Abstract.—The larval development of *Sillaginodes punctata*, *Sillago bassensis*, and *Sillago schomburgkii* is described based on both field-collected and laboratory-reared material. Larvae of the three species can be separated based on a combination of pigment and meristic characters, including extent and appearance of dorsal midline pigment, lateral pigment on the tail, presence or absence of pigment above the notochord tip, myomere number, extent and timing of gut coiling, and size at flexion. The most useful meristic character across the range of specimens was number of myomeres. *Sillaginodes punctata* with 42–45 myomeres are easily distinguished from *Sillago schomburgkii* with 36–38, and from *S. bassensis* with 32–35. The timing of gut coiling and its subsequent effect on anus position differed both among the three species examined here and from that previously reported for sillaginid larvae in general. Timing of gut coiling and extent of anus migration are not useful characters for the identification of temperate Australian sillaginids at the family level but are useful on a specific level. Possible implications of the development of the gut to diet are discussed.

Based on the presence of larvae, all three species spawn in South Australian waters. No larvae of a fourth sillaginid species, *S. flindersi*, were found during the study. South Australia is the western distributional limit for *S. flindersi* and it does not appear to spawn in the area.

Manuscript accepted 15 June 1994.
Fishery Bulletin 93:27–43 (1995).

Larval development of King George whiting, *Sillaginodes punctata*, school whiting, *Sillago bassensis*, and yellow fin whiting, *Sillago schomburgkii* (Percoidei: Sillaginidae), from South Australian waters

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The perciform family Sillaginidae (whiting and sand smelts) consists of three genera, three subgenera, and thirty-one species of small to moderately sized fishes found primarily in shallow coastal waters of the Indo-Pacific (McKay, 1992). Sillaginids are highly valued food fishes in many tropical and temperate waters. The Sillaginidae are related to the Percidae, Sciaenidae, and, to a lesser extent, the Haemulidae (McKay, 1985) although their sister group is yet to be determined (McKay, 1992). The most speciose of the three sillaginid genera (*Sillago*) includes twenty-nine species. The remaining two genera, *Sillaginodes* and *Sillaginopsis*, are monotypic. The taxonomy of the family is approaching stability; only a few species remain undescribed (McKay, 1992).

Two genera and thirteen species of sillaginids are found in Australian waters. Four species inhabit the waters off South Australia: the King George or spotted whiting, *Sillaginodes punctata*; yellow fin whiting, *Sillago schomburgkii*; western school whiting, *Sillago bassensis*; and eastern school whiting, *Sillago flindersii*. The latter two species were, until recently, considered subspecies of *S. bassensis* (McKay, 1992). All four species are widely distributed in southern Australia and form the basis for important commercial fisheries across their range (McKay, 1985; Kailola et al., 1993; May and Maxwell[1]).

The adult and juvenile biology of each of the four species has previously been documented by several authors (Scott, 1954; Gilmour, 1969; Lennanton, 1969; Robertson, 1977; Weng, 1983, 1986; Burchmore et al., 1988; Jones[2]; Jones et al.[3]), but very little is known of their early life history and neither the eggs nor the larvae of any of the four species have previously been described.

In 1986, the South Australian Department of Fisheries began an ichthyoplankton program to inves-

[1] May, J. L., and J. G. H. Maxwell. 1986. Field guide to trawl fish from temperate waters of Australia. CSIRO Division of Fisheries Res., Hobart, Tasmania, 492 p.

[2] Jones, G. K. 1979. Biological investigations on the marine scale fishery in South Australia. South Australian Dep. Agric. and Fisheries Rep., 72 p.

[3] Jones, G. K., D. A. Hall, K. L. Hill, and A. J. Staniford. 1989. The South Australian marine scale fishery: stock assessment, economics, management. South Australian Dep. Fisheries Green Paper, 186 p.

tigate the larval ecology of commercially important fishes of South Australian waters. An important prerequisite of any such program is the ability to make an accurate identification of larvae to species. This paper details the development of *Sillaginodes punctata*, *Sillago schomburgkii*, and *S. bassensis* larvae collected during this study.

Materials and methods

Specimens were obtained from plankton and beach seine samples collected between March 1986 and March 1991 aboard the research vessel MRV *Ngerin* in coastal waters and at various inshore nursery areas off South Australia. Details of sampling locations and procedures are described in Bruce (1989). Briefly, larvae were obtained from stepped oblique tows with 70-cm-diameter bongo nets fitted with 500-micron mesh. Postsettlement (refer to definition below) larvae and juveniles were captured with a fine mesh beach seine (7 m × 1.8 m, 2-mm mesh) as well as by dipnetting and diving. The field-collected series of *Sillaginodes punctata* was supplemented with larvae reared in the laboratory at West Beach, Adelaide.

All field-collected specimens used for description were fixed in a 10% formalin-seawater solution buffered with sodium tetraborate (borax) and were later transferred to a 5% solution buffered with sodium B-glycerophosphate (0.5 g per 1,000 mL). Reared larvae were fixed immediately in the 5% solution. Reared *S. punctata* were used for illustration when possible because of their superior condition. Some pigment differences were apparent between reared and field-collected larvae largely as a result of expansion or contraction of melanophores. Melanophores of field-collected larvae were generally less expanded than reared specimens. Reared larvae were typically greater in length than similarly developed field-collected material owing to increased shrinkage in the latter. Similar shrinkage effects have been previously reported for a variety of species (Theilacker, 1980; Hay, 1981; Bruce, 1988). Unless specified, development at length refers to field-collected material.

Representative series of *S. punctata* and *Sillago bassensis* are deposited with the I.S.R. Munro Fish Collection, CSIRO, Hobart Tasmania. Too few *S. schomburgkii* larvae were collected to allow a complete analysis and all are currently held in a collection maintained by the author at CSIRO Division of Fisheries, Hobart, Tasmania.

Developmental terminology and body measurements follow Leis and Trnski (1989). The term "postsettlement" is used to describe newly settled individuals prior to the acquisition of scales and juvenile colour patterns, after which they are referred to as juveniles. Body length measurements (BL) are measured as notochord length, NL (i.e. from the snout tip to the end of the notochord), in preflexion and flexion larvae, and standard length, SL (i.e. from the snout tip to the posterior margin of the superior hypural elements), in postflexion larvae and juveniles. Body depth is taken at two points. Body depth at pectoral (BDp) is equivalent to "body depth" as defined by Leis and Trnski (1989), that is, as "the vertical distance between body margins (exclusive of fins) through the anterior margin of the pectoral fin base." Body depth at anus (BDa) is defined as the vertical distance between body margins (exclusive of fins and, initially, the gut) through the midpoint of the anal opening. BDa includes the gut only after overlying musculature has developed. *Sillaginodes punctata* eggs were measured with a Zeiss photomicroscope III fitted with an ITC 510 video camera and linked to an Apple Macintosh SE computer via an HEI 582A video coordinate digitizer. Egg dimensions are reported to the nearest micron. Larvae were measured to the nearest 0.1 mm with a dissecting microscope fitted with an ocular micrometer. Postsettlement larvae and juveniles were measured to the nearest 0.1 mm with vernier calipers.

Meristic counts were made on *S. punctata* and *Sillago bassensis* specimens cleared and stained with alcian blue and alizarin red-S following Potthoff (1984). Insufficient specimens of *S. schomburgkii* were available for clearing and staining and therefore all meristics were taken from unstained material.

Descriptions are based primarily on the detailed examination of a representative series of specimens; however, comments on pigment and meristic variability stem from the routine examination of all larvae collected. The number of specimens examined in detail, the size range covered, and the museum reference numbers (for lodged material) are provided under each species account.

Results

Identification

Larvae were identified to family level from larval sillaginid characters reported in the literature. Sillaginid larvae are elongate and have 30–44 myomeres (Johnson, 1984; Miskiewicz, 1987; Leis and Trnski, 1989). The gut typically reaches to greater than 55% body length in preflexion larvae. The anus is reported to migrate anteriorly during development (often during flexion) as a result of coiling of the anterior section of the gut, thus shortening the preanal length

(Leis and Trnski, 1989). Sillaginids have a characteristic series of melanophores along the dorsal and ventral midlines (particularly prominent in small larvae) and generally have pigment located on the angle of the lower jaw.

Three types of sillaginid larvae were found during this study. Specific identity of two of the types (*S. schomburgkii* and *Sillaginodes punctata*) was established by comparing vertebral counts and fin meristics of postflexion larvae to those of adult and juvenile specimens. Smaller larvae were linked by establishing a developmental series based on the extent and appearance of dorsal midline pigment, lateral pigment on the tail, presence or absence of pigment above the notochord tip, myomere number, extent and timing of gut coiling, and size at flexion. The identity of *S. punctata* was also confirmed by comparison to reared larvae.

Though clearly separating *Sillaginodes punctata* from *Sillago schomburgkii*, fin meristics and vertebral counts overlap in the other two South Australian sillaginid species (*S. bassensis* and *S. flindersi*), thus making the specific separation of their larvae difficult. Sillaginid larvae from southern Tasmania (where only *S. flindersi* are found) and larvae believed to be *S. flindersi* from New South Wales (NSW) coastal waters were compared to the third sillaginid larval type collected in South Australia in order to ascertain its identity. The NSW and Tasmanian (referred to herein as eastern) specimens were highly similar but differed from the South Australian type with respect to two pigment characters. First, eastern specimens had a single prominent, elongate melanophore located below the level of the pectoral fin base and overlying the cleithrum that was absent in South Australian material (Fig. 1). Second, eastern specimens developed external lateral midline pigment on the tail at an earlier size (7.2 mm) than did South Australian material (14.8 mm). Two sillaginids are known from Tasmanian waters: *Sillaginodes punctata* and *Sillago flindersi* (Last et al., 1983). Only *S. flindersi* is known to spawn in Tasmanian waters. The eastern form was thus identified as *S. flindersi* and the South Australian specimens as *S. bassensis*. Insufficient material was available across the full size range to render an adequate description of the larval development of *S. flindersii,* and thus this species is not treated in further detail here.

