Larval development of *Spondyliosoma emarginatum* (Cuvier & Valenciennes) (Pisces: Sparidae) from southern Africa

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The larval development of the southern African endemic sparid *Spondyliosoma emarginatum* is described and illustrated from specimens collected in Algoa Bay and the Swartkops, Sundays and Swartvlei estuaries of the Cape Province. *S. emarginatum* has demersal eggs. Preflexion larvae are moderately elongate (BD = 18–23% BL) with body depth increasing to 31% BL in postflexion stages. The head is rounded and the snout blunt but becomes more elongate in postflexion stages. There are short spines on the preoperculum. Flexion occurs at about 6 mm BL and postflexion larvae are characterized by distinct medio-lateral pigmentation. Osteological development is described from a series of cleared and stained specimens. All fins have the adult complement of spines and rays by 12 mm BL. The larvae of *S. emarginatum* are compared with those of the European *S. canthurus* and other southern African sparids.

Die larwale ontwikkeling van die endemiese vis *Spondyliosoma emarginatum* word beskryf van monsters wat in Algoabaai en die Swartkops-, Sondags- en Swartvlei-getyriviere versamel is. *S. emarginatum* het demersale eiers. In prefleksie-larwes is die verhouding van liggaamsdiepte tot liggaamslengte 18–23% maar by postfleksie-larwes neem liggaamsdiepte toe tot 31% van die liggaamslengte. Die kop is rond, die snoet stomp en daar is klein stekels op die preoperkulum. Fleksie vind plaas by omtrent 6 mm liggaamslengte en postfleksie-larwes besit kenmerkende medio-laterale pigmentasie. Osteologiese ontwikkeling van die skedel en ruggraat word beskryf en alle vinne is teen 12 mm liggaamslengte ontwikkel. Die larwes van *S. emarginatum* word met dié van *S. canthurus* uit Europa en ander Suid-Afrikaanse Sparidae vergelyk.

Spondyliosoma emarginatum (Cuvier & Valenciennes 1830), a small sparid fish commonly known as the 'steentjie', is endemic to southern Africa (Smith & Heemstra 1986). It occurs chiefly over subtidal reefs and is regarded as an important bait fish by anglers. *S. emarginatum* is omnivorous, grows to about 300 mm in length, and is sexually mature at 220 mm (Van der Elst 1981). The breeding season is from September through to January and males prepare nests in the coarse grit substratum around reefs (Van Bruggen 1965; Penrith 1972). Both males and females have nuptial markings and exhibit courtship display behaviour. Demersal eggs are laid in the nest and are protected by the parents until they hatch after seven to ten days. The general biology of the species is thus known but the larval development has not been described.

Whilst monitoring juvenile fish populations in eastern Cape estuaries during the summer months of 1980/81 (Beckley 1983, 1984, 1985), some postflexion larvae of an unknown sparid species were captured in the lower reaches of the Swartkops estuary (33°52′S / 25°51′E) and Sundays estuary (33°43′S / 25°38′E). Repeated sampling at monthly intervals revealed cohort growth and eventually the fish were large enough to be recognized as juvenile *S. emarginatum.* Subsequent SCUBA diving observations in Algoa Bay during January, February and March 1982 revealed the presence of large shoals of *S. emarginatum* juveniles (20–50 mm TL) over subtidal reefs (Beckley & Buxton 1989). Recent ichthyoplankton studies near the mouth of the Swartvlei estuary (34°00′S / 22°47′E) along the Cape south coast (A.K. Whitfield in prep.) have resulted in the collection of some preflexion larvae and additional postflexion larvae of *S. emarginatum*. A size series has been assembled and the larval development of *S. emarginatum* is described and illustrated in this paper.

