Early life history of two *Channichthys* species from the Kerguelen Islands, Antarctica (Pisces: Notothenioidei: Channichthyidae)

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Examination of 172 larvae and juveniles of the genus *Channichthys* from the Kerguelen Islands confirmed the existence of two species in this genus, *Ch. rhinoceratus* and *Ch. rugosus*. They can be distinguished by the meristic characters and pigmentation.

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Introduction

There are different views on the number of channichthyid species endemic to the Kerguelen Islands. Some authors (Hureau, 1964; Iwami & Kock, 1990) consider *Channichthys* a monotypic genus with a single polymorphic species *Ch. rhinoceratus* Richardson, 1844. Miller (1993) considered *Ch. velifer* (Meissner, 1974) a valid species. Shandikov (1995a, 1995b) proposed that *Ch. rhinoceratus*, *Ch. velifer* and *Ch. rugosus* Regan, 1913 are the valid species, and described in addition four new species, *Ch. panticapaei*, *Ch. irinae*, *Ch. bospori* and *Ch. aelitae*, and also the form "*Ch. rugosus* aff." (the taxonomic status of those needs confirmation) on the basis of the number of rows of gill rakers and some meristic and morphometric characters. Balushkin (1996) confirmed the validity of *Ch. rhinoceratus*, *Ch. rugosus* and *Ch. velifer* and described *Ch. normani* that is probably a junior synonym of *Ch. panticapaei* Shandikov, 1995.

Larvae of different species of notothenioids differ in external morphological characters, particularly, in pigmentation (North & Kellermann, 1990). Examination of larval channichthyids may provide further evidence on the number of *Channichthys* species around Kerguelen. Spawning of *Ch. rhinoceratus* occurs during summer (Hureau, 1966); however, gravid females can be found throughout the year (Koubbi et al., 1990). Yolk-sac larvae are caught during spring and summer in the coastal zone (Koubbi et al., 1990). Efremenko (1989) and Koubbi et al. (1990) described early stages of *Ch. rhinoceratus* from relatively small number of specimens (10).

For this paper, I examined 172 specimens of *Channichthys* larvae and juveniles collected by A.F. Pushkin with bottom trawl on the research ship "Skif" at the Kerguelen Islands in the Antarctic summer of 1970-1971. This has allowed me to perform a more complete description of *Ch. rhinoceratus* and to describe the larvae and juveniles identified by Efremenko (1989) as *Ch. velifer*.

Materials and methods

A total of 172 specimens of larvae and juveniles of *Ch. rhinoceratus* and *Ch. rugosus* from the collection of Zoological Institute, St.Petersburg, was examined (Table 1). Plastic and meristic characters were studied with standard methods (e.g., Balushkin, 1976). The numbers of vertebrae were determined for 8 specimens of *Ch. rhinoceratus* and 15 specimens of *Ch. rugosus* cleared and stained with alizarin red (Potthoff, 1984).

In the text and tables, standard error values are given after the mean values. Fisher's F-test is used to compare the variances. Student's t-test for equal and unequal variances is used for the comparison of the mean values.