The most useful meristic character separating the three South Australian larval types was number of myomeres. *Sillaginodes punctata* with 42–45 myomeres are easily distinguished from *Sillago schomburgkii* with 36–38 and *S. bassensis* with 32–35. Meristic details for these three species and *S. flindersi* are listed in Table 1.

Descriptions

King George whiting (*Sillaginodes punctata* Cuvier 1829), Figure 2

Material examined—75 specimens, 2.0–30.5 mm BL (CSIRO L587-01, L587-02, L587-03, L587-04, L587-05, L587-06; L588-01; L589-01).

Larval development—The pelagic eggs of *S. punctata* are spherical and have an unsegmented yolk and smooth chorion. Late stage eggs are 839–935 microns in diameter (mean 880, n=25) and have a single oil droplet 246–263 microns in diameter (mean 255, n=25). Reared larvae hatched at 2.00–2.15 mm (mean 2.07, n=24) at 16.5–18.7°C. The timing of fertilization was not recorded as spawning occurred in brood stock tanks overnight. Estimates for incubation period are 48–60 hours. The temperature of the spawning tank was 16.5°C and fertilized eggs were transferred to a 90-liter tank held at 18.0–18.7°C for subsequent incubation, 24 hours prior to hatching.

Newly hatched larvae have a posteriorly located oil droplet and adopt a head-down position in rearing containers. Yolk absorption was complete in reared larvae by 3.5 mm (8 days), although the small-

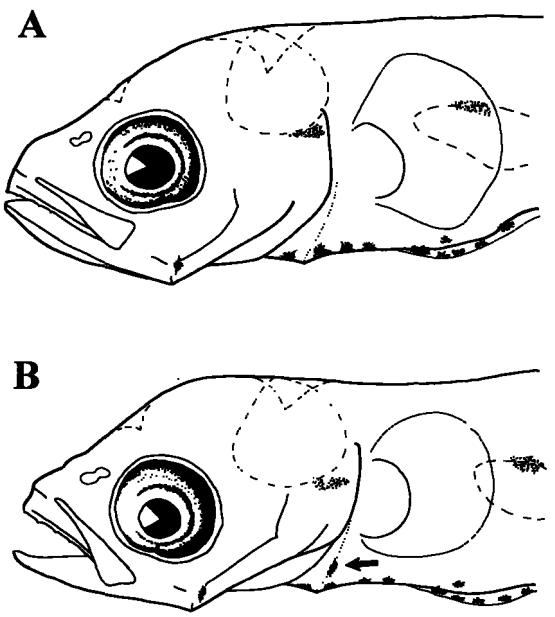

Figure 1

Detail of head and trunk pigment of (**A**) *Sillago bassensis* and (**B**) *Sillago flindersi*. Myomeres have been omitted for clarity. Position of cleithrum is indicated by a dotted line. Arrow indicates characteristic melanophore overlying cleithrum in *S. flindersi*.

Table 1

Selected early life history features useful for identifying sillaginid larvae (sizes are in mm).

Species	Size at gut coiling	Size at flexion	Size at first lat. midline pigment	Size at first dorsal banding	Size at settlement	Completion of fin formation[6]	Number of myomeres	Dorsal fin	Anal fin	Pectoral fin
Sillaginodes punctata[1]	21.0–24.0	5.7–7.0	8.0	6.5–7.0	15.0–18.0	C,P1,A,D2+D1,P2	42–45	XII–XIII+I,25–27	II,21–24	13–15
Sillago bassensis[1]	4.1–7.5	4.8–6.5	14.0	12.0–13.0	12.0–13.0	C,P1,A,D1+D2,P2	32–35	X–XII+I,16–19	II,18–20	15–16
Sillago schomburgkii[1]	>5.1<10.1[7]	4.8–?	2.7	<10.1	12.0–13.0	[8]	36–38	X–XII+I,19–22	II,17–20	15–16
Sillago ciliata[2,3]	<5.0	4.0–5.6	5.3	6.5	15.5	C,A,D2,D1,P1,P2	30–34	XI+I,16–18	II,15–17	15–17
Sillago maculata[2]	[8]	4.6–6.5	3.3	10.6	[8]	C,P1,A,D2,D1,P2	33–36	XI–XII+I,19–21	II,19–20	15–17
Sillago sihama[4]	5.9	5.9	5.9	9.0	[8]	[8]	33–34	XI+I,20–23	II,21–23	15–17
Sillago japonica[5]	<7.6	<7.6	7.6	7.6	11.5	[8]	35–37	XI+I,21–23	II,22–24	15–17

[1] This study.
[2] Miskiewicz, 1987.
[3] Munro, 1945.
[4] Uchida et al., 1958.
[5] Mito, 1966 (as *Sillago japonicus*); Kinoshita, 1988.
[6] Based on all elements present and ossified, C = caudal, P1 = pectoral, P2 = pelvic, A = anal, D1 = first dorsal, D2 = second dorsal.
[7] No specimens between 5.1 and 10.1 mm were available. Coiling of the gut had not commenced in the 5.1-mm specimen but had been completed in the 10.1-mm specimen.
[8] Data not available.

est field-collected larvae (2.9 mm) had already completed yolk absorption.

Larvae are elongate (BDp=11–16% BL) and have 42–45 myomeres (17–21 abdominal + 23 – 27 candal). Body depth at anus increases slightly from 7% to 9% BL during development. Other body proportions remain relatively constant (Table 2). The gut is initially straight and differentiates into defined fore, mid and hind gut sections by 3.7 mm. The gut exhibits some convolution but does not coil during the larval phase. The midgut becomes rugose by approximately 5.0 mm and remains so, although overlying musculature obscures this feature in postsettlement larvae larger than 21.0 mm. The gut begins to coil in postsettlement larvae of 21.0 –24.0 mm and is complete by 26.0 mm. Coiling of the gut proceeds without migration of the anus and is achieved by elongation and anterior looping of the midgut. Consequently, body proportions do not show a significant change in preanal length which remains at 50–52% BL. The gas bladder is first visible in reared larvae by 3.5 mm (5 days) and is prominent and inflated in 86% of field-collected larvae (random subsample, n=50; all larvae collected at night) and all postsettlement larvae collected (all postsettlement larvae collected during day). The gas bladder has its origin at myomeres 2–5 in preflexion larvae but migrates posteriorly during development to myomeres 13–18 by 18.7 mm.

The snout is initially slightly concave in profile, but after flexion, this gradually changes to straight or slightly convex. The eye is round. The mouth initially reaches to below the eye, but is short of the eye in postflexion larvae. Six to eight small villiform teeth are present on the premaxilla by 5.8 mm. The number of teeth increases to 10–12 by late flexion (6.5–7.0 mm). There are no head spines.

Scales are first present around the gut and lateral midline by approximately 27.5 mm.

The development of fins in larval and juvenile *S. punctata* is summarized in Table 1. Completion of fin development occurs in the following sequence: caudal; pectoral; anal and second dorsal (almost simultaneously); first dorsal; and pelvic.

The rays of the caudal fin are present just prior to flexion in larvae of 5.6 mm. Flexion commences by 5.7–6.0 mm and is usually complete by 7.0 mm. Pectoral fin buds are present in reared larvae as slight swellings on the body above the anterior margin of the oil droplet by 3.1 mm (2 days post hatch). Incipient rays are first visible by 7.5 mm and commence ossification by 8.5 mm. A full complement of 13–15 pectoral rays is present by 11.5 mm. Anal and second dorsal fin anlagen appear during flexion (5.8 mm). Distinct bases are present by 7.0 mm, incipient rays by 7.2 mm, and ossification commences by 8.0 mm. The anal and second dorsal fins complete development by 13.0 mm. The

