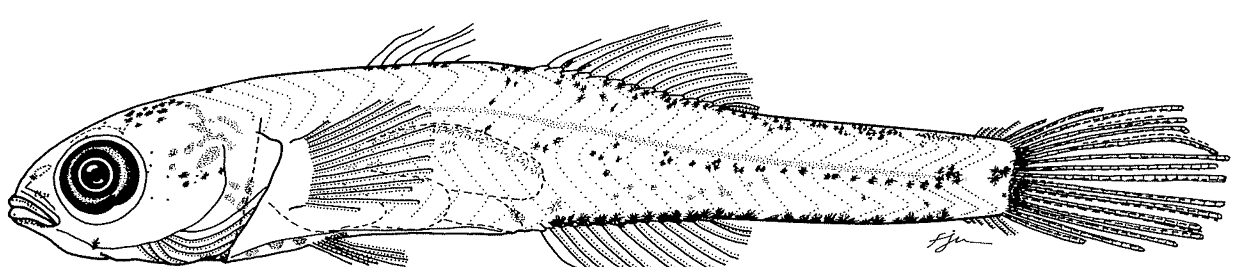
B 5.6 mm



C 7.5 mm



D 9.3 mm



E 12.0 mm

Gobiidae: Gobies

F. J. Neira and A.G. Miskiewicz

Gobiids are predominantly benthic fishes found in estuarine and coastal marine waters, occasionally in fresh water, in tropical to temperate regions worldwide. The family contains about 212 genera and over 1870 species, about 400 in Australia (Nelson, 1994; Larson & Hoese, 1996b). Approximately 23 genera and 45 species have been recorded from temperate Australia, although there may be several additional undescribed species (D.F. Hoese, AMS, pers. comm.; H.S. Gill, pers. comm.). Revisions of the Gobiidae include those of Hoese (1984), Birdsong *et al.* (1988) and Pezold (1993). Adults (up to 50 cm, most <10 cm) have a rounded to moderately depressed head, a terminal to subterminal mouth, five branchiostegal rays, two separate dorsal fins, the spinous dorsal fin, when present, with 2–9 flexible spines, large pelvic fins often joined and forming a cap-shaped disc, and a lateral-line system reduced to pores and papillae on the head (Hoese, 1984; Gomon *et al.*, 1994). Adults of many species are sexually dimorphic, with the males having a long, thin genital papillae for external fertilisation. Eggs are demersal and ovoid to ellipsoid, and are attached to the substrate by a series of adhesive filaments arising from the basal pole; size of fertilised eggs varies with species and ranges from about 0.4–5.5 mm on the long axis to 0.2–1.3 mm on the short axis (Dotsu & Mito, 1955; Breder & Rosen, 1966; Ruple, 1984; Dotsu *et al.*, 1988). Larvae have been described for representatives of many genera (see Ruple, 1984, and references therein; see also Leis & Rennis, 1983; Dotsu *et al.*, 1988; Matarese *et al.*, 1989; Leis *et al.*, 1993; Watson, 1996q). The prominent gas bladder, which is usually lost in most species at settlement, constitutes the only apparent specialisation of gobiid larvae to pelagic life (Leis & Rennis, 1983; Ruple, 1984).

Meristic characters of gobiid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal (segmented)	Vertebrae
*Acanthogobius**	(1)	VIII–IX + I,12–14	I, 11–12	21	I, 5	17	13 + 20–21 = 33–34
Acentrogobius	(2)	VI + I, 9–10	I, 8–10	17–19	I, 5	17	–
Afurcagobius	(2)	VI + I, 8	I, 7–8	15–18	I, 5	17	10–11 + 16–17 = 27
Amblygobius	(1)	VI + I, 13–15	I, 13–14	13–14	I, 5	17	10 + 16 = 26
Arenigobius	(2)	VI + I, 10–11	I, 10	16–19	I, 5	17	10 + 16 = 26
Bathygobius	(1)	VI + I, 9–11	I, 8–10	16–21	I, 5	17	10 + 17 = 27
Callogobius	(2)	VI + I, 10–12	I, 8–10	15–18	I, 5	17	10 + 16–17 = 26–27
Eviota	(1)	VI + I, 9	I, 8	16–17	I, 5	17	10 + 15–16 = 25–26
Favonigobius	(2)	VI + I, 8–9	I, 8–9	15–19	I, 5	17	10 + 16 = 26
Gnatholepis	(1)	VI + I, 11	I, 11	15–17	I, 5	17	10 + 16 = 26
Gobiid sp. 1	(1)	0 + I, 12–14	I, 12–14	17–19	I, 3	17	10 + 15 = 25
Gobiopterus	(2)	V + 7–10	11–13	14–15	I, 5	17	10 + 15 = 25
Mugilogobius	(2)	V–VI + I, 7–10	I, 7–10	13–18	I, 5	15–18	10–11 + 15–17 = 26–27
Nesogobius	(10)	VI–IX + 0–I, 7–12	0–I, 7–12	16–21	I, 5	13	10–12 + 18–21 = 29–33
Pandaka	(1)	VI + 6–8	6–8	14–16	I, 5	17	10 + 14–15 = 24–25
Papillogobius	(4)	VI + I, 7–9	I, 8–9	15–16	I, 5	17	10 + 16 = 26
Parkraemeria †	(1)	VI + 14	14	12–13	I, 5	13	10 + 15–16 = 25–26
Pseudogobius	(2)	VI + I, 7–9	I, 7–9	14–17	I, 5	16	10 + 15–17 = 25–27
Redigobius	(1)	VI + I, 7	I, 6–7	16–18	I, 5	17	10 + 16 = 26
Taenioides †	(1)	VI + 35	38	16–17	I, 5	17	10 + 16 = 26
Tasmanogobius	(3)	VI–VIII + 0–I, 13–16	0–I, 12–16	16–21	I, 5	17	11–13 + 15–20 = 26–32
Tridentiger *	(1)	VI + I, 12–13	I, 10–11	18–22	I, 5	17	10 + 16 = 26
Valenciennea	(1)	VI + I, 13–17	I, 11–16	18–20	I, 5	17	10 + 16 = 26

* Introduced species
† Counts from cleared and stained specimens

Main characters of gobiid larvae

- 24–34 myomeres, typically 25–27
- Body elongate to moderate (BD 11–26%)
- No head spines; 5 branchiostegal rays
- Gut moderate to long (PAL 43–61%), straight but usually slightly looped anterior to anus ('S'–shaped), never fully coiled
- Prominent, inflated gas bladder over midgut, present in all larval stages but lost in many taxa at settlement
- No gap between anus and origin of anal fin except in a few taxa
- 2 separate dorsal fins; second dorsal fin forms prior to first dorsal fin and usually originates almost directly above anus
- Pelvic fins large, usually joined and forming a sucking disc at settlement
- Body lightly to heavily pigmented, typically lightly pigmented
- Pigment ventrally along isthmus and cleithral symphysis in most taxa
- Pigment dorsally over gas bladder in most taxa
- One to many melanophores along ventral midline of tail

References to gobiid larvae

Leis & Rennis (1983), Ruple (1984), Dotsu *et al.* (1988), Watson (1996q).

Families with similar larvae

Apogonidae – 23–25 myomeres; preopercular spines in many taxa; mouth large, often reaching beyond mideye; body usually deep in postflexion stage; gut fully coiled and compact by flexion stage; large gas bladder over foregut.

Berycidae – 24 myomeres; preopercular spines in postflexion larvae; single dorsal fin; elongate, early forming pelvic-fin rays, I, 7–13; body lightly pigmented.

Eleotridae – Body very elongate to elongate; 6 branchiostegal rays; relatively long caudal peduncle; mostly freshwater species.

Microdesmidae (early stages) – 48–59 myomeres; body extremely elongate.

Sillaginidae – 32–45 myomeres, 32–35 in most taxa; snout elongate in postflexion larvae; late forming, very small preopercular spines in most taxa; long-based anal fin, II, 15–24; melanophore series ventrally along gut and tail.

Gobiidae *Afurcagobius suppositus* (Sauvage, 1880) Long-headed goby

D VI + I, 8 A I, 7 P_1 15–16 P_2 I, 5 C 17 V 27

Adults Endemic to southwestern Western Australia from Moore River (80 km north of Perth) to Esperance. Occurs in lower reaches of rivers, estuaries and coastal lakes. Adults have an elongate caudal fin and a dark stripe extending from the pectoral fin along the lower surface of the body. Males are brightly coloured during the breeding season. Maximum size about 11 cm (Gill, 1993).

Importance to fisheries Prey item for commercially important estuarine teleosts such as the southern blue-spotted flathead, *Platycephalus speculator* (Humphries *et al.*, 1992).

Spawning Eggs undescribed. Larvae have been collected in the Swan and Nornalup–Walpole estuaries, and in Wilson Inlet from October to April, with peak abundances in December (Neira & Potter, 1992b, 1994; Neira *et al.*, 1992).

Diagnostic characters

- 10–11 + 16 = 26–27 myomeres
- Yolk sac persists until early postflexion stage
- Base of second dorsal fin longer than base of anal fin
- Melanophore at tip of lower jaw
- Band of internal pigment dorsally along gas bladder and hindgut
- Conspicuous melanophore on caudal peduncle, just posterior to posterior end of dorsal fin

Description of larvae

Morphology Body elongate to moderate (BD 16–26%). Head moderate (HL 20–33%). Gut long (PAL 51–61%). Yolk sac persists until early postflexion stage and is resorbed by 4.5 mm. Base of second dorsal fin longer than base of anal fin; second dorsal fin originates 1–2 myomeres anterior to vertical line through anus. Scales form from 9.5 mm.

Size at

Hatching	<3.0 mm
Notochord flexion	3.5–4.0 mm
Settlement [1]	~9.0 mm

Formation of fins:
Caudal 3.1–3.9 mm; Pectoral 3.1–4.0 mm; Second dorsal 3.5–4.2 mm; Anal 3.5–4.2 mm; Pelvic 3.5–4.5 mm; First dorsal 4.2–4.9 mm

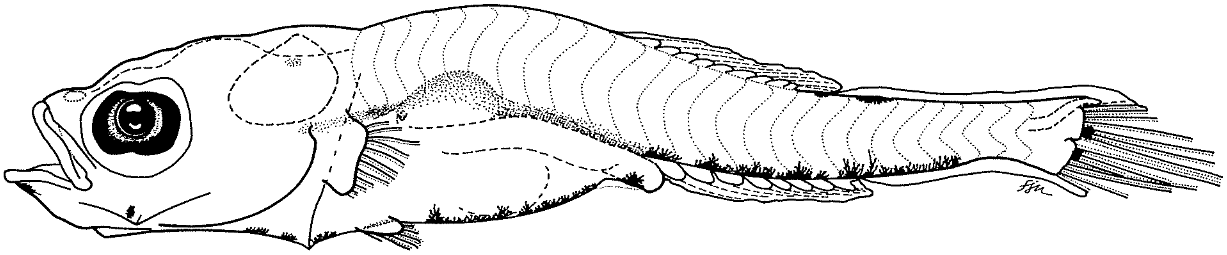
[1] H.S. Gill (pers. comm.)

Pigmentation Larvae are moderately pigmented. *External:* 1 melanophore at tip of lower jaw and 1 at angle of lower jaw; pigment along isthmus and just posterior to cleithral symphysis. Pigment along pelvic-fin base, ventral surface of gut and 1 melanophore ventrally at anus. Series of stellate melanophores along ventral midline of tail. One melanphore each on posterior edge of upper and lower hypural plates. One conspicuous dorsal melanophore just posterior to dorsal-fin base on caudal peduncle, between myomeres 18 and 20. Pigment on head, 5–7 pigment blotches along dorsal surface of trunk and tail, and pigment on pectoral base, first and second dorsal, anal, and caudal fins in newly settled juveniles. *Internal:* Pigment at base of hindbrain and around otic capsule. Band of pigment dorsally over gas bladder and hindgut.

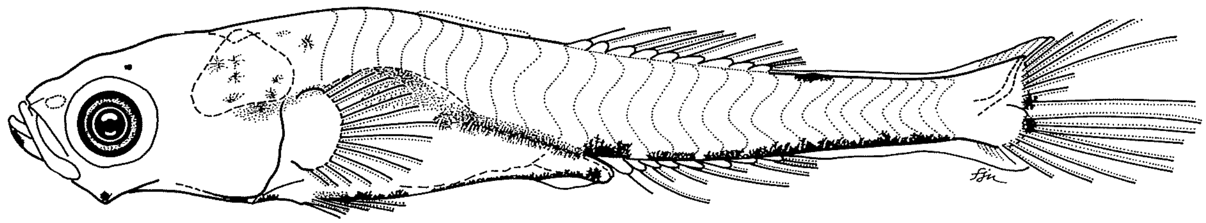
Material examined 12 larvae, 3.0–7.3 mm BL, and 1 juvenile, 12.8 mm BL, Wilson Inlet (WA).

Additional references –

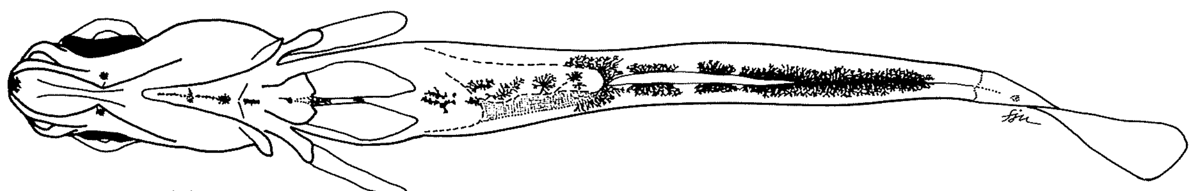
Figure 118 Larvae and juvenile of *Afurcagobius suppositus*. **A** Late flexion. **B** Early postflexion; note developing first dorsal fin. **C** Ventral view of larva in B. **D** Postflexion. Yolk sac is present in larvae A–D. **E** Juvenile; myomeres omitted. A, B, D, E from Wilson Inlet (WA). Illustrated by F. J. Neira.



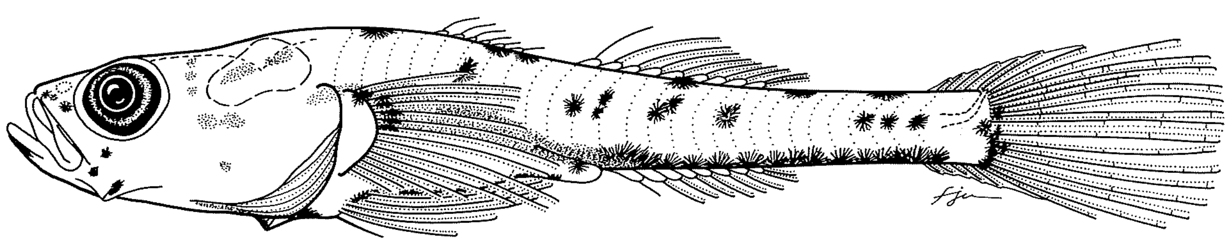
A 3.7 mm



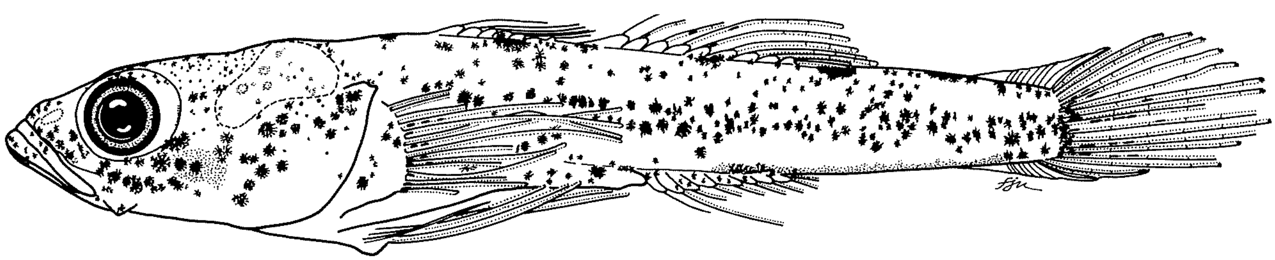
B 4.2 mm



C 4.2 mm



D 4.7 mm



E 7.3 mm

Gobiidae *Arenigobius bifrenatus* (Kner, 1865) Bridled goby

D VI + I, 10 A I, 10 P_1 16–18 P_2 I, 5 C 17 V 26

Adults Endemic to southern Australia from Fremantle (WA) to Moreton Bay (Qld), including Tasmania. Found in burrows on sand and silty bottoms, and in seagrass beds and mangrove areas in estuaries and coastal bays. Adults have white bars on the lower side of the body and dark spots along the lateral midline. *Amoya* is a generic synonym. Maximum length 18 cm, rarely exceeding 10 cm (Last *et al.*, 1983; Hutchins & Swainston, 1986; Kuiter, 1993; Larson & Hoese, 1996b).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been caught in the upper Swan Estuary (WA) in every month except July, mainly between October and January (Neira *et al.*, 1992).

Diagnostic characters

- 10 + 16 = 26 myomeres
- Melanophore ventrally at anus
- Internal pigment above anus
- Large melanophore on ventral midline of tail, between myomeres 18–21
- No pigment on head, and dorsal and lateral surfaces of trunk and tail prior to settlement

Description of larvae

Morphology Body elongate (BD 11–17%). Head small in preflexion larvae (HL 17–19%), moderate in flexion and postflexion larvae (HL 20–26%). Gut moderate in preflexion larvae (PAL 43–46%), long in flexion and postflexion larvae (PAL 50–54%). Scales begin to form at settlement.

Size at

Hatching	<3.1 mm
Notochord flexion	4.2–5.3 mm
Settlement	7.4–10.0 mm

Formation of fins:

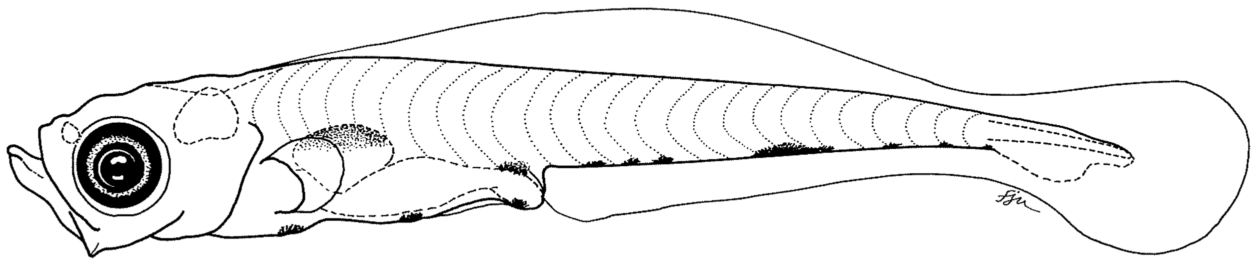
Caudal 3.1–6.4 mm; Second dorsal 4.3–6.0 mm; Anal 4.3–6.0 mm; Pectoral 4.7–6.2 mm; Pelvic 4.9–6.8 mm; First dorsal 6.0–6.8 mm

Pigmentation Larvae are lightly pigmented. *External:* Elongate melanophore between pelvic-fin bases; 1 melanophore ventrally on midgut, and 1 ventrally at anus. Series of 3–6 melanophores along ventral midline of tail, followed by a large melanophore between myomeres 18 and 21; pigment ventrally along caudal peduncle posterior to large melanophore. Two melanophores at caudal-fin base along upper and lower hypural plates in postflexion larvae. Juveniles possess a dark, broad bar of pigment extending from below eye to lower portion of pectoral-fin base, blotches of pigment along ventrolateral surface of trunk and tail, and pigment on all fins; longitudinal stripe of pigment along proximal portion of first and second dorsal-fin membranes. *Internal:* Pigment dorsally over gas bladder; 1 melanophore above anus.

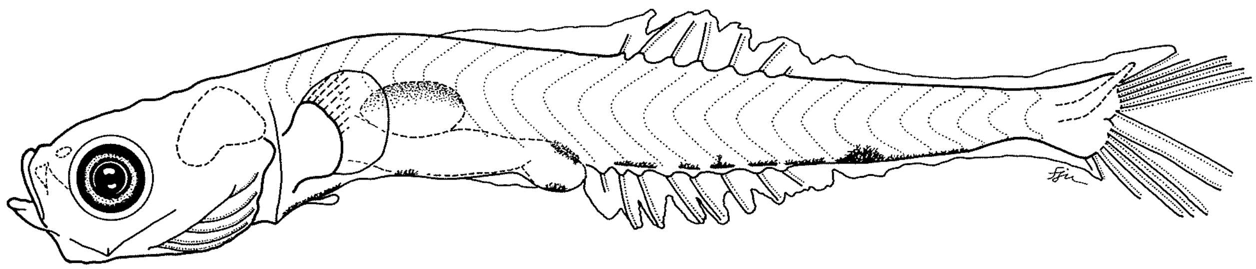
Material examined 20 larvae, 3.1–7.6 mm BL, and 1 juvenile, 28.5 mm BL, Swan Estuary (WA); 2 juveniles, 7.4 and 12.8 mm BL, Botany Bay (NSW).