The following abbreviations are used in the text

Table 1. Material of *Ch. rhinopceratus* and *Ch. rugosus*

Date	Station	Trawl No.	Coordinates	Depth, m	*Ch. rhinoceratus* n; TL, mm	Ch. Rugosus n; TL, mm n; TL, mm
15.XII.1970	1010.99	67	49°57'9 S, 70°29'2 E	217	11; 13.2-24.0	8; 16.4-22.1
21.XII.1970	1023/112	72	48°05'4 S, 70°38'4 E	149	3; 32.0-43.0	–
22.XII.1970	1032/121	81	47°52'2 S, 70°42'7 E	157-158	3; 27.7-57.5	3; 48.5-56.7
25.XII.1970	1045/134	95	47°52'5 S, 70°28'9 E	150	4; 47.0-54.0	23; 37.0-59.0
25.XII.1970	1046/135	96	47°56'9 S, 70°28'9 E	150	2; 52.0-73.3	11; 47.3-65.5
25.XII.1970	1048/137	98	48°03'1 S, 70°29'1 E	148	–	1; 56.0
26.XII.1970	1057/146	107	48°06'2 S, 70°36'2 E	148	2; 52.8-54.0	12; 44.5-64.5
26.XII.1970	1059/148	109	48°03' S, 70°34' E	147-149	1; 44.0	–
12.I.1971	1126/215	144	48°23'2 S, 69°7'05 E	132	7; 25.5-74.0	1; 49.0
12.I.1971	1127/216	145	48°26'3 S, 70°05' E	132	–	4; 62.5-70.0
12.I.1971	1136/225	147	48°25'2 S, 70°17'8 E	134	3; 66.2 -86.0	6; 26.0-67.5
13.I.1971	1144/233	152	48°24' S, 70°05'4 E	134	9; 26.5-73.1	–
15.I.1971	1154/243	162	48°22'5 S, 70°01'1 E	134-130	21; 17.5-106.7	2; 66.5-72.0

and tables: A – anal fin; C – caudal fin; P – pectoral fin; V – pelvic fin; ID – 1st dorsal fin; IID – 2nd dorsal fin; HL – head length; SL – standard length; TL – total length; n – number of specimens examined.

Channichthys rhinoceratus Richardson, 1844 (Figs 1a, 2a)

Meristic characters of larvae and juveniles as in Table 2. Body long, its height 9.4-12.9 (11.3 ± 0.5)% of SL. Head large, length 34.4-44.3 (37.3 ± 0.7)% of SL. Eye diameter 12.5-19.4 (17.0 ± 0.5)% of HL, interorbital width 14.0-20.5 (17.2 ± 0.5)% of HL. 2nd-4th rays of ID the longest. ID relatively low and, in specimens with SL less than 60 mm, its posterior end not reaching IID. In some specimens, ends of ID-rays free of membrane. In larvae with TL up to 55 mm, ceratobranchial with several connective tissue processes; in larger specimens, some of these processes transformed into gill rakers. Formation of gill raker beginning from the posterior end of ceratobranchial. In outer row, about 14 gill rakers in all larvae; in inner row, one gill raker in approximately 1/5 of specimens. In one damaged larva with TL 55 mm, ceratobranchial with two irregular rows of numerous connective tissue processes.

Larval pigmentation present in specimens with TL 13.2-66.1 mm (Figs 1a, 2a). Pigmentation of small larvae (Fig. 1a) corresponding to that described by Koubbi et al. (1990). Some melanophores present on anterior end of snout and on lower jaw, and a few rows of melanophores, along upper and lower jaws. Few dark melanophores present along the base of dorsal fin fold from occiput to caudal peduncle, on most of the jaw and beyond the eye. Large pigment cells visible on occiput. Body with a row of 1-3 dark pigment cells along myosepta. Peritoneum with some large melanophores on dorsal surface and a few small melanophores on ventral surface. V-base with some melanophores. Unpaired fin folds, P and C transparent. Pigment cells on V reaching maximum density on membrane between spine and 1st soft ray, and also on posterior edge of fin; most of the membrane between other rays transparent or pale with few melanophores.

Pigmentation of larvae with TL more than 38 mm (Fig. 2a) generally corresponding to brief description by Efremenko (1989). Snout, lacrimal and throat only with few small melanophores. Irregular row of small melanophores along upper and lower jaw forming tight spots near symphyses. Occiput with a spot of large pigment cells. Cheek with a few small melanophores; posterior end of lower jaw with characteristic large vertical melanophores. Small spots of melanophores present at the joint of inter- and suboperculum and along lower temporal canal