Materials and Methods

Spondyliosoma emarginatum larvae and juveniles collected in plankton nets and small seine nets at the localities mentioned above were fixed and stored in 5% formalin. Sixty larvae were measured to the nearest 0,1 mm using a dissecting microscope fitted with an ocular micrometer. Terminology and measurements follow Leis & Rennis (1983). Body length (BL) given in millimetres refers to notochord length in preflexion and flexion larvae, and standard length in postflexion larvae. Drawings were done with the aid of a camera lucida. Fin counts were obtained by staining specimens with alizarin red S, and for the dorsal and anal fins each element with a separate base was counted. To determine vertebral counts and the sequence of bone ossification, an additional series of eight specimens was cleared and double stained for cartilage and bone following the techniques of Taylor (1967) and Potthoff (1984). Myomere and paired-fin counts were made on the left-hand side of the body. All the material examimed was deposited at the J.L.B. Smith Institute of Ichthyology in Grahamstown, South Africa (RUSI 27002, 27003, 27004).

Results

Identification

Larvae were identified as sparids by their moderately elongate body shape, short compact gut, inconspicuous gas bladder, small preopercular spines and the number of myomeres. Specimens were assembled into a series using body pigmentation and sequence of fin development. Fin counts from the larger specimens in the series indicated the species to be *Spondyliosoma emarginatum,* which is the only representative of the genus *Spondyliosoma* found along the southern coast of Africa. Meristic and morphometric characteristics of adult *S. emarginatum* are as follows: D XI, 11–13; A III, 10; P 16; LL 80–92; GR (7–9)+(15–18); depth 2,0–2,6 (Smith & Heemstra 1986).

The general larval features listed above characterize a number of other percoid families, such as Gerreidae, Teraponidae, Kuhliidae, Nemipteridae, Pomacentridae, Mullidae, Haemulidae and Sciaenidae and larvae of these families can be easily confused with sparid larvae (Leis & Trnski in prep). These families, with the exception of the sciaenids, whose larvae are known (Beckley in prep.), are, however, not well represented in south-east Cape ichthyofauna (Smith & Heemstra 1986). The fin counts of 10 southern African sparids overlap with those of *S. emarginatum.* Four of these species, *Polyamblyodon gibbosum, P. germanum, Pachymetopon blochii* and *Crenidens crenidens* do not occur in the south-east Cape (Smith & Heemstra 1986). Small juveniles of the other six species, *Sparodon durbanensis, Rhabdosargus holubi, R. globiceps, Pachymetopon aeneum, P. grande* and *Lithognathus mormyrus* were compared with the specimens of > 20 mm BL in the present series and found to be dissimilar particularly with regard to pigmentation.

Description

Morphology

The smallest larva in the series (2,7 mm BL) has no yolk-sac, a moderately elongate body shape (BD = 18% BL), a coiled gut, pectoral buds, dorsal and anal fin folds (Figure 1A). The mouth is differentiated and the eye pigmented. In preflexion larvae (Figure 1B–C) there are 24 myomeres (6 pre-anal + 18 postanal), pre-anal length ranges between 35 and 44% BL and pre-gas bladder length ranges between 23 and 30% BL (Table 1). Flexion occurs at around 6 mm BL. Body depth at flexion is 23% BL and this further increases so that early juveniles (20–25 mm BL) have a body depth of 31% BL. The head of *S. emarginatum* is rounded and 20–25% BL prior to flexion but increases to 38% BL in early juveniles (Figure 1D–F). Snout length and eye diameter increase from 5% BL and 8% BL respectively in the smallest larvae to 9% and 13% in early juveniles.

