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Larval development of the Patagonian brotula *Cataetyx messieri* (Pisces, Bythitidae) from fjords of southern Chile

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Larvae of *Cataetyx messieri* (Bythitidae) are described from 14 individuals (12·3–27·9 mm body length) collected in deep fjords and channels of the inland sea of southern Chile (41–55° S), between 137 and 604 m depth. The larvae are elongate, with a large, flattened mouth and a coiled gut. They are lightly pigmented and show three distinctive features: a band of melanophores from the snout to the opercle, melanophores spread over the dorsolateral surface of the stomach and the intestine and a band of melanophores on both dorsal and ventral margins of the tip of the tail and adjacent finfold.

Key words: Bythitidae; *Cataetyx*; ichthyoplankton; southern Chile.

The brotulas of the family Bythitidae are small benthic fishes that inhabit shallow waters to the continental slope, with circumglobal distribution in tropical and temperate waters (Leis & Rennis, 2000). The family contains 107 species included in 37 genera (Nelson, 2006). All bythitids are live bearers (Wourms & Bayne, 1973; Goodwin *et al.*, 2002) and release elongate larvae with a striated gut. The larval bithytids have been documented in a few species (Meyer-Rochow, 1972; Wourms & Bayne, 1973; Gordon *et al.*, 1984; Ambrose, 1996; Leis & Rennis, 2000). They are elongate with relatively large heads and preanal lengths 40–50% of body length (L_B). They have a straight gut that coils during development, either during intraovarian or external development. A remarkable feature of all known bythitid larvae is observed in notochord flexion; it occurs at a relatively large size (>17mm) and the process continues even until transformation (Sabatés & Fortuño, 1988; Ambrose, 1996).

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The genus *Cataetyx* has a worldwide distribution in tropical and temperate regions (Bañón, 2001) and contains 12 known species. According to Nielsen *et al.* (1999), the genus is in need of revision; there are at least two morphotypes that differ according to the size and colour of the adults that may correspond to different genera. One morphotype comprises large (up to 650 mm standard length, L_S), dark coloured specimens, and this would appear to be typical of *Cataetyx laticeps* Koefoed, whereas the other morphotype comprises smaller (up to 300 mm L_S), light coloured specimens, and is more typical of *Cataetyx alleni* (Byrne). Nielsen *et al.* (1999), however, noted that the type species of *Cataetyx*, *Cataetyx messieri* (Günther) has characteristics of both groups; adult specimens are <280 mm, but the body is uniformly dark brown with ventral parts of the head and trunk pale (Nakamura, 1986). Only three species have been collected in the south-eastern Pacific Ocean (Pequeño, 1989) (Table I). Two of them occur along the coast of northern and central Chile (from 18°24′ S to 35°38′ S) and are normally caught in deep trawls: *Cataetyx rubrirostris* Gilbert (between 280 and 820 m depth) and *Cataetyx simus* Garman (between 170 and 900 m depth) (Kong *et al.*, 1988; Sielfeld & Vargas, 1996).

Nielsen *et al.* (1999) thought that specimens of *Cataetyx* from the Gulf of Panamá and Chile may correspond to an undescribed species, although other studies have not confirmed this (I. Kong & W. Sielfeld, pers. comm.). The third species, the Patagonian brotula *C. messieri* occurs south of 42° S at depths below 350 m (Günther, 1887; Chirichigno *et al.*, 1982; Ojeda, 1983; Nakamura, 1986). Little is known of the biology of this species, which appears as by-catch in the southern blue whiting *Micromesistius australis* Norman fishery (J. C. Quiroz, pers. com.). The larvae of the Patagonian brotula *C. messieri* are described here using specimens collected during several surveys carried out in Chilean fjords (Balbontín & Bernal, 1997; Bernal & Balbontín, 1999).