Additional references –

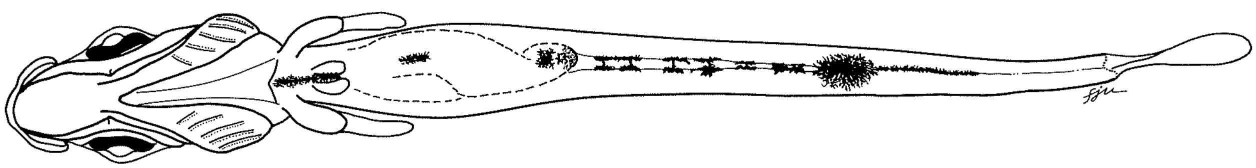
Figure 119 Larvae and juvenile of *Arenigobius bifrenatus*. **A** Preflexion. **B** Flexion. **C** Ventral view of larva in B; note pelvic-fin buds. **D** Postflexion. **E** Juvenile; scales omitted. A, B, D, E from upper Swan Estuary (WA). Illustrated by F.J. Neira.



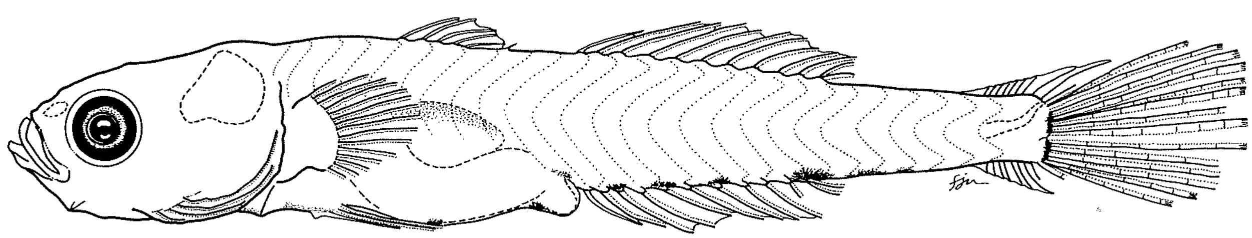
A 3.1 mm



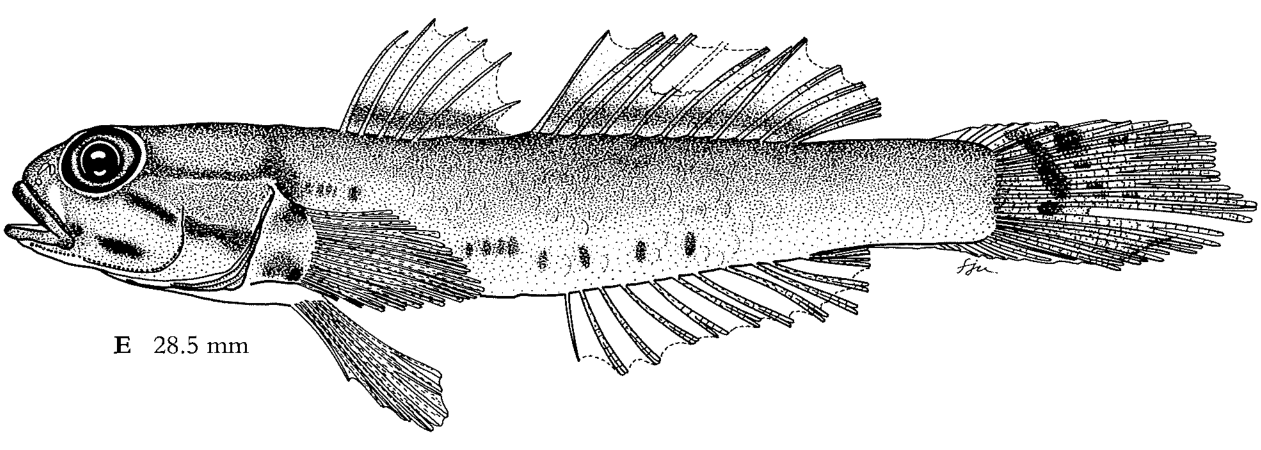
B 4.9 mm



C 4.9 mm



D 6.9 mm



E 28.5 mm

Gobiidae *Favonigobius lateralis* (Macleay, 1881) Long-finned goby

D V–VI + I, 8–9 A I, 8–9 P_1 15–17 P_2 I, 5 C 17 V 26

Adults Endemic to southern Australia from Shark Bay (WA) to central Queensland, including Tasmania. Occurs on shallow sandy bottoms of estuaries and coastal marine embayments. Adults have about 5 pairs of dark spots laterally, and a series of white bars on the lower half of the body. Maximum size 9 cm (Last *et al.*, 1983; Gill & Miller, 1990; Kuiter, 1993, 1996).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been collected in the Nornalup–Walpole Estuary and Wilson Inlet (WA) from September to April, with peak abundances between December and February (Neira & Potter, 1992b, 1994). Larvae exit Wilson Inlet on the ebb tide in the preflexion stage and enter the inlet on the flood tide in the postflexion stage (Neira & Potter, 1992a).

Diagnostic characters

- 0–11 + 16 = 26–27 myomeres
- 1–4 melanophores, usually 3, along dorsal midline of tail, between myomeres 16–21
- 4–13 melanophores along ventral midline of tail in flexion and postflexion larvae
- 3 internal melanophores above hindgut in preflexion larvae

Description of larvae

Morphology Body elongate (BD 13–17%). Head small to moderate (HL 18–30%). Gut moderate to long (PAL 46–53%). Scales form from 10 mm.

Size at

Hatching	<2.0 mm
Notochord flexion	3.0–4.0 mm
Settlement	11.1–13.5 mm

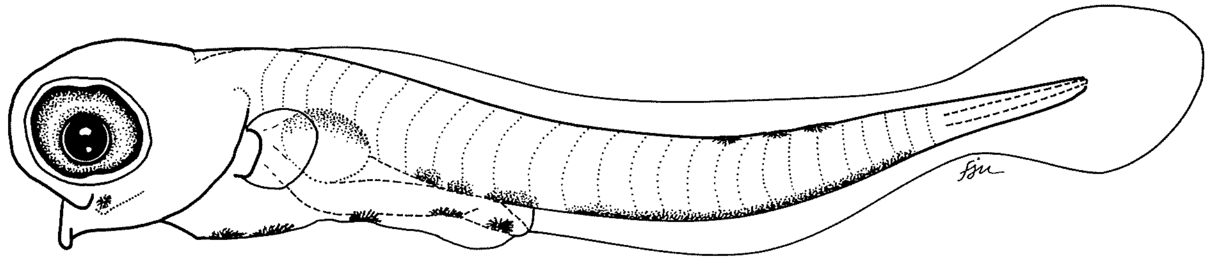
Formation of fins:
Caudal 2.3–6.2 mm; Second dorsal 2.5–4.1 mm; Anal 2.5–4.1 mm; Pectoral 3.0–6.3 mm; Pelvic 3.9–6.2 mm; First dorsal 4.8–8.0 mm

Pigmentation Larvae are lightly pigmented. *External:* 1 melanophore at angle of lower jaw; 1 elongate melanophore along isthmus and 1 between pelvic-fin bases. One to five melanophores, usually 3–5, ventrally along gut, and 1–2 ventrally at anus. Series of 1–4 melanophores, usually 3, along dorsal midline of tail, between myomeres 16 and 21, reduced to 1–2 in postflexion larvae. Continuous stripe of pigment along ventral midline of tail in preflexion larvae, becoming a discrete series of 4–13 melanophores from flexion stage. One melanophore along lower caudal-fin base. Juveniles possess 6–7 blotches of pigment laterally on trunk and tail, and pigment on first and second dorsal, pectoral and caudal fins. *Internal:* Pigment dorsally along gas bladder; 3 melanophores above hindgut in preflexion and flexion larvae, the one above anus remaining in postflexion larvae.

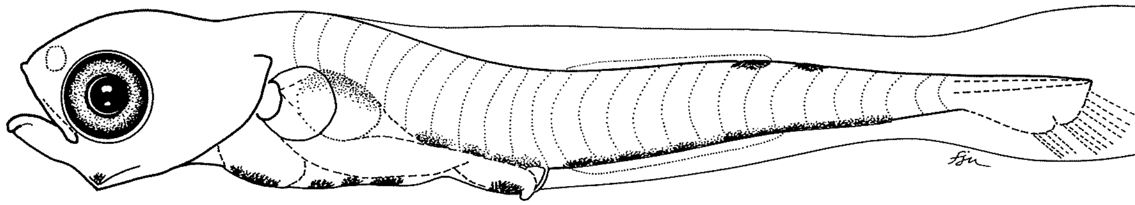
Material examined 26 larvae, 2.0–11.1 mm BL, and 3 juveniles, 18.1–23.8 mm BL, Wilson Inlet (WA); 9 juveniles, 12.9–15.5 mm BL, Botany Bay and Port Hacking (NSW).

Additional references –

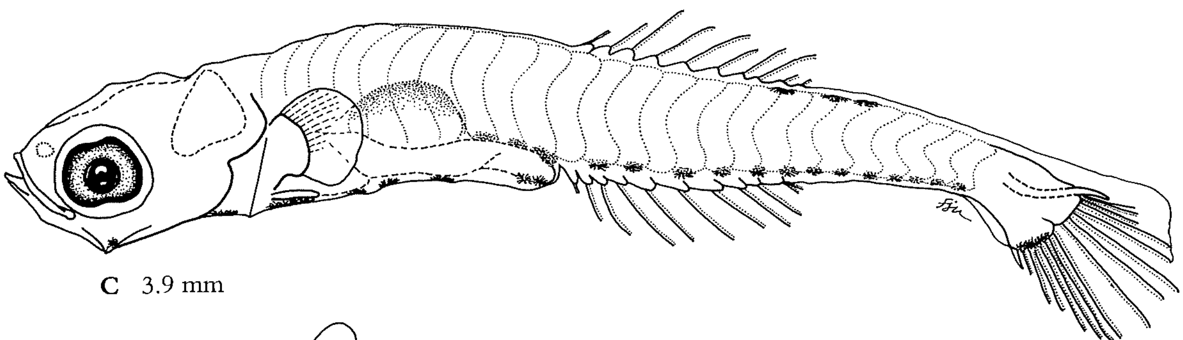
Figure 120 Larvae and juvenile of *Favonigobius lateralis*.
A Preflexion. **B** Late preflexion; note developing second dorsal and anal fin. **C** Flexion. **D** Ventral view of larva in C; note pelvic-fin buds. **E** Postflexion. **F** Juvenile; scales omitted. A–C, E, F from Wilson Inlet (WA). Illustrated by F. J. Neira.



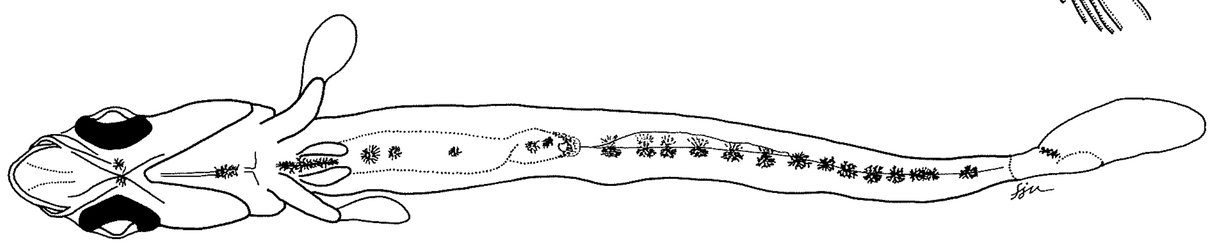
A 2.1 mm



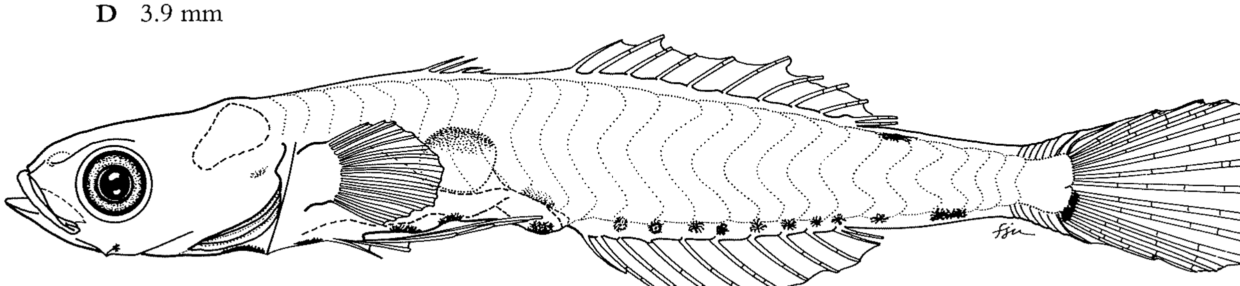
B 2.5 mm



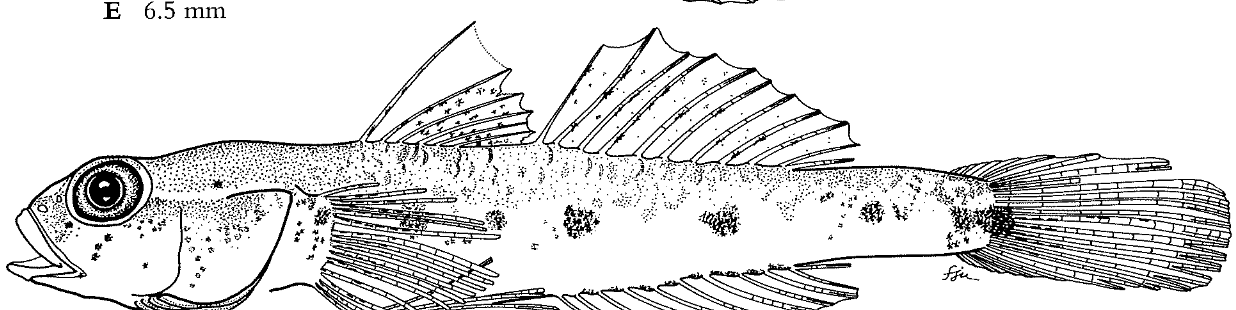
C 3.9 mm



D 3.9 mm



E 6.5 mm



F 21.0 mm

Gobiidae Gobiid sp. 1 Wide-gape paedomorphic goby

D 0 + I, 12–14 A I, 12–14 P_1 17–19 P_2 I, 3 C 17 V 25

Adults Undescribed paedomorphic species recorded in New South Wales in Lake Macquarie (Miskiewicz, 1987, as Goby L), Botany Bay and the Hawkesbury River (AMS records); also occurs in Japan, suggesting a broader distribution. Adults lack the first dorsal fin and have a transparent body with pigment ventrally. Maximum size about 1.5 cm. New genus and species currently being described (A. Iwata, BLIH, pers. comm.).

Importance to fisheries –

Spawning Eggs undescribed. Paedomorphic and sexually dimorphic species, sexually mature at approximately 12–13 mm. Larvae have been collected in Lake Macquarie (NSW) from August to May, with peak abundances between January and April (Miskiewicz, 1987).

Diagnostic characters

- 9–10 + 15–16 = 25 myomeres
- First dorsal fin absent
- Eye squarish in preflexion larvae, round in postflexion larvae
- Elongated basipterygium, pigmented along ventral surface
- 12–15 melanophores along ventral midline of tail

Description of larvae

Morphology Body elongate (BD 13–20%). Head moderate (HL 21–28%). Teeth are present in both jaws in early postflexion larvae, becoming very enlarged in mature males. Eye squarish, with posteroventral projection in preflexion larvae, round in postflexion larvae. Gut moderate to long (PAL 48–61%). Elongate basipterygium from end of flexion stage; pelvic fins develop from end of basipterygium.

Size at

Hatching	<1.7 mm
Notochord flexion	4.5–5.5 mm
Transformation	12.0–13.0 mm
Formation of fins:	

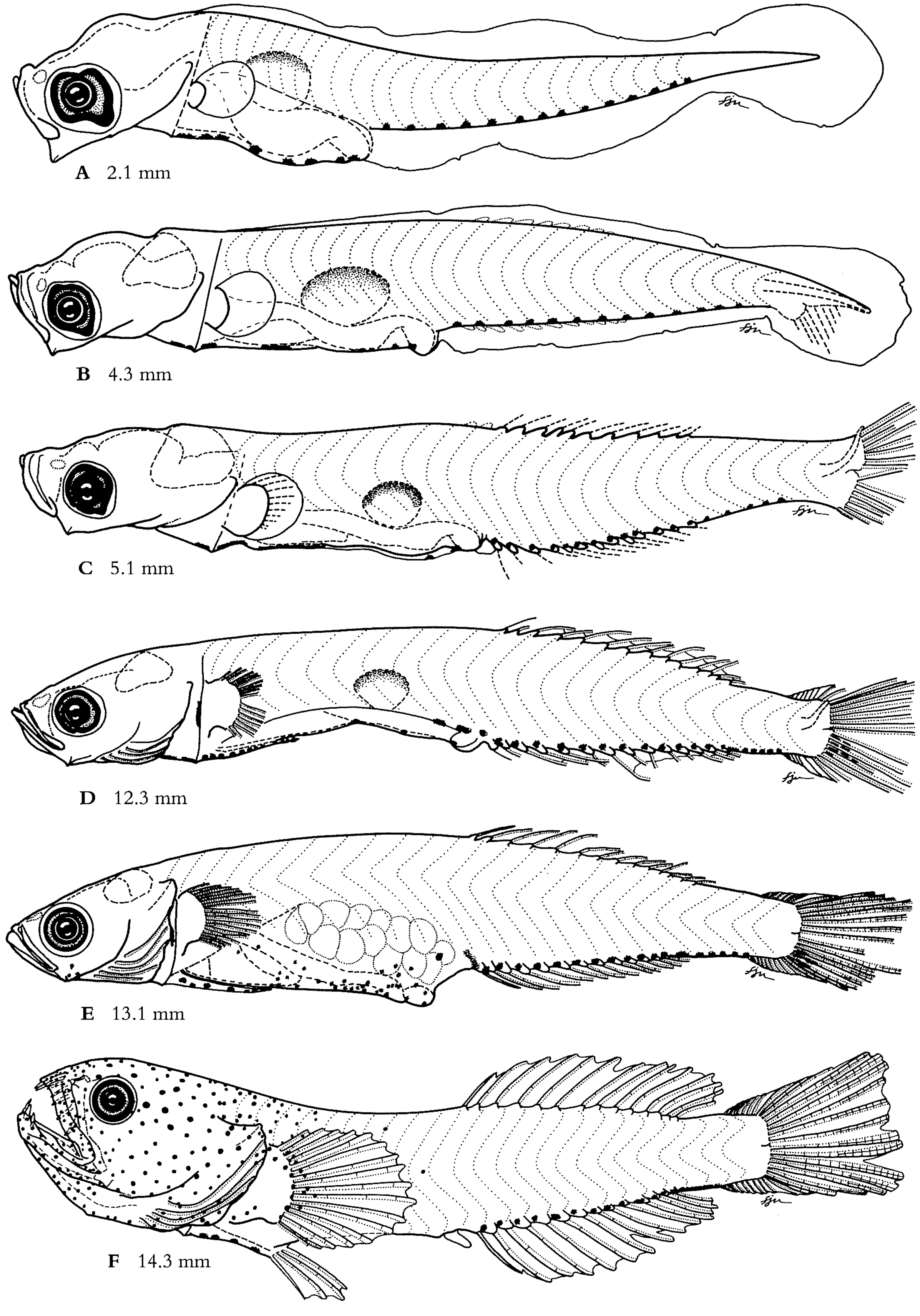
Caudal 3.0–5.5 mm; Second dorsal 3.6–6.0 mm; Anal 3.6–6.0 mm; Pectoral 5.1–12.4 mm; Pelvic 11.7–13.4 mm

Pigmentation Larvae are lightly pigmented. *External:* 1 elongate melanophore on isthmus, 2 posterior to cleithral symphysis; 1 melanophore under pectoral-fin base in postflexion larvae. Up to 8 small melanophores ventrally along gut, disappearing with growth. Series of 12–15 melanophores along ventral midline of tail. Pigment at base of lower caudal-fin rays in postflexion larvae. One melanophore at angle of lower jaw, 4 on opercle and a series of small melanophores along ventral surface of basipterygium in juveniles. *Internal:* Pigment dorsally over gas bladder. One melanophore at base of otic capsule, 1 on upper cleithrum and a pair above anus in juveniles.

Material examined 22 specimens, including larvae, juveniles and adults, 1.7–14.3 mm BL, Lake Macquarie and Botany Bay (NSW).

Additional references Miskiewicz (1987, as Goby L).

Figure 121 Larvae and adults of Gobiid sp. 1. **A** Preflexion. **B** Late preflexion; note developing second dorsal and anal fins. **C** Early postflexion; note posteroventral projection of eye in this and in larvae in A, B. **D** Postflexion; note ventrally pigmented, elongate basipterygium with small pelvic-fin rays at the tip (also noticeable in C), and lack of first dorsal fin. **E** Adult female; note eggs in body cavity. **F** Adult male. A–D from Lake Macquarie (NSW); E–F from Botany Bay (NSW). Illustrated by F. J. Neira.



A 2.1 mm

B 4.3 mm

C 5.1 mm

D 12.3 mm

E 13.1 mm

F 14.3 mm

Gobiidae *Gobiopterus semivestita* (Munro, 1949) Transparent goby

D V + 7–10 A 11–13 P_1 14–15 P_2 I, 5 C 17 V 25

Adults Endemic to southeastern Australia from South Australia to central Queensland, excluding Tasmania. Occurs in seagrass beds in estuaries, sometimes entering fresh water. Adults have a minute first dorsal fin, and a transparent body with small scattered black spots. Maximum size 3.5 cm (Kuiter, 1993; Gomon *et al.*, 1994).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been collected in Lake Macquarie (NSW) from September to May, with peak abundances between January and March (Miskiewicz, 1987).