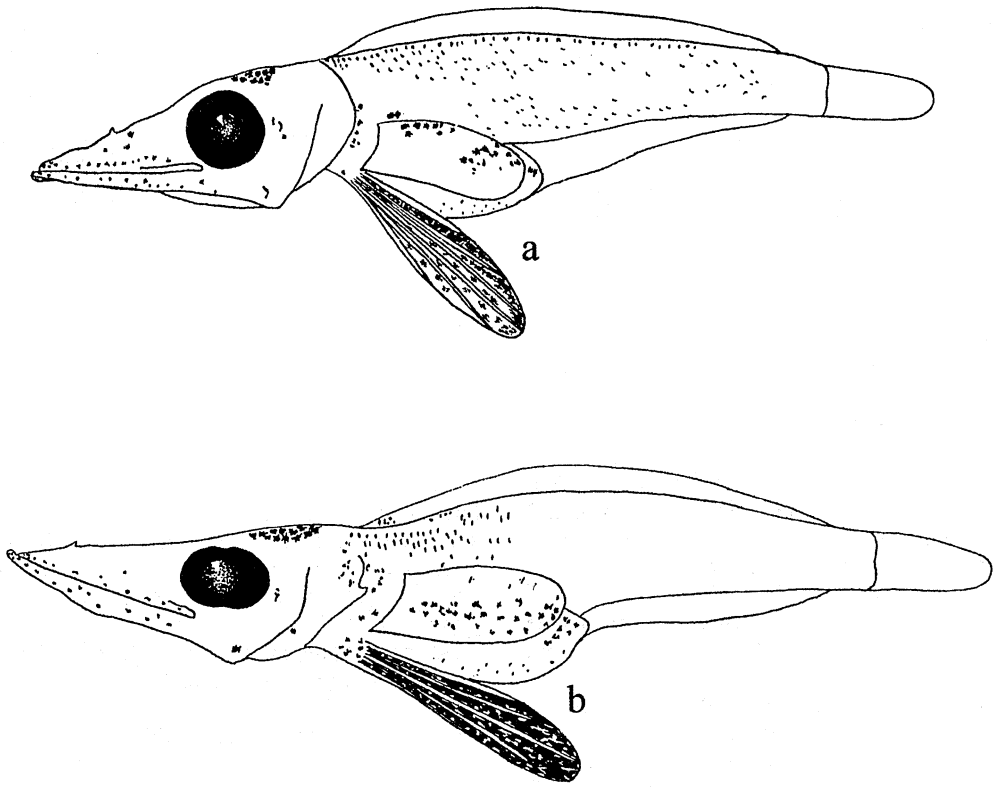

Fig. 1. Larvae of *Channichthys rhinoceratus*, TL = 17.5 mm (a), and *Ch. rugosus*, TL = 16.8 mm (b).

of seismosensorial system. Posterior to head on some extent, small bright superficial pigment cells arranged in two irregular rows and posteriorly, in a scalloped row reaching posterior end of ID-base. Dorsal and ventral rows of melanophores present along the bases of the IID and A. Both dorsal and ventral septa up to end of caudal peduncle with 1-3 large melanophores. Bases of P and V, and upper part of peritoneum with some large pigment cells. ID transparent or with some large melanophores on membranes; IID membrane with few melanophores; A transparent. Small melanophores densely densely distributed over V-rays. Distribution of melanophores on V, and its membrane coloration as in smaller larvae (see above), but V-membranes transparent or pale with few melanophores. On C-base, a narrow vertical pigment bar reaching the beginning of C-rays.

Juvenile pigmentation present in specimens with TL more than 48.9 mm. In juveniles, many elements of larval pigmentation retained. Moreover, body side at the level of beginning and end of IID with two light spots of small melanophores; later, a small spot appearing between them, and two spots, at beginning and end of ID. Still later, those spots enlarge and become darker, and larval pigmentation on body turns light. Scalloped row of melanophores is retained along the base of the dorsal fins. Pigmentation of ID and V increasing. From TL of 106.7 mm, adult coloration observed; juvenile spots dividing into small dark spots; ID and V turning into black.