The larvae of *C. messieri* are extremely rare, as only a total of 14 specimens (12·3–27·9 mm) were collected from five oceanographic surveys over 5 years around southern Chile, in a latitudinal range encompassing >1500 km (41°30′–55° S). The cruises were during October to November 1995, September 1998, October 1998, November 2002 and August 2003. Samples were collected onboard the Chilean navy Auxilliary General Oceanographic Research

TABLE I. Meristic counts and adult distribution of bythitid species along the Chilean coast

	D	A	P_1	P_2	Br	GR	Distribution	Reference
Cataetyx	105	75	24	1			47°49′ S	Günther (1887)
messieri	*c.* 100	*c.* 70	25–28	1	8	3	44–55° S	Nakamura (1986)
	100–116	76–86	22–32	1	8	3	44–55° S	Nielsen *et al.* (1999)
Cataetyx	100–104	74–80	24–26	1			21°28′–35°38′ S	Kong *et al.* (1988)
rubrirostris	100–114	76–86	25–26	1	8	3	29°40′–46° N	Ambrose (1996)
	100–116	76–86	22–32	1	8	3		Nielsen *et al.* (1999)
Cataetyx	98–109	75–85	28–29	1			19°19′–35°32′ S	Kong *et al.* (1988)
simus	93–107	69–83	22–32	1	8	3	8–10° S	Nielsen *et al.* (1999)

A, anal fin rays; Br, branchiostegal rays; D, dorsal fin rays; GR, gill rakers; P_1, pectoral fin rays and P_2, pelvic fin rays.

(AGOR) R. V. *Vidal Gormaz* using a bongo net (0·6 m diameter, 350 μm mesh, TSK flowmeters; Tsurumi-Seiki-Kosakusho Co. Ltd., Yokohama, Japan). Samples were collected in oblique tows from 200 m depth, or from close to the bottom in shallow stations, and preserved in 5% formalin. The abundance of larvae was expressed as number of individuals per 10 m^2. Measurements of larvae were made to the nearest 0·01 mm. The value of L_B (Neira *et al.*, 1998) corresponds to notochord length (L_N) in preflexion, and to L_S in postflexion stages. Measurements used here are defined by Moser (1996), and correspond to body depth (BD), head length (L_H), preanal length (L_{PA}), predorsal length (L_{PD}), prepelvic length (L_{PP}), eye diameter (ED) and snout length (L_{Sn}). Pigmentation refers solely to melanophores. Two larvae (14·1 and 15·7 mm L_B) were deposited at the Museo Nacional de Historia Natural de Chile (MNHNC) (catalogue numbers MNHNC P. 7308 and MNHNC P. 7309).

The identification of the larvae as *C. messieri* was confirmed with myomere counts. The number of myomeres in a larva closely corresponds to the number of vertebrae for the species (Neira *et al.*, 1998). Additional meristic data for the largest specimens (>24 mm L_B) are also consistent with those reported for comparably sized specimens of this species (dorsal, D 100–116; anal, A 70–86; pectoral P_1 22–32; pelvic P_2 1), however, these meristics are not distinctive because they overlap with those for other species of *Cataetyx* from Chile (Table I). The other two species, however, are not found in the distributional range of *C. messieri* (which occurs south of 42° S in the south-eastern Pacific Ocean).

The larvae of *C. messieri* (Fig. 1) are elongate (BD 13·0–18·2% L_B; Table II) and have a long head (L_H 19·2–28·6% L_B) throughout their development. The mouth is large and the snout is elongate and flattened (L_{Sn} 30·7–46·1% L_H). The eyes are round and pigmented in the smallest larva examined (12·3 mm L_B), becoming proportionally smaller as the head enlarges during development (ED 14·2–28·0% L_H). The gut is moderate to long (L_{PA} 47·2–59·5% L_B) and coiled posteriorly inside the visceral cavity in the smallest larva examined. Flexion begins at *c*. 23 mm L_B. One opercular spine was evident in the largest stained larva (27·9 mm L_B; Fig. 2), which is a feature observed in the adults of the species (Møller *et al.*, 2004). The largest larva examined (27·9 mm) has small villiform teeth on the premaxilla [Figs 1(c) and 2]. They have 16–18 preanal and 46–51 postanal myomeres, 63–67 total, consistent with the vertebral counts of adults (62–64) reported by Nielsen *et al.* (1999). *Cataetyx rubrirostris* and *C. simus* have lower numbers of vertebrae (59–63 and 56–63, respectively).