Diagnostic characters

- 10 + 14–15 = 24–25 myomeres
- Eye squarish in preflexion and flexion larvae, round in postflexion larvae
- 10–15 small melanophores along ventral midline of tail, with 1 enlarged melanophore between myomeres 18–19

Description of larvae

Morphology Body elongate (BD 15–19%). Head moderate (HL 19–28%). Numerous small villiform teeth along premaxilla from early flexion stage, along dentary by early postflexion stage. Eye squarish and with a prominent posteroventral projection in preflexion and flexion larvae, round in postflexion larvae. Gut moderate to long (PAL 46–59%).

Size at	
Hatching	<2.2 mm
Notochord flexion	3.4–5.3 mm
Settlement	10.5–15.0 mm
Formation of fins:	

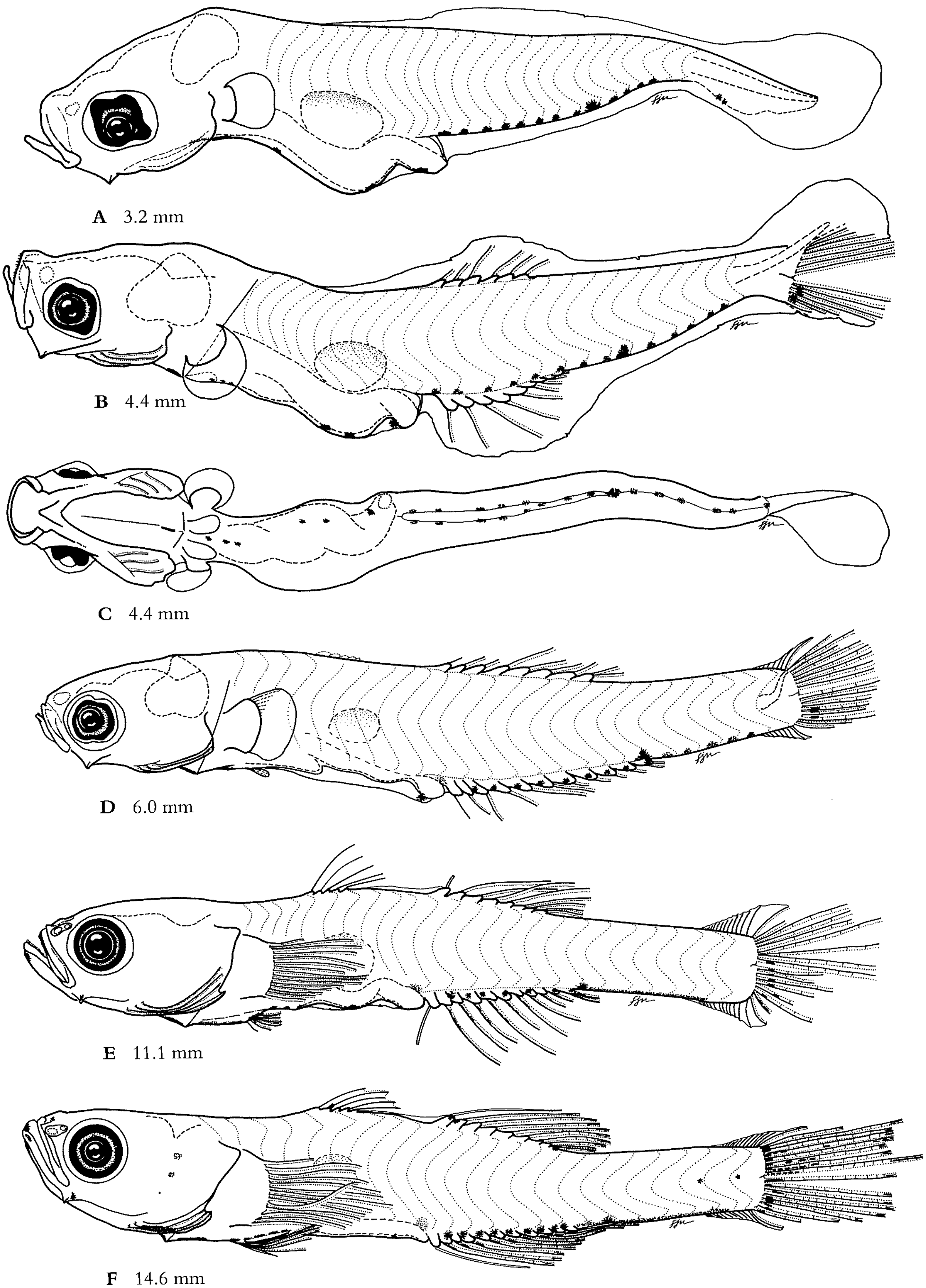
Caudal 3.2–5.3 mm; Second dorsal 3.9–6.0 mm; Anal 3.9–6.0 mm; Pelvic 4.4–9.4 mm; First dorsal 6.0–7.3 mm; Pectoral 6.0–9.0 mm

Pigmentation Larvae are lightly pigmented. *External:* 1 elongate melanophore along isthmus, 1 posterior to cleithral symphysis, 1 between pelvic-fin bases, and up to 5 small melanophores ventrally along gut. Series of 10–15 melanophores along ventral midline of tail in preflexion larvae, with 1 enlarged melanophore between myomeres 18 and 19; series along anal-fin base paired from flexion stage, enlarged melanophore remaining at base of last anal-fin ray. One melanophore at angle of lower jaw, pigment on branchiostegals, and a few melanophores posteriorly on lateral midline of tail in late postflexion larvae. Numerous melanophores on head, trunk and tail by settlement stage. *Internal:* 1 melanophore at base of otic capsule. Pigment dorsally on gas bladder; 1 melanophore above anus in postflexion larvae.

Material examined 19 larvae and juveniles, 2.2–14.7 mm BL, Lake Macquarie, Broken Bay and Merimbula (NSW).

Additional references Miskiewicz (1987).

Figure 122 Larvae of *Gobiopterus semivestita*. **A** Preflexion. **B** Flexion; note posteroventral projection of eye in this and larva in A. **C** Ventral view of larva in B; note pelvic-fin buds. **D–F** Postflexion. A, B, D–F from Lake Macquarie (NSW). Illustrated by F. J. Neira.



A 3.2 mm

B 4.4 mm

C 4.4 mm

D 6.0 mm

E 11.1 mm

F 14.6 mm

Gobiidae *Papillogobius punctatus* Gill & Miller, 1990 Red-spotted goby

D VI + I, 7–9 A I, 8–9 P_1 15–16 P_2 I, 5 C 17 V 26

Adults Known only from the Swan Estuary (WA). Restricted to shallow sand flats, where it is often found with another goby, *Pseudogobius olorum*. Some consider this species to belong to the genus *Favonigobius* (D.F. Hoese, AMS, pers. comm.). Adults have a short snout, small nape scales, usually a heavily pigmented branchiostegal membrane, and lack a dark spot on the first dorsal fin. Maximum size recorded for males and females is 6.7 and 5.4 cm TL, respectively (Gill & Miller, 1990).

Importance to fisheries –

Spawning Eggs undescribed. Larvae have been collected in the Swan Estuary (WA) between January and April (Neira *et al.*, 1992).

Diagnostic characters

- 9–10 + 16–17 = 26 myomeres
  Large melanophore on ventral midline of tail, between myomeres 17–21, followed by 1–2 melanophores along caudal peduncle
- Dorsal melanophore on dorsal midline of tail, between myomeres 18–19
- Internal melanophore above anus

Description of larvae

Morphology Body elongate (BD 13–16%). Head small to moderate (HL 17–26%). Gut moderate to long (PAL 46–52%).

Size at

Hatching	<2.5 mm
Notochord flexion	3.0–3.7 mm
Settlement	10.0–11.1 mm

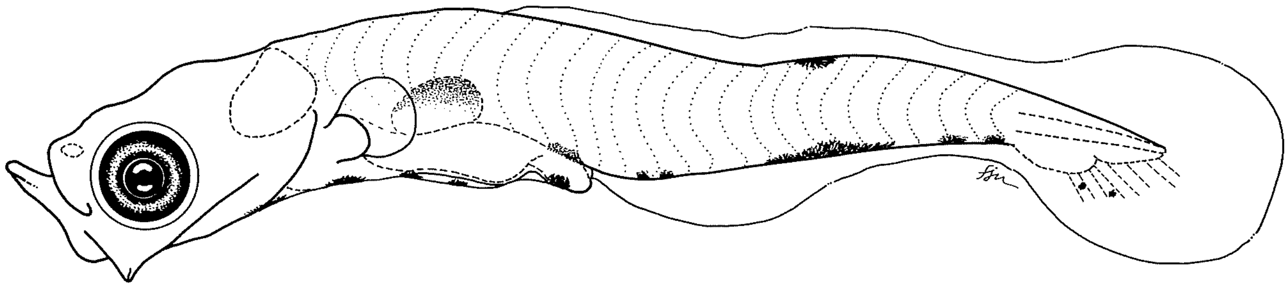
Formation of fins:
Caudal 2.5–3.9 mm; Second dorsal 3.2–3.7 mm; Anal 3.2–3.7 mm; Pelvic 3.7–5.2 mm; Pectoral 3.7–5.5 mm; First dorsal 4.6–5.2 mm

Pigmentation Larvae are lightly pigmented. *External:* 1 elongate melanophore on isthmus, and several between pelvic-fin bases. Three to four melanophores ventrally on gut, and 1 below anus. Several melanophores along ventral midline of tail, 1 large melanophore on caudal peduncle between myomeres 17 and 21, and 1–2 on caudal peduncle. One melanophore on dorsal midline of caudal peduncle between myomeres 18 and 19, opposite to large ventral melanophore. Several small melanophores under notochord tip in preflexion larvae, remaining on lower caudal-fin rays in postflexion larvae. Juveniles possess 5–7 blotches of pigment along lateral midline of trunk and tail, and pigment on first and second dorsal-, pectoral- and caudal-fin elements. *Internal:* Pigment dorsally over gas bladder. One melanophore above anus.

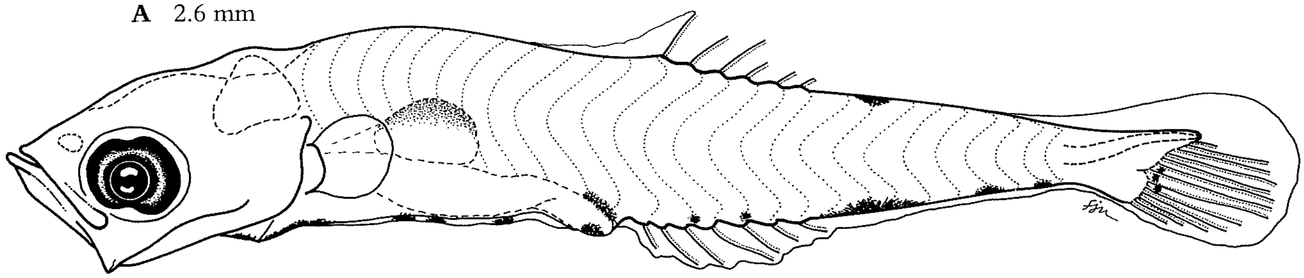
Material examined 20 larvae, 2.5–11.1 mm BL, Swan Estuary (WA).

Additional references –

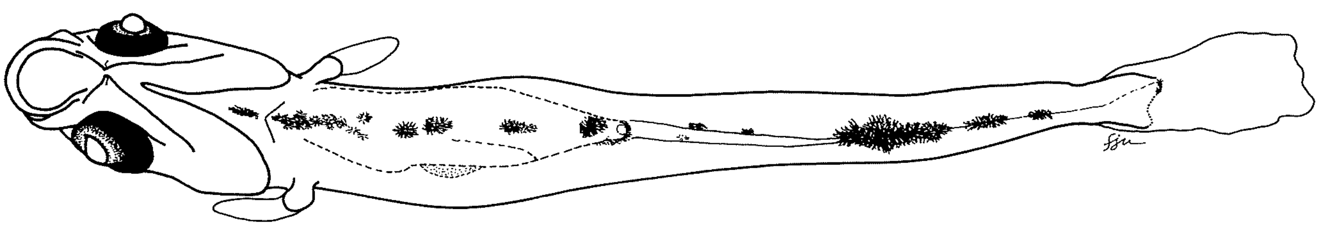
Figure 123 Larvae and juvenile of *Papillogobius punctatus*. **A** Preflexion. **B** Flexion. **C** Ventral view of larva in B. **D** Postflexion; pectoral-fin rays broken. **E** Juvenile; myomeres omitted. A, B, D, E from middle Swan Estuary (WA). Illustrated by F. J. Neira.



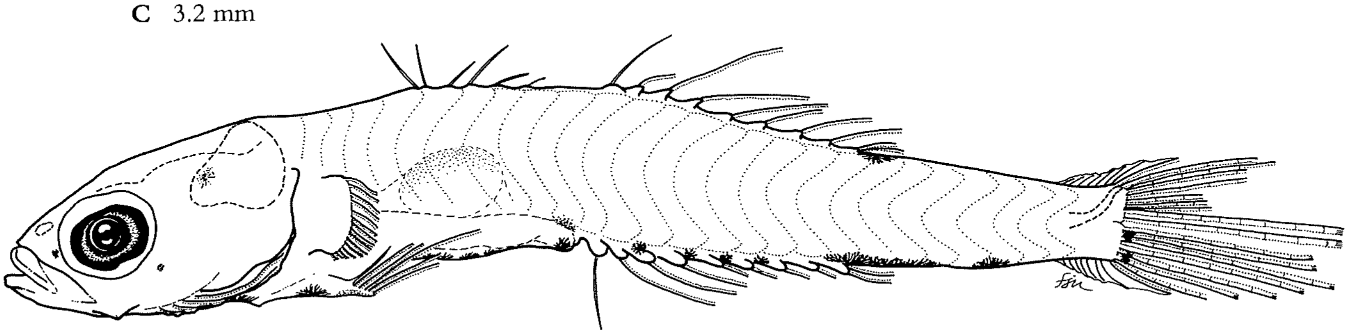
A 2.6 mm



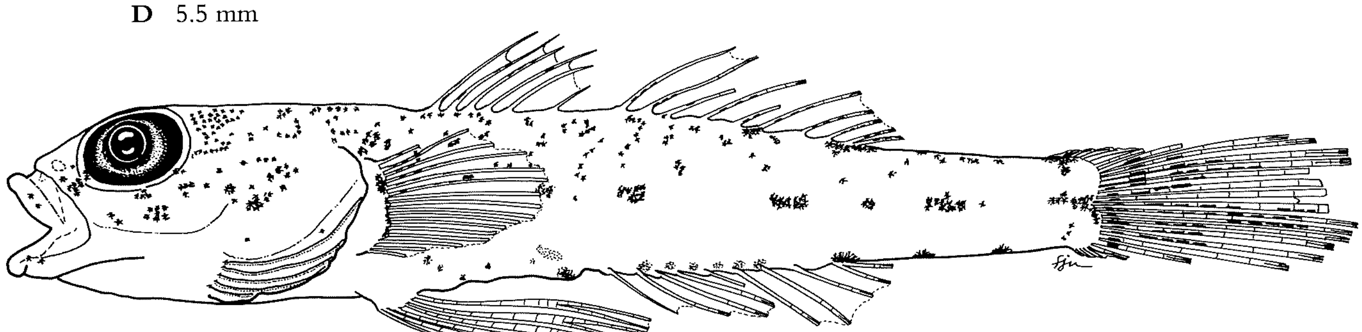
B 3.2 mm



C 3.2 mm



D 5.5 mm



E 11.1 mm

Gobiidae *Pseudogobius olorum* (Sauvage, 1880) Swan River goby

D VI + I, 7–9 A I, 7–9 P_1 15–17 P_2 I, 5 C 17 V 27

Adults Endemic to southern Australia from southwestern Western Australia to western Victoria. Occurs in brackish lagoons and estuaries, usually associated with muddy and sandy bottoms. Adults have a rounded snout with a slightly inferior mouth, 25–27 lateral-line scales, 5 roughly rectangular brown saddles dorsally and 6 blotches laterally, and usually a blue spot on the first dorsal fin. Mature adults are sexually dimorphic. Maximum size 6 cm (Kuiter, 1993; Larson & Hoese, 1996b).

Importance to fisheries Adapts well to aquaria, although it is not particularly attractive (Larson & Hoese, 1996b).

Spawning Eggs undescribed. Spawns in the upper reaches of estuaries, usually among thick vegetation (Gill *et al.*, 1996; Larson & Hoese, 1996b). The population in the Swan Estuary spawns biannually in spring and autumn, with peak activity in March and October (Gill *et al.*, 1996). Larvae have been caught in the Swan and Nornalup–Walpole estuaries, and in Wilson Inlet (WA) in most months of the year, with peak abundances between November and January (Neira & Potter, 1992b, 1994; Neira *et al.*, 1992).

Diagnostic characters

- 10 + 17 = 27 myomeres
- Internal melanophore above anus
- Melanophore on dorsal midline of tail, between myomeres 18–20
- 4–13 melanophores ventrally along gut
- 4–8 melanophores along anal-fin base
- Continuous pigment stripe along ventral midline of caudal peduncle

Description of larvae

Morphology Body elongate (BD 11–19%). Head small to moderate (HL 17–28%). Gut moderate to long (PAL 45–55%). Scales develop from 8.2 mm.

Size at

Hatching	<2.0 mm
Notochord flexion	3.9–4.9 mm
Settlement	8.2–10.5 mm

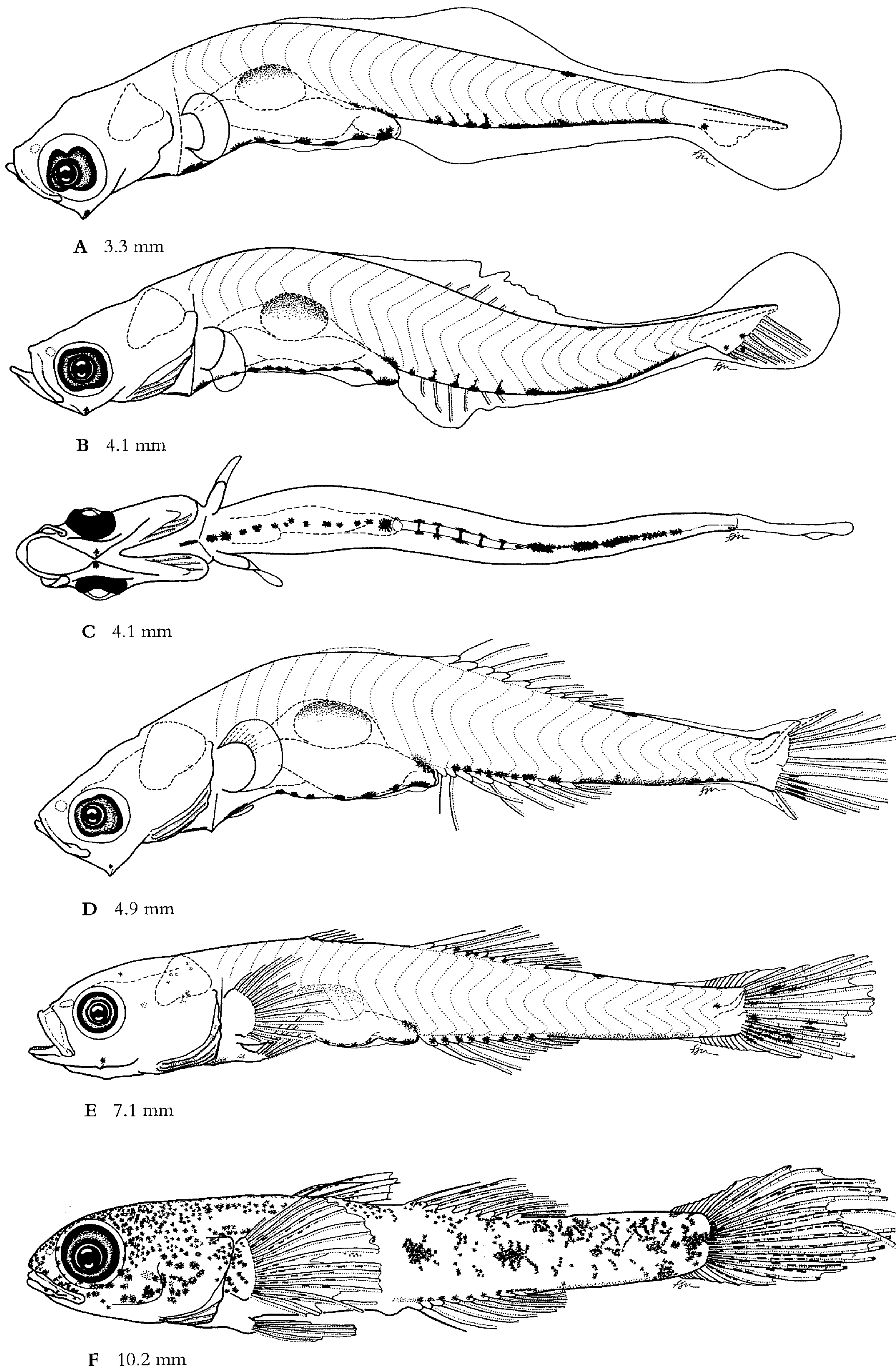
Formation of fins:
Caudal 3.3–5.0 mm; Second dorsal 3.7–4.5 mm; Anal 3.7–4.5 mm; Pelvic 4.5–6.6 mm; First dorsal 4.9–6.6 mm; Pectoral 4.9–6.8 mm

Pigmentation Larvae are lightly pigmented. *External:* 1 melanophore at angle of lower jaw, 1 elongate melanophore on isthmus, and 1–2 between pelvic-fin bases. Series of 4–13 melanophores along ventral surface of gut, and 1 ventrally at anus. Series of 4–8 melanophores along anal-fin base, followed by a continuous pigment stripe along ventral midline of caudal peduncle. One melanophore on dorsal midline of tail, between myomeres 18 and 20. Small melanophores on lower hypural plate in flexion larvae, remaining on base of lower caudal-fin rays in postflexion larvae. Juveniles possess 4–6 blotches of pigment mid-laterally along trunk and tail, and pigment on first and second dorsal-, pectoral- and caudal-fin membranes and elements. *Internal:* Pigment dorsally over gas bladder. One melanophore above anus.