Pigmentation

Pigmentation changes markedly in *S. emarginatum* during development, with preflexion larvae having little pigment and postflexion larvae characterized by conspicuous medio-lateral pigmentation. In the smallest larvae examined (2,7 mm BL) a row of ventral melanophores extends posteriorly from the anus towards the tip of the notochord (Figure 1A). There is a large internal peritoneal melanophore dorsal to the intestine, two smaller peritoneal melanophores situated posteriorly and dorsally to the coiled portion of the gut and a melanophore dorsal to the gas bladder. Three external melanophores are found on the midline, ventral to the gut. There are no dorsal melanophores on the head, trunk or tail in very small larvae but a single melanophore appears on the dorsal surface of the head above the mid-brain at 3,8 mm BL. A single melanophore develops at the anterior edge of the anus, the internal peritoneal melanophores dorsal to the gut expand and another internal melanophore appears at the anterior edge of the gut coil below the pectoral base (Figure 1B). Lateral pigment first appears as isolated melanophores midway between the anus and tip of the notochord when larvae are 4,5 mm BL. These stellate melanophores increase in number so that postflexion larvae < 10 mm BL bear a characteristic medio-lateral band of pigment between the anus and caudal peduncle (Figure 1C–E). In addition, postflexion larvae have dorsal and ventral pigment on the caudal peduncle. A single melanophore at the angle of the jaw is apparent in postflexion larvae from 6,4 mm BL. Numerous melanophores develop dorsally on the head of postflexion larvae (Figure 1E) and from 10 mm BL these increase in number and spread down onto the operculum. Pigmentation also develops on the upper and lower jaws and on the snout. At 10 mm BL melanophores appear at the base of the dorsal fin elements and by 11,5 mm BL these form a double row of melanophores extending to the

Table 1 Morphometrics of *Spondyliosoma emarginatum* larvae. Size class ranges are in mm body length, mean values are percentages of body length and blanks indicate absence of specimens

Body length	*n*	Head length	Snout length	Eye diameter	Body depth	Pre-anal length	Pre-gas bladder length
2,0– 2,9	1	21,0	5,0	8,0	18,0	38,0	
3,0– 3,9	14	20,8	5,0	8,7	18,9	36,9	24,1
4,9– 4,9	5	23,4	5,8	9,0	20,2	39,0	26,0
5,0– 5,9	7	25,1	6,7	9,3	21,4	39,4	28,3
6,0– 6,9	2	28,5	7,5	9,5	23,0	42,5	28,5
7,0– 7,9							
8,0– 8,9							
9,0– 9,9	1	33,0	10,0	10,0	23,0	54,0	37,0
10,0–10,9							
11,0–11,9	1	33,0	9,0	11,0	23,0	59,0	35,0
12,0–12,9	5	36,0	9,2	11,6	26,6	60,2	36,2
13,0–13,9	4	36,0	9,3	11,8	27,8	61,0	36,7
14,0–14,9	4	36,8	9,5	12,0	27,8	58,5	35,7
15,0–15,9	4	37,0	8,5	13,5	28,0	58,3	37,5
16,0–16,9	1	36,0	9,0	13,0	28,0	58,0	38,0
17,0–17,9	1	34,0	9,0	12,0	29,0	55,0	36,0
18,0–18,9							
19,0–19,9							
20,0–20,9	1	37,0	10,8	13,0	31,0	62,0	39,0
21,0–21,9	3	37,7	9,0	12,7	31,0	60,3	38,3
22,0–22,9	4	36,3	9,5	12,8	31,8	59,5	37,3
23,0–23,9	1	37,0	9,0	12,0	31,0	61,0	38,0
24,0–24,9	1	38,0	9,0	13,0	30,0	59,0	38,0