The dorsal and anal fin features appear during the preflexion stage by 15 mm L_B and the fin rays begin to develop anteriorly from the end of the tail. Caudal-fin rays begin to form before 23 mm, prior to notochord flexion. Pectoral fin rays have not yet formed by 28 mm L_B. Minute pelvic buds are visible after 15 mm L_B, but no rays were observed in any specimen [Fig. 1(b) and Table II].

The larvae of *C. messieri* are lightly pigmented throughout the development (Fig. 1) and develop their main features during preflexion. Small and elongate melanophores form on the upper jaw along the premaxilla [Fig. 1]. The main pigmentation feature is the early appearance, observed in all larvae examined, of a band of small dendritic melanophores that develops from the snout to the margin of the opercle; this is a unique feature among ophidiiform larvae. Small

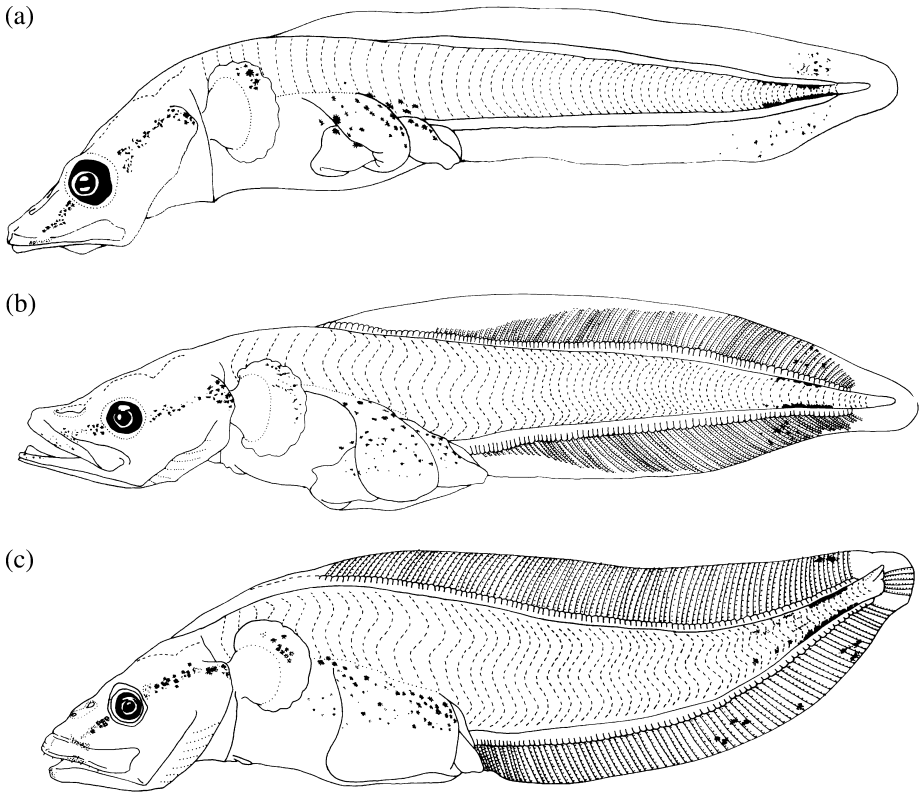

FIG. 1. Larval development of *Cataetyx messieri* at (a) 13·1, (b) 18·9 and (c) 27·9 mm body length.