Material examined 22 larvae, 2.0–7.3 mm BL, and 4 juveniles, 8.2–10.5 mm BL, Nornalup–Walpole Estuary and Wilson Inlet (WA).

Additional references –

Figure 124 Larvae and settlement stage of *Pseudogobius olorum*. **A** Preflexion. **B** Early flexion. **C** Ventral view of larva in B. **D** Early postflexion; note pelvic-fin bud. **E** Postflexion. **F** Settlement stage; scales omitted. A, B, D, E from Nornalup–Walpole Estuary (WA); F from Wilson Inlet (WA). Illustrated by F. J. Neira.


A 3.3 mm
B 4.1 mm
C 4.1 mm
D 4.9 mm
E 7.1 mm
F 10.2 mm

Gobiidae *Redigobius macrostoma* (Günther, 1861) Large-mouth goby

D VI + I, 7 A I, 6–7 P_1 16–18 P_2 I, 5 C 17 V 26

Adults Endemic to southeastern Australia from western Victoria to southern Queensland, including northeastern Tasmania. Occurs in seagrass beds of estuaries and coastal lakes, and may move into fresh water. Adults are laterally compressed and have a large mouth, dark bars on the body and a dark spot posteriorly on the first dorsal fin. Mature adults are sexually dimorphic. Maximum size 5 cm (Kuiter, 1993, 1996; Gomon *et al.*, 1994; Larson & Hoese, 1996b).

Importance to fisheries Adapts well to aquaria (Larson & Hoese, 1996b).

Spawning Eggs undescribed. Larvae have been caught in Lake Macquarie (NSW) from September to May, with peak abundances between November and February (Miskiewicz, 1987).

Diagnostic characters

- 10–11 + 15–16 = 26 myomeres
- 2 melanophores at tip of lower jaw and 1 on gular membrane
- 2 very large stellate melanophores along ventral surface of trunk and tail
- Internal band of pigment extending dorsally between snout and hindgut

Description of larvae

Morphology Body moderate (BD 20–26%). Head moderate in preflexion and flexion larvae (HL 24–29%), moderate to large in postflexion larvae (HL 32–35%). Gut long (PAL 50–61%). Scales form after settlement.

Size at

Hatching	<2.2 mm
Notochord flexion	3.8–4.8 mm
Settlement	6.7–8.5 mm

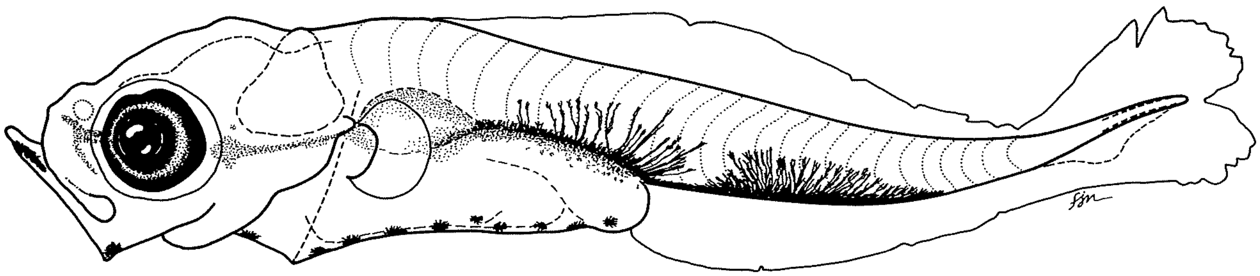
Formation of fins:
Caudal 2.7–4.5 mm; Second dorsal 3.3–5.1 mm; Anal 3.3–5.1 mm; Pectoral 4.0–6.5 mm; Pelvic 4.0–6.9 mm; First dorsal 4.5–6.9 mm

Pigmentation Larvae are moderately pigmented. *External:* 2 melanophores at tip of lower jaw, and 1 at angle of lower jaw. One elongate melanophore at isthmus and 1 between pelvic-fin bases. Numerous small melanophores ventrally along gut, reducing in number after flexion stage. Two very large stellate melanophores on ventral surface of trunk and tail, the anteriormost above hindgut. *Internal:* Stripe of pigment extending from snout region to base of otic capsule and continuing dorsally over entire gut. Pigment dorsally over gas bladder.

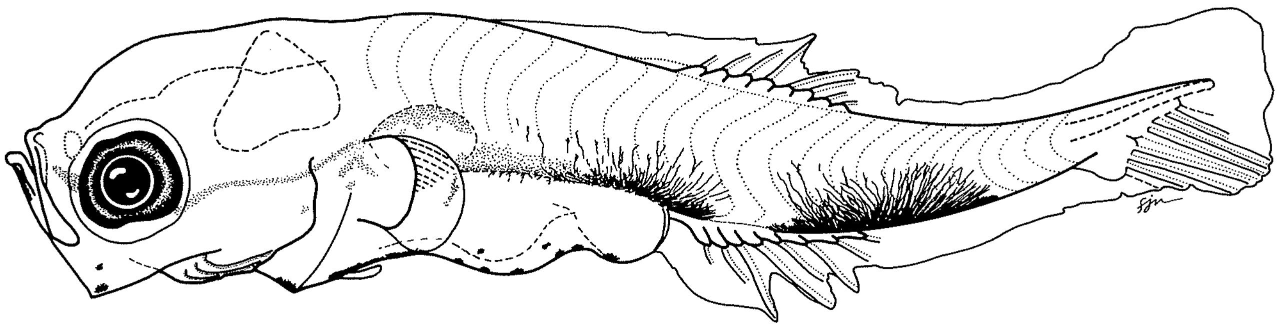
Material examined 20 larvae, 2.2–7.1 mm BL, and 6 juveniles, 6.7–10.3 mm BL, Lake Macquarie and Botany Bay (NSW).

Additional references Miskiewicz (1987).

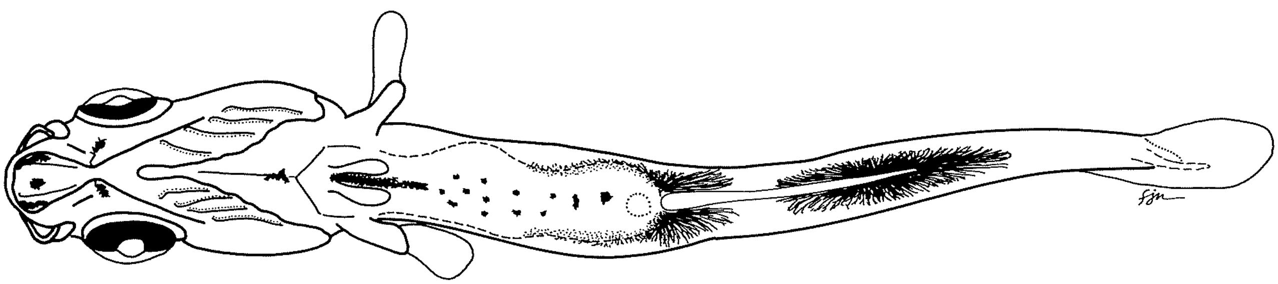
Figure 125 Larvae of *Redigobius macrostoma*. **A** Preflexion. **B** Early flexion; note pelvic-fin bud. **C** Ventral view of larva in B. **D** Postflexion. A, B, D from Lake Macquarie (NSW). Illustrated by F. J. Neira.



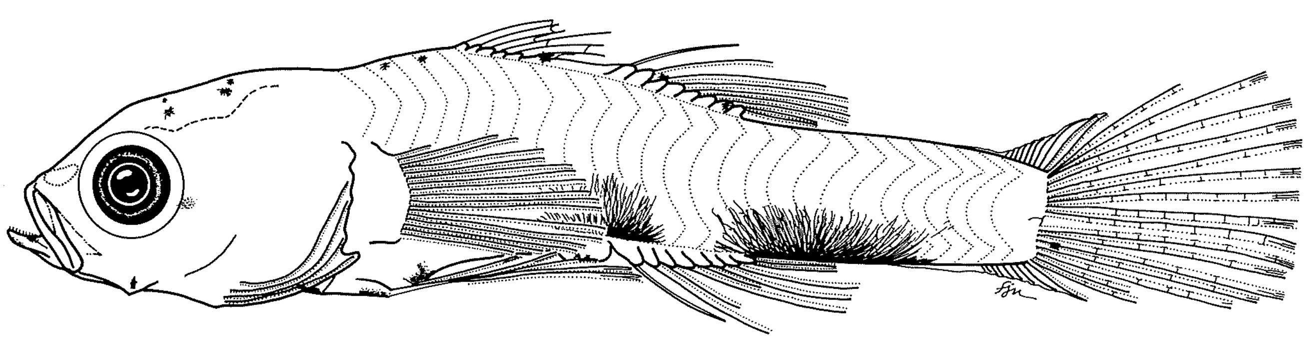
A 2.7 mm



B 4.0 mm



C 4.0 mm



D 6.9 mm

Scombroidei

The Scombroidei is a small perciform suborder of marine, epipelagic or bathypelagic, fast-swimming predatory fishes well represented in coastal to oceanic waters worldwide. As the taxonomic arrangement of the suborder remains unsettled (see Johnson, 1986; Carpenter *et al.*, 1995), we follow the classification of Nelson (1994) with the Scombroidei containing 5 families, 45 genera and about 136 species. Families comprise the Gempylidae (snake mackerels), Scombridae (mackerels, tunas), Sphyraenidae (barracudas), Trichiuridae (cutlassfishes) and Xiphiidae (billfishes) (see also Collette *et al.*, 1984b; Johnson, 1986). Many of the species, e.g. sailfish, swordfish and tunas, have considerable commercial and recreational importance (Collette & Nauen, 1983). The main anatomical character that unifies scombroid fishes is the fixed, beak-like premaxilla which makes the upper jaw non-protrusible (Collette *et al.*, 1984b). Larvae have been described for representatives of the five families (see review of early life history stages by Collette *et al.*, 1984b; see also Miller *et al.*, 1979; Fahay, 1983; Leis & Rennis, 1983; de Sylva, 1984; Zhang *et al.*, 1985; Ozawa, 1986a; Nishikawa, 1987, 1988a,b,c; Nishikawa & Rimmer, 1987; Kinoshita, 1988a; Jenkins, 1989; Leis & Trnski, 1989; Richards, 1989; Ambrose, 1996g,h; Sandknop & Watson, 1996b).

Families and species included here

GEMPYLIDAE
Rexea solandri
Thyrsites atun

SCOMBRIDAE
Scomber australasicus

TRICHIURIDAE
Lepidopus caudatus

Gempylidae: Gemfishes, snake mackerels, escolars

A.G. Miskiewicz and T. Trnski

Gempylids are pelagic to benthopelagic fishes found in tropical to temperate waters worldwide, with one species (*Paradiplospinus antarcticus*) in Antarctic waters. Most species occur from surface waters to depths of about 2500 m, usually between 50 and 500 m. Many species have considerable commercial importance. The family contains 16 genera and about 23 species (Collette *et al.*, 1984b; Nakamura & Parin, 1993). Thirteen genera and 16 species have been recorded from Australia, 5 genera and 6 species in temperate waters (Nakamura & Parin, 1993). Adults (1–3 m) are elongate and moderately compressed, have a protruding lower jaw with often large, fang-like teeth in both jaws, two separate dorsal fins, small to reduced pelvic fins, a large, forked caudal fin and, in most species, detached dorsal and anal finlets (Nakamura & Parin, 1993; Gomon *et al.*, 1994). Eggs of *Thyrsites atun* are pelagic and spherical, 0.9–1.1 mm in diameter, and have a single oil globule (Robertson, 1975a). Larvae have been described for representatives of all genera except *Rexichthys*, *Thyrsitoides* and *Tongaichthys* (see Collette *et al.*, 1984b, and references therein; see also Voss, 1954; Ozawa, 1986c; Nishikawa, 1987, 1988c; Nishikawa & Rimmer, 1987; Ambrose, 1996g). The large head and eyes, the head spines, and the serrate, elongate dorsal- and pelvic-fin spines constitute specialisations of gempylid larvae to pelagic life.

Meristic characters of gempylid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Lepidocybium	(1)	VIII–IX + 16–18+4–6	I–II, 12–14+4–6	15–17	I,5	17	16 + 15=31
Rexea	(2)	XVII–XIX + I, 15–19 + 2	II, 12–16 + 2	13–15	0–I, 0–3	17	20 + 14–16=34–36
Ruvettus	(1)	XIII–XV + 15–18 + 2	15–18 + 2	15	I, 5	17	16 + 16 = 32
Thyrsites	(1)	XIX–XXI, 11–13 + 5–7	I, 10–12 + 5–7	13–15	I, 5	17	21 + 14 = 35
Thyrsitoides	(1)	XVII–XIX + I, 16–17	I, 16–17	I, 13–14	I, 5	17	20 + 14 = 34

Main characters of gempylid larvae

- 31–67 myomeres
- Body elongate to moderate (BD 17–33%), compressed
- Head moderate to large (HL 22–46%); moderate mouth with canine-like teeth in both jaws
- Moderate head spination, with small to large preopercular spines
- Gut moderate to long in preflexion larvae, becoming long to very long in postflexion larvae due to posterior migration of anus (PAL 34–79%), coiled and compact
- Large gap between anus and origin of anal fin, closed by postflexion stage due to posterior migration of anus
- Dorsal-fin spines elongate and serrate (except in *Thyrsitops*), formed prior to dorsal soft rays and anal-fin elements
- Early forming pelvic fins; pelvic-fin spine elongate and strongly serrate (except in *Thyrsitops*)
- Pigment over snout, and fore- and midbrain
- Pigment along dorsal-fin base
- None to light pigment along tail in early stages
- Pigment dorsally along gut and gas bladder

References to gempylid larvae

Fahay (1983), Collette *et al.* (1984b), Ozawa (1986c), Nishikawa (1987, 1988c), Ambrose (1996g).

Families with similar larvae

Alepisauridae – 47–51 vertebrae; small to moderate preopercular spines; dorsal and anal fins spineless.
Lutjanidae – 23–24 myomeres; elongate, early forming second dorsal-fin spine.
Paralepididae – 60–100 vertebrae; short-based, posteriorly located dorsal fin; dorsal and anal fins spineless; large pigment patches on gut.
Scombridae – Lack elongate, early forming pelvic-fin spines; lack serrations on fin spines.
Trichiuridae – 84–198 myomeres; body very elongate to elongate; elongate, early forming first dorsal-fin spine in some taxa; pigment blotches on finfold; pigment on notochord tip.

Gempylidae *Rexea solandri* (Cuvier, 1832) Gemfish

D XVII–XVIII + I, 16–19 + 2 A I–II,13–16 + 2 P_1 13–15 P_2 I, 2–3 C 17 V 35–36

Adults Distributed around southern Australia from Point Quobba (WA) to Moreton Bay (Qld), including Tasmania; also in New Zealand. Occurs in schools in deeper continental shelf and upper slope waters from 100 to 800 m. Adults are elongate and laterally compressed, and have immovable and movable fangs in the upper jaw, pelvic fins with I, 2–3 elements, and a lateral line that bifurcates below or behind the fifth dorsal-fin spine. Maximum size 1.1 m (Kailola *et al.*, 1993; Nakamura & Parin, 1993; Gomon *et al.*, 1994; Rowling, 1994a; Williams *et al.*, 1996).

Importance to fisheries One of the most important trawled fish species in southeastern Australia in the 1970s and 1980s, with a peak catch of over 5000 tonnes in 1980. Catches of gemfish have declined rapidly since the late 1980s and currently there is a zero total allowable catch on the east coast. Rarely caught by recreational fishers (Kailola *et al.*, 1993; Rowling, 1994a; Tilzey *et al.*, 1994).

Spawning Eggs undescribed. There are two separate spawning populations (Gorman *et al.*, 1987; Rowling, 1994a; Colgan & Paxton, 1997). Adults on the east coast undertake an annual spawning migration, aggregating along eastern Bass Strait in early June and migrating north to spawn in coastal waters off northern New South Wales in August. Spawning has not been confirmed on the west coast but is presumed to occur off southern Western Australia in summer (Rowling, 1994a). Larvae have been caught in coastal and offshore waters of northern and central New South Wales from August to September (Gorman *et al.*, 1987), and in coastal waters off Sydney (NSW) from July to September (Gray, 1995).

Diagnostic characters

- 6–20 + 16–30 = 35–36 myomeres
- Up to 4 posterior preopercular spines, spine at angle long from flexion stage and finely serrate by 10.4 mm
- Early forming dorsal-fin elements; dorsal-fin spines long, and serrate anteriorly and laterally from late preflexion stage
- Pelvic-fin spine strongly serrate ventrally, laterally and medially by late preflexion stage
- 1–2 melanophores on ventral midline of tail, becoming internal by 4.5 mm

Description of larvae

Morphology Body moderate (BD 20–33%). Head moderate to large in preflexion larvae (HL 22–38%), large in flexion and postflexion larvae (HL 37–46%). Small teeth along both jaws in mid-preflexion larvae, anteriormost large from flexion stage. One anterior preopercular and 2 posterior preopercular spines from mid-preflexion stage; 2 anterior preopercular and 4 posterior preopercular spines by late postflexion stage, spine at angle long by flexion stage, and finely serrate dorsally from 10.4 mm. Low, smooth supraocular ridge from late preflexion stage, with fine serrations and 2 small spines by end of flexion stage. One supracleithral, 1 posttemporal and 1 opercular spine by late preflexion stage. Gut moderate to long in preflexion larvae (PAL 34–60%), long in flexion larvae (PAL 61–69%), very long in postflexion larvae (PAL 77–79%), coiled and compact, becoming voluminous with growth. Small gas bladder above foregut. Large gap between anus and origin of anal fin, closed from about 10 mm. Dorsal-fin spines long and serrate anteriorly and laterally from late preflexion stage; serrations progressively develop on posterior spines as larvae grow. Anal-fin spine with serrations only laterally from 10.4 mm. Early forming pelvic fins, pelvic-fin spine strongly serrate ventrally, laterally and medially from late preflexion stage.

Size at

Hatching	<2.9 mm
Notochord flexion	6.5– <10.1 mm
Settlement	>16.7 mm
Formation of fins:	

Caudal 3.6–<10.1 mm; Pelvic 3.8–6.3 mm; Dorsal 4.0–10.8 mm; Anal 5.7–10.4 mm; Pectoral 5.7–<10.1 mm

Pigmentation Larvae are lightly pigmented. *External:* Melanophores on snout and dorsally on head above midbrain in mid-preflexion larvae; additional pigment on snout and over brain with growth. Pigment on tip of premaxilla, and on tip and laterally along margin of dentary from flexion stage. Small melanophores on gular membrane and around posterior of orbit in late preflexion larvae. Melanophores over dorsolateral surface of gut from late preflexion stage, scattered laterally on gut by postflexion stage. Series of small melanophores along dorsal midline of anterior of trunk in late preflexion larvae, extending along dorsal-fin base and caudal peduncle in late postflexion larvae. One small melanophore, occasionally 2, midway along ventral midline of tail, becoming internal by 4.5 mm and absent by early flexion stage. Small melanophores around notochord tip in early preflexion larvae. A few melanophores on membrane between each dorsal-fin spine from late preflexion stage. *Internal:* Pigment under hindbrain and otic capsule. Pigment band along snout from late preflexion stage. Large melanophore in opercular region from flexion stage. Pigment over peritoneum and heavy pigment dorsally over gas bladder and gut.

Material examined 22 larvae, 2.9–7.6 and 10.1–16.7 mm BL, coastal and offshore waters of northern and central New South Wales.