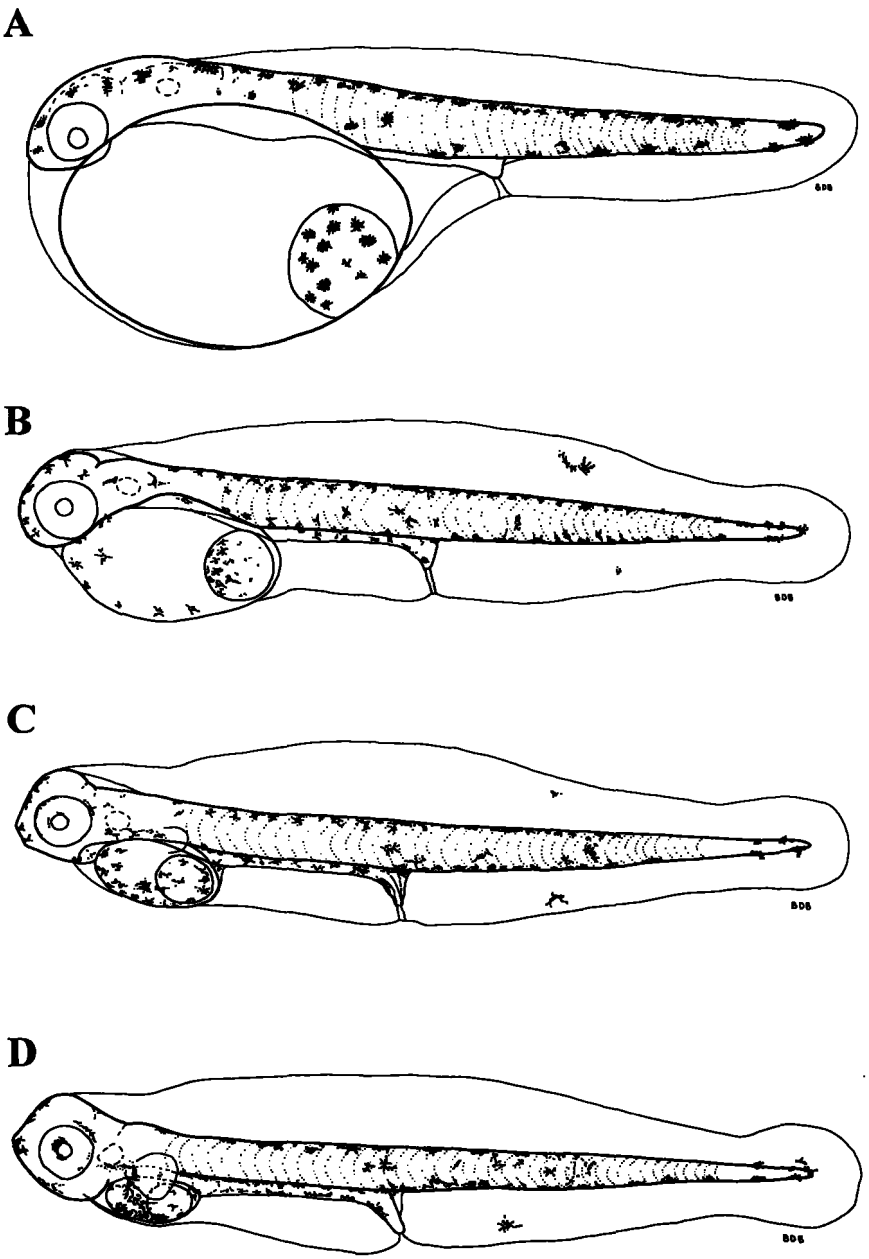

Figure 2

Development of *Sillaginodes punctata*. (**A**) 2.1 mm; (**B**) 2.9 mm; (**C**) 3.1 mm; (**D**) 3.5 mm; (**E**) 3.6 mm; (**F**) 4.2 mm; (**G**) 5.8 mm; (**H**) 6.5 mm; (**I**) 8.5 mm; (**J**) 12.0 mm; (**K**) 18.7 mm postsettlement; (**L**) 22.4 mm (postsettlement: myomeres omitted for clarity). A–I are reared specimens, J–L are field-collected specimens.

first dorsal fin anlage is present by 6.2 mm. Distinct bases are present by 7.6–8.6 mm and ossification of spines has commenced by 8.5–8.9 mm. The first dorsal fin completes development by 13.1 mm. Pelvic fins first appear as slight swellings on either side of the gut in 9.2-mm larvae. Well-developed buds are present by 13.0 mm, incipient rays form shortly thereafter. The pelvic fin does not complete development until 20.0–21.5 mm.

Larval pigment—The oil droplet is well pigmented with large stellate melanophores from at least 24

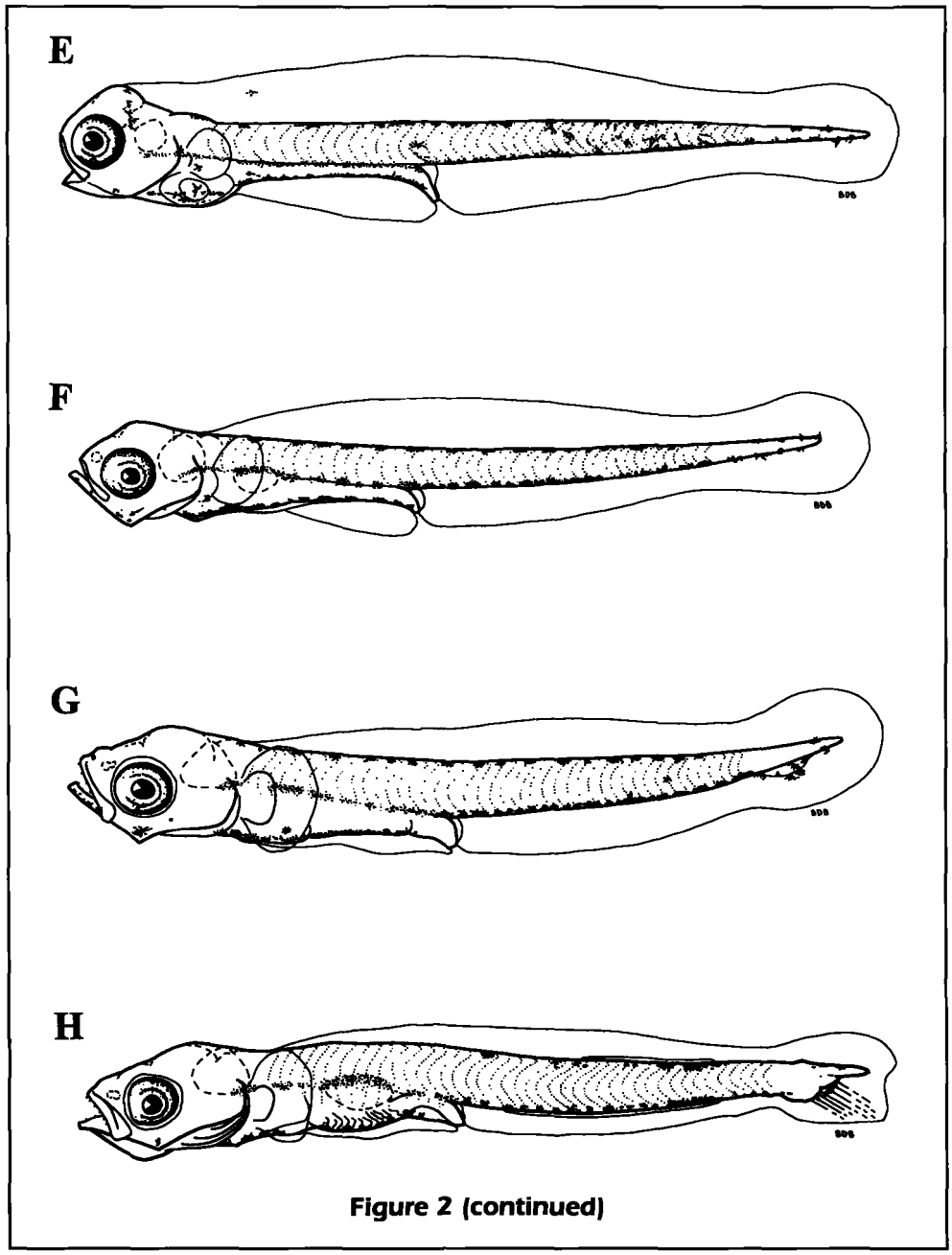

Figure 2 (continued)

hours prior to hatching until yolk exhaustion. Newly hatched larvae have melanophores scattered over the body. Melanophores appear on the ventral and anterior regions of the yolk sac by 2.8 mm and pigment also appears within the finfold (both dorsal and anal) between myomeres 25–32 in reared larvae (not apparent in field-collected larvae — probably owing to finfold damage). Finfold pigment disappears by 3.5 mm.

Initially, melanophores are scattered over the snout but they disappear by 3.5 mm. Pigment appears at the angle of the lower jaw and is retained throughout the larval period. Melanophores are typically present on the lower jaw, ventrally on the gular membrane, and internally below the otic capsule. Further pigment does not form on the head until after settlement.

The dorsal surface of both the gut and the gas bladder are covered with melanophores during development. A linear series of discrete melanophores is present on the ventral midline of the gut in preflexion and flexion larvae. Ventral melanophores disappear from the hindgut by 10.0 mm and this region then remains unpigmented. Concurrently, the remaining 5–8 melanophores between the cleithral symphysis and the hindgut become elongate and are retained in postsettlement larvae.