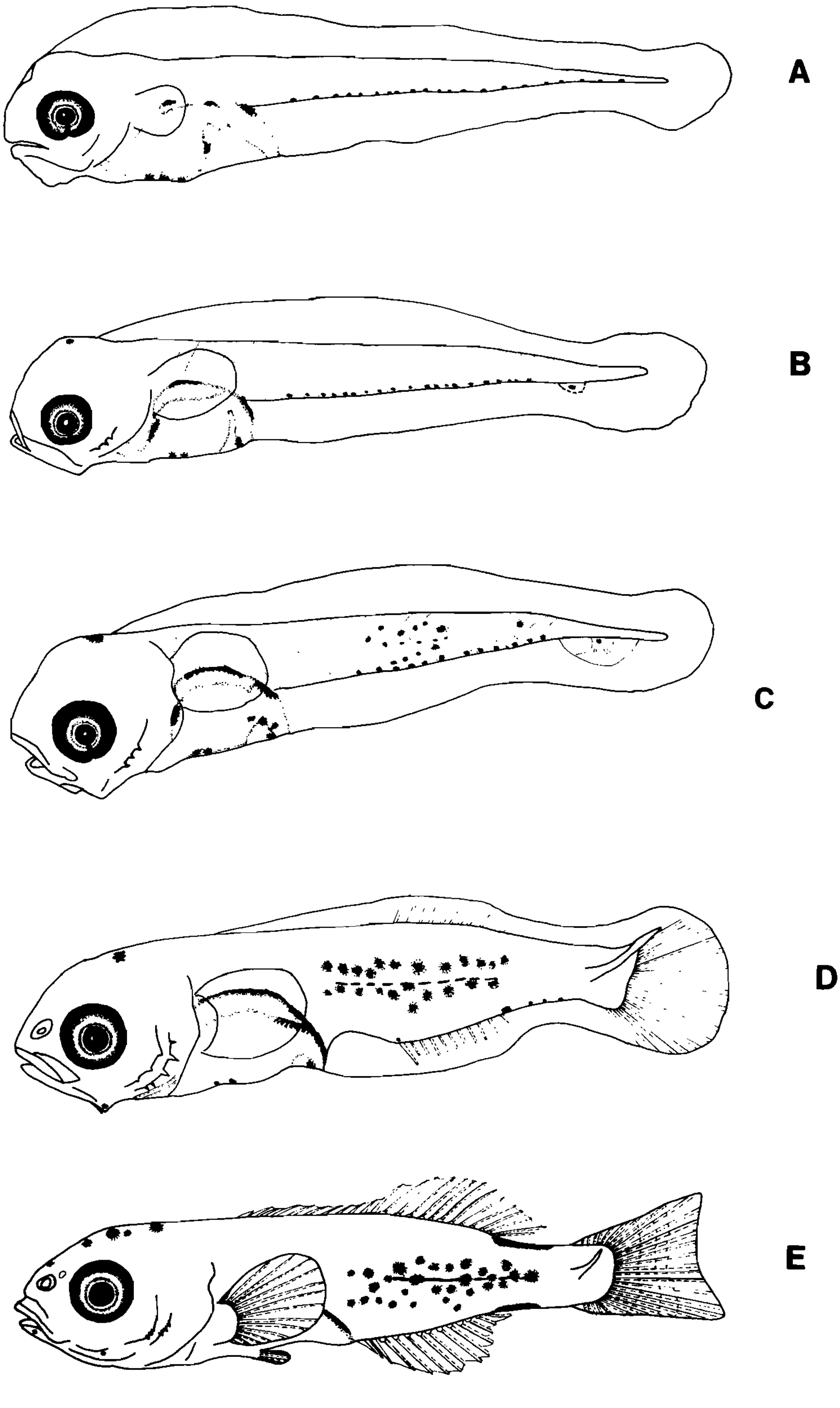

Figure 1 Larval development of *Spondyliosoma emarginatum.* A — 2,7 mm BL; B — 4,4 mm BL; C — 5,1 mm BL; D — 6,6 mm BL; E — 9,6 mm BL.

origin of the dorsal fin. Melanophores also develop between the head and dorsal fin and a saddle of melanophores extends down from the nape to the midline above the pectoral fin. By 12,5 mm BL additional external melanaphores appear between the mediolateral pigment band and the dorsal and anal fins so that by 14,5 mm BL the sides of the postflexion larva with the exception of the gut area are covered with pigment. In a 17,4 mm BL specimen a well-defined sensory lateral line is evident and pigment covers the entire body except for the flank area extending from the opening of the operculum to the ventral insertion of the pectoral fin and posteriorly to the anus. This area becomes lightly pigmented in juveniles.