Additional references –

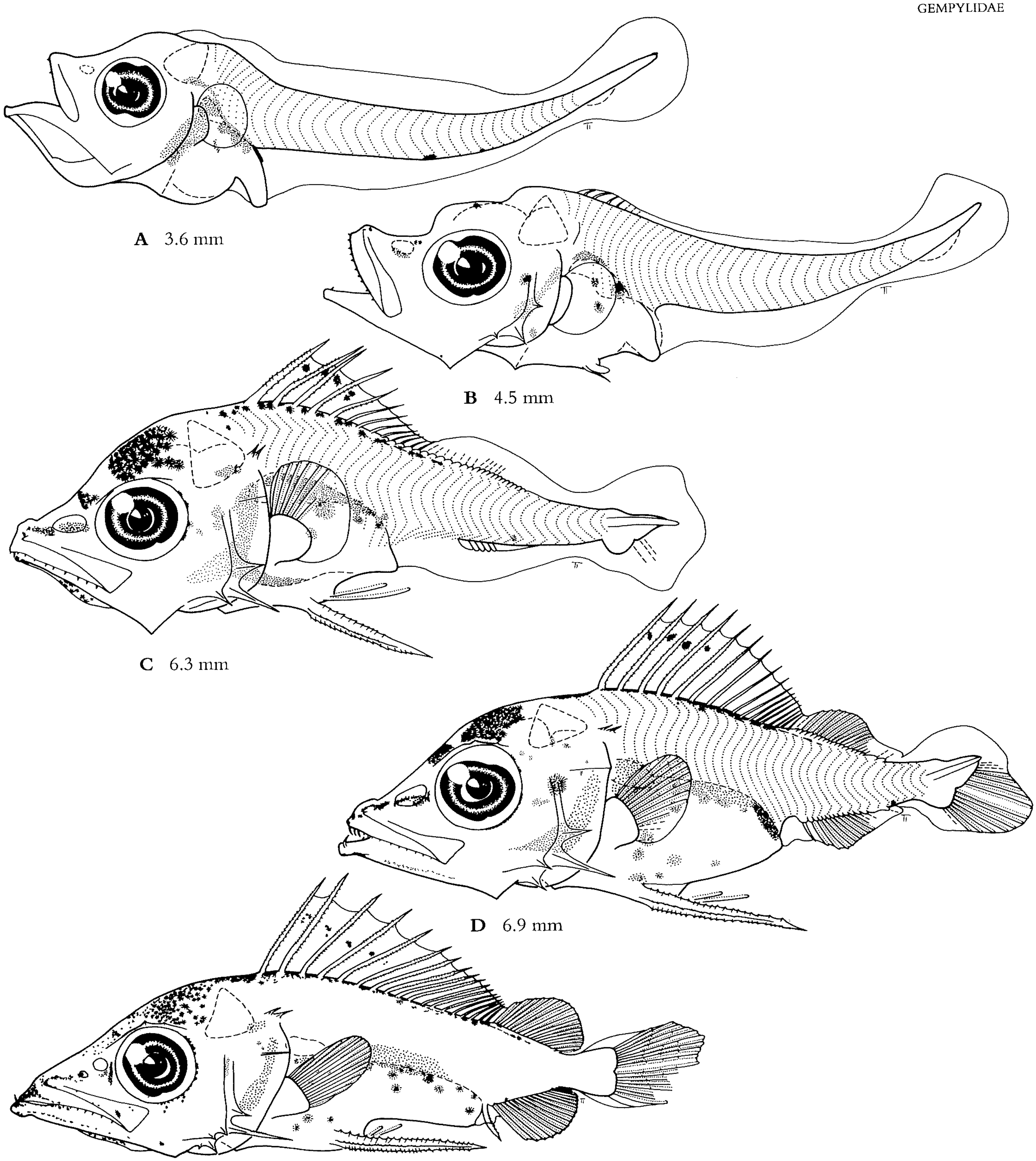


Figure 126 Larvae of *Rexea solandri*. **A** Preflexion. **B** Preflexion. **C** Late preflexion; note elongate, serrate pelvic-fin spine. **D** Flexion. **E** Postflexion. A–D from northern and central NSW coastal waters; E from Lake Macquarie (NSW). Illustrated by T. Trnski.

Gempylidae *Thyrsites atun* (Euphrasen, 1791) Barracouta, snoek

D XIX–XXI + 11–13 + 5–7 A I, 10–12 + 5–7 P_1 13–15 P_2 I, 5 C 17 V 35

Adults Distributed around southern Australia from Shark Bay (WA) to Moreton Bay (Qld), including Tasmania. Also widely distributed in coastal regions of the Southern Hemisphere from 35° to 55°S. Often found in large schools in shelf and slope waters to a depth of 550 m, sometimes entering estuaries and bays. Adults are elongate and laterally compressed, and have pelvic fins with I, 5 elements, a single lateral line, and 3–4 enlarged fang-like teeth in the upper jaw. Maximum size 1.5 m (Kailola *et al.*, 1993; Nakamura & Parin, 1993; Gomon *et al.*, 1994).

Importance to fisheries Fished commercially by trawling mainly off New Zealand and southwestern Africa (Nakamura & Parin, 1993). Trawled in large numbers during the 1960s and 1970s in Victoria, Tasmania and southern New South Wales. Catches have declined since 1975 due to changes in targeting practices. Also targeted by recreational fishers throughout southern Australia except New South Wales (Kailola *et al.*, 1993).

Spawning Eggs are pelagic and spherical, 0.9–1.1 mm in diameter, and have a smooth chorion, an unsegmented yolk, and a single oil globule 0.24–0.27 mm (Robertson, 1975a). Spawning has been reported in Western Australia and South Australia between late autumn and winter, in western Victoria, Bass Strait and Tasmania between spring and early autumn, and in eastern Victoria and New South Wales in winter and spring (Kailola *et al.*, 1993). Larvae have been caught in coastal waters of Tasmania from November to April.

Diagnostic characters

- 7–17 + 18–29 = 34–36 myomeres
- Up to 4 posterior preopercular spines, moderate and smooth
- Dorsal-fin spines long and serrate laterally from flexion stage
- Pelvic-fin spine strongly serrate ventrally and medially from flexion stage
- Up to 8 melanophores along ventral midline of tail, anteriormost becoming internal during flexion stage

Description of larvae

Morphology Body elongate to moderate (BD 17–26%). Head moderate in preflexion larvae (HL 25–32%), moderate to large in flexion and postflexion larvae (HL 31–37%). Small teeth in both jaws, anteriormost large by late flexion stage. One anterior preopercular and 1 posterior preopercular spine in preflexion larvae; 4 posterior preopercular spines in postflexion larvae, moderate and smooth. Low, smooth supraocular ridge from flexion stage. One posttemporal spine by early flexion stage; 1 supracleithral and 1 opercular spine by late flexion stage; a second opercular spine by postflexion stage. Posttemporal spine by 10.2 mm. Gut moderate in preflexion larvae (PAL 34–44%), moderate to long in flexion larvae (PAL 41–56%), long to very long in postflexion larvae (PAL 61–73%), coiled and compact. Small gas bladder above foregut. Large gap between anus and origin of anal fin, small from about 15 mm. Dorsal-fin spines long and serrate laterally from flexion stage; serrations on posterior spines with growth. Early forming pelvic fins, pelvic-fin spine strongly serrate ventrally and medially from flexion stage.

Size at

Hatching	<5.2 mm
Notochord flexion	6.8–10.2 mm
Settlement	>15.7 mm
Formation of fins:	

Caudal <5.2–10.8 mm; Pelvic <5.2–10.8 mm; Dorsal 5.3–10.8 mm; Anal 5.5–10.8 mm; Pectoral 7.8–10.8 mm

Pigmentation Larvae are initially lightly pigmented, moderately to heavily pigmented by postflexion stage. *External:* Melanophores on tip of upper and lower jaws, on snout, and over brain in preflexion larvae; along dentary and gular membrane, on opercle and around posterior of orbit in late preflexion larvae; pigment over head intensifies with growth. One or two melanophores on hindgut near anus, absent from flexion stage. Pigment on dorsolateral surface of gut during flexion stage, and over entire gut by postflexion stage. Series of small melanophores along dorsal midline of anterior of tail, extending to nape and along entire dorsal-fin base by late postflexion stage. Up to 8 small melanophores along ventral midline of tail in early preflexion larvae; anteriormost become internal during flexion stage, posteriormost remain along anal-fin base. Numerous small melanophores scattered over lateral surface of trunk and tail in late postflexion larvae. *Internal:* Pigment under hindbrain and otic capsule; melanophores below nostrils and opercle by late preflexion stage. Pigment over peritoneum and heavy pigment dorsally over gas bladder and gut. Melanophores above and below notochord posteriorly on tail from flexion stage. Melanophores on ventral midline of anterior of tail during flexion stage.

Material examined 18 larvae, 5.2–15.7 mm BL, Bass Strait and coastal waters of Tasmania.

Additional references De Jager (1955), Haigh (1972), Olivar & Fortuño (1991).

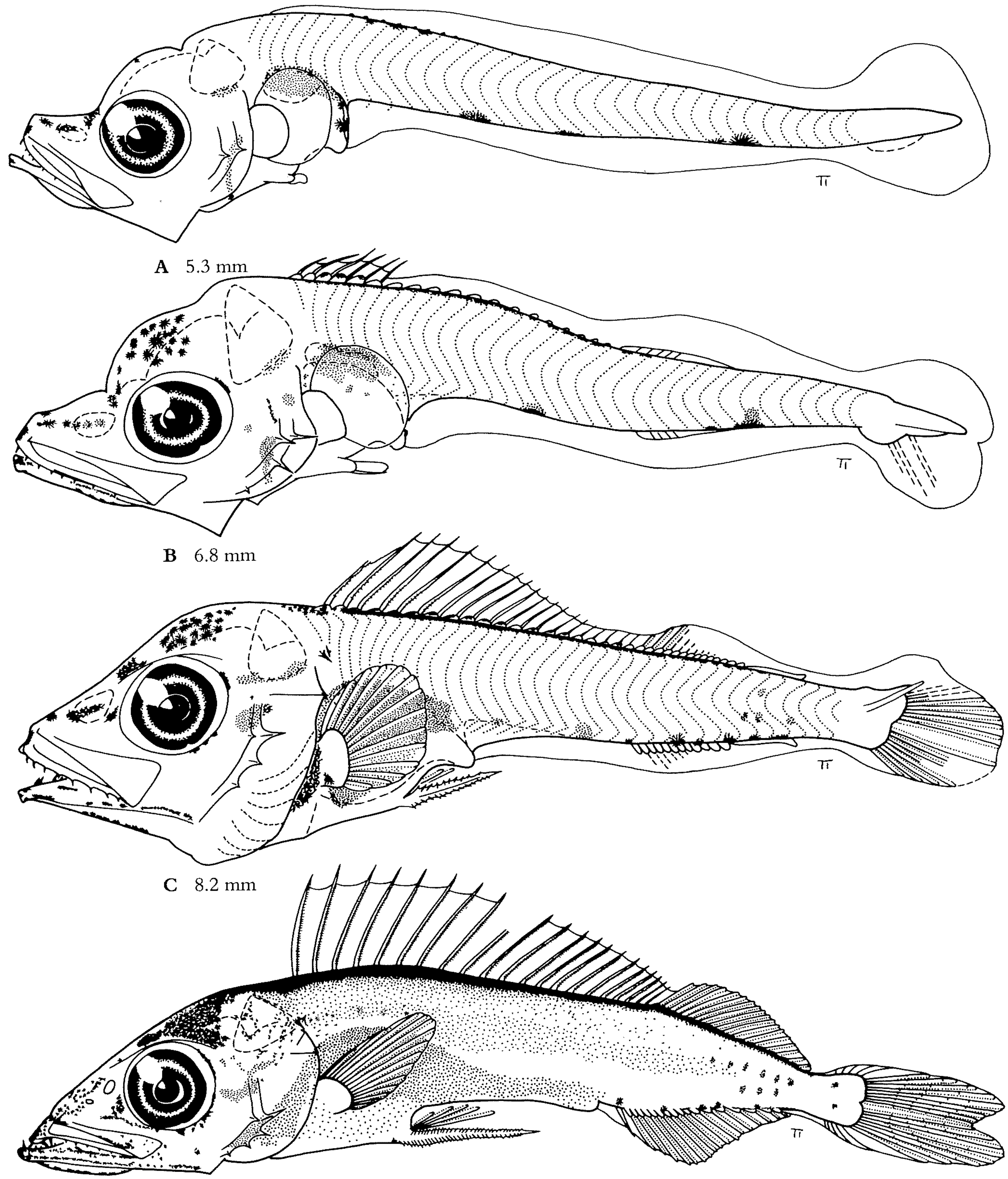


Figure 127 Larvae and settlement stage of *Thyrsites atun*. **A** Preflexion; note pelvic-fin bud. **B** Late preflexion. **C** Late flexion; first dorsal-fin spine broken. **D** Settlement stage. A–D from NSW coastal waters. Illustrated by T. Trnski.

Scombridae: Tunas, mackerels, bonitos

T. Trnski and F. J. Neira

Scombrids are epipelagic, fast-swimming fishes found in coastal to oceanic waters in tropical to temperate regions worldwide. The family contains 15 genera and 49 species (Collette & Nauen, 1983; Nelson, 1994). Eight genera and at least 12 species have been recorded from temperate Australia, although several species are summer migrants which follow warm currents (Collette & Nauen, 1983; Gomon *et al.*, 1994). Adults (to 4.3 m) are fusiform and elongate to robust, have two separate dorsal fins depressible into grooves, finlets behind the second dorsal and anal fin, a slender caudal peduncle, and a forked to lunate caudal fin (Collette & Nauen, 1983; Nelson, 1994). Eggs are pelagic and spherical, 0.8–1.9 mm in diameter, usually with a single oil globule (Collette & Nauen, 1983; Collette *et al.*, 1984b). Larvae have been described for most genera (see Collette *et al.*, 1984b, and references therein; see also Matsumoto, 1958, 1959, 1967; Matsumoto *et al.*, 1972; Fritzsche, 1978; Fahay, 1983; Zhang *et al.*, 1985; Ozawa, 1986b, 1988a; Nishikawa & Rimmer, 1987; Nishikawa, 1988b; Jenkins, 1989; Ambrose, 1996h). The large head and eyes and, in most taxa, the moderately to well developed head spination, constitute specialisations of scombrid larvae to pelagic life (Jenkins, 1989).

Meristic characters of scombrid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Allothunnus	(1)	XV–XVIII + 12–13 + 6–7	13–14 + 6–7	24–26	I, 5	17	20 + 20 = 40
Auxis	(1)	X–XII + 10–12 + 6–9	12–15 + 6–8	22–23	I, 5	17	20 + 19 = 39
Gasterochisma	(1)	XVI–XVIII + 10–11 + 6–8	11–12 + 6–8	19–22	I, 5	17	21 + 23 = 44
Katsuwonus	(1)	XIV–XVI + 14–16 + 7–9	14–16 + 7–8	26–29	I, 5	17	20 + 21 = 41
Sarda	(2)	XVII–XIX + 15–17 + 7–8	14–16 + 5–7	23–27	I, 5	17	23–25 + 20–22 = 44–46
Scomber	(1)	X–XIII + 11–12 + 5–6	I,10–12 + 5–6	20–21	I, 5	17	14 + 17 = 31
Scomberomorus	(1)	XIV–XVII + 15–20 + 8–10	16–21 + 8–10	21–24	I, 5	17	19–20 + 23–27 = 42–46
Thunnus	(4)	XII–XV + 13–16 + 7–10	12–15 + 7–10	30–36	I, 5	17	18 + 21 = 39

Main characters of scombrid larvae

- 30–66 myomeres, typically 31–46
- Body elongate to moderate (BD 16–38%), laterally compressed
- Head moderate to large (HL 22–69%), with a short, rounded to extremely elongate and pointed snout depending on taxon
- Mouth moderate, jaws usually equal in length (upper jaw projects beyond lower jaw in postflexion larvae of some taxa); conspicuous teeth along premaxilla and dentary from early preflexion stage
- Moderately to well developed head spination in most taxa, completely absent in some (e.g. *Rastrelliger*, *Scomber*); when present, head spination includes preopercular, opercular, supraocular, pterotic and supraoccipital spines
- Gut moderate in preflexion larvae, becoming very long in postflexion larvae due to posterior migration of anus (PAL 38–81%), coiled and compact
- Moderate to large gap between anus and origin of anal fin, closed by postflexion stage due to posterior migration of anus
- Pigment usually over midbrain and along dorsal and ventral midlines of tail
- Heavily pigmented gut and pigment dorsally over gas bladder
- Melanophore series ventrally along tail, pattern species-specific

References to scombrid larvae

Richards & Klawe (1972), Fritzsche (1978), Okiyama & Ueyanagi (1978), Fahay (1983), Collette *et al.* (1984b), Ozawa (1986b, 1988a), Nishikawa & Rimmer (1987), Nishikawa (1988b), Jenkins (1989), Ambrose (1996h).

Families with similar larvae

Alepisauridae – 47–51 vertebrae; small to moderate preopercular spines; dorsal and anal fins spineless.

Arripidae – 24–26 myomeres; 1 dorsal fin; 5–6 internal melanophores along nape and anterior of trunk; mid-lateral pigment posteriorly on tail from preflexion stage.

Gempylidae – Elongate, early forming pelvic-fin spines; fin spines strongly serrated.

Myctophidae (e.g. *Lampanyctus*) – No head spines; straight (uncoiled), striated gut; none (usually) to a few melanophores along tail.

Nemipteridae (early stages) – 22–24 myomeres; rounded head with short snout; no head spines except in *Scolopsis*; persistent gap between anus and origin of anal fin.

Omosudidae – No fin spines; short-based, posteriorly located dorsal fin; large pigment blotches dorsally over gut.

Pinguipedidae (early stages) – 29–34 myomeres; head short and round; small to moderate head spines; no gap between anus and origin of anal fin; expanded ventral melanophore on posterior region of tail.

Pomatomidae – 25–27 myomeres; weak head spination; dorsal fin VII–VIII + I, 23–28; moderate gap between anus and origin of anal fin; melanophore series along dorsal, lateral and ventral midlines of tail.

Sciaenidae – 24–29 myomeres; head deep; short-based, posteriorly located anal fin; prominent, persistent gap between anus and origin of anal fin; pigment at nape.

Scombrolabricidae – 30 myomeres; second dorsal fin develops prior to first.

Scombridae *Scomber australasicus* Cuvier, 1832 Slimy mackerel, blue mackerel

D X–XIII + 11–12 + 5–6 A I, 10–12 + 5–6 P_1 20–21 P_2 I, 5 C 17 V 31

Adults Distributed around southern Australia from North West Cape (WA) to Moreton Bay (Qld), including Tasmania and Lord Howe Island. Also found in the West Pacific from New Zealand to Japan, the Hawaiian Islands and off Mexico in the East Pacific. Juveniles are usually found inshore, with larger adults in continental shelf waters at depths of 40–200 m; often found among schools of jack mackerel (*Trachurus declivis*). Adults are elongate and have 2 widely separated dorsal fins, 5–6 finlets behind dorsal and anal fins, and 2 small keels at the base of each caudal-fin lobe. Maximum size 65 cm FL (Matsui, 1967; Collette & Nauen, 1983; Hutchins & Swainston, 1986; Kuiter, 1993; AMS records).

Importance to fisheries Fished commercially with purse seines mainly in New South Wales and Tasmania, with catches of up to 1800 tonnes per year. Caught often as a by-catch of jack mackerel in Tasmania, and used as bait for tuna fisheries and for human consumption (Collette & Nauen, 1983; Kailola *et al.*, 1993).

Spawning Eggs undescribed. Eggs of *Scomber japonicus* and *S. scomber* are pelagic and spherical, 1.0–1.3 mm in diameter, and have a single oil globule 0.22–0.38 mm (Kramer, 1960; Berrien, 1975; Fritzsche, 1978). *Scomber australasicus* spawns repeatedly in summer in Australia (Kailola *et al.*, 1993). Larvae have been caught in coastal waters of New South Wales from May to September (Gray, 1995). Small juveniles have been caught in the Great Australian Bight in May (Stevens *et al.*, 1984).

Diagnostic characters

- 10–15 + 16–20 = 30–32 myomeres
- Head spines restricted to low, smooth supraocular and supracleithral ridges
- Mouth slightly subterminal from flexion stage
- Large gap between anus and origin of anal fin, reduced with growth
- Melanophore dorsally on nape, becoming internal in late preflexion larvae from 4.9 mm
- Series of melanophores along ventral midline of tail, anteriormost becoming internal during flexion stage

Description of larvae

Morphology Body elongate to moderate (BD 20–27%). Head moderate to large (HL 23–35%). Mouth slightly subterminal from flexion stage. Villiform teeth along both jaws by 3.2 mm. Low, smooth supraocular and supracleithral ridges in postflexion larvae. Gut moderate to long (PAL 40–65%), coiled and voluminous. Gas bladder inconspicuous. Large gap between anus and origin of anal fin, reduced as anus migrates posteriorly (VAFL 10–15% prior to flexion stage; <6% by postflexion stage from 10 mm).