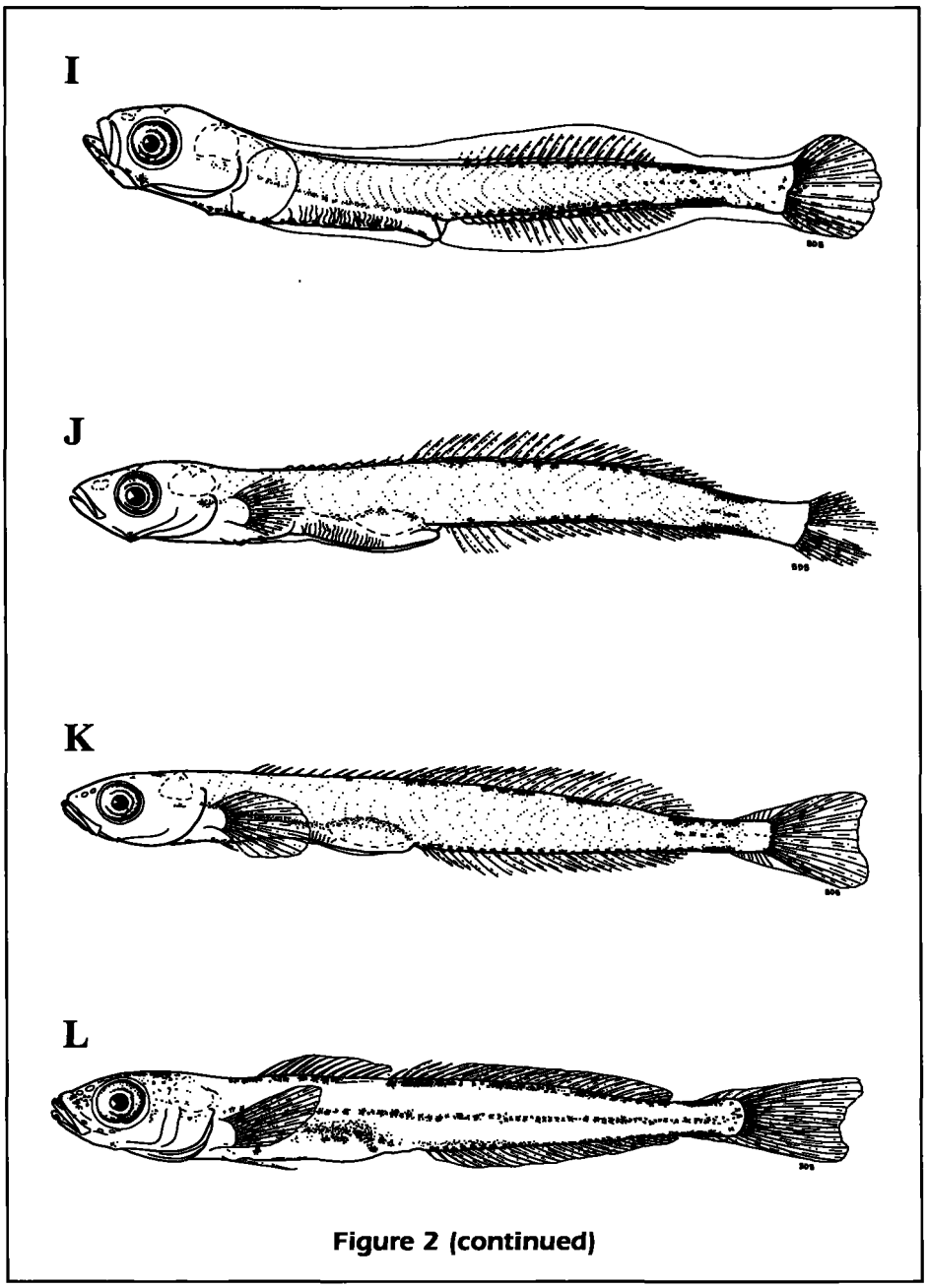

Figure 2 (continued)

By 4.0 mm, pigment on the dorsal surface of the trunk and tail coalesce to form 11–18 discrete, evenly placed melanophores that extend in a linear series posteriorly from the nape to within about 4 or 5 myomeres from the notochord tip. The dorsal surface of the notochord tip has 0–3 melanophores (most commonly 1 or 2) and when present they are useful in separating preflexion *Sillaginodes punctata* from *Sillago bassensis* and *S. schomburgkii*, both of which lack pigment dorsally on the notochord tip. The dorsal series of melanophores on the trunk and tail gradually disappears by the end of flexion (6.5–7.0 mm), excepting those between myomeres 31–40, which become prominent and may extend laterally over the body surface when expanded. Lateral midline pigment develops in this area during late flexion and is retained throughout the postflexion stage. Dorsal pigment gradually redevelops in postflexion larvae as a series of discrete bands, each comprising 3 or 4 pairs of stellate melanophores. Postsettlement larvae have 4–6 such bands which subsequently increase in number to 8–10 as juvenile pigmentation develops.

Ventral pigment on the tail in newly hatched larvae is initially scattered but coalesces to form a se-

Table 2

Body proportions of larvae of *Sillaginodes punctata* (expressed as a percentage of body length). d = damaged; g = gas bladder not visible; — = character not yet formed. Specimens between dotted lines were undergoing flexion.

Body length (mm)	Pre-anal length	Pre-dorsal fin length	Pre-gas-bladder length	Head length	Snout length	Eye diameter	Vent to anal fin length	Body depth at pectoral	Body depth at anus
3.1	51.6	—	37.1	22.5	6.4	9.7	—	12.9	8.1
3.2	53.1	—	23.4	18.7	3.1	6.2	—	10.9	6.2
3.3	51.5	—	28.8	24.2	6.1	9.1	—	15.1	9.1
3.6	51.3	—	22.2	19.4	4.1	8.3	—	11.1	5.5
3.7	51.3	—	24.3	21.6	4.1	8.1	—	12.2	6.8
4.1	47.5	—	24.4	19.5	3.7	7.3	—	12.2	6.1
4.2	50.0	—	23.8	19.0	2.3	7.1	—	11.9	7.1
4.3	55.8	—	32.5	23.2	4.6	9.3	—	16.2	9.3
4.7	51.1	—	34.0	23.4	4.2	8.5	—	14.9	8.5
5.0	50.0	—	30.0	24.0	5.0	8.0	—	13.0	8.0
5.3	52.8	—	32.1	22.6	3.7	7.5	—	13.2	8.5
5.4	50.0	—	29.6	20.4	1.8	7.4	—	13.0	7.4
5.7	47.3	—	31.6	22.8	5.3	7.0	—	12.3	7.9
5.9	45.8	—	28.8	18.6	5.1	6.8	—	11.9	6.8
6.0	48.3	60.0	31.6	23.3	6.7	6.7	—	13.3	8.3
6.2	50.0	—	31.4	21.0	4.0	6.4	6.4	12.1	8.1
6.3	47.6	50.8	33.3	23.8	6.3	6.3	4.2	11.1	7.9
6.4	51.6	46.9	32.0	20.3	6.2	6.2	—	12.5	7.8
6.5	47.7	49.2	33.1	23.8	6.1	d	6.9	12.3	7.7
6.6	47.0	—	30.3	22.7	5.3	6.1	6.6	10.6	7.5
6.8	50.0	48.5	30.9	20.6	5.9	6.6	—	12.5	8.1
7.0	51.4	52.3	34.3	21.4	d	d	—	11.4	10.0
7.2	54.1	50.0	37.5	23.6	5.7	7.6	0.7	11.1	8.3
7.6	52.6	53.9	34.2	22.3	5.3	7.2	2.6	11.8	7.9
8.4	52.3	40.4	40.4	21.4	5.9	7.1	0.0	12.5	10.7
9.3	52.3	30.1	39.7	21.5	6.4	6.4	1.6	10.7	9.1
10.3	52.4	31.1	40.8	21.3	5.8	6.8	0.5	11.1	9.7
12.0	50.0	27.5	39.2	21.7	6.7	5.0	0.6	10.0	9.2
13.1	49.6	27.5	40.4	19.8	5.3	5.3	0.7	9.2	8.4
15.7	50.9	27.4	40.8	19.1	5.7	d	0.0	10.2	11.5
16.1	50.9	26.7	41.0	19.2	5.0	5.6	0.0	9.9	9.9
18.2	51.1	27.5	40.6	20.3	6.0	6.0	0.5	9.9	10.4
18.7	49.2	25.7	38.0	19.8	5.3	5.9	1.1	9.6	9.1

ries of closely spaced melanophores extending to the notochord tip by 3.6 mm. Preflexion larvae have 2–4 melanophores ventrally on the notochord tip. During flexion, melanophores between myomeres 23–38 become more prominent (similar to the dorsal series). The ventral series of melanophores on the tail becomes gradually obscured by overlying musculature (excepting the prominent region between myomeres 32–38) in postflexion larvae. Paired external melanophores develop ventrally on the tail in larvae greater than 8.5 mm and by settlement stage, approximately one pair per myomere is present. This ventral series forms a regular pattern of expanded and contracted melanophores in postsettlement specimens, matching the banding pattern of the dorsal series.

School whiting (*Sillago bassensis* Cuvier, 1829), Figure 3

Materials examined—40 specimens, 2.3–17.2 mm BL (CSIRO L586-01—10 specimens).

Larval development—The smallest *S. bassensis* larva examined was 2.3 mm BL. At this size the mouth and gut are functional, the eyes are pigmented, a gas bladder is present, and yolk absorption is complete.

Larvae are elongate (BDp=13–20% BL) and have 32–35 myomeres (11–15+19–23). Body depth at anus increases slightly from 8–12% BL during development. Other body proportions remain relatively constant (Table 3). The gut forms a convoluted tube in the smallest specimen and is already differentiated

