



***Fundulopanchax kamdemi* (Cyprinodontiformes: Nothobranchiidae) a new species from Korup National Park, western Cameroon**

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Abstract

Fundulopanchax kamdemi, new species, is described from small swampy pools and rivulets of the Ndiang and Akpa-Yafe River systems, Cameroon. *F. kamdemi* is distinguished from all other known *Fundulopanchax* species by a unique male coloration and from most congeners by a higher number of rays in dorsal and anal fins.

Key words: Nothobranchiidae, *Fundulopanchax kamdemi* sp. nov., Western Central Africa, systematics

Introduction

The Nothobranchiidae are the most speciose of the African cyprinodontiform families and have their highest diversity in the two main rainforest areas of West and Central Africa. Of these two, the Central African rainforest area is the most diverse and species rich. Within this region, two large and endemic groups of nothobranchiids, *Fundulopanchax* and *Aphyosemion* have a partially overlapping distribution. The knowledge about phylogeny and biogeography of both genera increased in recent years as well as the number of known species. However, the knowledge of the distribution of some species is limited as they are known from a small number of localities, often far apart (Huber, 2000; Wildekamp, 1996).

Fundulopanchax was originally described by Myers (1924) as a subgenus in *Aphyosemion* Myers, 1924 but his diagnostic characters were not adopted in subsequent revisions. On the basis of two synapomorphic characters, Parenti (1981) recognized *Fundulopanchax* as a monophyletic sister group to *Nothobranchius* Peters, 1868 and consequently designated *Fundulopanchax* as a genus. Van der Zee and Wildekamp (1994) accepted the generic status of *Fundulopanchax*, but the value of Parenti's (1981) diagnostic characters was disputed. Additionally, they found four diagnostic characters for the genus *Fundulopanchax*: chorionic structure (puncti), anal-fin skeleton (lateral processes on anal radials reduced), otolith morphology and caudal peduncle squamation (16 or more scales, except *Paludopanchax* Radda, 1977) (see Van der Zee & Wildekamp, 1994). Murphy and Collier (1999), using mitochondrial DNA sequences, corroborated the generic status of *Fundulopanchax*, but they did not, in most cases, find correlation between the species groups as proposed by Radda (1977) on morphological arguments. In Murphy and Collier (1999), *Aphyosemion* is the sister group to *Fundulopanchax*, whereas in a second molecular genetic study, based on more limited material and focused on the evolution of diapause in New World Rivulidae, by Hrbek and Larson (1999), *Aphyosemion* is the sister group to a clade comprised of *Fundulopanchax* and *Nothobranchius* (Fig. 1). Morphological char-

acters discriminate between *Aphyosemion* and *Fundulopanchax* but it should be the subject of a future study if they are apomorphies of a monophyletic group *Fundulopanchax*, or if in a broader study with the remaining African Nothobranchiidae, they will be assessed as plesiomorphic characters.

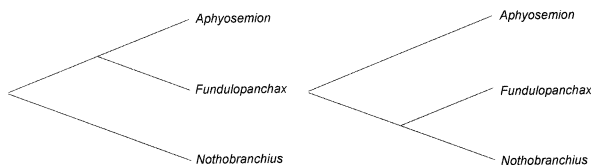


FIGURE 1. Schematic version of Murphy and Collier's (1999) and Hrbek and Larson's (1999) phylogenetic hypotheses.

The distribution of *Fundulopanchax* ranges from Côte d'Ivoire to Equatorial Guinea with the highest species diversity in southeastern Nigeria and adjacent southwestern Cameroon (species numbers and distribution see Huber, 2000; Wildekamp, 1996). Within this area lies the Korup National Park in Cameroon, the fish fauna of which was first studied by McGregor Reid (1989). Up to 140 species were identified from the rivers draining the park, upper Cross, Ndian and Akpa-Yafe. With regard to the cyprinodontiform fishes, eleven different types were recognized of which only three, *Aphyosemion* (*Chromaphyosemion*) *bivittatum* (Lönnberg, 1895), *Epiplatys sexfasciatus* Gill, 1862 and *Aplocheilichthys spilauchen* (Duméril, 1859) were identified to the species level. Kamdem Toham (1992) studied the cyprinodontiform fishes of the southern part of the park in more detail. The three species that could be identified in McGregor Reid (1989) were rediscovered and two more, *Aphyosemion calliurum* (Boulenger, 1911) and *Fundulopanchax marmoratus* (Radda, 1973), added. Like McGregor Reid, Kamdem Toham was also unable to identify the four collected phenotypes of the genus *Procatopus* Boulenger, 1904 and two collected species of *Aphyosemion*.