Fin development

Fin meristics for postflexion *S. emarginatum* larvae are given in Table 2 and details of fin development derived from cleared and stained specimens are as follows. The anlage of the caudal fin is evident from 4,3 mm BL and in a 6,4 mm BL postflexion larva the principal elements of the caudal fin have ossified and four hypurals are differentiated. By 9,3 mm BL the four hypurals are ossified and five cartilaginous precurrent caudal elements have formed dorsal and ventral to the principal caudal rays. By 11,7 mm BL a fifth ossified hypural is apparent and the full complement of principal and procurrent caudal elements is present (9 + 8 / 9 + 9).

Pectoral buds are present in the smallest larvae examined and pectoral elements are differentiated but not ossified by 6,4 mm BL. By 9,3 mm BL the coracoids and pterygoids stain positively for cartilage and the 16 pectoral elements are ossified. A pelvic fin anlage is evident at 6,4 mm BL, by 9,3 mm BL this fin comprises 4 ossified elements and by 11,7 mm BL it is complete with six elements.

Soft rays in the dorsal and anal fins develop before the spines (Figure 1D) and by 9,3 mm BL the elements of the dorsal and anal fins are ossified with cartilaginous pterygiophores evident at the bases of the fin elements. By 11,7 mm BL three cartilaginous predorsals have developed and the dorsal fin comprises 11 spines and 12 rays. The anal fin consists of two differentiated spines and 11 elements and at 12–13 mm BL the adult complement of three spines and 10 rays is attained by transformation of the first soft ray into a spine.

Although the pectoral buds appear before the caudal fin, the sequence of ossification is reversed. The sequence of appearance and ossification of the dorsal and anal fins is uncertain owing to the shortage of specimens in the 6–9 mm BL size range. The pelvic fin is the last to appear and ossify. The sequence of fin formation can be summarized as C — ? (D — A) — P1 — P2. Scales are present on all specimens > 14 mm BL.

Table 2 Fin development in postflexion larvae of *Spondyliosoma emarginatum.* Blanks indicate absence of character, Pect = pectoral fin, Caud[1] = principal caudal elements, Caud[2] = procurrent caudal elements (dorsal/ ventral)

BL (mm)	*n*	Pect	Caud[1]	Caud[2]	Anal	Dorsal	Pelvic
6,0	1	Bud	Anlage				
6,6	1	Bud	9+7		11	10	Anlage
9,6	1	16	9+7	6/6	II11	IX13	6
11,8	1	16	9+8	9/8	II11	XI11	6
12,0–12,9	5	16	9+8–9	8–10/8–9	II–III10–11	XI11–12	6
13,0–13,9	4	16	9+8–9	9–10/8–9	II–III10–11	XI11–12	6
14,0–14,9	4	16	9+8–9	8–9/8–10	III10	XI11–12	6
15,0–15,9	4	16	9+8	9–10/9–10	III10	XI12	6
16,3	1	16	9+8	9/8	III10	XII2	6
17,4	1	16	9+8	9/9	III10	XI12	6
20,6	1	16	9+9	9/9	III10	XI12	6
21,0–21,9	3	16	9+8	9/9	III10	XI12–13	6
22,0–22,9	4	16	9+8	9/9	III10	XI12–13	6
23,1	1	16	9+9	9/9	III10	XI12	6
24,2	1	16	9+8	9/8	III10	XI13	6

Ossification

From the series of cleared and stained specimens the following sequence in skull development was determined. The cleithrum develops first and stains for cartilage by 3,2 mm BL and for bone from 3,8 mm BL. The supracleithrum is ossified by 5,5 mm BL and the postcleithrum by 9,3 mm BL. Cartilaginous branchiostegals are present at 3,2 mm BL with four pairs ossified by 5,5 mm BL and six pairs by 6,4 mm BL. At 3,2 mm BL the jaws are differentiated with the premaxilla, dentary and articular elements staining for cartilage. At 3,8 mm BL the premaxilla stains for bone and by 4.1 mm BL the dentary is also ossified. The maxilla is ossified at 4,9 mm BL and the articular at 5,5 mm BL. Sharp conical teeth are evident on the premaxilla and dentary from 5,5 mm BL. The parasphenoid stains for cartilage from 3,2 mm BL and is ossified by 4,9 mm BL. Ossification of the preopercle commences with the development of small preopercular spines that number two at 4,1 mm BL, three at 4,9 mm BL, seven at 5,5 mm BL and finally by 6,4 mm BL the preoperculum is well ossified and bears nine small spines. With increase in body length these spines become reduced in relative size so that in small juveniles (> 30 mm BL) preopercular spines are no longer evident. Ossification of the supraorbital, frontal and quadrate regions commences from 6,4 mm BL and by 9,3 mm BL most of the skull elements including the operculum are ossified. The gill rakers are also evident at this stage and by 11,7 mm BL specimens have the minimum adult complement of 7 + 15 gill rakers.