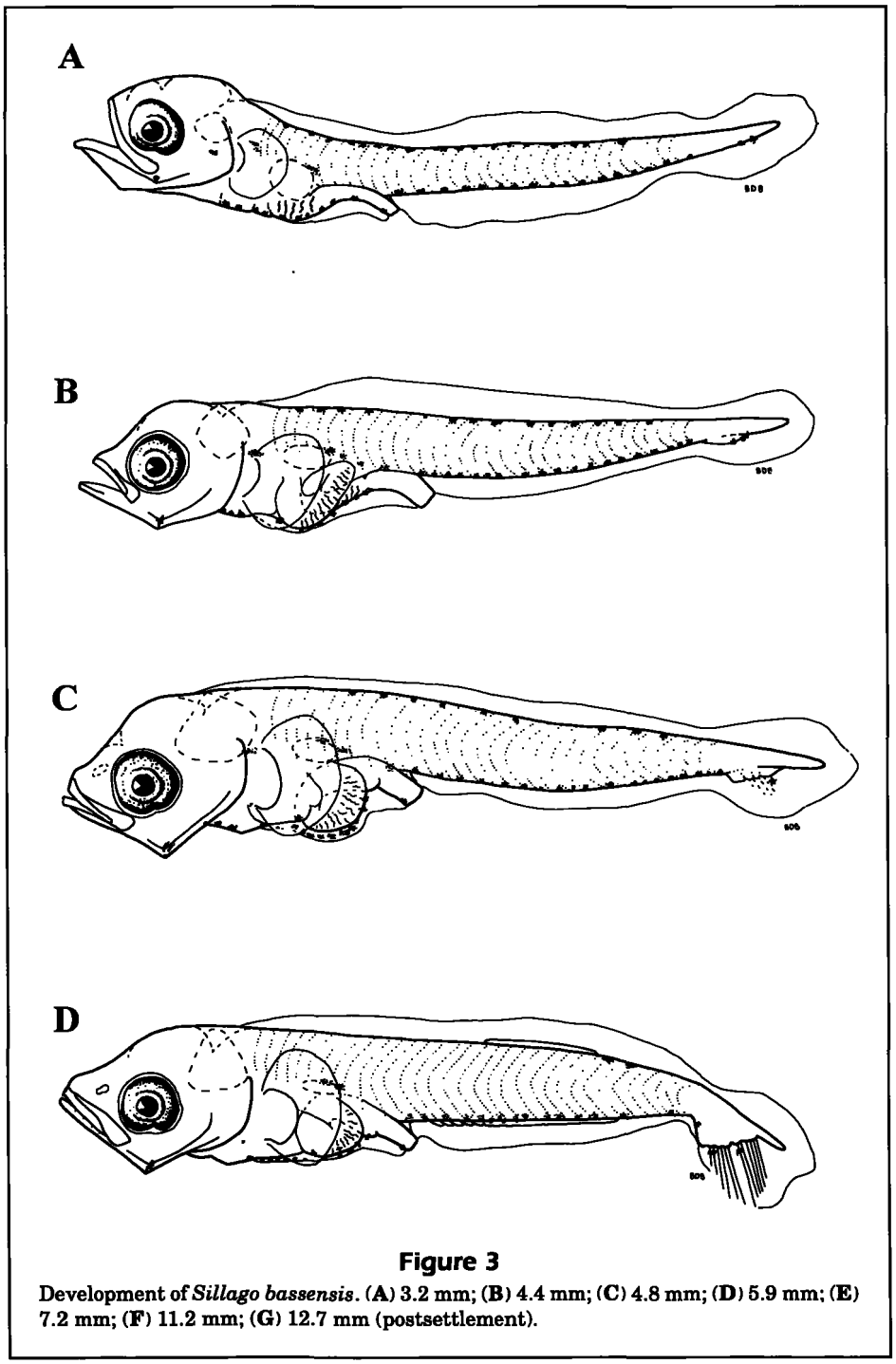

Figure 3

Development of *Sillago bassensis*. (**A**) 3.2 mm; (**B**) 4.4 mm; (**C**) 4.8 mm; (**D**) 5.9 mm; (**E**) 7.2 mm; (**F**) 11.2 mm; (**G**) 12.7 mm (postsettlement).

into fore, mid, and hindgut regions. The midgut becomes rugose by 3.0 mm and remains so, although overlying musculature obscures this feature prior to settlement. The gut begins to coil in preflexion larvae by 4.1 mm. Coiling proceeds without migration of the anus and is achieved by elongation and anterior looping of the midgut (Fig. 4). Consequently, body proportions do not show a significant change in preanal length which remains at 47–48% BL. Coiling of the gut is completed in postflexion larvae (7.0–7.5 mm). The gas bladder has its origin at myomeres 2–8 in preflexion larvae but migrates posteriorly during development to myomeres 5–10 in postflexion larvae. The gas bladder is inflated and prominent in 90% of field-collected larvae (random subsample n=40; all larvae were collected at night).

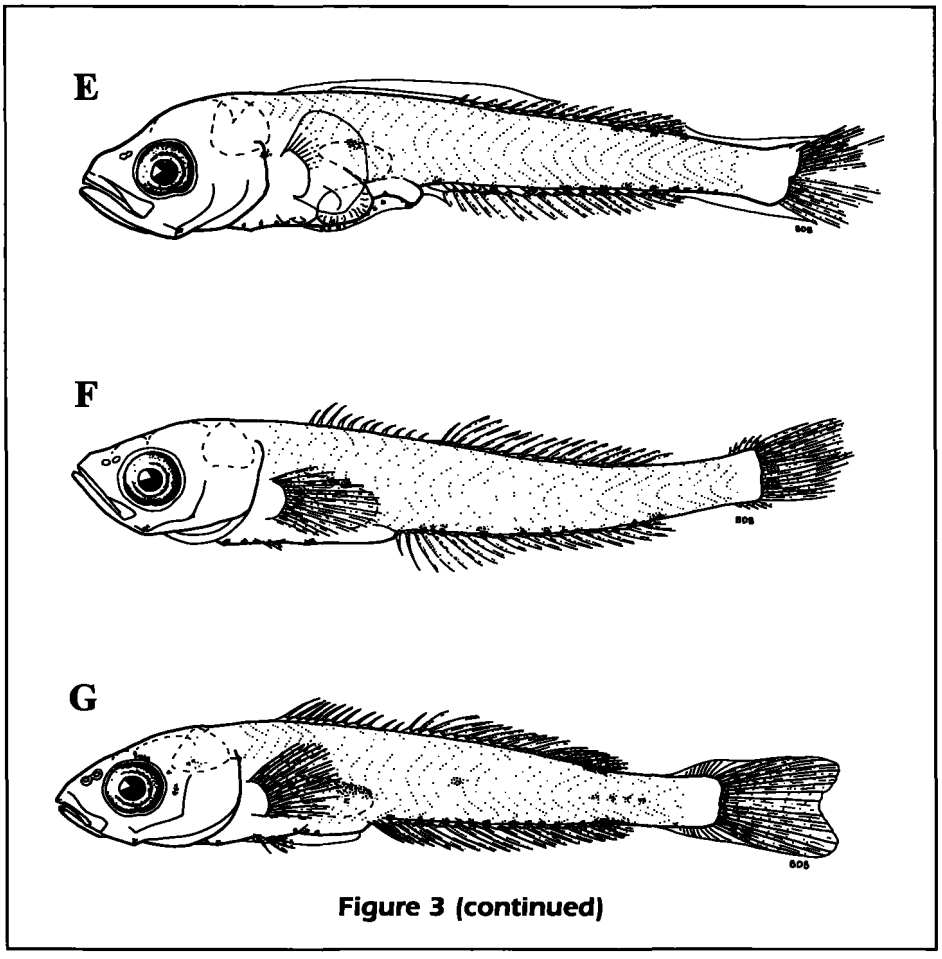

Figure 3 (continued)

The snout is initially slightly concave in profile, but after flexion, this gradually changes to straight or slightly convex. The eye is round. The mouth initially reaches to below the center of the eye but extends only to the anterior margin of the eye in postflexion larvae. Four to six small villiform teeth are present on the premaxilla by 4.7 mm. The number of teeth increases to 7 or 8 during flexion (4.8–6.5 mm). Head spination is only weakly developed. A single minute preopercular spine is present by 7.8 mm but is not visible after settlement (12.5 mm). A weak posttemporal ridge is present by 7.2 mm and is retained; however, no posttemporal spines develop. The single opercular spine is first visible by 12.7 mm and is retained in juveniles.

Scales develop after settlement and are first visible around the gut and lateral midline of the tail by approximately 16.0 mm.

The development of fins in larval and juvenile *S. bassensis* is summarized in Table 1. Completion of fin development occurs in the following sequence: caudal; pectoral; anal, first dorsal and second dorsal fins (almost simultaneously); and pelvic.

The rays of the caudal fin are present just prior to flexion in larvae of 4.4 mm. Flexion commences by 4.8–5.0 mm and is complete by 6.8 mm. Pectoral fin buds are present in the smallest specimen (2.3 mm), incipient rays form during flexion (5.8–6.0 mm), and a full complement of 15 or 16 rays is present by 10.0 mm. Anal-fin and second-dorsal-fin anlagen appear during flexion. Distinct bases are present by 6.5–7.0 mm, incipient rays by 6.8–7.1 mm, and ossification of posterior rays has regularly commenced by 7.2 mm. Ossification of dorsal and anal elements proceeds anteriorly and both fins complete development by 10.0–10.5 mm. The first dorsal fin anlage is present by 7.0 mm. Distinct bases are present by 7.5–8.0 mm and ossification of spines has commenced by 8.0–8.5 mm. Development of the first dorsal fin is complete by 10.0–10.5 mm. Pelvic fin buds are present in 7.0–7.2 mm larvae below the pectoral fin bases. Development of the pelvic fin is complete by 12.5 mm.

Larval pigment—*S. bassensis* larvae were the least pigmented of the three sillaginid species examined.

Pigment on the head in preflexion larvae is limited to the angle of the lower jaw and internally to

Table 3

Body proportions of larvae of *Sillago bassensis* (expressed as a percentage of body length). d = damaged; g = gas bladder not visible; — = character not yet formed. Specimens between dotted lines were undergoing flexion.