Size at

Hatching	<3.2 mm
Notochord flexion	5.2–6.7 mm
Transformation	>23.3 mm
Formation of fins:	

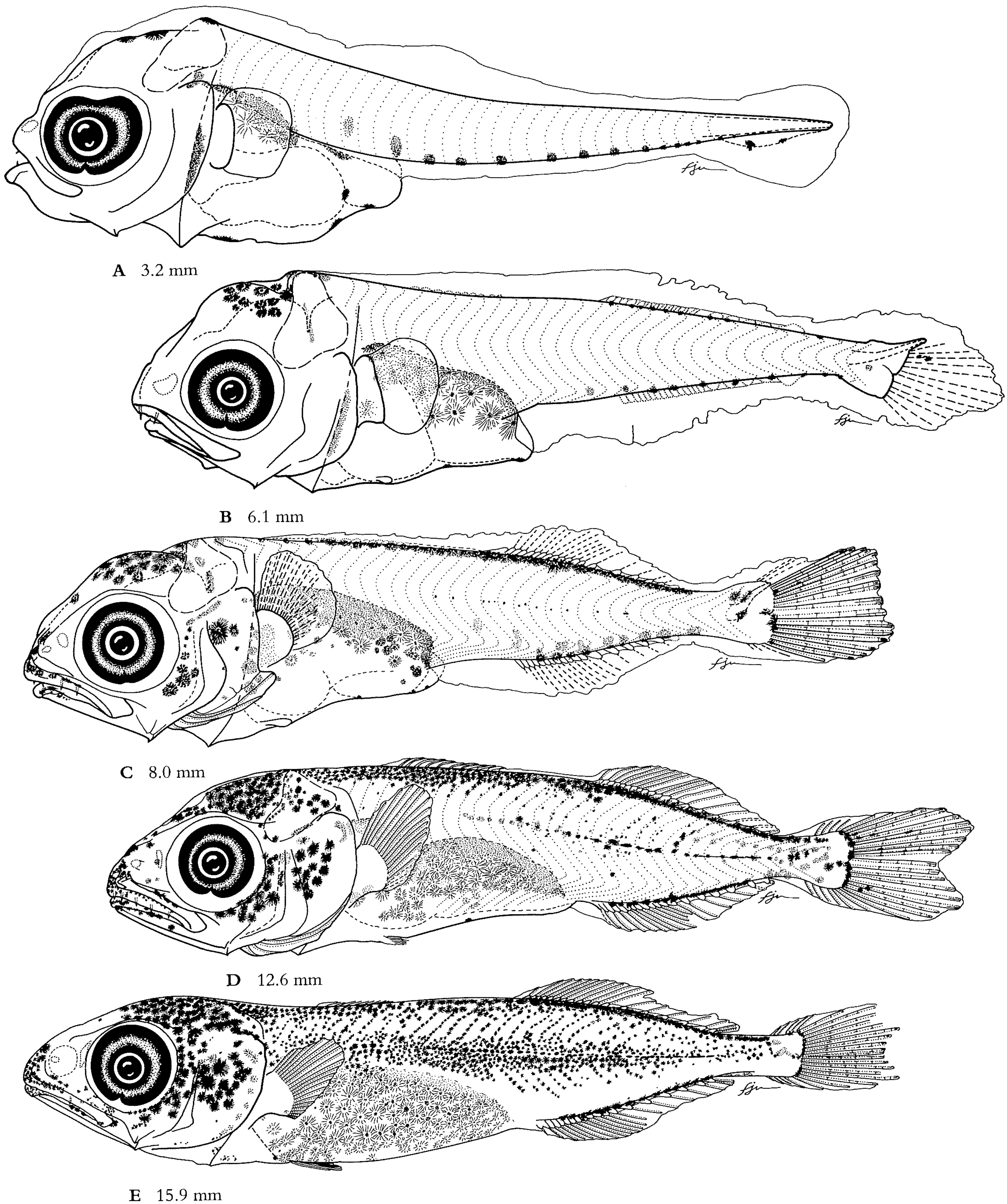
Caudal 3.2–7.0 mm; Anal 4.9–12.7 mm; Dorsal 4.9–15.9 mm; Pelvic 6.0–12.7 mm; Pectoral 6.5–15.9 mm

Pigmentation Larvae are initially moderately pigmented, heavily pigmented by postflexion stage. *External:* A few melanophores over midbrain. Pigment over midbrain, snout, over forebrain, lower jaw and opercle in postflexion larvae. Two or three melanophores ventrally on gut, absent in late postflexion larvae. Melanophore series along ventral midline of tail; anteriormost melanophores become internal during flexion stage, others remain along anal-fin base. One melanophore dorsally on nape, becoming internal prior to flexion stage. Melanophores series along dorsal midline of tail from flexion stage, extending anteriorly and posteriorly with growth. Series along lateral midline of tail in postflexion larvae, extending anteriorly and posteriorly with growth. Pigment dorsally and laterally on trunk and tail in postflexion larvae, heavy pigment by 10 mm. A few melanophores under notochord tip, remaining on caudal-fin base. *Internal:* Pigment between mid- and hindbrain, below hindbrain and on peritoneum; melanophore at nape in flexion larvae. Melanophores over gut, spreading laterally by postflexion stage. Melanophores along ventral midline of tail by late flexion stage. Several melanophores on caudal peduncle.

Material examined 26 larvae, 3.2–23.3 mm BL, coastal waters of northern and central New South Wales.

Additional references Ozawa (1984, 1986b, 1988a).

Figure 128 Larvae and transforming stage of *Scomber australasicus*. **A** Preflexion. **B** Flexion; note pelvic-fin bud. **C** Postflexion; note internal pigment on nape. **D** Postflexion. **E** Transforming stage. A–E from northern and central NSW coastal waters. Illustrated by F. J. Neira.


A 3.2 mm
B 6.1 mm
C 8.0 mm
D 12.6 mm
E 15.9 mm

Trichiuridae: Cutlassfishes, hairtails, frostfishes

T. Trnski and A.G. Miskiewicz

Trichiurids are predominantly benthopelagic fishes found in tropical to temperate waters worldwide, to a depth of 2000 m. The family contains 9 genera and 35 species. Six genera and 14 species have been recorded from Australia, all 6 genera and 9 species in temperate waters (Nakamura & Parin, 1993; Gomon *et al.*, 1994; Parin, 1995). Adults (to 2.3 m) are extremely elongate, with a ribbon-like body ending in either a thin point without a caudal fin or in a narrow caudal peduncle with a small, forked caudal fin. Other characteristics include elongate jaws with large, fang-like teeth, a long-based dorsal fin extending along most of the body, pelvic fins absent or reduced, caudal fin absent in some taxa, and no body scales (Nakamura & Parin, 1993; Gomon *et al.*, 1994). Eggs of *Lepidopus caudatus*, *Lepturacanthus*, *Tentoriceps cristatus* (as *Trichiurus muticus*) and *Trichiurus lepturus* (as *T. savala*) are pelagic and spherical, 1.5–2.5 mm in diameter, and have a single oil globule (Delsman, 1927; Padoa, 1956a; Tsukahara, 1961; Fursa, 1975; Fritzsche, 1978; Robertson, 1980; Zhang, 1981; Sandknop & Watson, 1996b). Larvae have been described for all genera except *Evoxymetopon* (see Collette *et al.*, 1984b, and references therein; see also Fursa, 1975; Gorbunova, 1977; Ozawa, 1986d, 1988b; Leis & Trnski, 1989; Evseyenko *et al.*, 1994; Sandknop & Watson, 1996b; Gago, 1997). Gago (1997) used larval characters to resolve phylogenetic hypotheses. The head spination, the serrate spines of the dorsal, anal and, when present, pelvic fins, and the elongate first dorsal spine in some genera (e.g. *Assurger*, *Benthodesmus*, *Lepidopus*) constitute specialisations of trichiurid larvae to pelagic life (Leis & Trnski, 1989).

Meristic characters of trichiurid genera of temperate Australia *

	(n)	Dorsal †	Anal ‡	Pectoral	Pelvic	Caudal	Vertebrae
Aphanopus	(3)	XLII–XLVI, 54–65	II, 44–54	12–13	absent	–	104–115
Assurger	(1)	XXXIV–XXXV, 85–86	II, 72–85	12	I, 2	–	125–129
Benthodesmus	(2)	XXXIX–XLVI, 88–108	II, 76–98	12	I, 1	18	130–152
Lepidopus	(1)	IX, 90–96	II, 59–66	12	I, 1	18–20	105–114
Tentoriceps	(1)	V, 126–144	I, 84–89	11–12	1	absent	152–164
Trichiurus	(1)	III, 120–137	I, 100–108	12–14	absent	absent	167–173

* Supplemented by data provided by F. J. Gago (LACM) based on cleared and stained specimens.
† Adults of some taxa have very weak spines which are difficult to distinguish from rays.
‡ Anal-fin rays of juveniles and adults are reduced and might not be emergent along entire length of anal fin.

Main characters of trichiurid larvae

- 84–198 myomeres
- Body very elongate to elongate (BD 5–17%), compressed
- Moderate head spination, including small to moderate preopercular spines, and a low, smooth to finely serrate supraocular ridge; other spines species-specific (e.g. opercular, low and smooth supraoccipital ridge, serrate frontal ridges)
- Head small to large (HL 10–35%), with long, pointed snout; teeth usually along premaxilla and dentary from preflexion stage
- Gut initially short but becoming long with posterior migration of anus (PAL 24–67%), coiled and compact
- Large gap between anus and origin of anal fin, reduced to a small gap by postflexion stage due to posterior migration of anus

- Elongate, early forming first dorsal-fin spine in some taxa; dorsal-fin spines serrate in some taxa
- Serrate or scale-like anal-fin spine and, when present, pelvic-fin spine
- Pigment on snout and brain
- Pigment along base of dorsal fin under formed fin elements
- Conspicuous pigment blotches (1–4) along dorsal and ventral margins of tail and adjacent finfolds, which disappear with development
- Pigment around notochord tip in some taxa

References to trichiurid larvae

Collette *et al.* (1984b), Ozawa (1986d, 1988b), Leis & Trnski (1989), Sandknop & Watson (1996b), Gago (1997).

Families with similar larvae

Chiasmodontidae (early stages) – 33–44 myomeres; small head spines; small spinules over body; large pigment blotches along tail.

Gempylidae – 31–67 myomeres; small to large preopercular spines; <25 dorsal-fin rays; <20 anal-fin rays; elongate, early forming pelvic-fin spines, often serrate; no pigment around notochord tip.

Paralepididae – 60–100 vertebrae; short-based, posteriorly located dorsal fin; dorsal and anal fins spineless; large pigment patches on gut.

Trichiuridae *Lepidopus caudatus* (Euphrasen, 1788) Ribbonfish, frostfish

D IX, 90–96 A II, 59–66 P_1 12 P_2 1, 1 C 18–20 V 105–114

Adults Distributed along southern Australia from Eucla (WA) to Newcastle (NSW), including Tasmania. Also in New Zealand and South Africa, and widespread in the eastern North Atlantic and western Mediterranean. Occurs in shelf and upper slope waters to a depth of about 600 m. Adults have rudimentary pelvic fins, a small forked caudal fin and no scales. Maximum size 2.1 m (Nakamura & Parin, 1993; Gomon *et al.*, 1994).

Importance to fisheries Fished by trawling in southern Australia but of no commercial importance. Important commercial species in the North Atlantic, particularly in Portugal, where it is highly esteemed as a food fish. It is also fished off New Zealand and Namibia (Nakamura & Parin, 1993; Gomon *et al.*, 1994).

Spawning Eggs are pelagic and spherical, 1.6–1.9 mm in diameter, and have a smooth chorion, an unsegmented yolk, and a single oil globule 0.39–0.51 mm (Padoa, 1956a; Robertson, 1975a, 1980; Olivar & Fortuño, 1991). Spawning in New Zealand waters occurs between October and April (Robertson, 1980). Larvae have been caught in coastal waters of northern New South Wales from May to September, and in coastal waters off Sydney (NSW) from April to November (Gray *et al.*, 1992; Gray, 1993).

Diagnostic characters

- 10–31 + 85–92 = 102–116 myomeres
- Up to 2 small to moderate, smooth posterior preopercular spines
- Early forming, elongate first dorsal-fin spine; dorsal-fin spines serrate laterally
- Pelvic-fin spine serrate laterally and medially
- 2 large pigment blotches on dorsal finfold and 1 on anal finfold
- Shield of pigment on snout and head in early preflexion larvae

Description of larvae

Morphology Body very elongate to elongate (BD 9–16%). Head small to moderate (HL 10–28%), increasing in length as snout becomes longer. Small teeth along premaxilla by 7.2 mm. Low, very finely serrate supraocular ridge by late preflexion stage. One small to moderate, smooth posterior preopercular spine by 7.2 mm, a second small spine by late preflexion stage. One opercular spine by late flexion stage. Gut short to moderate (PAL 24–43%), coiled and compact. Small gas bladder above gut, visible in larvae caught at night. Large gap between anus and origin of anal fin. First dorsal-fin spine elongate in early preflexion larvae, remaining longer than other dorsal-fin spines. Dorsal-fin spines (early forming) finely serrate laterally from late preflexion stage; serrations progressively develop on posterior spines with growth. Pelvic-fin spine finely serrate laterally and medially by flexion stage.

Size at

Hatching [1]	4.8–5.0 mm
Notochord flexion	11.5–<17.2 mm
Settlement	>17.2 mm
Formation of fins:	

Dorsal <6.3–>17.2 mm; Caudal 9.2–>17.2 mm; Pelvic 9.2–11.5 mm; Pectoral 11.0–>17.2 mm; Anal 17.2– – mm

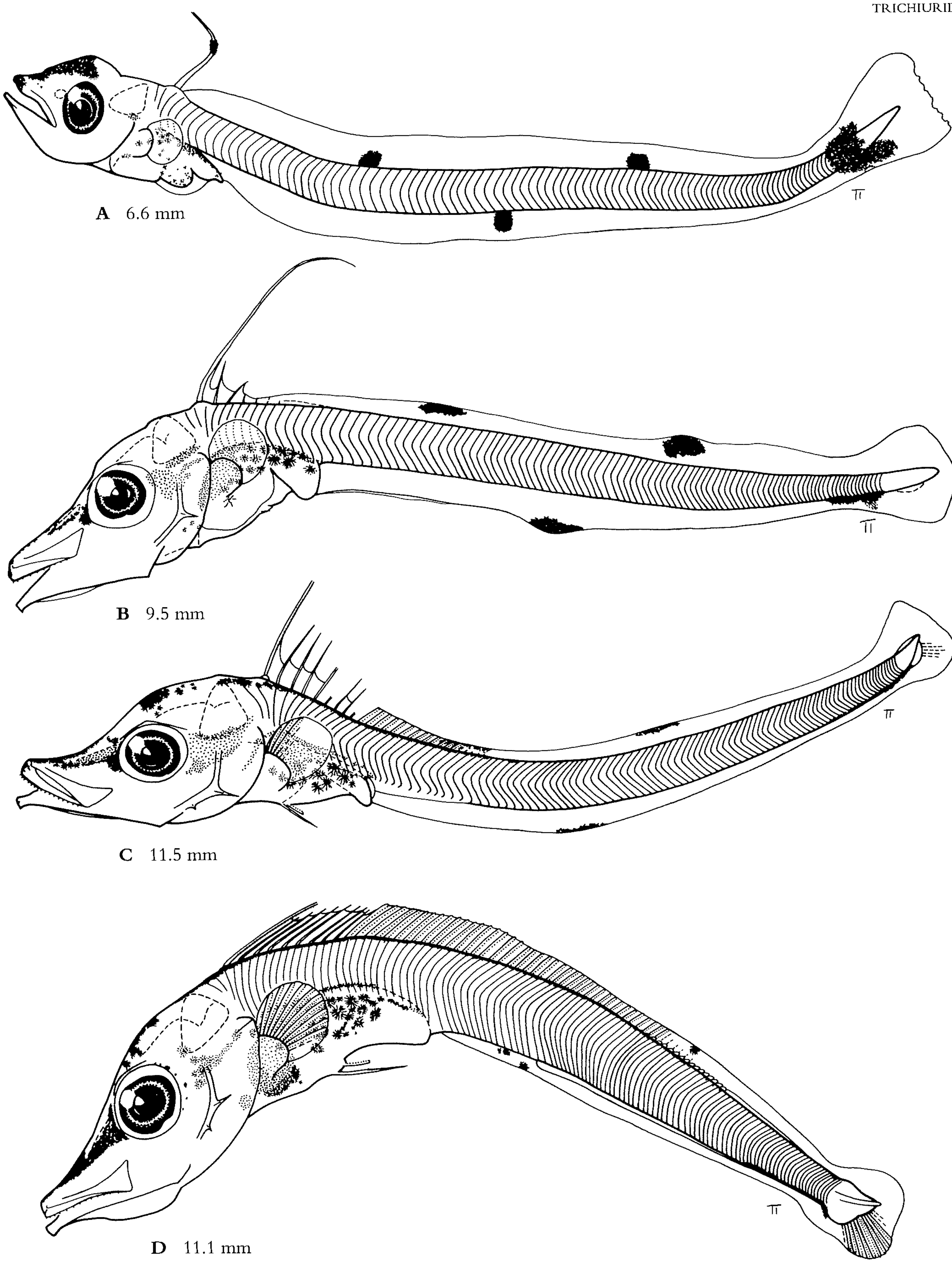
[1] Robertson (1980), Olivar & Fortuño (1991)

Pigmentation Larvae are lightly pigmented. *External:* Shield of pigment dorsally on snout and head in early preflexion larvae; additional pigment dorsally and laterally on snout in late preflexion larvae, from tip of upper jaw to anterior margin of orbit. Melanophores over brain during flexion stage. Small melanophores ventrally on gut in early preflexion larvae, disappearing by about 8 mm. Small melanophores laterally on gut. Two large pigment blotches on dorsal finfold and 1 on anal finfold, gradually decreasing in size with growth. Large patch of pigment around caudal peduncle in early preflexion larvae, reducing in size with growth but remaining ventrally along caudal peduncle. Pigment distally on first dorsal-fin spine in early preflexion larvae. *Internal:* Pigment under hindbrain and otic capsule; melanophores in opercular region by late preflexion stage. Pigment over peritoneum and heavy pigment dorsally over gas bladder and gut.

Material examined 14 larvae, 6.3–12.5 mm BL, and 17.2 mm BL, coastal waters of New South Wales.

Additional references Padoa (1956a), Robertson (1980), Olivar & Fortuño (1991), Gago (1997).

Figure 129 Larvae of *Lepidopus caudatus*. **A** Preflexion. **B** Preflexion; note short pelvic-fin spine; dorsal spine drawn from a similar size larva. **C** Late preflexion. **D** Late flexion; specimen shrunken, size approximate. First dorsal-fin spine broken in all specimens illustrated. A, B, D from coastal waters off Newcastle (NSW); C from coastal waters off Ulladulla (NSW). Illustrated by T. Trnski.


A 6.6 mm
B 9.5 mm
C 11.5 mm
D 11.1 mm

Stromateoidei

The Stromateoidei is a small perciform suborder of exclusively marine fishes found in coastal to oceanic waters in tropical and temperate regions worldwide, in a variety of pelagic and demersal habitats (Haedrich, 1967). Several shelf and upper slope species have commercial importance (Kailola *et al.*, 1993). The suborder contains 6 families, 16 genera and about 65 species (Horn, 1984; Nelson, 1994). Families include the Amarsipidae, Ariommatidae, Centrolophidae (medusafishes), Nomeidae (driftfishes), Stromateidae (butterfishes) and Tetragonuridae (squaretails). Larvae have been described for over half of the species in the 6 families (see review of early life history stages by Horn, 1984; see also Ahlstrom *et al.*, 1976; Miller *et al.*, 1979; Fahay, 1983; Zhang *et al.*, 1985; Kimura, 1988c; Watson, 1996s,t,u,v).

Family and species included here

CENTROLOPHIDAE
Seriolella brama
Seriolella punctata

Centrolophidae: Warehous, medusafishes

B.D. Bruce, C.A. Sutton and F. J. Neira

Centrolophids are epipelagic to epibenthic fishes found in coastal to oceanic waters in tropical and temperate regions worldwide, except most of the mid-Indian and mid-Pacific oceans. The family comprises 7 genera and about 27 species (Haedrich, 1967; McDowall, 1982; Nelson, 1994). Five genera and about 9 species have been recorded from temperate Australia (Last *et al.*, 1983; Bolch *et al.*, 1994; Gomon *et al.*, 1994). Two other genera (*Icichthys* and *Psenopsis*) occur in northern Australian waters but may also be found in southern Australia (Gomon *et al.*, 1994). Centrolophids are morphologically diverse and undergo marked morphological changes during the transformation from juvenile to adult. Adults (0.45–1.4 m) are slender to deep bodied with firm to flabby musculature, have numerous small pores over the head and (sometimes) dorsally on body, one or two weak, flat opercular spines, and a moderate to large mouth with fine teeth in a single row along each jaw. The dorsal fin is continuous with either 0–V weak spines graduating into soft rays or V–IX short stout spines followed by a distinct soft rayed portion (McDowall, 1982; Haedrich, 1986; Nelson, 1994). Eggs are pelagic and spherical, 0.7–1.8 mm in diameter, and have a single oil globule (Robertson, 1975a; Ahlstrom *et al.*, 1976; Grimes & Robertson, 1981; Fahay, 1983; Horn, 1984). Larvae have been described for representatives of *Centrolophus*, *Icichthys*, *Schedophilus* and *Seriolella* (see Horn, 1984, and references therein; see also Sanzo, 1932; Padoa, 1956c; Haedrich, 1967; Ahlstrom *et al.*, 1976; Grimes & Robertson, 1981; Fahay, 1983; Watson, 1996s). Postflexion larvae and juveniles are often associated with jellyfish (hence the name 'medusafishes') or inanimate floating objects in surface waters (Ahlstrom *et al.*, 1976; Last *et al.*, 1983). The head spination (absent in *Centrolophus* larvae), and the gas bladder which is lost during the transformation from juvenile to the adult stage (Horn, 1975), are the only apparent specialisations of centrolophid larvae to pelagic life.