Ch. rugosus Regan, 1913
(Figs 1b, 2b)

Meristic characters of larvae and juveniles as in Table 2. Body relatively longer and deeper than in *Ch. rhinoceratus*, its height 10.7-14.7 (12.6 ± 0.5)% of SL. Head large, 34.4-41.1 (36.4 ± 0.4)% of SL, eye diameter 14.0-21.2 (17.5 ± 0.3)% of HL, interorbital space 15.3-21.1 (18.3 ± 0.3)% of HL. 2nd-4th rays of ID the longest. Posterior

Table 2. Meristic characters of *Ch. rhinoceratus* and *Ch. rugosus* and their comparison. (in each cell, range of deviation of character [underlined] and mean value with standard error are given; *n*, number of specimens used for calculations of values in the subsequent columns)

Species	n	ID	IID	A	P	n	Vertebrae number
Ch. rhinoceratus	60	V-VIII 6.7±0.09	32-35 33.3±0.21	30-33 31.2±0.26	19-22 20.6±0.13	8	55-58 56.8±0.48
Ch rugosus	64	VI-X 7.5±0.12	30-34 32.1±0.18	28-32 30.3±0.14	18-22 19.5±0.12	15	52-55 53.6±0.26
t-criterium value		5.35 (p<0.001)	4.32 (p<0.001)	3.05 (p<0.01)	6.19 (p<0.001)		6.13 (p<0.001)

end of ID usually reaching IID. In some specimens, ends of ID-rays free of membrane. Formation of gill raker similar to that in *Ch. rhinoceratus*. In one specimen with TL 56.4 mm, 7 gill rakers and 8 connective tissue processes in external row and 6 connective tissue processes in internal row.

Larval pigmentation described from postlarvae and juveniles with TL 16.4 and 66.2 mm (Fig. 1b). Head pigmentation of small larvae similar to that of *Ch. rhinoceratus*. Body with row of dark pigment cells along the base of dorsal fin fold consisting of only a few melanophores. 1-3 melanophores present in dorsal septa above peritoneum. V black.

Pigmentation of larvae with TL 40.0 mm similar to that of *Ch. rhinoceratus*, but small dark superficial melanophores few (5-15) beyond the head and absent behind posterior end of ID. Dorsal and ventral body septa usually with 1-2 melanophores being lighter than in *Ch. rhinoceratus*; posterior caudal part of body without pigmentation. Pigment cells often absent along IID-base. In some larvae, pigmentation of body represented by one row of melanophores along A-base only. Membrane of ID more or less coloured; P sometimes not pigmented; V with intensely black-coloured membrane between all rays.

Juvenile pigmentation observed in specimens with TL 49.0 mm or more (Fig. 2b) and very simi-

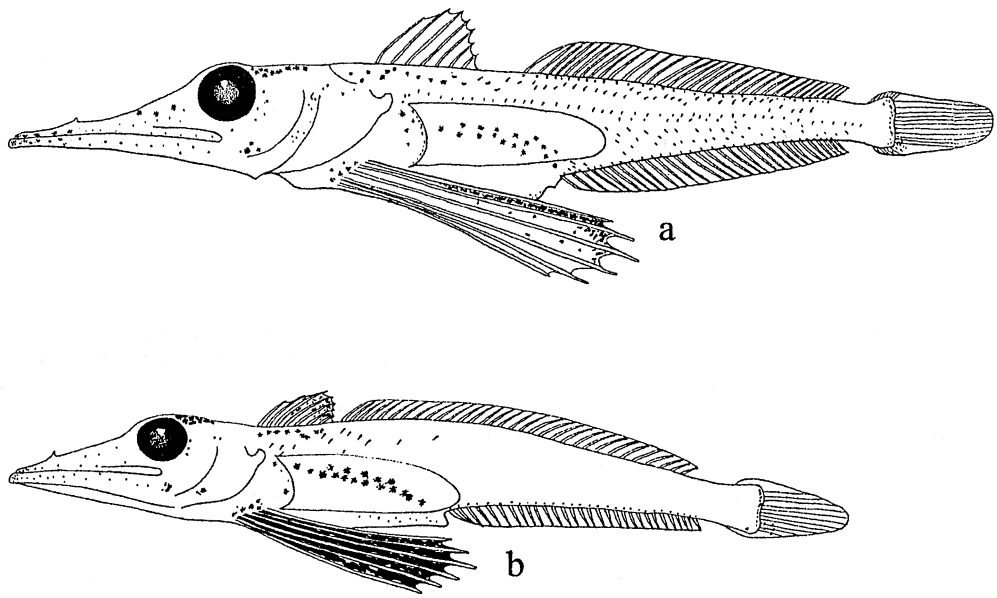

Fig. 2. Larvae of *Channychthys rhinoceratus*, TL = 48.9 mm (a), and *Ch. rugosus*, TL = 45.6 mm (b).

