Larval development of the southern sea garfish (*Hyporhamphus melanochir*) and the river garfish (*H. regularis*) (Beloniformes: Hemiramphidae) from South Australian waters

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Abstract—Larval development of the southern sea garfish (*Hyporhamphus melanochir*) and the river garfish (*H. regularis*) is described from specimens from South Australian waters. Larvae of *H. melanochir* and *H. regularis* have completed notochord flexion at hatching and are characterized by an elongate body with distinct rows of melanophores along the dorsal, lateral, and ventral surfaces; a small to moderate head; a heavily pigmented and long straight gut; a persistent preanal finfold; and an extended lower jaw. Fin formation occurs in the following sequence: caudal, dorsal and anal (almost simultaneously), pectoral, and pelvic. Despite the similarities between both species and among hemiramphid larvae in general, *H. melanochir* larvae are distinguishable from *H. regularis* by 1) having 58–61 vertebrae (vs. 51–54 for *H. regularis*); 2) having 12–15 melanophore pairs in longitudinal rows along the dorsal margin between the head and origin of the dorsal fin (vs. 19–22 for *H. regularis*); and 3) the absence of a large ventral pigment blotch anteriorly on the gut and isthmus (present in *H. regularis*). Both species can be distinguished from similar larvae of southern Australia (other hemiramphids and a scomberosocid) by differences in meristic counts and pigmentation.

Manuscript accepted 25 October 2002.
Manuscript received 31 December 2002 at NMFS Scientific Publications Office.
Fish. Bull. 101:368–376 (2003).

The beloniform family Hemiramphidae (garfishes or halfbeaks) are small to medium-size surface-dwelling marine, estuarine, and freshwater fishes. The family contains 12 genera and 101 species worldwide, and more than one-third of the species belong to the genus *Hyporhamphus* (Froese and Pauly[1]). The Hemiramphidae are related to the Exocoetidae (flyingfishes) and, more distantly, to the Scomberosocidae (sauries), Belonidae (needlefishes), and Adrianichthyidae (ricefishes) (Collette et al., 1984). Six genera and 17 species of hemiramphids occur in Australian waters, where garfishes have long been considered valuable food and bait fish (Collette, 1974; Kailola et al., 1993).

Two hemiramphid species inhabit the waters of South Australia (S.A.), namely the southern sea garfish *Hyporhamphus melanochir* (Valenciennes, 1846) and the river garfish *H. regularis* (Günther, 1866). Adults of both are widely distributed along southern Australia from Western Australia (W.A.) to New South Wales, although *H. regularis* have not been recorded in Tasmania (Tas.). They support important commercial and recreational fisheries, particularly in S.A. (Kailola et al., 1993). *H. melanochir* are commonly found in sheltered coastal waters, whereas *H. regularis* are confined to estuaries (Jones et al., 1996). Juveniles and adults of both species co-occur in some estuaries of southern Australia, e.g. Port River-Barker Inlet of S.A. (34°45′S, 138°31′E) (Jones et al., 1996) and Peel-Harvey Estuary of W.A. (32°32′S, 115°43′E) (Noell, unpubl. data).

Despite their widespread distribution and economic importance, the early life history of *H. melanochir* is only partially described (i.e. reproductive biology [Ling, 1958]; egg development [Jordan et al., 1998], and there is no published information for *H. regularis*. Furthermore, although adults are easily identified with keys and descriptions provided by Collette (1974), no such information exists for the larvae. A fundamental prerequisite for any larval fish study is, undoubtedly, their accurate identification (Neira et al., 1998).

Thus far, at least some larval stages have been described for 19 hemiramphids worldwide (Sudarsan, 1966; Talwar, 1967; Hardy, 1978; Chen, 1988; Watson, 1996; Prince Jeyaseelan, 1998), eight of which belong to *Hyporhamphus*. The purposes of this paper are to describe the larval development of *H. melanochir* and *H. regularis* and to document distinguishing characters between larvae of these species.

[1] Froese, R., and D. Pauly. 2001. FishBase. World Wide Web electronic publication. Accessed 28 Nov 2001. Web site: www.fishbase.org.

Materials and methods

Most larvae were collected with a neuston net in Gulf St. Vincent (34°29′S, 138°15′E) and the Bay of Shoals (35°37′S, 137°37′E) of South Australia. The neuston net was a square-framed bongo net with a mouth area of 0.5 m^2 fitted with 500-µm mesh, to which a 30-cm diameter pneumatic float was attached to both sides of the frame. This attachment ensured that, while being towed, the top of the frame rode steadily above the water surface and that ~0.4 m^2 of the mouth area was submerged. The net was towed from the stern of the vessel inside a circular direction for 5 min at speeds of 2–4 knots. Additional larvae were collected by hand from beneath a wharf in Barker Inlet where they often school during daylight at mid-flood tide. Transforming larvae and juveniles were collected at night with a dip net and spotlight at Outer Harbor (34°46′S, 138°28′E) and Barker Inlet. The term "transforming" is used here to describe the stage between the end of the larval phase and the start of the juvenile phase, i.e. after the attainment of all fin rays and before the formation of scales. All specimens examined in this study were collected between November and March. Larvae were sorted from plankton samples immediately after collection based on reference larval specimens from the South Australian Museum fish collection that were identified to family. Larvae were fixed in 10% formalin buffered with sodium β-glycerophosphate (1 g/L) and later preserved in 70% ethanol.