Body-length (mm)	Pre-anal length	Pre-dorsal fin length	Pre-gas-bladder length	Head length	Snout length	Eye diameter	Vent to anal fin length	Body depth at pectoral	Body depth at anus
2.3	56.5	—	g	23.9	4.3	8.6	—	17.4	6.5
3.1	48.4	—	27.4	24.2	d	d	—	16.1	8.1
3.4	44.1	—	23.5	19.1	5.9	7.3	—	14.7	5.9
3.7	51.3	—	28.4	d	4.1	8.1	—	16.2	8.1
3.8	47.4	—	25.0	22.4	3.9	9.2	—	17.1	6.6
4.1	51.2	—	29.3	26.8	6.1	8.5	—	18.3	8.5
4.2	52.4	—	29.8	26.2	7.1	8.3	—	19.0	10.7
4.3	46.5	—	g	23.2	5.8	7.0	—	13.9	6.9
4.4	52.3	—	34.1	28.4	6.8	9.1	—	20.4	11.4
4.5	50.0	—	g	24.4	4.4	7.7	—	15.5	8.9
4.6	44.6	—	28.2	23.9	6.5	8.7	—	14.1	7.6
4.7	44.7	—	29.8	22.3	6.4	7.4	—	12.8	6.4
4.8	54.2	—	36.4	29.2	6.2	8.3	2.1	18.7	12.5
4.9	44.9	—	29.6	22.4	5.1	8.2	—	13.3	8.2
5.3	47.2	—	33.0	26.4	7.5	7.5	—	15.1	8.5
5.5	50.9	38.1	g	30.9	9.1	9.1	0.0	20.9	12.7
5.7	50.9	—	31.6	29.8	8.8	8.8	0.0	17.5	10.5
5.8	44.8	56.9	56.9	25.9	6.9	7.7	0.6	13.8	7.7
5.9	49.1	55.9	g	27.1	8.5	8.5	2.5	18.6	11.0
6.3	46.0	47.6	33.3	26.2	6.3	7.9	0.8	14.	8.7
7.7	49.3	54.5	32.5	25.3	7.8	7.8	0.0	18.8	13.6
7.9	45.6	53.2	32.9	25.3	6.3	7.6	2.5	13.9	8.9
8.9	51.7	38.2	34.3	28.6	7.8	7.8	0.0	18.5	16.3
9.6	47.9	33.3	37.5	25.0	7.3	8.3	0.0	14.6	12.5
10.1	44.5	30.7	g	22.8	4.9	7.9	0.9	14.8	10.9
10.2	45.1	31.3	g	24.5	5.9	8.3	1.0	14.7	10.8
11.3	46.9	33.6	33.6	28.3	7.1	8.0	0.0	16.8	13.3

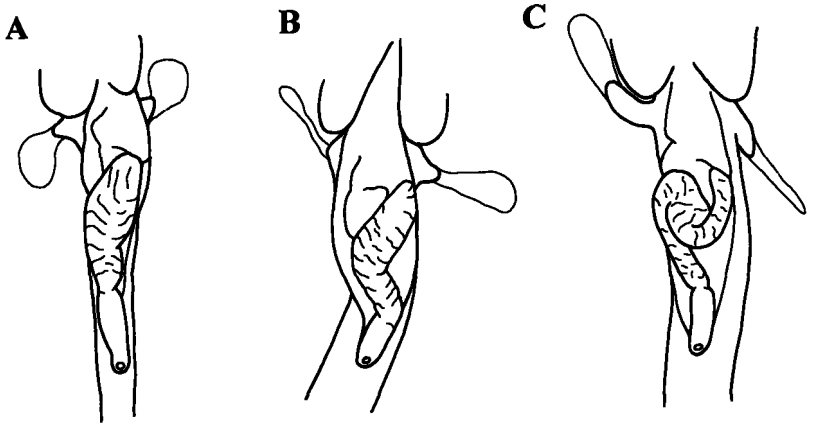

Figure 4

Morphology of the gut in *Sillago bassensis* (ventral view of pigment omitted). (**A**) 2.9 mm; (**B**) 4.2 mm; (**C**) 5.5 mm.

below the otic capsule. Melanophores are irregularly present ventrally on the gular membrane. Additional pigment on the head does not develop until after settlement. Melanophores then develop immediately anterior to and above the eye as well as on the snout and lower jaw. Larger specimens quickly develop a cap of melanophores over the mid and hindbrain.

Pigment on the dorsal surface of the gut consists of 2–7 approximately evenly spaced melanophores in preflexion larvae. This reduces to 2 or 3 just prior to flexion. In postflexion larvae, internal pigment over the gut is restricted to above the gas bladder. Ventral pigment on the gut consists of a midline series of 8–14 melanophores extending from just anterior to the cleithral symphysis to the anus in both preflexion and flexion larvae. One to two additional melanophores are usually present either side of this series below the level of the pectoral fin base (76% of larvae, random subsample n=25), forming a diamond pattern when viewed ventrally (Fig. 5).

Preflexion larvae have 10–18 discrete, evenly placed melanophores that extend in a dorsal linear series on the trunk and tail to within 1–3 myomeres of the notochord tip. The dorsal surface of the notochord tip remains unpigmented throughout development. The dorsal series of melanophores gradually disappears during flexion (4.9–6.5 mm). Postflexion larvae have 0–3 melanophores (most commonly 0) below the bases of the second dorsal fin. Dorsal pigment redevelops after settlement as a series of discrete bands each comprising 3–6 pairs of stellate melanophores. The first of these bands develops immediately below the posterior-most second dorsal fin rays, 5 or 6 additional bands subsequently develop anteriorly, and a single band developes posteriorly on the caudal peduncle by 20.0 mm. Lateral midline pigment on the tail does not form until after settlement, although some internal pigment may be present over vertebrae between myomeres 25–30 after 11.0 mm.

A single row of 14–19 melanophores is present along the ventral midline of the tail in preflexion larvae. This ventral row is gradually obscured by overlying musculature during flexion. Paired external melanophores subsequently develop ventrally on the tail in postflexion larvae, approximately one pair per myomere. After settlement, this ventral series forms a regular pattern of expanded and contracted melanophores producing a similar banding pattern to the dorsal series. One to two (most commonly 2) melanophores are present ventrally on the notochord tip in preflexion larvae. These are retained in postflexion larvae and, with additional melanophores, form a band of pigment over the caudal-fin ray bases.

Yellow fin whiting (*Sillago schomburgkii* Peters 1865), Figure 6

Material examined—16 specimens, 2.7–18.7 mm BL.

Larval development—The smallest *S. schomburgkii* examined was 2.7 mm. At this size the mouth and gut are functional, the eyes are pigmented, a gas bladder is present, and yolk absorption is complete.

Larvae are elongate (BDp=14–18% BL) and have 36–38 myomeres (15–17+20–22). Body depth at anus increases from 8 to 16% BL during development. Other body proportions remain relatively constant (Table 4). The gut forms a convoluted tube in the smallest specimen and is already differentiated into fore, mid and hindgut regions. The midgut becomes rugose by 4.4 mm and remains so, although overlying musculature obscures this feature prior to settlement. The gut has not begun coiling in the largest flexion-stage larva available (5.1 mm). Coiling of the midgut has begun in the 10.1-mm larva and is well developed in all postsettlement larvae. Insufficient specimens were available to further document the timing of gut coiling. Coiling of the gut proceeds without migration of the anus and is achieved by elongation and anterior looping of the midgut. Consequently, body proportions do not show a significant change in preanal length which remains at 51–53% BL. The gas bladder has its origin at myomeres 1–8 in preflexion larvae and is inflated and prominent in all larvae collected during night tows. The gas bladder is inconspicuous in larvae caught during the day.

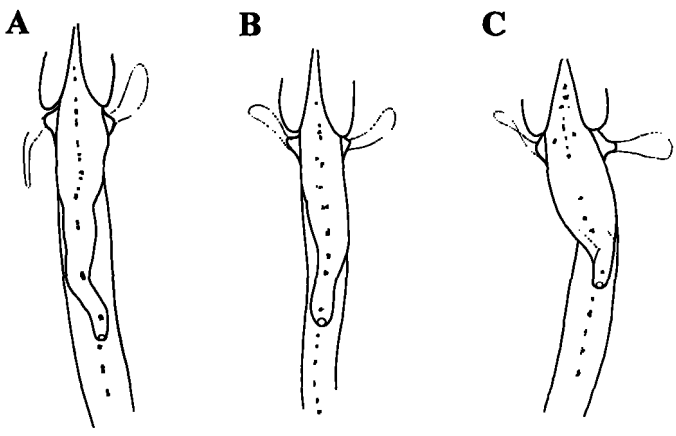

Figure 5

Ventral pigment on the gut: (**A**) *Sillaginodes punctata*, 4.7 mm; (**B**) *Sillago schomburgkii*, 4.4 mm; (**C**) *Sillago bassensis*, 4.1 mm.