Meristic characters of centrolophid genera of temperate Australia

	(n)	Dorsal	Anal	Pectoral	Pelvic	Caudal	Vertebrae
Centrolophus	(1)	V, 32–37	III, 21–24	20–23	I, 5	17	10 + 15 = 25
Hyperoglyphe	(1)	IX, 15–20	III, 14–16	19–21	I, 5	17	10 + 14–15 = 24–25
*Schedophilus**	(2)	35–62	26–41	18–19	I, 5	17	10–12 + 15–20 = 25–32
Seriolella	(4)	VII–IX, 25–39	III, 18–24	19–23	I, 5	17	10–11 + 14–16 = 25–26
*Tubbia**	(1)	47–51	33–37	18–21	I, 5	17	43–45

* Dorsal- and anal-fin counts refer to total elements; although VIII dorsal and III weak anal-fin spines are reported by some authors for *Schedophilus*, dorsal- and anal-fin spines are barely distinguishable in both genera (Last *et al.*, 1983).

Main characters of centrolophid larvae

- 23–61 myomeres, 23–26 in most taxa
- Body elongate to moderate (BD 11–37%)
- Head large by postflexion stage (HL 33–37%), with a short, rounded snout
- Weak to moderate head spination in most taxa (head spines are lacking in *Centrolophus*), including preopercular, interopercular and subopercular spines
- Gut long (PAL 51–66%), initially straight but becoming loosely coiled during preflexion or flexion stage
- Small gas bladder over foregut, lost during transition from juvenile to adult stage
- Persistent preanal membrane
- Body moderately to heavily pigmented
- External melanophore series along lateral midline of posterior region of tail from early stages in some taxa (e.g. *Seriolella*); internal melanophore series along notochord

- Series of pigment blotches along dorsal midline of trunk and tail and ventral midline of tail in preflexion and flexion larvae
- Pigment blotches or banding common on trunk and tail in postflexion larvae

References to centrolophid larvae
Ahlstrom *et al.* (1976), Fahay (1983), Horn (1984), Watson (1996s).

Families with similar larvae

Arripidae – Prominent gap between anus and origin of anal fin; short-based dorsal and anal fins, IX, 13–17 and III, 9–10 respectively; lack pigment blotches along dorsal and ventral surfaces of tail; distinct pigment around notochord tip in early larvae.

Girellidae – Weak head spination, without interopercular spines; short-based dorsal and anal fins; gut moderate to long (PAL 41–52%); prominent gap between anus and origin of anal fin; body lightly pigmented; lack pigment blotches along dorsal and ventral surfaces of tail.

Kyphosidae – Short-based dorsal and anal fins, XI, 12–16 and III, 10–11 respectively; pigment under notochord tip; melanophore series along lateral midline of tail in postflexion larvae; lack pigment blotches along dorsal and ventral surfaces of tail.

Microcanthidae – Small to large gap between anus and origin of anal fin; body lightly pigmented; pigment around notochord tip.

Nomeidae – Body deep; head with a rounded snout and a large eye; usually weak preopercular spines; early forming, often pigmented pelvic fins (e.g. *Nomeus*, *Psenes*); lack pigment blotches along dorsal and ventral surfaces of tail.

Pomatomidae – Lack interopercular spines; gut coiled and voluminous; moderate gap between anus and origin of anal fin; body lightly pigmented until postflexion stage; lack pigment blotches along dorsal and ventral surfaces of tail.

Scorpididae – Gut coiled and compact, moderate to long; gap between anus and origin of anal fin; lack pigment blotches along dorsal and ventral surfaces of tail; pigment around notochord tip.

Centrolophidae *Seriolella brama* (Günther, 1860) Blue warehou

D VIII–IX, 25–29 A III, 19–23 P_1 19–22 P_2 I, 5 C 17 V 25

Adults Distributed along southern Australia from the eastern Great Australian Bight to Port Stephens (NSW), including Tasmania; also in New Zealand. Found in shelf and upper slope waters to a depth of 520 m. Late postflexion larvae and small juveniles are commonly found under drifting jellyfish, larger juveniles in bays and estuaries. Adults have a moderately deep body, a slender caudal peduncle with small lateral keels, long falcate pectoral fins, and are steel–blue dorsally and silver–white ventrally with a large dark blotch above each pectoral-fin base. Maximum size 90 cm (Last *et al.*, 1983; Gomon *et al.*, 1994; CSIRO, unpublished data).

Importance to fisheries Fished commercially with trawl and gill nets in southeastern Australia, mostly in depths between 50 and 250 m. Total catch in 1993 was 1460 tonnes. Subadults are caught by recreational fishers in estuaries and large bays (Kailola *et al.*, 1993; Smith, 1994c; Staples & Tilzey, 1994).

Spawning Eggs are pelagic and spherical, 1.4–1.6 mm in diameter, and have a single oil globule 0.36–0.40 mm (Grimes & Robertson, 1981). Spawns between late winter and early spring (Kailola *et al.*, 1993). Larvae have been caught in coastal waters of eastern Victoria, Tasmania and southern New South Wales from August to November (Bruce *et al.*, 1996).

Diagnostic characters

- 11–12 + 14 = 25–26 myomeres
- 4 large, stellate melanophores dorsally from nape to caudal peduncle, extending ventrally and forming pigment bands in postflexion larvae
- Pigment on pelvic fin by 9.2 mm

Description of larvae

Morphology Body elongate to moderate (BD 17–37%). Head moderate in preflexion and flexion larvae (HL 24–33%), large in postflexion larvae (HL 33–37%). Small villiform teeth along both jaws by end of flexion stage. Two or three small anterior preopercular and 3–4 posterior preopercular spines in flexion larvae; up to 5 anterior preopercular and 9 posterior preopercular spines in postflexion larvae. One small interopercular spine by end of flexion stage; 2 interopercular spines and 1 small subopercular spine by 11 mm. Low, smooth supraocular ridge from late flexion stage. A small supracleithral spine in postflexion larvae from 8.7 to 10.5 mm. Gut long (PAL 55–66%), initially straight, coiled in postflexion larvae. Gas bladder over foregut. Last dorsal- and anal-fin spines transform from rays in late postflexion larvae. Pectoral and pelvic fins large from 14 mm.

Size at

Hatching [1]	4.2 mm
Notochord flexion	6.9–9.4 mm
Settlement	>14.5 mm
Formation of fins:	
Caudal 6.0–9.4 mm; Dorsal 7.5–10.1 mm; Anal 7.5–10.1 mm; Pelvic 7.6–8.5 mm; Pectoral 7.6–9.6 mm	

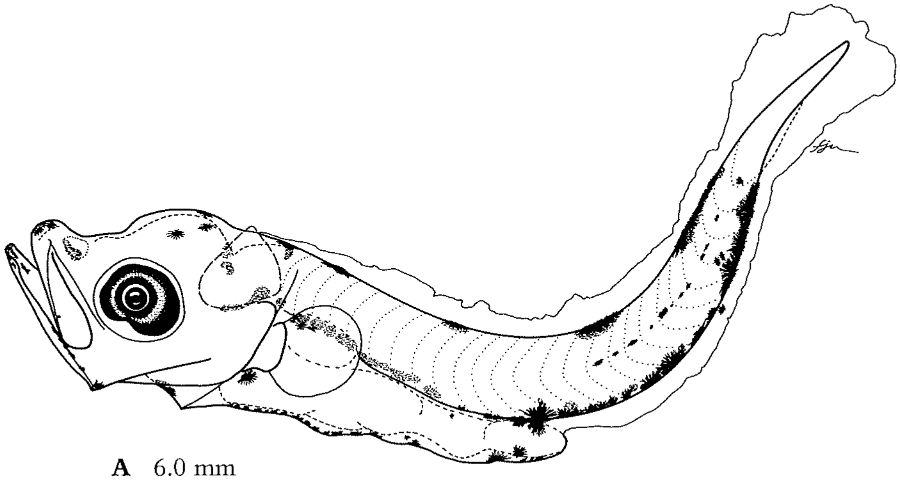
[1] Grimes & Robertson (1981)

Pigmentation Larvae are moderately pigmented. *External:* Melanophores on tip of jaws, along dentary, dorsally over brain, and 1 at angle of lower jaw. Melanophores along isthmus, and ventrally along gut to anus. Melanophores laterally over gut by late flexion stage. Melanophore dorsally over nape, becoming internal by late preflexion stage. Four large, stellate melanophores dorsally from nape to caudal peduncle in preflexion larvae, posteriormost elongate from flexion stage; melanophores expand laterally by postflexion stage. Additional melanophores along dorsal midline in postflexion larvae which coalesce. Melanophores along ventral midline of tail above middle of anal fin and on caudal peduncle; these expand laterally in early flexion larvae and join dorsolateral melanophores forming 2 vertical pigment bands on tail in postflexion larvae. Series of elongate melanophores along lateral midline of tail, extending anteriorly to trunk in postflexion larvae, some obscured by musculature in postflexion larvae by 9 mm. Melanophores on pelvic, dorsal- and anal-fin rays by 10 mm, and along leading edge of dorsal-fin spines from 11 mm. *Internal:* Melanophores below nostril, over hindbrain and at nape. Pigment from below otic capsule extending dorsally over gas bladder and along entire gut to above anus. Melanophores dorsally along each vertebrae in early postflexion larvae.

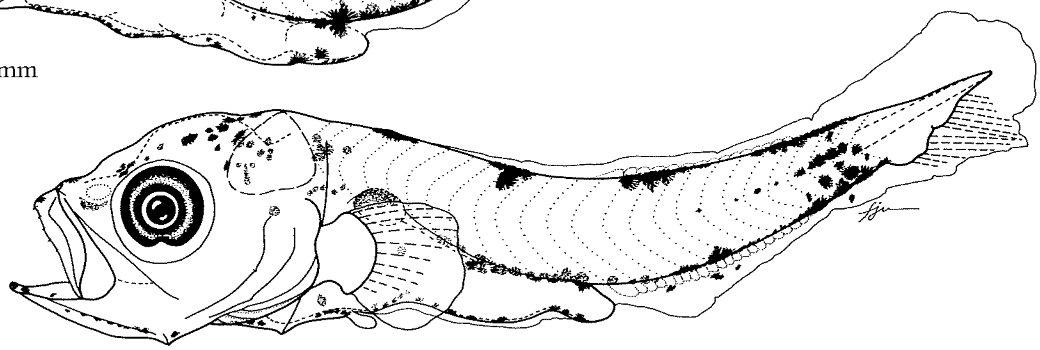
Material examined 11 larvae, 6.5–14.5 mm BL, coastal waters of southern New South Wales; 5 larvae, 5.7–7.6 mm BL, coastal waters of western and southern Tasmania.

Additional references Robertson (1973), Grimes & Robertson (1981), Bruce *et al.* (1996).

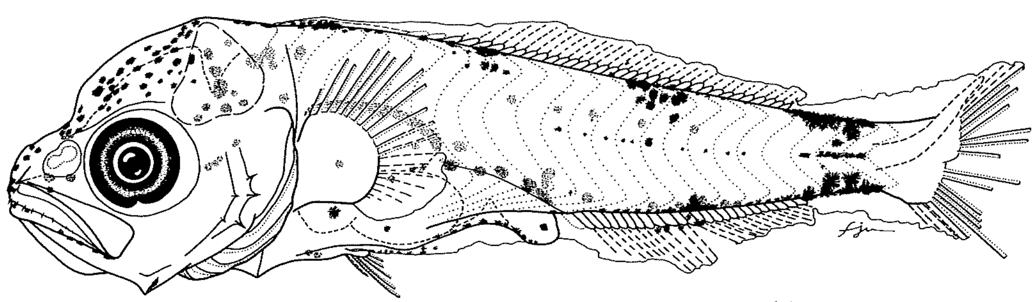
Figure 130 Larvae of *Seriolella brama*. **A** Preflexion. **B** Late preflexion; note pelvic-fin bud and developing dorsal and anal fins. **C** Late flexion. **D** Early postflexion. **E** Postflexion; myomeres omitted. A, B from Tas coastal waters; C–E from NSW coastal waters. Illustrated by F. J. Neira.



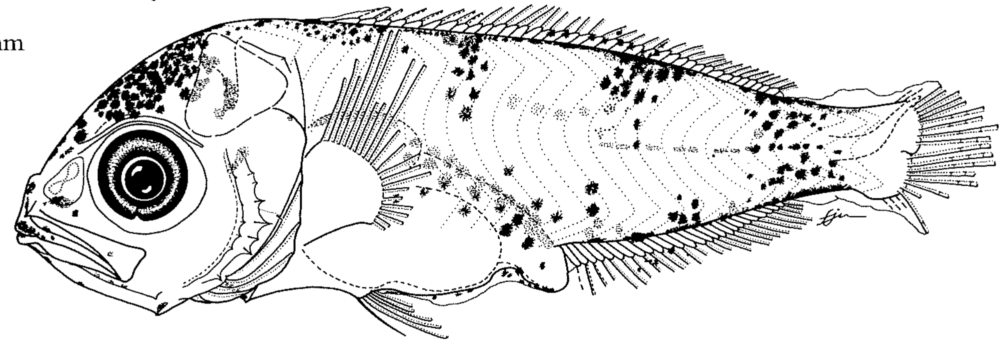
A 6.0 mm



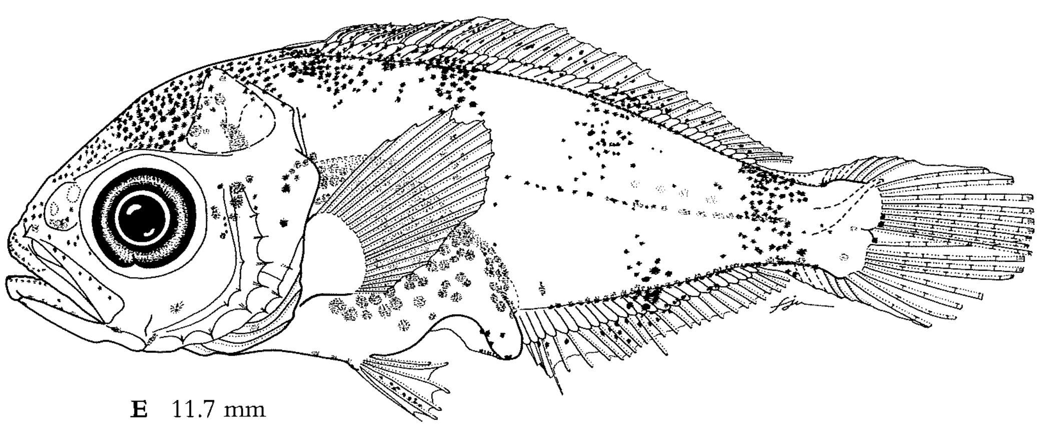
B 7.6 mm



C 8.3 mm



D 9.6 mm



E 11.7 mm

Centrolophidae *Seriolella punctata* (Forster, 1801) Silver warehou, spotted trevalla

D VII–IX, 35–39   A III, 21–24 P_1 19–24 P_2 I, 5   C 17   V 25

Adults Distributed along southern Australia from Spencer Gulf (SA) to Newcastle (NSW), including Tasmania. Confined to the Southern Hemisphere, including New Zealand and both coasts of South America. Occurs in outer shelf and slope waters to a depth of 650 m. Late postflexion larvae and small juveniles are occasionally found under drifting jellyfish and floating objects; larger juveniles may enter bays and estuaries. Adults have a streamlined body with a slender caudal peduncle, and are silver–blue dorsally and silver–white ventrally, with a small dark blotch above each pectoral-fin base, and an irregular series of small dark spots on the sides which disappear in large individuals. Maximum size 66 cm (Last *et al.*, 1983; Gomon *et al.*, 1994).

Importance to fisheries Fished commercially mainly with trawl and gill nets in southeastern Australia, one of the main species in the South East Trawl fishery. Total catch in 1993 was 2210 tonnes. Subadults are caught by recreational fishers in estuaries and bays (Kailola *et al.*, 1993; Smith, 1994b; Staples & Tilzey, 1994).

Spawning Eggs are pelagic and spherical, 1.1–1.2 mm in diameter, and have a single oil globule 0.30–0.35 mm (Grimes & Robertson, 1981). Spawns between late winter and early spring (Kailola *et al.*, 1993). Larvae have been caught in coastal waters of eastern Victoria, Tasmania and southern New South Wales from July to October (Bruce *et al.*, 1996).

Diagnostic characters

- 11–12 + 13–14 = 25 myomeres
- 5 large, stellate melanophores dorsally between nape and caudal peduncle in preflexion and flexion larvae
- 4–5 melanophores on dorsal finfold above dorsal midline melanophores
- About 1 melanophore distally on base of each dorsal- and anal-fin ray in late postflexion larvae
- Pigment on membrane above and below caudal peduncle during flexion stage
- No pigment on pelvic fin

Description of larvae

Morphology Body elongate to moderate (BD 11–34%). Head small to moderate in preflexion larvae (HL 14–26%), large in postflexion larvae (HL 33–35%). Small villiform teeth along both jaws by end of flexion stage. One or two small anterior preopercular and 3–4 posterior preopercular spines during flexion stage, 3–4 anterior preopercular and 6–8 posterior preopercular spines by postflexion stage. Up to 4 small interopercular spines by 10.4 mm. A low, smooth supraocular ridge from flexion stage and a smooth supracleithral ridge by postflexion stage. Gut long (PAL 51–65%), initially straight, coiled in postflexion larvae. Gas bladder over foregut. Last dorsal- and anal-fin spines transform from rays by 11.3 mm. Pectoral and pelvic fins large in larvae >11 mm.

Size at

Hatching [1]	2.3–2.8 mm
Notochord flexion	6.4–8.8 mm
Settlement	>11.7 mm
Formation of fins:	
Caudal 6.0–8.8 mm; Anal 6.3–9.6 mm; Dorsal 6.3–11.3 mm; Pelvic 6.4–9.0 mm; Pectoral 8.3–10.6 mm	

[1] Larger length is TL (Grimes & Robertson, 1981).

Pigmentation Larvae are moderately pigmented. *External:* Melanophores on tip of jaws, along dentary from flexion stage, dorsally over brain, and 1–2 at angle of lower jaw. Melanophores along isthmus and ventrally along gut to anus. Melanophores laterally over gut by mid-flexion stage. Five large, stellate melanophores dorsally from nape to caudal peduncle, and 4–5 on dorsal finfold in early preflexion larvae; additional melanophores which merge along dorsal midline in postflexion larvae. Two to five melanophores along ventral midline of tail, merging and forming a continuous pigmented band from anus to caudal peduncle prior to flexion stage; band becomes less distinct during flexion stage. Series of melanophores along lateral midline of tail, extending anteriorly to trunk in postflexion larvae. A ventrolateral series of melanophores above anal-fin base in flexion larvae and scattered melanophores dorsolaterally below dorsal-fin base in postflexion larvae. Pigment extends onto membrane above and below caudal peduncle during flexion stage, and onto base of dorsal-fin rays by postflexion stage. About 1 melanophore distally on base of each dorsal- and anal-fin ray in late postflexion larvae. Melanophores on dorsal and anal fins during flexion stage. *Internal:* Melanophores below nostril, over hindbrain and at nape. Pigment from below otic capsule, extending dorsally over gas bladder and along entire gut to above anus. Melanophores dorsally along vertebrae from flexion stage; additional melanophores ventrally along vertebrae from early postflexion stage.

Material examined 15 larvae, 6.4–11.7 mm BL, coastal waters of southern New South Wales; 6 larvae, 4.5–9.0 mm BL, coastal waters of western and southern Tasmania; 4 larvae, 2.3–4.2 mm BL, reared at the Department of Primary Industries and Fisheries (Tas).

Additional references Grimes & Robertson (1981).

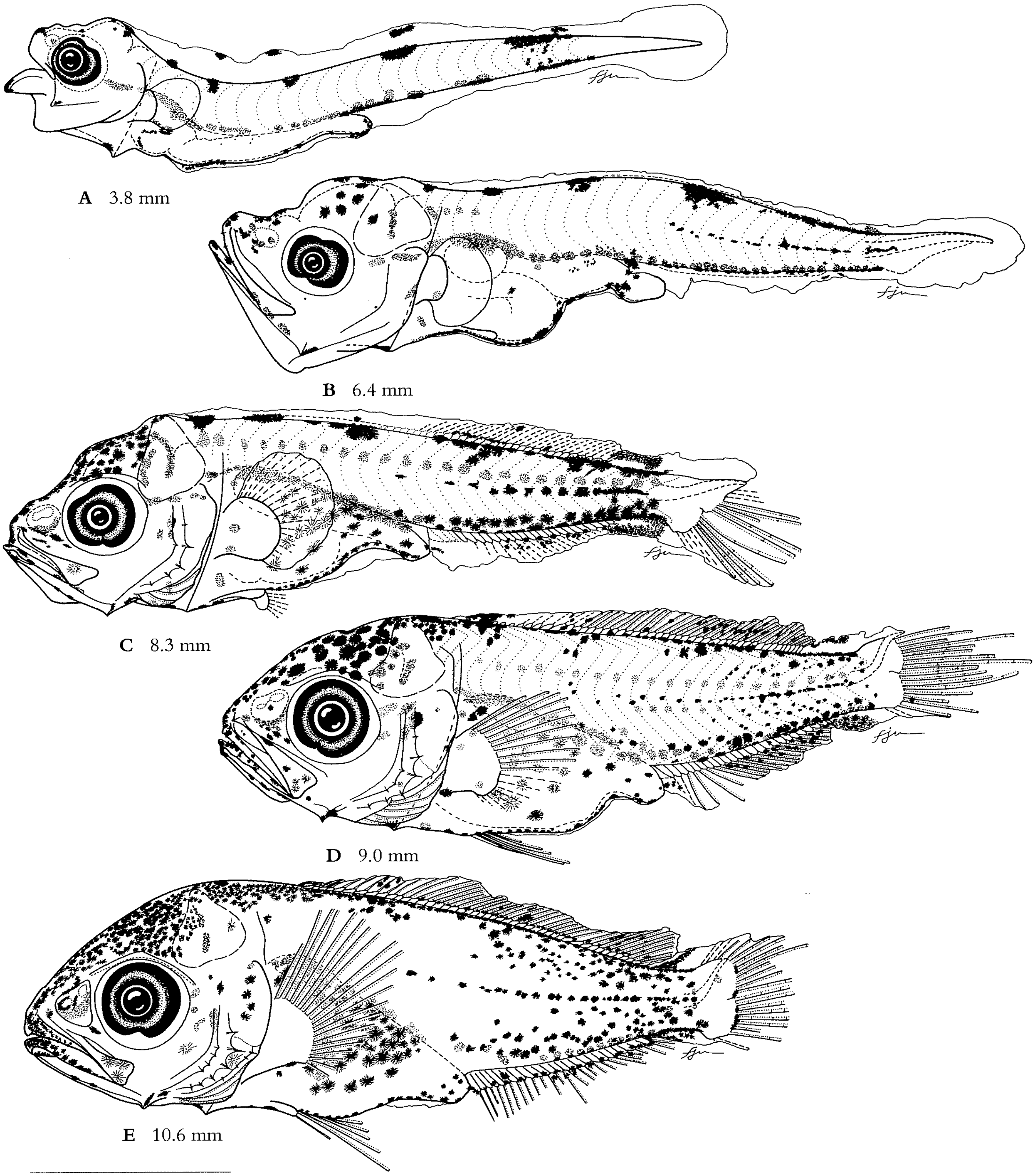


Figure 131 Larvae of *Seriolella punctata*. **A** Preflexion. **B** Early flexion; note pelvic-fin bud and developing dorsal and anal fins. **C** Late flexion. **D** Early postflexion. **E** Postflexion; myomeres omitted. A–C, E from NSW coastal waters; D from Tas coastal waters. Illustrated by F. J. Neira.