A total of 47 *H. melanochir* (6.4–48.3 mm body length, BL) and 49 *H. regularis* (7.0–46.9 mm BL) larvae through juveniles were used to describe morphometrics, meristics, and pigmentation. Larvae were identified as hemiramphids based on larval and adult characters reported in the literature (Collette, 1974; Hardy, 1978; Collette et al., 1984; Chen, 1988; Watson, 1996; Trnski et al., 2000). Developmental series were assembled by using the series method (Neira et al., 1998), the accuracy of which was verified by a molecular technique (Noell et al., 2001). Terminology of early life history stages follows that of Kendall et al. (1984). Representative series for both species are deposited with the I.S.R. Munro Fish Collection (CSIRO, Hobart, Tas.). (Registration numbers: *H. melanochir* (n=13), CSIRO L 3072-01, 3073-01 to -08, 3074-01 to -02, 3075-01 to -02; *H. regularis* (n=12), CSIRO L 3076-01 to -07, 3077-01 to -02, 3078-01 to -03.)

Larvae were examined with a Wild M3Z stereomicroscope at 6.5–40× magnifications by using various combinations of incident and transmitted light. Body measurements were taken with SigmaScan Pro® 4.01 image measurement software (SPSS Inc., 1999) and are accurate to less than 0.05 mm. This method was particularly useful for measuring cumulative distances of bent larvae. Abbreviations and definitions of routinely taken body measurements follow Leis and Carson-Ewart (2000). Lower jaw length (LJ) is defined as the horizontal distance from the tip of the lower jaw to the anterior margin of the pigmented region of the eye. Lower jaw extension (LJx) is defined as the horizontal distance from the tip of the lower jaw to the tip of the snout. Eye diameter was measured along both horizontal (EDh) and vertical midlines (EDv) of its pigmented region. Body depth was measured at two points: at the pectoral base (BDp) and at the anus (BDa). Other measurements taken were snout length (SnL), head length (HL), pre dorsal-fin length (PDL) and preanal length (PAL). All measurements are expressed as a percentage of BL. Pigment refers to melanin. Drawings were prepared with the aid of a camera lucida.

Selected specimens were cleared and stained with alcian blue and alizarin red-S, following the method of Potthoff (1984), in order to count fin rays and vertebrae. Myomeres were difficult to count reliably at either end and thus vertebral counts (which include the urostyle) of stained larvae were taken instead. For small larvae that had unformed centra, corresponding neural or haemal spines were counted to obtain the number of vertebrae.

Results

Southern sea garfish (*Hyporhamphus melanochir* Valenciennes, 1846) (Fig. 1)

Description of larvae The smallest *H. melanochir* larva examined was a 6.4-mm newly hatched, laboratory-reared, postflexion-stage specimen. Some yolk remained, although yolk absorption was complete in the smallest field-collected larva (6.9 mm).

Larvae are elongate to very elongate (BDp=7–13% BL), and have a body depth slightly tapered towards the anus (BDa= 7–9% BL). Relative body depth at the pectoral base decreases slightly during larval development (Table 1). Larvae have 58–61 vertebrae (Table 2). The gut is relatively thick, long, straight, and nonstriated. PDL and PAL remain in the ranges of 70–75% and 71–76% BL, respectively (except for the 17.0-mm larva, which had a PDL and PAL of 62% BL). The first dorsal-fin ray is slightly anterior to or directly above the corresponding anal-fin ray. There is no gap between the anus and the anal fin. A long preanal finfold, initially the same length as the gut, persists through to the transformation stage before it disappears. There is no head spination. The small to moderate head (HL=16–24% BL) decreases in size in relation to BL with larval growth (Table 1). The longer lower jaw protrudes beyond the snout (LJx) by 4% BL at 11.0–11.5 mm, increasing to a maximum of 34% BL in the 29.3-mm juvenile. The mouth is oblique and reaches to the level of the center of the eye in newly hatched larvae. The maxilla subsequently moves forward in relation to the eye and by 12.1–14.4 mm it does not reach the eye. Very small villiform teeth are present on both the premaxilla and dentary in newly hatched larvae. The moderate to large eye (EDh=6–10% BL or 33–42% HL) is elongate (EDv=78–88% EDh) and decreases in size in relation to BL. A single rudimentary nasal papilla first appears as a small fleshy lump in the olfactory pit by 17.0 mm. Scales first appear between 20.4 and 29.3 mm laterally on the tail, anterior to the caudal peduncle.