melanophores develop over the upper portion of the pectoral fin membrane. The dorsolateral surface of the gut, which includes the stomach and the intestine, is 'peppered' with dendritic melanophores, mainly at the gut loop; after 18 mm L_B, this pigmentation becomes lighter [Fig. 1(c)]. Small dendritic melanophores appear dorsally and ventrally along the margins of the body immediately anterior to the tip of the notochord (Fig. 1); these melanophores are so close to each other that they form dorsal and ventral bands. In the vicinity of these bands, the finfold is also pigmented with small dendritic melanophores; they become embedded between the rays of the developing dorsal and anal fins. The melanophores on the dorsal and anal fins decrease in number with development [Fig. 1(c)]. At *c.* 15 mm L_B, a series of small melanophores develop on the tip and laterally along the margin of the dentary and persist in the largest larvae examined. The pigmentation pattern of larvae of *C. messieri* differs somewhat from other species of the genus. The larvae of *C. rubrirostris* from the California region (Ambrose, 1996) lack pigmentation on the head and pectoral fins, and the melanophores on the tail region are limited to the ventral margin (Ambrose, 1996). A small preflexion larva of *C. simus* from Colombia (Beltrán-León & Ríos, 2000) showed scarce body pigmentation, which was restricted to the dorsal and ventral margins of the tip of the tail (not in the finfolds), and a double line of small melanophores along the midside of the body.

TABLE II. Morphometric data (% of body length, L_B) and meristic counts (see Table I) for larvae of *Cataetyx messieri*

L_B (mm)	Head length (% L_B)	Snout length (% L_H)	Eye diameter (% L_H)	Predorsal length (% L_B)	Preanal length (% L_B)	Prepelvic length (% L_B)	Body depth (% L_B)	P_2	D	A
12·34	27·47	30·68	23·01	34·20	59·48	—	17·75	—	—	—
12·90	22·95	36·82	23·65	26·20	49·69	—	14·81	—	—	—
13·13	28·56	37·60	19·47	34·35	52·40	—	16·30	—	—	—
13·95	23·94	32·63	23·35	29·82	47·53	—	13·41	—	—	—
14·10	23·62	30·93	23·12	30·92	47·59	—	12·98	—	—	—
14·10	23·69	35·03	23·35	30·85	47·23	—	13·55	—	—	—
14·40	19·17	35·14	25·36	24·58	47·50	—	13·26	—	—	—
15·52	22·81	36·72	27·97	25·52	53·03	—	13·79	—	—	—
15·68	23·28	42·74	21·37	28·89	51·85	24·94	18·24	1	—	—
15·75	23·24	33·88	21·31	25·65	50·10	23·81	13·08	1	—	—
16·72	20·87	46·13	23·78	30·50	52·93	25·84	14·65	1	—	—
18·90	23·44	38·60	18·51	22·86	53·97	21·11	16·03	1	73	76
23·85	24·91	38·55	15·82	36·69	53·50	24·03	15·51	1	92	78
27·90	22·97	38·69	14·20	17·78	49·46	22·62	16·49	1	107	79

L_H, head length.

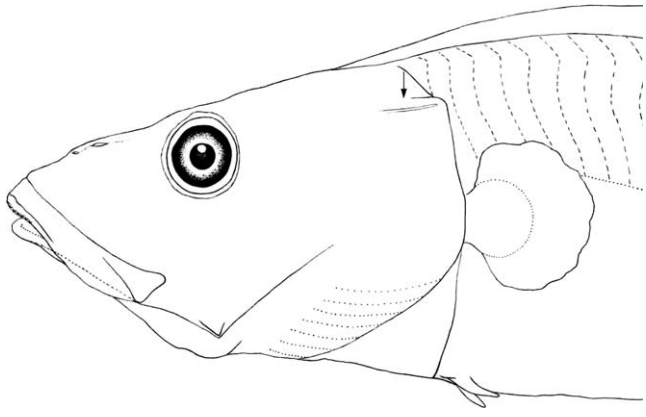

FIG. 2. Opercular spine in a 27·9 mm L_B postflexion specimen of *Cataetyx messieri* (arrow).

The larvae of *C. messieri* were caught mainly during austral spring cruises; only one specimen was collected during austral winter (August 2003). They were found in deep fjords and channels of the inland sea of southern Chile, between 137 and 604 m depth (Table III). They were not abundant, ranging between 1·94 and 44·29 individuals 10 m^{-2} (mean ± S.D., 8·79 ± 11·69 larvae 10 m^{-2}).