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GLOSSARY

The definitions given below apply to larval and/or adult fishes. Most were obtained or modified from various publications, including Last *et al.* (1983), Leis & Rennis (1983), Fahay (1983), Leis & Trnski (1989), Rojo (1991), Moser (1996a), and dictionaries such as those of Lincoln *et al.* (1982), Charton (1989) and Walker (1994).

abdominal Pertaining to the abdomen, the region between the pectoral-fin bases and the anus (e.g. abdominal pelvic fins).
abyssal Pertaining to great depths into which light does not penetrate; in the ocean water column below 2000 m, but more usually used for depths between 4000 and 6000 m.
adhesive eggs Eggs that attach to other eggs and/or to the substrate or floating objects.
adipose fin Small fleshy fin posterior to the dorsal fin and made up of adipose tissue (e.g. salmonids).
anadromous Pertaining to fishes that migrate up rivers to spawn.
angle of lower jaw Ventrally directed process formed by the junction of the angular, articular and quadrate bones, process prominent in some larvae.
anlage German word for an organ, cell or other structure (e.g. a fin) in the earliest stage of development or differentiation. Also primordium. Anlagen (plural).
ascending process of premaxilla Vertical extension at the anterior end of the premaxilla in most teleost fishes, particularly elongate in larvae of some taxa (e.g. gerreids).
barbels Slender, tentacle-like structures around the mouth and on snout in some groups, mostly used as sensory organs (e.g. siluriforms).
basipterygium Paired chondral bone supporting the pelvic fins.
bathybenthic Living above the bottom in the bathypelagic zone.
bathypelagic Living in the portion of the ocean water column between 1000 and 4000 m deep and above the abyssal zone.
benthic Living in, on or near the bottom.
body depth (BD) The vertical distance between the margins of the body through the anterior margin of the pectoral-fin base; excludes yolk sac in yolk-sac larvae, and fins.
body depth at anus (BDA) The vertical distance between the margins of the body through the anus, excluding fins.
body length The distance from the tip of the snout to the notochord tip (= notochord length) in preflexion and flexion larvae, and from the tip of the snout to the posterior margin of the hypural bones (= standard length) in postflexion, settlement and transforming larvae.
body rings Dermal plates encircling body of some fishes (e.g. syngnathids).
brackish water Water of salinity intermediate between fresh water and sea water.
branchiostegal rays Series of long, curved and often pointed bones that support the branchiostegal (gill) membrane.
bud Outgrowth or bump of undifferentiated tissue which develops at the initial formation of paired fins (e.g. pelvic-fin buds).
catadromous Pertaining to fishes that migrate from rivers to spawn at sea.
caudal peduncle Region between the posterior end of the dorsal-/anal-fin base and the base of the caudal fin.
caudal vertebrae All posterior vertebrae from the centrum bearing the first haemal spine to the urostyle.
choroid tissue Mass of primordial vascular tissue, usually unpigmented, under the ventral margin of the eye; mostly associated with narrow, elliptical eyes.
cleithral symphysis Region where both the cleithra articulate ventrally with the scapula and coracoid through a cartilaginous joint.
cleithrum Elongate, vertically oriented bone that acts as a support for the primary pectoral girdle.
coastal waters Waters within the 200 m depth contour of the continental shelf, including protected bays and

estuaries; includes inshore waters. Also referred to as shelf waters.

coiled gut A gut which is curled or looped (cf. **straight gut**).

cryopelagic Living under the ice, in subzero temperatures.

cryptic Organism that uses coloration and markings that resemble the substratum and aid in concealment.

ctenoid scales Laminar scales with pointed spinules (ctenii) along the posterior margin.

cycloid scales Laminar scales without pointed spinules along the posterior margin.

demersal Living at or occurring near or at the bottom; substrate-associated (cf. **pelagic**).

demersal egg Egg found near or at the bottom (not pelagic) and either free or attached to the substrate.

dendritic organ Fleshy extension protruding from behind the anus in marine plotosids and which apparently functions as a salt regulatory organ. Also referred to as arborescent organ.

dentary Paired, V-shaped dermal bone on the anterior part of the lower jaw, usually bearing teeth.

diadromous Pertaining to fishes that migrate between freshwater and the sea.

epibenthic Living above the bottom; also **demersal**.

epibranchials Bones arranged in pairs in the branchial apparatus in most teleost fishes, usually covered with toothed pads along the inner and outer sides.

epipelagic Living in the uppermost layer of the ocean water column to a depth of 200 m.

estuary A partially enclosed body of water either permanently or periodically open to the sea, and within which there is a measurable variation of salinity due to the mixture of fresh water derived from land drainage and sea water.

eye diameter (ED) In larvae with round eyes, the horizontal diameter of the eye across the pigmented region; in larvae with oval or elliptical eyes, the horizontal and vertical distances of the pigmented region.

finfold Medial membrane or integument extending along the body of a larva and from within which the dorsal, caudal and anal fins develop.

finlets Small fin-like structures located posterior to the dorsal and anal fins in some groups (e.g. scombrids) and supported by rays.

fin spines Unsegmented and unbranched bony structures which support the fins in teleost fishes, commonly present in the anterior part of the dorsal and anal fins. Spines, or spiny rays, are usually hard and pointed, and either smooth or serrate, and made up of two components paired along the midline (bilateral).

flexion Upward bending of the notochord tip in larvae of most teleost fishes (urostyle from postflexion stage) as part of the formation of the caudal complex.

flexion larva Larva in the flexion stage.

flexion stage Developmental stage from the time the notochord tip commences bending upwards to the time the posterior edge of the hypural bones assumes a vertical position.

forebrain Anteriormost region of the brain, and which includes the olfactory lobes.

foregut Anterior region of gut from which the oesophagus and stomach develop.

fork length The horizontal distance from the tip of the snout to the posterior edge of the fork of the caudal fin.

frontal Large paired dermal bone of the head above the eye.

gap length (VAFL) Length of gap between anus and origin of anal fin.

gas bladder Gas-filled sac located above the gut which helps in regulating buoyancy; size at initial inflation and diel pattern of inflation vary among taxa. Also referred to as air or swim bladder.

gill rakers Rows of tooth-like or filamentous, cartilaginous or bony elements along the internal edges of the branchial (gill) arches.

gular region Area of the lower jaw between the dentary bones and anterior to the isthmus.

halfbeak stage Stage in the development of most belonids characterised by a greatly elongate lower jaw and a comparatively short upper jaw.

head length (HL) The horizontal distance from the tip of the snout to the posteriormost margin of the opercular membrane. For larval fishes in which the opercle has not yet developed, head length is measured to the cleithrum above the pectoral-fin base.

hindbrain Posteriormost region of the brain.

hindgut Posterior region of the gut, and which includes the intestine and rectum.

hypurals Median series of fan-like bones of the caudal skeleton that articulate with the urostyle (the last vertebra) and which support the caudal-fin rays; hypural complex.

ichthyoplankton The fish component of the plankton; includes eggs and larvae.

inshore waters See coastal waters.

interopercle Lower dermal bone of the gill cover located below the preopercle.

isthmus Ventral region of the head between the gills connecting the gular and cleithral regions.

jugular Pertaining to the throat, the region anterior to the pectoral-fin bases (e.g. jugular pelvic fins).

juvenile Developmental stage from attainment of full complement of external meristic characters (fin rays and scales) and loss of specialised larval characters to first sexual maturity.

lachrymal The anteriormost of the infraorbital bones; also **preorbital**.

larva Developmental stage between hatching and the attainment of full external meristic complements, including when structures that migrate during development (e.g. dorsal fin in clupeiforms) assume their ultimate position, and the loss of specialisations to pelagic life. Includes yolk-sac through to postflexion stages.

maxilla Paired dermal bone of the upper jaw located posterior to the premaxilla.

melanophores Nucleated cells containing the brown and black pigment melanin; melanophores can expand and contract thus changing in size and shape, and remain in larval fishes even after fixation and preservation.

meristic characters Characters or characteristics repeated serially which can be counted, e.g. scales, fin rays, gill rakers, vertebrae.

mesopelagic Living in the oceanic water column at depths between 200 and 1000 m.

midbrain Middle region of the brain, and which includes the optic lobes.

midgut Middle region of gut.

monotypic A taxon (e.g. a family or a genus) comprising a single species.

morphometric characters Characters that can be measured and expressed by a numerical value, e.g. head length.

mouth brooding Reproductive mode in which fertilised eggs are incubated in the buccal cavity until hatching, usually by the males (e.g. apogonids). Also referred to as oral brooding.

myomeres Muscle bands aligned sequentially and in transverse series along the trunk and tail, separated from each other by myosepta; total number of myomeres is approximately equal to the number of vertebrae.

myoseptum Partition of connective tissue separating two adjacent myomeres. Myosepta (plural).

nape Dorsal region of the trunk immediately posterior to the head.

neustonic Living at the surface of the water column.

notochord Longitudinal rod of specialised skeletal tissue which provides the initial supporting axis for the body in larvae of teleost fishes, and which is later replaced by the vertebral column by substitution of the notochord tissue.

notochord length See **body length**.

oceanic waters Marine waters beyond the 200 m depth contour of the continental shelf. Also referred to as offshore waters.

oil globule Oil bubble within the yolk in eggs of some fishes. Also referred to as oil droplet.

ontogenetic characters Those characters associated with development.

ophioblennius stage Pelagic stage of some salariin blenniids, characterised by enlarged, hooked teeth anteriorly in the lower jaw or both jaws, and large pectoral fins.

otic capsule Triangular-shaped tissue mass corresponding to the ear primordium. Externally visible over the lateral region of the hindbrain in larval fishes.

oviparous Reproductive mode in which eggs are spawned and hatch outside the maternal body (cf. **viviparous**).

ovoviviparous Reproductive mode in which eggs are retained and hatch within the maternal body, with the release of live young.

paedomorphic Organism which retain larval or juvenile characters in the adult stage.

paperfish stage Prolonged pelagic stage in the development of some families (e.g. Cheilodactylidae), characterised by a deep, strongly compressed silvery body with a prominent ventral keel.

pectoral-fin length (P_1L) The distance from the anterior edge of the pectoral-fin base to the end of the longest pectoral-fin ray.

pelagic Free in the water column, not associated with the bottom.

pelagic egg Egg free in the water column, often slightly positively buoyant.

peritoneum The serous membrane which lines the gut cavity.

pharyngobranchials Bones of the uppermost segment of the branchial arch skeleton.

photophores Small, light-producing organs in the head and body of some groups, most with a lens and a small reflector (e.g. myctophids). Also referred to as light organs.

postanal membrane Membrane along the gap between anus and origin of anal fin in larvae of some taxa with a prominent gap (e.g. terapontids).

postflexion larva Larva in the postflexion stage.

postflexion stage Developmental stage between the end of notochord flexion and the beginning of the juvenile stage.

preanal length (PAL) The horizontal distance between the tip of the snout and the vertical that passes through the posterior margin of the anus.

preanal membrane Medial membrane along ventral surface of gut and anterior to anus.

precaudal vertebrae All anterior vertebrae to the one immediately anterior to the first centrum bearing a haemal spine.

precocious Pertaining to any structure(s) which in some fishes develops comparatively earlier than it would do typically in most fishes (e.g. fin elements); early forming.

preflexion larva Larva in the preflexion stage.

preflexion stage Developmental stage from hatching (or birth) to the start of the upward bending of the notochord tip; in some groups, larvae may already have the notochord flexed at hatching, thus skipping the preflexion stage (e.g. scomberesocids).

premaxilla Paired dermal bone which forms the anterior part of the upper jaw, usually bearing teeth along its lower border.

principal caudal-fin rays The caudal rays supported by the hypural and parahypural elements.

procurrent rays Small, unsegmented and unbranched rays located along the dorsal and ventral edges of the posterior region of the caudal peduncle.

protogyny Condition in which a hermaphroditic organism assumes a functional female role first before becoming a functional male; protogynia.

pterygiophores Bony elements supporting each of the dorsal- and anal-fin rays. In larvae of teleost fishes, distinguished by their short and fleshy, finger-like appearance with a ball-and-socket joint at their distal ends.

rostrum Paired dermal bone in the anteriormost region of the snout, above the premaxilla.

scutes Hard, thick external plates derived from scales and present on the skin of some teleost fishes, e.g. carangids.

settlement Process by which a pelagic larva or juvenile leaves the pelagic environment and adopts a substrate-associated mode of life. In this book, applied to benthic and demersal fishes (cf. **transformation**).

settlement larva Larva in the settlement stage.

settlement stage Developmental stage in which the pelagic larva or juvenile is morphologically and physiologically ready to adopt a substrate-associated mode of life; not applicable to juveniles or adults of pelagic species.

shelf waters The ocean water column above the continental shelf, the shallow and gradually sloping seabed around a continental margin, to a depth of approximately 200 m; include inshore waters. Also referred to as coastal waters.

slope waters The ocean water column above the continental slope, the steeply sloping seabed from the outer edge of the shelf to the continental rise, at depths between 200 m and 1000 m.

snout Anterior region of head between the tip of the upper jaw and the eyes.

snout length (SnL) The horizontal distance from the tip of the snout to the anterior margin of the pigmented region of the eye.

soft ray Flexible, bilaterally paired structure which supports fins. Rays can be either segmented and unbranched (simple), or both segmented and branched at their distal ends.

specialisations to pelagic life Those morphological characters (not pigment) that are present during pelagic larval life but which are lost at settlement (demersal, benthic fishes) or after transformation (pelagic fishes).

stalked eyes Eyes attached to peduncles.

standard length (SL) The horizontal distance from the edge of the snout to the edge of the hypural plates. Referred to as body length in postflexion larvae.

straight gut A gut which is not coiled or twisted.

striated gut Gut with (usually) many sinusoidal folds which in lateral view resemble lines or bands.

subopercle Posterior bone of the gill cover between the opercle and interopercle.

subterminal mouth Mouth posterior to the tip of the snout. Sometimes also referred to as inferior mouth.

supraoccipital crest Unpaired, medial bony protrusion originating from supraoccipital bone, often serrate (e.g. larval carangids).

tail Region of the body posterior to the anus.

terminal mouth Mouth located at the anteriormost region of the snout.

thoracic Pertaining to the chest, the region below the pectoral-fin bases (e.g. thoracic pelvic fins).

total length (TL) The horizontal distance from the tip of the snout to the posterior edge of the caudal-fin rays.

transformation Process of metamorphosis at the end of the larval stage to the attainment of juvenile morphological characters and pigmentation, including the loss of specialised larval characters. This process may be gradual and occur over an extended period of time. In this book, applied to species with pelagic larvae which remain pelagic as juveniles and adults (e.g. clupeids); specimens undergoing transformation are considered to be larvae.

transforming larva Larva undergoing transformation to juvenile. Also referred to as transforming stage.

trunk Body region between head and tail, or between the posteriormost margin of the opercular membrane and the vertical through the anus.

urogenital duct Tube draining the urogenital organs, noticeable as a fine canal just posterior to the anus and joined to the anus in small larvae

urostyle The last segment of the vertebral column, formed by the fusion of several vertebrae; usually counted as the last vertebral centrum.

ventral keel Fleshy ridge along abdomen and caudal peduncle (e.g. paperfish stage in cheilodactylids).

vexillum Elongate, thread-like process anterior to the dorsal fin in larvae of carapids.

viviparous Reproductive mode in which embryos develop within the maternal body and receive nutrition, and the young are released as larvae or juveniles; live-bearing.

whitebait stage Pelagic juvenile stage of some galaxiine galaxiids with a marine or lacustrine (lake) phase in which the body is elongate and transparent.

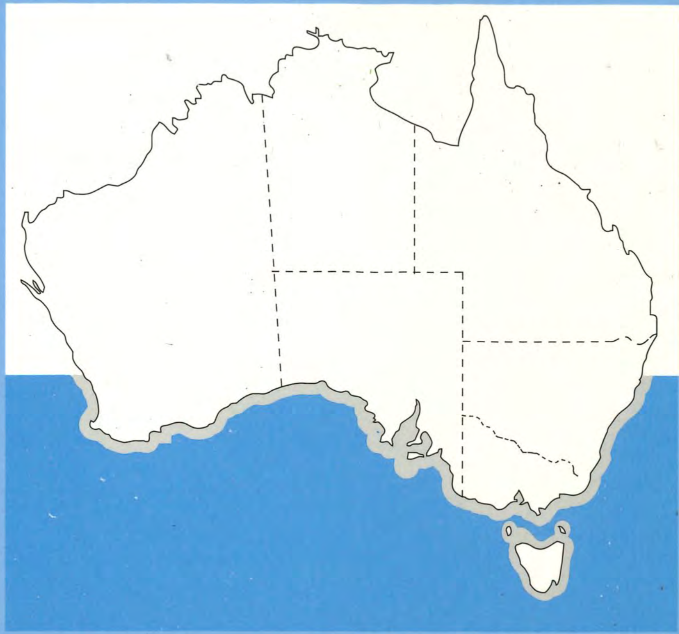
yolk sac Sac-like extension of the embryonic gut containing the yolk, the nutritive material, in embryos and many newly hatched larvae.

yolk-sac larva Developmental stage characterised by the presence of a yolk sac ventrally in the gut region which ends with the exhaustion of the yolk reserves.

INDEX

Note: Family names in bold refer to those treated in the book. Page numbers in bold refer to major descriptions.

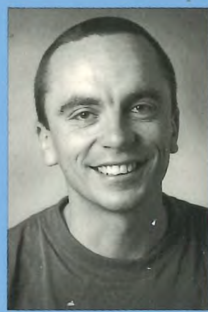
Over 700 species of marine fishes, belonging to some 117 families, occur in freshwater and coastal marine waters of temperate Australia. While there has been a great deal of work published on the adults of many of these species, knowledge of their larval stages is very limited. Since larval fishes are morphologically different from adults, their accurate identification is essential in any biological study of fishes.



In *Larvae of Temperate Australian Fishes* the larval stages of 124 fish species from 57 families which occur in fresh water, estuarine and inshore marine waters of temperate Australia are described. Each family chapter includes a summary of the taxonomy and life history information for the family, a list of the main characters used to identify larvae to family level, a table of the meristic characters of the genera found in temperate Australian waters, and a list of families whose larvae may be confused with those of the family being described, and the characters which will distinguish them. For each species there is information on adult distribution, importance to fisheries, spawning, diagnostic characters of larvae, and larval morphology and pigmentation.

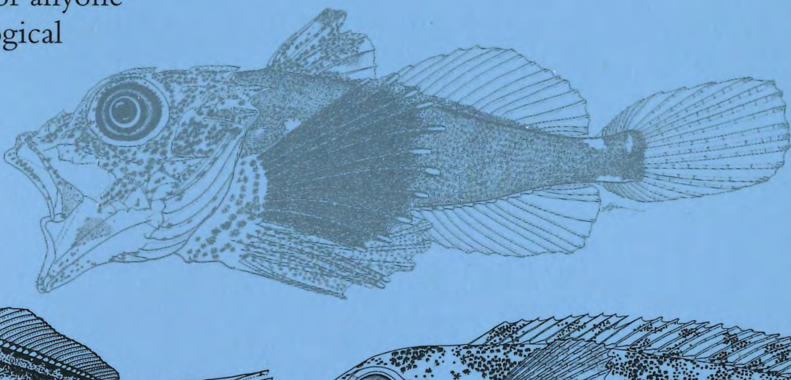
Francisco J. Neira

Anthony G. Miskiewicz



Thomas Trnski

With over 570 scientific illustrations of larval fishes throughout, and a concise and accurate text, this is an essential reference for anyone conducting taxonomic, ecological and fisheries research.



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