Development of fins Completion of fin development in *H. melanochir* occurs in the following sequence: C → D → A → P_1, P_2 (Table 2). All principal rays of the caudal fin (7+8)

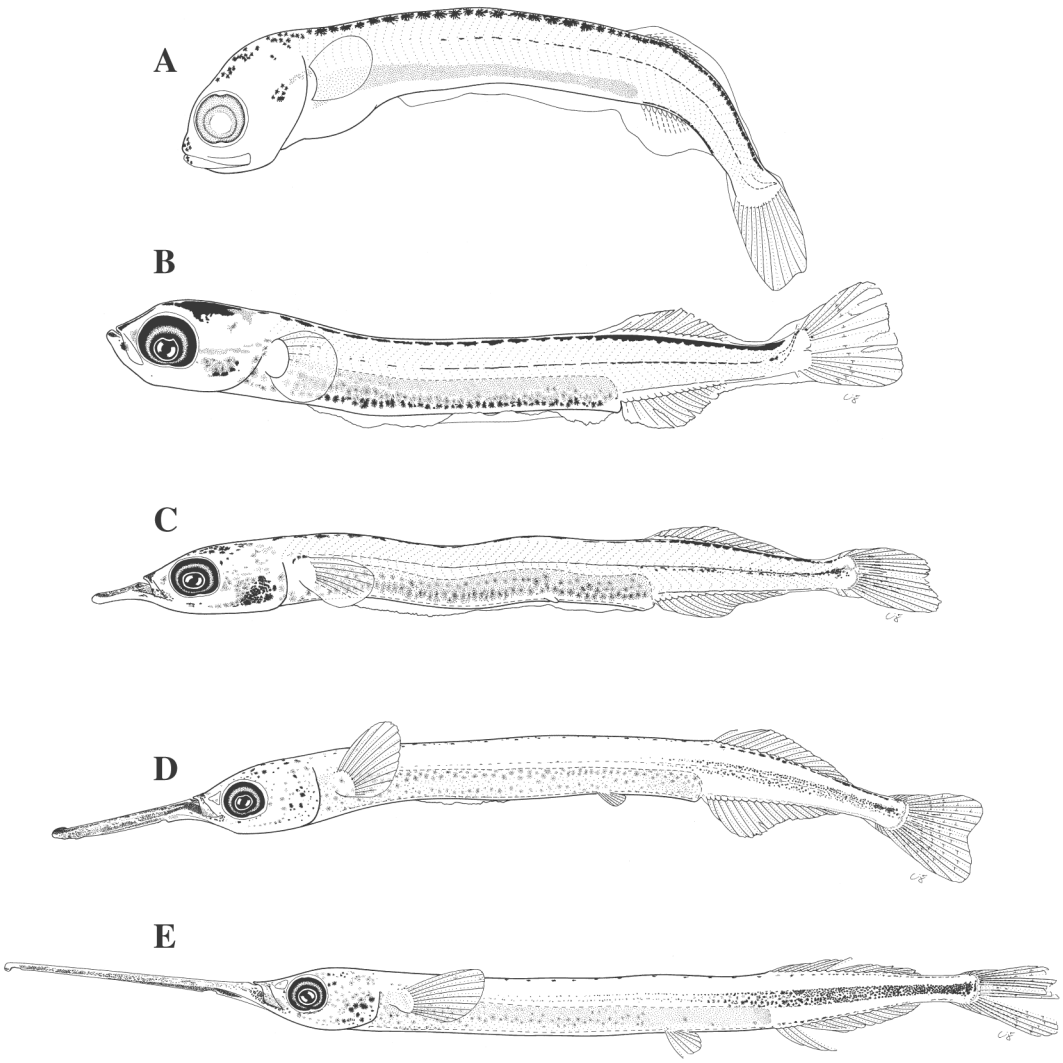

Figure 1

Larval, transforming larval, and juvenile *Hyporhamphus melanochir*. (**A**) 6.4-mm reared yolksac larva; newly hatched (redrawn from Jordan et al., 1998) (L 3072-01). (**B**) 9.3-mm larva (L 3073-01). (**C**) 13.3-mm larva (composite drawing of two damaged larvae of same BL) (L 3073-02 and -03). (**D**) 20.4-mm transforming larva (L 3074-01). (**E**) 29.3-mm juvenile (L 3074-02). Myomeres omitted in (D) and (E).

and several incipient dorsal- and anal-fin rays are present in newly hatched larvae. A full complement of 15–18 dorsal-fin and 17–20 anal-fin rays is attained at 11.4 and 12.1 mm, respectively. The pectoral base and finfold form prior to hatching, and incipient rays appear shortly after (by 7.2 mm); all 11–13 rays are formed by 19.6 mm. The pelvic fin buds appear by 13.3 mm, and all six pelvic-fin rays are formed by 19.6 mm.