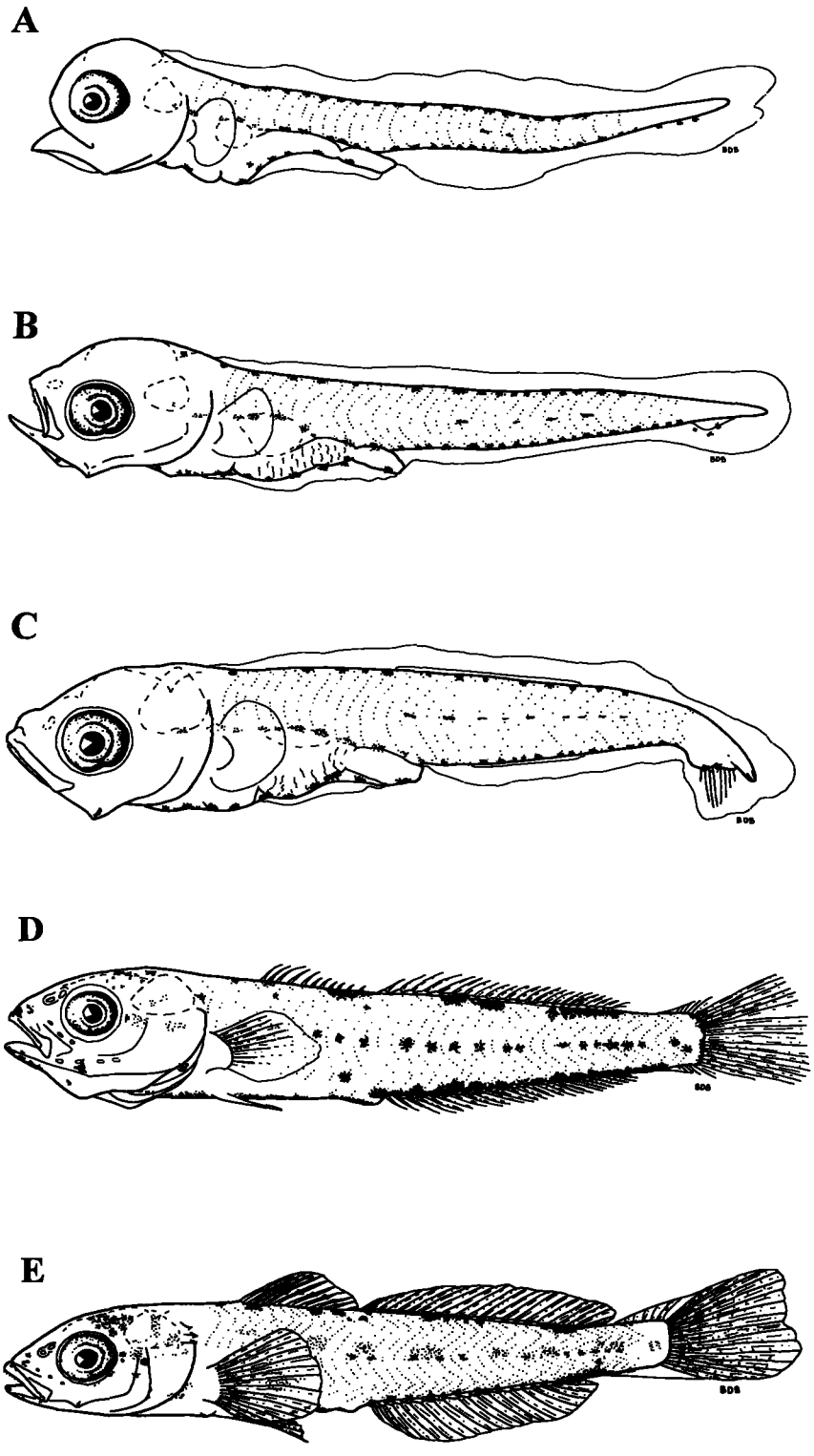

Figure 6

Development of *Sillago schomburgkii*. (**A**) 2.7 mm; (**B**) 4.4 mm; (**C**) 5.0 mm; (**D**) 10.1 mm; (**E**) 13.0 mm (postsettlement).

The snout is initially slightly concave in profile, but after flexion this gradually changes to straight or slightly convex. The eye is round. The mouth initially reaches below the eye but is short of the eye in postflexion larvae. Four to six small villiform teeth are present on the premaxilla by 4.4 mm. The number of teeth increases from 10 to 12 during flexion (from 4.8 to greater than 5.1 mm). Head spination is only weakly developed. One to two preopercular spines are discernible in postsettlement larvae. A weak posttemporal ridge with 1 or 2 small spines is developed in the 10.1-mm postflexion larva and is present in all postsettlement larvae examined. The single opercular spine is not visible in the 10.1-mm larva but is present in postsettlement larvae and is retained in juveniles.

Scales develop after settlement and are first visible around the gut and lateral midline by 17.2 mm.

Insufficient numbers of specimens were available to document the full sequence of fin development or the completion of flexion in *S. schomburgkii*.

The rays of the caudal fin are present in flexion larvae of 4.8 mm. Flexion commences by 4.8 mm. Pectoral fin buds are present in the smallest specimen (2.7 mm) and incipient rays form during flexion. Rays of the pectoral fin have commenced ossification in the 10.1-mm postflexion larva. A full complement of 15 or 16 pectoral fin rays is present in the smallest postsettlement larva (12.7 mm). Anal-fin and second-dorsal-fin anlagen appear during flexion. Full complements (spines and rays) of the anal fin and both dorsal fins are present in the 10.1-mm specimen. The pelvic fin has commenced development in the 10.1-mm larva and has completed development by 12.7 mm.

Larval pigmentation—Pigment on the head in preflexion *S. schomburgkii* larvae is limited to the angle of the lower jaw and internally to the base of the otic capsule. One or two melanophores are also present ventrally on the gular membrane, increasing to three during flexion. Additional melanophores develop on the snout tip, scattered over the lateral surface of the head, and a cap of pigment forms over the mid and hindbrain in postflexion larvae.

Pigment on the dorsal surface of the gut and gas bladder consists of 8–10 approximately evenly spaced melanophores. Scattered internal melanophores gradually spread over the lateral walls of the gut in postflexion larvae. Ventral pigment on the gut consists of a midline series of 8–14 melanophores extending from just anterior of the cleithral symphysis to the anus (Fig. 5).

Preflexion larvae have 15–22 discrete, evenly spaced melanophores that extend in a dorsal linear series from the nape to within 2–5 myomeres of the notochord tip. The number of dorsal melanophores decreases to 13 by 5.0 mm. A series of three discrete dorsal bands consisting of 3–5 paired stellate melanophores has replaced this dorsal series in the 10.1 mm postflexion larva. Lateral midline pigment in *S. schomburgkii* larvae is the most pronounced of all three species examined and is present on the tail in the smallest larva (2.7 mm) as 2 or 3 elongated mel-

Table 4

Body proportions of larvae of *Sillago schomburgkii* (expressed as a percentage of body length). d = damaged; g = gas bladder not visible; — = character not yet formed. Specimens between dotted lines were undergoing flexion.

Body length (mm)	Pre-anal length	Pre-dorsal fin length	Pre-gas-bladder length	Head length	Snout length	Eye diameter	Vent to anal fin length	Body depth at pectoral	Body depth at anus
2.7	53.7	—	24.1	20.4	3.7	9.2	—	14.8	6.3
3.3	51.5	—	25.7	21.2	5.1	9.1	—	15.1	7.6
3.6	48.6	—	g	25.0	6.1	8.3	—	13.9	8.3
3.7	50.0	—	g	24.3	5.4	8.1	—	16.2	9.4
3.8	51.3	—	25.0	22.4	2.6	7.9	—	14.5	7.9
3.9	52.3	—	28.2	22.3	6.4	7.7	—	15.4	7.7
4.0	51.2	—	g	25.0	7.5	7.5	—	17.5	9.0
4.3	52.3	—	g	22.1	5.8	8.1	—	15.1	9.3
4.4	53.4	—	28.4	22.7	5.7	8.4	—	14.8	7.9
4.8	53.1	—	31.2	25.0	6.2	8.3	—	15.6	10.4
5.0	53.0	—	34.0	25.0	7.0	9.0	8.0	18.0	11.0
10.1	52.5	34.6	g	27.7	8.9	6.9	2.0	17.8	15.8
13.6	49.3	32.3	g	27.2	7.3	8.1	3.6	16.9	14.7
17.2	53.5	36.0	g	30.2	9.3	8.1	2.9	17.4	14.5

anophores in the vicinity of myomeres 24–26. Lateral midline pigment spreads both anteriorly and posteriorly as a linear series of elongated myomeres during development. By 10.1 mm, lateral midline pigment consists of 18 stellate and approximately evenly spaced melanophores extending from the pectoral fin to the caudal peduncle. Internal pigment along the vertebrae is visible in the 10.1-mm postflexion larva but is most pronounced in postsettlement larvae as clusters of melanophores located over every 2–5 vertebrae.

A single row of 16–18 melanophores is present along the ventral midline of the tail in preflexion larvae. This ventral row is gradually obscured by overlying musculature during flexion. Paired external melanophores (approximately one pair per myomere) subsequently develop ventrally on the tail in postflexion larvae, approximately one per myomere. Two to three (most commonly three) melanophores are present ventrally on the notochord tip in preflexion larvae. These are retained in postflexion larvae and form a band of pigment over the caudal-fin ray bases.

Discussion

Egg or larval development, or both, have been described for only four other species of sillaginid larvae: *Sillago japonica* (Kamiya, 1925; Ueno and Fujita, 1954; Ueno et al., 1958; Mito, 1966 — as *Sillago japonicus*; Ikeda and Mito, 1988; Kinoshita, 1988; Oozeki et al., 1992); *Sillago sihama* (Gopinath, 1946; Uchida et al., 1958; Ikeda and Mito, 1988; Kinoshita, 1988); *Sillago maculata* (Miskiewicz, 1987; Kinoshita, 1988); and *Sillago ciliata* (Munro, 1945; Miskiewicz 1987; Tosh[4]). In addition, Miskiewicz (1987, p. 62) reported a series of unidentified sillaginid larvae which, based on pigment on the lateral wall of the gut below the pectoral fin base, were almost certainly *Sillago flindersi*.

Characters useful for the identification of tropical sillaginid larvae at the family level and similarity of sillaginid larvae to those from other families have been considered in detail by Leis and Trnski (1989) and Miskiewicz (1987). Although most of the characters discussed by these authors also apply to the temperate species considered here, an exception was the timing of gut coiling. Leis and Trnski (1989) reported that the gut of tropical sillaginid larvae commenced coiling during notochord flexion and was accompanied by the anterior migration of the anus. In the South Australian species, coiling of the gut commenced prior to flexion in *S. bassensis*, after settlement in *Sillaginodes punctata,* and had not yet commenced in the largest flexion larva available for *Sillago schomburgkii* (although coiling of the gut was present in a 10.1-mm postflexion larva). In all cases, coiling of the gut proceeded without migration of the anus and was achieved by anterior looping of the midgut. The implications of these variations are unclear but suggest that, although useful on a specific level, the timing of gut coiling and migration of the anus are not useful characters for the identification of temperate sillaginids at the family level.