Among the species that occur in southern Chile, the larvae of *C. messieri* are most likely to be confused with those of the pink ling *Genypterus blacodes* (Forster), a muraenolepidid *Muraenolepis* sp. and the carapid *Echiodon cryomargarites* Markle, Williams & Olney. The larvae of these species share a similar elongate body with little pigment, and a similar myomere count in the case of *G. blacodes* and *Muraenolepis* sp. (60–68 and 67–69 myomeres, respectively; Fahay & Markle, 1984; Furlani, 1998). Pink ling larvae, however, have small teeth along both jaws in preflexion larvae >4·5 mm, a series of melanophores ventrally along the tail region, and in specimens >8 mm L_B, a row of pigment

TABLE III. Location of stations, depth and larval abundance of *Cataetyx messieri* in southern Chile

Zone	Latitude (S)	Longitude (W)	Depth (m)	Abundance (individuals per 10 m^2)
Gulf of Ancud	41°51′	73°24′	215	2·61
Moraleda Channel	44°18′	73°15′	350	9·89
	44°26′	73°28′	380	3·52
Puyuguapi Fjord	44°31′	72°39′	228	13·52
Moraleda Channel	44°41′	73°30′	322	2·08
	44°51′	73°27′	301	5·02
Aysen Fjord	45°22′	73°23′	235	6·77
Pulluche Channel	45°48′	74°26′	168	1·94
Elefantes Channel	46°28′	74°52′	137	6·17
Magellan Strait	52°58′	73°48′	515	6·54
Beagle Channel	55°03′	69°49′	604	44·29

along the lateral midline of the tail (Furlani, 1998). Larvae of *Muraenolepis* sp. have an elongate first dorsal ray and restricted gill opening, which is absent in *Cataetyx* larvae (Fahay & Markle, 1984). Larvae of *E. cryomargarites* have a higher myomere count (>80) and have a vexillum (absent in *C. messieri*), with a short and compact gut (Olney & Markle, 1979).

The larvae of bythitids show fewer morphological and pigment specializations compared to the larvae of the other families within the order Ophidiiformes (Fahay & Nielsen, 2003; Okiyama & Yamaguchi, 2004; Evseenko & Okiyama, 2006). Indeed, the typical slender body and the remarkably late, and prolonged, notochord flexion stage, cited as characteristic for larval bythitids, are generalized ophidiiform features. The larvae of the genus *Cataetyx* show few pigment specializations. The pigment on the dorsal and ventral margins of the tail, which are usually the only larval pigments recorded in species from the Mediterranean sea and Colombia (Sabatés & Fortuño, 1988; Beltrán-León & Ríos, 2000), is also a trait found in all ophidiiform genera. Compared to other species of the genus *Cataetyx*, *C. messieri* shows the unique feature of a band of pigment on the side of the head.

The larvae of *C. messieri* share a similar shape with *C. rubrirostris* (from the California Current region) and *C. simus* (from Colombia). Although the pigmentation is light in all the known larvae (Sabatés & Fortuño, 1988; Ambrose, 1996; Beltrán-León & Ríos, 2000), there are differences between species. The species *C. messieri* has a comparatively more elaborate pigment pattern, with the band of melanophores on the head being a particularly striking feature. It seems that the coiling of the gut occurs early in the ontogeny in the genus; the smallest specimens obtained of *C. messieri* (12·3 mm L_B), *C. rubrirostris* (7·3 mm L_B) and *C. simus* (5·3 mm L_B) (Ambrose, 1996; Beltrán-León & Ríos, 2000) have a coiled gut.

Within the order Ophidiiformes, the known larvae of Bythitoidei (Bythitidae and Aphyonidae) are less specialized than those included in Ophidioidei (Ophidiidae and Carapidae) (Ambrose, 1996, Okiyama & Yamaguchi, 2004; Evseenko & Okiyama, 2006). Further comparative analyses of larvae from other species of *Cataetyx*, other Bythitidae and from the related family Aphyonidae are needed in order to assess the ontogenetic significance of the features discussed here.

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