Pigmentation *Hyporphamphus melanochir* larvae are moderately to heavily pigmented. Head pigmentation consists of melanophores on the tip of the lower jaw, snout, olfactory pit, and opercula, and a patch of several large melanophores on the midbrain. The extended lower jaw is heavily pigmented throughout development and melanophores extend laterally along the dentary. The eye is partially pigmented in the newly hatched larva, but fully pigmented by 6.9 mm. The gut is heavily and uniformly pigmented dorsally and laterally along the entire length, and melanophores are often coalesced, but pigmentation becomes obscured as the overlying musculature develops. Dorsal pigmentation initially consists of 12–15 large melanophore pairs in longitudinal rows between the head and origin of the dorsal fin (Fig. 2A), and a continuous band along either side of the dorsal-fin base. Dorsal pigmentation gradually decreases in intensity thereafter. Three

Table 1

Morphometrics of larval, transforming larval, and juvenile *Hyporhamphus melanochir* (expressed as % of BL). Mean ±SD is given when sample size n >1. Dashed lines differentiate larvae, transforming larvae, and juveniles in descending order.

BL (mm)	n	SnL	LJ	LJx	EDh	EDv	HL	PDL	PAL	BDp	BDa
6.4[1]	1	2.1	2.7	0.6	9.9	8.7	24.4	74.6	75.5	16.3[2]	8.0
6.9	1	3.0	4.0	1.0	9.2	7.5	23.5	69.7	71.9	12.7	8.6
7.0–7.5	9	2.8 ±0.8	3.9 ±1.1	1.1 ±0.4	9.1 ±0.3	7.3 ±0.3	22.0 ±0.8	70.8 ±0.9	72.6 ±1.0	11.9 ±0.3	8.9 ±0.3
7.5–8.0	7	3.6 ±0.9	4.6 ±1.2	1.0 ±0.4	9.1 ±0.5	7.1 ±0.3	22.8 ±1.6	71.3 ±1.3	73.0 ±0.9	11.8 ±0.6	8.9 ±0.7
8.0–8.5	9	3.6 ±0.5	4.9 ±0.8	1.3 ±0.4	8.8 ±0.3	7.1 ±0.3	21.9 ±1.0	70.9 ±0.7	72.7 ±0.9	11.7 ±0.7	8.9 ±0.7
8.5–9.0	3	3.5 ±0.8	5.0 ±1.1	1.5 ±0.3	8.6 ±0.2	7.0 ±0.3	21.1 ±0.2	71.5 ±0.2	72.5 ±0.4	11.3 ±0.5	9.1 ±0.5
9.0–9.5	4	3.4 ±0.5	5.0 ±0.7	1.6 ±0.3	8.0 ±0.3	6.5 ±0.2	20.9 ±0.8	71.7 ±0.7	72.8 ±0.6	11.4 ±0.7	8.4 ±0.3
11.0–11.5	4	3.7 ±0.7	7.2 ±1.5	3.5 ±1.2	7.5 ±0.4	6.3 ±0.2	20.3 ±1.3	71.6 ±0.6	72.3 ±0.5	10.6 ±0.7	8.5 ±0.6
12.1	1	4.1	9.0	4.9	7.6	6.4	19.7	72.6	72.6	10.2	8.6
14.4	1	3.7	12.3	8.6	6.9	5.8	19.2	70.2	71.4	9.4	7.8
17.0	1	2.9	10.3	7.4	5.6	4.7	15.9	61.7	61.7	7.3	6.6
19.6	1	4.9	28.7	23.8	6.0	4.9	18.6	70.4	71.2	8.2	7.4
20.4	1	4.0	24.2	20.2	5.7	5.0	17.5	72.5	71.6	8.9	7.6
29.3	1	4.4	38.4	34.0	5.3	4.8	17.0	69.9	71.0	8.2	7.2
33.3	1	4.9	38.3	33.4	5.3	4.6	17.9	71.7	72.7	8.5	7.6
41.3	1	5.2	36.2	31.1	5.5	5.1	18.6	74.1	74.1	9.2	7.8
48.3	1	5.6	36.9	31.3	5.2	4.8	17.8	74.0	74.0	9.7	8.1

[1] Yolksac larva.
[2] Includes yolk sac.

Table 2

Meristic counts of larval, transforming larval, and juvenile *Hyporhamphus melanochir*. Numbers in bold indicate the BL at which a full complement of rays is first attained. Dashed lines differentiate larvae, transforming larvae, and juveniles in descending order. D = dorsal; A = anal; P_1 = pectoral; P_2 = pelvic; C = caudal.

	Fin rays						
BL (mm)	D	A	P_1	P_2	C	Branchiostegal rays	Vertebrae
6.4[1]	8	9	base		0+**7**+**8**+0	3	38+21
7.2	8	8	1		0+7+8+0	3	39+20
7.3	9	10	1		0+7+8+0	3	39+19
7.6	11	11	1		0+7+8+0	3	38+20
7.9	10	11	1		0+7+8+0	3	40+20
8.3	11	11	2		0+7+8+0	4	39+20
8.4	13	14	2		1+7+8+1	5	39+21
9.4	14	16	4		1+7+8+1	5	40+21
11.4	**15**	16	6		2+7+8+1	7	38+20
12.1	16	**17**	7		2+7+8+2	7	39+20
14.4	16	19	9	bud	2+7+8+2	9	39+20
19.6	17	19	**11**	**6**	**4**+7+8+**4**	**12**	38+20
20.4	16	17	12	6	4+7+8+4	12	39+19
29.3	17	18	11	6	4+7+8+4	13	38+20
33.3	17	18	12	6	5+7+8+5	12	38+20
41.3	16	19	11	6	4+7+8+5	12	40+19
48.3	16	19	11	6	4+7+8+5	12	39+19

[1] Yolksac larva.