The significance of gut coiling may relate to shifts in diet. Robertson (1977) reported a dietary shift in postsettlement *Sillaginodes punctatus* (= *punctata*) in Westernport Bay (Victoria) between November and December, a shift from harpacticoid copepods, gammarid amphipods, and mysids to larvae of the ghost prawn *Callianassa australiensis*, polychaetes, and juvenile crabs. Robertson correlated this dietary shift with increasing body size and mouth gape as well as with the availability of *C. australiensis* larvae. However, from his length-frequency data, this period also corresponds to the size range during which postsettlement *S. punctata* undergo gut coiling. Alternatively, because evacuation rates are believed to decrease after gut coiling (Arthur, 1976, and references within; Young[5]), perceived changes in diet may be confounded by increased food retention times. Stomach contents were not analyzed during this study; they provide a valuable topic for further research.

Despite seasonal sampling over five years, larvae of only three of the four sillaginid species with adult distributions extending to South Australia were located during this study. The lack of *Sillago flindersi* larvae suggests either that this species does not spawn in South Australian waters, that sampling frequency was too course to detect the presence of larvae of this species, or that *S. flindersi* larvae behave differently from other sillaginid species and are less prone to capture (e.g. epibenthic and neustonic).

Sillago flindersi larvae are frequently encountered in similar sampling regimes in coastal waters of eastern Australia[6] and in Tasmanian waters (author's pers. observ.) and thus it seems unlikely that a lack of their larvae in South Australian samples represents an artifact of sampling or that their behavior is fundamentally different from other sillaginid larvae.

[4] Tosh, J. R. 1903. Notes on the habits, development etc. of the common food fishes of Moreton Bay. Queensland Marine Dep.: Marine Biologist's Report.

[5] Young, J. W. CSIRO Div. Fisheries, GPO Box 1538 Hobart, Tasmania, Australia 7001. Personal commun., 1993.

[6] Miskiewicz, A. G. Sydney Water Board, PO Box A53, Sydney South, NSW, Australia 2000. Personal commun., 1993.

South Australian waters represent the western distributional limit of *S. flindersi* in southern Australia (McKay, 1992; Gomon et al., 1994; Kailola et al., 1993). Spawning times for *S. flindersi* vary throughout its range; a summer spawning is recorded for Victorian populations (Hobday and Wankowski[7]). No data are available on either the reproductive condition of *S. flindersi* or on the presence or absence of juveniles in South Australian waters. However, on the basis of a lack of larvae, I suggest that spawning does not occur in South Australia and that the western limit of *S. flindersi* comprises fish recruited from eastern populations.

Acknowlegments

I would like to thank G. K. Jones, S. A. Shepherd, A Miskiewicz, J. M. Leis, and A. J. Butler for their helpful comments on the manuscript. Thanks are also due to A. R. Knight, R. Hudson, R. Moehring, and D. A. Short for their help in collecting and processing plankton samples.

Literature cited

Arthur, D. K.
1976. Food and feeding of larvae of three fishes occurring in the California Current, *Sardinops sagax*, *Engraulis mordax*, and *Trachurus symmetricus*. Fish. Bull. 74:517–529.

Bruce, B. D.
1988. Larval development of blue grenadier, *Macruronus novaezelandiae* (Hector), in Tasmanian waters. Fish. Bull. 86:119–128.
1989. Studying larval fish ecology: an aid to predict future catches. SAFISH 13(4):4–9.

Burchmore, J. J., D. A. Pollard, M. J. Middleton, J. D. Bell, and B. C. Pease.
1988. Biology of four species of whiting (Pisces: Sillaginidae) in Botany Bay, New South Wales. Aust. J. Mar. Freshwater Res. 39:709–727.

Gilmour, A. J.
1969. The ecology of King George whiting *Sillaginodes punctatus* (Cuvier and Valenciennes) in Westernport Bay, Victoria. Ph.D. thesis, Monash Univ., Australia.

Gopinath, K.
1946. Notes on the larval and post-larval stages of fishes found along the Trivandrum coast. Proc. Indian Natl. Sci. Acad. 12(1):7–21.

Gomon M. F, C. J. M. Glover, and R. H. Kuiter.
1994. The fishes of Australia's south coast. State Print, Adelaide, Australia, 992 p.

Hay, D. E.
1981. Effects of capture and fixation on gut contents and body size of Pacific herring larvae. Rapp. P.-V. Reun. Cons. Int. Explor. Mer 178:395–400.

Ikeda, T., and S. Mito.
1988. Pelagic fish eggs. *In* M. Okiyama (ed.), An atlas of the early stage fishes in Japan, p. 999–1083. Tokai Univ. Press, Tokyo.

Johnson, G. D.
1984. Percoidei: development and relationships. *In* H. G. Moser, W. J. Richards, D. M. Cohen, M. F. Fahay, A. W. Kendall Jr., and S. L. Richardson (eds.), Ontogeny and systematics of fishes, p. 464–498. Am. Soc. Ichthyol. Herpetol., Spec. Publ. 1.

Jones, G. K.
1980. Research on the biology of the spotted (King George) whiting in South Australian waters. SAFIC 4:3–7.

Kailola, P. J., M. J. Williams, P. C. Stewart, R. E. Reichelt, A. McNee, and C. Grieve.
1993. Australian fisheries resources. Bureau of Rural Sciences, Fisheries Res. and Develop. Corp., Canberra, Australia, 422 p.

Kamiya, N.
1925. Description of pelagic fish eggs and their larvae in Tateyama Bay. J. Imperial Fish. Inst. 21: 71–85. [In Japanese.]

Kinoshita, I.
1988. Sillaginidae. *In* M. Okiyama (ed.), An atlas of the early stage fishes in Japan, p. 449–452. Tokai Univ. Press, Tokyo.

Last, P. R., E. O. G. Scott, and F. Talbot.
1983. Fishes of Tasmania. Tasmanian Fisheries Development Authority, Hobart, Australia, 563 p.

Leis, J. M., and T. Trnski.
1989. The larvae of Indo-Pacific shore fishes. Univ. New South Wales Press, 371 p.

Lennanton, R. C. J.
1969. Whiting fishery—Shark Bay. Fishing Industry News Service. W. Aust. Dep. Fish. Wildl. 2(1):4–11.

McKay, R. J.
1985. A revision of the fishes of the family Sillaginidae. Mem. Queensl. Mus. 22: 1–73.
1992. FAO species catalogue. Vol. 14: Sillaginid fishes of the world. FAO, Rome., 87 p.

Miskiewicz, A. G.
1987. Taxonomy and ecology of fish larvae in Lake Macquarie and New South Wales coastal waters. Ph.D. thesis, Univ. New South Wales.

Mito, S.
1966. Fish eggs and larvae. *In* S. Motoda (ed.), Illustrations of the marine plankton of Japan, Vol. 7. Soyosha, Tokyo, 74 p. [In Japanese.]

Munro, I. S. R.
1945. Postlarval stages of Australian fishes—No. 1. Mem. Queensl. Mus. 12:136–153.

Oozeki, Y., P. Hwang, and R. Hirano.
1992. Larval development of the Japanese whiting, *Sillago japonica*. Jpn. J. Ichthyol. 39:59–66.

Potthoff, T.
1984. Clearing and staining techniques. *In* H. G. Moser, W. J. Richards, D. M. Cohen, M. F. Fahay, A. W. Kendall Jr., and S. L. Richardson (eds.), Ontogeny and systematics of fishes, p. 35–37. Am. Soc. Ichthyol. Herpetol., Spec. Publ. 1.

Robertson, A. I.
1977. Ecology of juvenile King George whiting *Sillaginodes punctatus* (Cuvier and Valenciennes) (Pisces: Perciformes) in Western Port, Victoria. Aust. J. Mar. Freshwater Res. 28:35–43.

Scott, T. D.
1954. The life history of the spotted whiting, *Sillaginodes punctatus* (Cuvier and Valenciennes) in South Australia. M.Sc. thesis, Univ. Adelaide, Australia.

[7] Hobday, D. K., and J. W. J. Wankowski. 1987. School whiting *Sillago bassensis flindersi*: reproduction and fecundity in eastern Bass Strait, Australia. Victorian Dep. Conserv., Forests and Lands, Fisheries Div. Int. Rep. 153, 24 p.

Theilacker, G. H.
1980. Changes in body measurements of larval northern anchovy, *Engraulis mordax*, and other fishes due to handling and preservation. Fish. Bull. 78:685–692.

Uchida, K., S. Imai, S. Mito, S. Fujita, M. Ueno, Y. Shojima, T. Senta, M. Tahaku, and Y. Dotu.
1958. Studies on the eggs, larvae and juveniles of Japanese fishes. Series 1: Second laboratory of fish biology. Fish. Dep. Fac. Agric., Kyushu Univ., Fukuoka, Japan. [In Japanese.]

Ueno, M., and S. Fujita.
1954. On the development of the egg of *Sillago sihama* (Førskal). Jpn. J. Ichthyol. 3:118–120.

Ueno, M., T. Senta, and S. Fujita.
1958. *Sillago sihama* (Førskal). *In* Kyushu University eds., Second laboratory of fisheries biology: studies on the eggs, larvae and juveniles of Japanese fishes. Shyukousha, Fukuoka. [In Japanese.]

Weng, H. T.
1983. Identification, habitats and seasonal occurrence of juvenile whiting (Sillaginidae) in Moreton Bay, Queensland. J. Fish Biol. 23:195–200.

1986. Temporal distribution of whiting (Sillaginidae) in Moreton Bay, Queensland. J. Fish Biol. 29:755–764.