The notochord stains positively for cartilage at 3,2 mm BL. The first two trunk vertebrae are ossified by 5,5 mm BL and by 6,4 mm BL, 17 vertebrae, complete with haemal and neural spines, have ossified sequentially from the trunk to the caudal region. By 9,3 mm BL all 24 vertebrae are ossified and the haemal and neural spines of all except the last three vertebrae are ossified. All vertebral spines are ossified by 11,7 mm BL.

Four pairs of cartilaginous pleural ribs are evident by 9,3 mm BL. At 11,7 mm BL there are six pairs of ossified ribs subtended by vertebrae 3–8 inclusive, and seven pairs of epipleural ribs on vertebrae 1–7.

Discussion

The demersal eggs and nesting behaviour of *S. emarginatum* (Van Bruggen 1965) are unusual in that sparid eggs are usually pelagic (Brownell 1979; Johnson 1984). *S. canthurus,* the European species, also produces demersal eggs that have been described as about 1 mm in diameter and flattened ventrally and laterally where they adhere to the substrate and neighbouring eggs (Wilson 1958).

The larvae of *S. emarginatum* described and illustrated in this paper resemble the 3,2 mm BL and 5,3 mm BL larvae of *S. canthurus* described from the south of

England (Russell 1976). However, in *S. canthurus* there appear to be melanophores on the head in the 3,2-mm specimen and on the caudal fin and lower jaw in the 5,3-mm specimen. In addition, it appears that in *S. canthurus* flexion is complete by 5,3 mm. The 9–14 mm BL juveniles of *S. canthurus* described by Ranzi (1933) are similar to those of *S. emarginatum* and also have conspicuous medio-lateral pigmentation.

The larvae of only nine of the 41 species of Sparidae occurring off the coast of southern Africa have been described. These are *Argyrosoma argyrosoma, Chrysoblephus gibbiceps, Rhabdosargus globiceps, Rhabdosargus sarba, Diplodus cervinus, Diplodus sargus, Gymnocrotaphus curvidens, Lithognathus mormyrus* and *Pachymetopon blochii* (Gilchrist 1903, 1916; Brownell 1979; Kinoshita 1986). The medio-lateral pigmentation of flexion and postflexion larvae of *S. emarginatum* makes them readily distinguishable from similar stages of larvae of these nine species. However, the preflexion larvae of *S. emarginatum* can easily be confused with those of *D. sargus, D. cervinus* or *L. mormyrus* although *D. cervinus* has more marked pigmentation around the gut and anterior part of the body and *D. sargas* and *L. mormyrus* have characteristic dorsal pigmentation in the postorbital and shoulder regions (Brownell 1979).

Although the larvae of many northern hemisphere Sparidae have been described (see Ranzi 1933; Houde & Potthoff 1976; Mook 1977; Johnson 1978; Hussain, Akatsu & El-Zahr 1981; Divanach, Kentouri & Paris 1982; Karrer 1984; Fukuhara 1985; Kinoshita 1986; Houde, Almatar, Leak & Dowd 1986), relatively little is known of the larval development of the largely endemic sparid ichthyofauna of southern Africa. As these endemic sparids are an important component of the commercial and recreational line fishery along the southern African coast (Van der Elst 1981; Smith & Heemstra 1986) further studies of their early life history stages are clearly needed.

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