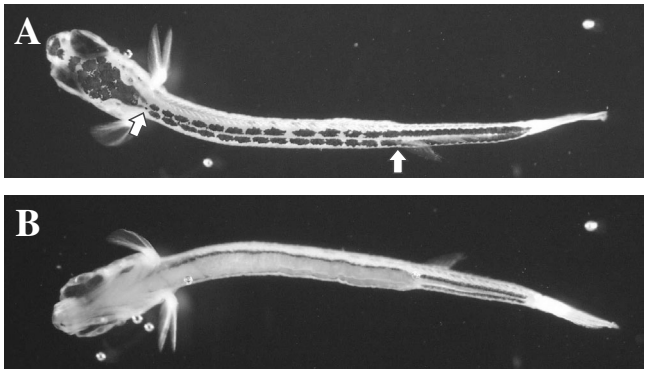

Figure 2

Pigmentation of an 8.5-mm *Hyporhamphus melanochir* larva. (**A**) Dorsal view; arrows indicate the margins of the 12–15 melanophore pairs in longitudinal rows. (**B**) Ventral view.

Table 3

Morphometrics of larval, transforming larval, and juvenile *Hyporhamphus regularis* (expressed as % of BL). Mean ±SD is given when sample size $n > 1$. Dashed lines differentiate larvae, a transforming larva, and juveniles in descending order.

BL (mm)	*n*	SnL	LJ	LJx	EDh	EDv	HL	PDL	PAL	BDp	BDa
7.0[1]	1	3.2	4.4	1.2	8.2	6.5	20.4	73.2	71.6	11.6[2]	7.4
7.5–8.0	9	2.8 ±0.3	4.4 ±0.4	1.7 ±0.3	7.6 ±0.1	6.3 ±0.1	19.9 ±0.6	73.1 ±0.6	71.8 ±0.4	11.2 ±0.2	8.2 ±1.2
8.0–8.5	12	2.8 ±0.4	4.3 ±0.5	1.5 ±0.3	7.5 ±0.3	6.2 ±0.2	19.6 ±0.9	72.8 ±0.7	71.6 ±0.6	11.0 ±0.5	7.7 ±0.3
8.5–9.0	10	2.8 ±0.2	4.2 ±0.2	1.5 ±0.2	7.2 ±0.2	5.9 ±0.1	19.2 ±0.3	72.9 ±0.9	71.8 ±0.9	10.6 ±0.2	7.4 ±0.3
9.0–9.5	5	2.8 ±0.1	4.4 ±0.4	1.6 ±0.4	7.0 ±0.1	6.0 ±0.2	19.1 ±0.4	72.3 ±0.7	71.5 ±0.6	10.6 ±0.2	7.6 ±0.3
9.5–10.0	3	2.8 ±0.1	4.4 ±0.3	1.7 ±0.2	6.9 ±0.4	5.8 ±0.2	18.7 ±0.5	72.1 ±1.6	71.2 ±1.7	10.6 ±0.4	7.3 ±0.2
10.0–10.5	3	3.0 ±0.3	4.8 ±0.9	1.8 ±0.6	6.8 ±0.2	5.8 ±0.2	18.9 ±0.6	72.2 ±0.6	71.3 ±0.6	10.2 ±0.3	7.6 ±0.3
13.1	1	4.0	7.6	3.7	6.9	5.4	19.6	73.2	71.9	9.1	7.8
18.1	1	4.5	18.6	14.1	6.3	5.4	19.9	73.8	72.6	9.5	8.1
24.7	1	5.6	27.7	22.1	6.3	5.5	20.8	72.9	73.6	9.7	8.1
31.5	1	6.2	30.0	23.9	6.0	5.5	21.0	74.4	75.5	10.7	8.5
33.8	1	6.4	27.7	21.3	6.1	5.6	21.6	74.3	74.3	10.9	8.9
46.9	1	7.3	damaged	damaged	5.6	4.7	21.8	75.4	75.4	11.2	9.8

[1] Yolksac larva.
[2] Includes yolk sac.

distinct lines of pigment appear along the dorsal margin in juveniles (by 29.3 mm) and remain to adult stage. A series of melanophores form a dashed, sometimes continuous, midlateral line. Melanophores appear laterally on the caudal peduncle by 14.4 mm and then proliferate anteriorly to form a broad medial stripe that remains, forming a silver stripe from the caudal peduncle to the operculum of adults. Ventral pigmentation consists of continuous bands of melanophores either side of the anal-fin base (Fig. 2B). Fins are unpigmented, except the caudal fin, which has small melanophores on the ray bases.