lar to that of juvenile *Ch. rhinoceratus*. In all juveniles of *Ch. rugosus*, pigment spots on body well expressed and situated as in *Ch. rhinoceratus*. The most significant difference from the larvae of *Ch. rhinoceratus* is that in *Ch. rugosus* there are not more than 10 melanophores in the row below the base of ID.

Discussion

Variability of the meristic and morphometric characters (besides the number of vertebrae) in both species of *Channichthys* is considerable (Table 2). Although the meristic and morphometric characters of both species overlap, the mean values differ from each other statistically ($p<0.01$; Table 2). Numbers of vertebrae in larval and juvenile *Ch. rhinoceratus* and *Ch. rugosus* rarely overlap (55-57 and 52-55, respectively) and distinctly differ from each other as well ($p<0.01$; Table 2).

The most consistent differences among two species are the relative size of ID (in *Ch. rugosus*, ID is higher and reaches the beginning of IID) and the larval pigmentation, including the presence or absence of small dark superficial pigment cells in the scalloped row below the dorsal fins, the number and expression of melanophores on intermuscular septa, and pigmentation of V. These differences confirm the results published by Efremenko (1989). However, the pigmentation of juveniles of these two species is more similar than that described by Efremenko (1989). Larger specimens differ only in the presence or absence of the scalloped row of melanophores below the dorsal fins. Efremenko (1989) identified specimens in his material as *Ch. rhinoceratus* and *Ch. velifer*. However, the ray number in ID of *Ch. velifer* reported by Efremenko (1989) is equal to VIII-IX that does not correspond to the original description of this species (Meissner, 1974: ID ray number X-XI) and the later descriptions (Miller, 1993; Shandikov, 1995a, 1995b; Balushkin, 1996).

The pigmentation of larvae and juveniles described by Efremenko (1989) is comparable to our description of *Ch. rugosus*, whereas the number of vertebrae in our specimens of *Ch. rugosus* is smaller. Our specimens also have relatively small average numbers of IID, A and P rays, which is similar to the characters of the holotype of *Ch. rugosus* (IID 30; A 29; P 18/19) (Regan, 1913; Balushkin, 1996). There is no *Ch. velifer* in our material, since the specimen with only ten ID-rays has IID 30 and P 19, which does not correspond to the characters of *Ch. velifer* (Meissner, 1974).

Most specimens of both species have one gill raker row on the ceratobranchial and cannot be identified as *Ch. panticapaei*, *Ch. irinae*, or *Ch. bospori*, which are characterized by two rows of gill rakers on 1st gill arch (Shandikov, 1995b), proposed that these three species are valid. However, one specimen of *Ch. rhinoceratus* and one specimen of *Ch. rugosus* had two rows of the connective-tissue processes on the ceratobranchial. Obviously, not all these processes will transform into gill rakers, and it is impossible to be certain if there might have been one or two gill raker rows, if they had fully developed. Thus, on the basis of pigmentation and vertebrae number, these specimens were identified as *Ch. rhinoceratus* and *Ch. rugosus*.

None of our specimens identified as *Ch. rhinoceratus* can also be identified as *Ch. aelitae* (if it is valid), inasmuch as they do not have the combination of morphometric characters described by Shandikov (1995b): interorbital space 20.2-22.1 % of HL, diameter of eye 18.2-18.9 % of HL.

Considering that ID-rays are free from membrane in some larvae of both species, this character may be variable and probably has no high systematic value.

In conclusion, the differences in pigmentation and vertebrae number in larvae and juveniles give an additional confirmation of the validity of two *Channichthys* species, *Ch. rhinoceratus* and *Ch. rugosus*.

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