River garfish (*Hyporhamphus regularis* Günther, 1886) (Fig. 3)

Description of larvae The smallest *H. regularis* larva examined (7.0 mm) had completed notochord flexion and had a yolk sac. Yolk absorption was complete by 7.6 mm.

Larval *H. regularis* closely resemble larval *H. melanochir* morphologically (see Tables 1 and 3), but differ somewhat in relative length of the lower jaw, relative positions of the dorsal- and anal-fin origins, and in number of vertebrae. The longer lower jaw protrudes beyond the snout (LJx) by

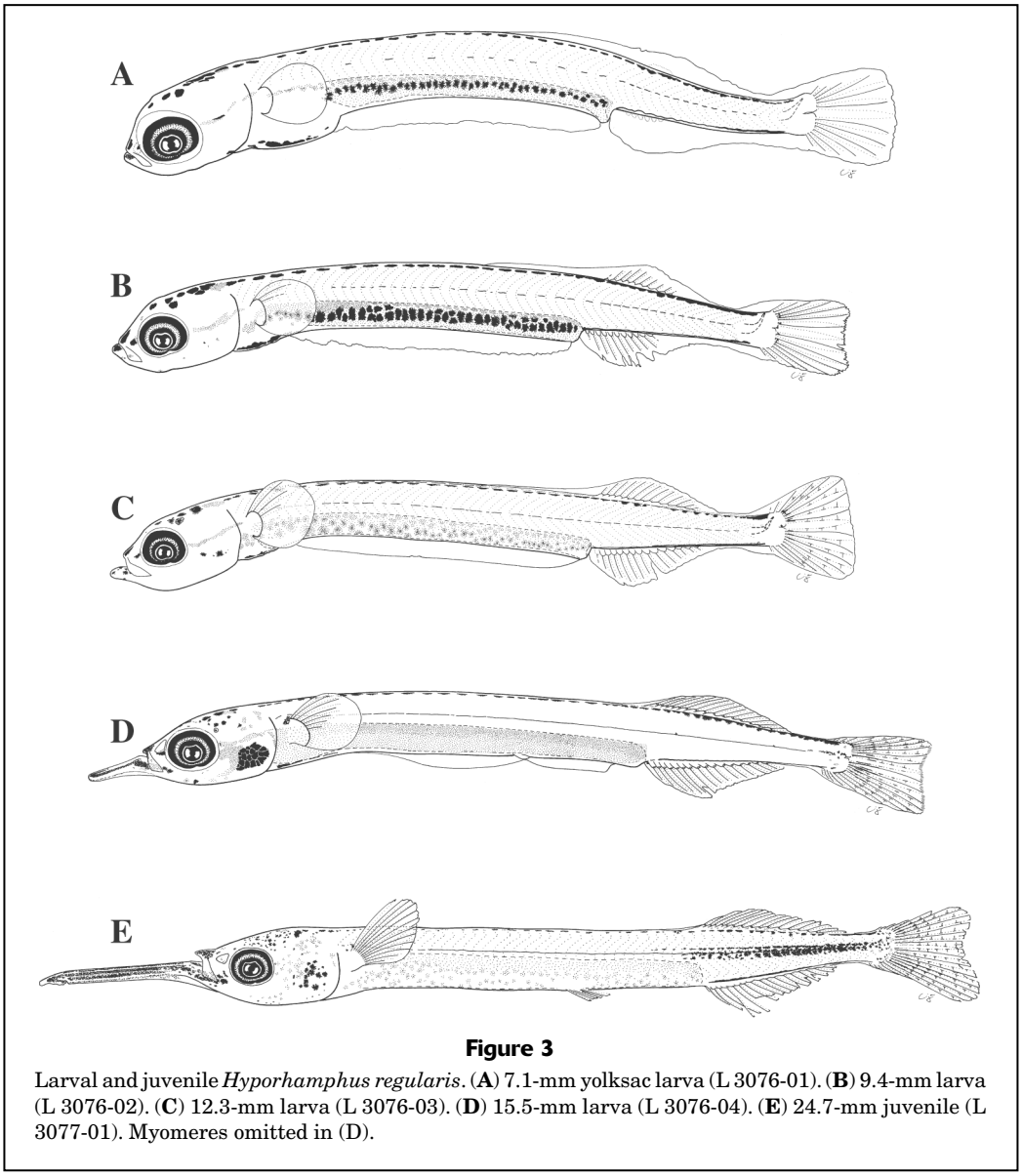

Figure 3

Larval and juvenile *Hyporhamphus regularis*. (**A**) 7.1-mm yolksac larva (L 3076-01). (**B**) 9.4-mm larva (L 3076-02). (**C**) 12.3-mm larva (L 3076-03). (**D**) 15.5-mm larva (L 3076-04). (**E**) 24.7-mm juvenile (L 3077-01). Myomeres omitted in (D).

4% BL at 13.1 mm and increases to a maximum of 24% BL in the 31.5 mm juvenile. The first dorsal-fin ray is slightly posterior to or directly above the corresponding anal-fin ray. Larvae have 51–54 vertebrae. Scales first appear between 18.1 and 24.7 mm laterally on the tail, anterior to the caudal peduncle.

Development of fins Completion of fin development in *H. regularis* occurs in the following sequence: C → D → A → P_1, P_2 (Table 4). Development of the caudal fin is incomplete at birth; 6 + 7 principal rays are present in the 7.0-mm yolksac larva, and the full complement (7+8) shortly after, by 7.7 mm. Distinct anal-fin bases are visible at 7.0 mm. A full complement of 14–17 dorsal and 15–19 anal-fin rays is attained at 10.1 and 10.5 mm, respectively. The pectoral base and finfold are present at birth, and incipient rays first appear by 8.1 mm; all 11–12 rays are formed by 18.1 mm. The pelvic fin buds appear by 13.1 mm, and all six pelvic-fin rays are formed by 18.1 mm.

Pigmentation Pigmentation of *H. regularis* larvae is similar to that of *H. melanochir* larvae except along the dorsal and ventral margins. Dorsal pigmentation consists of 19–22 melanophore pairs in longitudinal rows between the head and dorsal fin origin (Fig. 4A). A large pigment blotch is present ventrally on the isthmus and anteriorly on the gut.

Discussion

This study provides the first descriptions of larval development of hemiramphids endemic to marine (*H. melanochir*) and estuarine (*H. regularis*) waters of Australia.

Table 4

Meristic counts of larval, transforming larval, and juvenile *Hyporhamphus regularis*. Numbers in bold indicate the BL at which a full complement of rays is first attained. Dashed lines differentiate larvae, a transforming larva, and juveniles in descending order. D = dorsal; A = anal; P_1 = pectoral; P_2 = pelvic; C = caudal.

	Fin rays						
BL (mm)	D	A	P_1	P_2	C	Branchiostegal rays	Vertebrae
7.0[1]	anlage	bases	base		0+6+7+0	2	35+19
7.7	4	6	base		0+**7**+**8**+0	3	34+19
7.8	6	7	base		0+7+8+0	4	34+18
8.1	5	7	1		0+7+8+0	4	34+19
8.3	8	9	2		0+7+8+0	4	33+20
8.6	9	11	2		0+7+8+0	5	34+19
8.9	11	11	2		0+7+8+1	5	34+20
9.3	11	12	3		1+7+8+1	5	33+18
9.6	10	11	3		0+7+8+1	5	35+19
10.1	**14**	14	4		1+7+8+1	6	33+20
10.5	13	**15**	5		1+7+8+1	6	35+19
13.1	14	16	7	bud	2+7+8+2	8	35+19
18.1	14	17	**11**	**6**	**4**+7+8+**4**	**12**	35+18
24.7	16	17	12	6	4+7+8+4	11	34+19
31.5	15	17	12	6	4+7+8+4	11	34+18
33.8	15	18	11	6	4+7+8+4	11	33+19
46.9	16	17	11	6	4+7+8+4	11	35+18

[1] Yolksac larva.

Both *H. melanochir* and *H. regularis* share characters common to other described hemiramphid larvae. They are generally characterized by their lack of head or fin spines; elongate body; long straight gut; extended lower jaw; a main pigmentation pattern consisting of rows of melanophores on the dorsal, lateral, and ventral surfaces of the body; and advanced state of development at hatching (Collette et al., 1984; Watson, 1996; Trnski et al., 2000). Although the size at which fins develop varies slightly between *H. melanochir* and *H. regularis*, the sequence of development for both species is the same as that for most hemiramphids, i.e. C → D, A → P_1 → P_2 (Collette et al., 1984).

Hyporhamphus melanochir larvae are distinguishable from *H. regularis* by 1) having 58–61 vertebrae (vs. 51–54 for *H. regularis*); 2) having 12–15 melanophore pairs in longitudinal rows along the dorsal margin between the head and origin of the dorsal fin (vs. 19–22 for *H. regularis*); and 3) the absence of a large ventral pigment blotch anteriorly on the gut and isthmus which is present in *H. regularis*. Despite the difficulty in counting myomeres, either the number of vertebrae in cleared and stained specimens or the number of myomeres between the pectoral-fin base and anus (usually three less than the number of precaudal vertebrae; see Tables 2 and 4) revealed a consistent difference between both species.

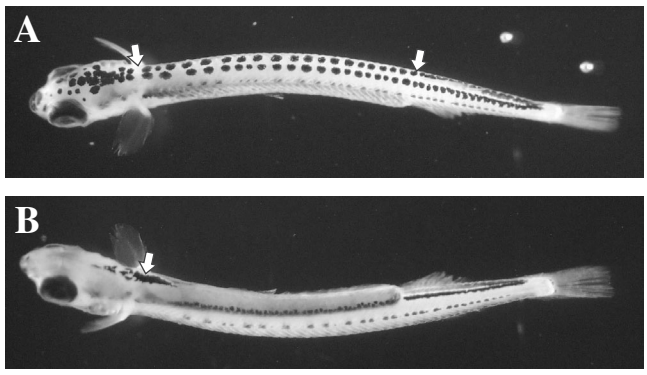

Figure 4

Pigmentation of an 8.7-mm *Hyporhamphus regularis* larva. (**A**) Dorsal view; arrows indicate the margins of the 19–22 melanophore pairs in longitudinal rows. (**B**) Ventral view; arrow indicates the ventral pigment blotch.

The geographic distributions of larval *H. melanochir* and *H. regularis* were separate in most samples; only three *H. melanochir* were found among *H. regularis* from Barker Inlet, whereas no *H. regularis* were among *H. melanochir* from the Bay of Shoals or Gulf St. Vincent. Larvae of other

hemiramphid species may overlap in distribution with those of *H. melanochir* and *H. regularis* outside South Australian waters. Meristic characters (summarized in Table 5) can often distinguish *H. melanochir* and *H. regularis* from the other species, except the eastern sea garfish (*H. australis*), which has overlapping meristic counts and currently undescribed larvae. The storm garfish (*Hemiramphus robustus*) has fewer anal-fin rays (11–14) and develops both a dark blotch below the dorsal fin and a pigmented pelvic fin in the juvenile stage (Collette, 1974; Collette et al., 1984). The long-finned garfish (*Euleptorhamphus viridis*), an oceanic species that rarely frequents nearshore waters, is strikingly different from other hemiramphids, being much more elongate and slender, and having divergent meristic counts, including more dorsal- and anal-fin rays (21–25 and 20–24, respectively), more vertebrae (69–73), fewer pectoral-fin rays (7–9), and fewer gill rakers (25–33) (Collette, 1974; Hardy, 1978; Chen, 1988; Trnski et al., 2000).

Larvae of the saury (*Scomberosox saurus*) (family Scomberosocidae) also occur in southern Australia and are the only other species that could be confused with hemiramphids. These are distinguishable from hemiramphid larvae by their higher myomere count (62–70), greater number of principal caudal-fin rays (16–17), presence of dorsal and anal finlets, and much heavier pigmentation (Bruce and Sutton, 1998; Trnski et al., 2000).

Acknowledgments

I am grateful to D. Short, L. Triantafillos, and the crew of the RV *Ngerin* for assisting in the field collection of specimens. The South Australian Museum allowed access to catalogued hemiramphid specimens, and A. Jordan donated a newly hatched *H. melanochir* larva and assisted with the examination of distinguishing characters. B. Bruce and F. J. Neira provided tips on larval drawing techniques. I also thank B. Bruce, S. Donnellan, A. Fowler, A. Jordan, F. J. Neira, T. Trnski, and T. Ward for kindly reviewing the manuscript. This project was supported by a Fisheries Research and Development Corporation grant 97/133 and was undertaken while receiving an Australian Postgraduate Award (Industry) at Adelaide University.

Table 5

Meristic counts of adult hemiramphids found in southern Australia. Data collated from Collette (1974) except where footnoted. A second range from another source is given if not in total agreement with Collette (1974). The distinguishing vertebral counts for *H. melanochir* and *H. regularis* in this study are also included. Vertebrae are given as precaudal + caudal; gill rakers are given as upper + lower. ? = no information available. D = dorsal; A = anal; P_1 = pectoral; P_2 = pelvic; C = caudal.

Species	Fin rays					Branchiostegal rays	Vertebrae	Gill rakers
	D	A	P_1	P_2	C			
Euleptorhamphus viridis	21–25	21–24 20–24[2]	8–9 7–9[2]	6[2]	?+7+8+?[4]	?	69 – 73 (44 – 46) + (26 – 29) = 70 – 75[4]	(5 – 9) + (18 – 23) = 25 – 33
Hemiramphus robustus	13–15	11–14	12–13	6[5]	4+7+8+5[5]	13[5]	(35 – 37) + (17 – 19) = 52–55 (33 –34) + (16 – 17) = 49-50[1]	(27 – 33) + (20 – 25) = ?
Hyporhamphus australis	15–17	17–20	11–13 10–13[1]	6[5]	4+7+8+4[5]	12–13[5]	(37 – 39) + (18 – 20) = 56–58 (38 – 40) + ?[1]	(31 – 39) + (23 – 33) = ?
Hyporhamphus melanochir	15–18	17–20	11–13	6[3]	4–5+7+8+4–5[5,6]	12–13[5,6]	(36 – 41) + (18 – 21) = 55-61 (38 – 40) + (19 – 21) = 58–61[6]	(27 – 35) + (21 – 29) = ?
Hyporhamphus regularis	14–17	15–19	11–12	6[3]	4+7+8+4[5,6]	10–12[5,6]	(33 – 38) + (18 – 20) = 51 – 58 (33 – 35) + (18 – 20) = 51 – 54[6]	(30 – 36) + (21 – 27) = 52 – 61

[1] Parin et al. (1980).
[2] Chen (1988).
[3] Gomon et al. (1994).
[4] Trnski et al. (2000).
[5] Noell (unpubl. data).
[6] This study.

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