Based on specimens collected by A. Kamdem Toham, G. Chiambeng and C. Akum, we were able to identify the unknown cyprinodontiform phenotypes of Kamdem Toham. Specimens of the McGregor Reid collection were not studied. All species and phenotypes regarded as *Aphyosemion* in Kamdem Toham (1992), with the exception of *A. (C.) bivittatum* and *A. calliurum* are referred here to the genus *Fundulopanchax*. Three out of four of Kamdem Toham's unidentified species are recognized in this study as members of the *Fundulopanchax gardneri* (Boulenger, 1911) and *F. mirabilis* (Radda, 1970) species groups. The fourth is here described as new species.

Material and methods

The description is based on specimens in the collection of the Musée Royal de l'Afrique Centrale (MRAC), and the collection of the Zoologisches Forschungsmuseum Alexander Koenig (ZFMK), a number of specimens of the type series will be sent to the IRAD Fisheries and Oceanography Research Station, Batoke, Limbe, Cameroon.

Morphometric characters were recorded by means of a micrometer and compass. Counts and data protocols follow Amiet (1987). Measurements, except where indicated, are presented as percentages of standard length (SL). All visible rays of dorsal and anal fin were counted; the count of scales on the mid-longitudinal series is the number of scales between upper attachment of the opercular membrane and caudal-fin base. Excluded are the small scales posterior to the hypural junction, which were counted separately. Nomenclature for supra-orbital (frontal) squamation follows Hoedeman (1958). Terminology for cephalic neuromast systems follows Scheel (1968).

***Fundulopanchax kamdemi*, new species**

(Figs. 2–4)

Aphyosemion sp. 01 (cf. *A. cameronense*)=(McGregor Reid, 1989: 27)

Aphyosemion sp. (KORUP 01) (Kamdem Toham, 1992: 6–10)

Fundulopanchax sp. aff. *ndianus* (Wildekamp, 1996: 193–194)

Aphyosemion aff. *amieti* (Huber, 1996: 323)

Fundulopanchax aff. *ndianus* (Huber, 2000: 472)

Holotype. MRAC A2–003–P–0001, male, 50.0 mm SL; Cameroon: Korup National Park, small pools under forest cover; 05°05'N 08°52'E; G. Chiambeng, 12 January 2001.

Paratypes. MRAC A2–003–P–0002–0003, two males, 43.1–46.1 mm SL; same data as holotype.

- MRAC 92–144–P–0384–0386, 2 males, 40.5–45.7 mm SL and female, 47.3 mm SL; Cameroon: Korup National Park: west of science camp; 05°05'N 08°52'E; A. Kamdem Toham, 19 December 1992.

- ZFMK 39900–39917, 7 males, 38.3–54.4 mm SL and 11 females, 31.9–51.6 mm SL; Cameroon: Korup National Park, small forest stream emptying in swampy pools; 05°00'20"N 08°47'01"E; C. Akum, December 2001.

- ZFMK 39918–39931, juvenile specimens, not measured; Cameroon: Korup National Park, small forest stream emptying in swampy pools; 05°00'20"N 08°47'01"E; C. Akum, December 2001, same data as ZFMK specimens.

- IRAD Research Station, Batoke, Limbe, Cameroon, four specimens, two males and two females; Cameroon: Korup National Park, small forest stream emptying in swampy pools; C. Akum, December 2001.

Additional material. *Fundulopanchax kamdemi*

Fundulopanchax ndianus (Scheel, 1968),

MRAC 73–39–P–1649–1660 (paratypes); Nigeria, near Osomba, H.S. Clausen and J.J. Scheel, 1961.

MRAC 84–51–P–27–28; Nigeria, 88 km NE on MCC road. (female in this lot = *Aphyosemion calliurum*).

MRAC 84–51–P–162–163; Nigeria, Nsan village, appr. 40 km N. of Calabar (female in this lot = *Aphyosemion calliurum*).

Fundulopanchax mirabilis

MRAC A2–003–P–0004–0008; Cameroon, Korup National Park; G. Chiambeng, 12 January 2001.

Uncatalogued material in the collection of the second author, used for DNA studies, of the following species: *F. amieti*, *F. arnoldi*, *F. avichang*, *F. deltaensis*, *F. fallax*, *F. gularis*, *F. ndianus*, *F. puerzli*, *F. rubrolabialis*, *F. sjoestedti*, *F. spoorenbergi*, *F. traudeae* and *F. walkeri*.

Diagnosis. *Fundulopanchax kamdemi* shares with all other *Fundulopanchax* species except those of the subgenus *Paludopanchax* 16 or more scales around the caudal peduncle versus 12 in *Aphyosemion* s.l. It is distinguished from all *Aphyosemion* species and many *Fundulopanchax* except *F. arnoldi*, *F. deltaensis*, *F. gularis*, *F. kribianus*, *F. ndianus*, *F. robertsoni*, *F. rubrolabialis*, *F. schwoiseri*, *F. sjoestedti*, and *F. walkeri* by the high number of dorsal (15–18) and anal fin rays (16–19) (according to the descriptions and data in Huber 2000). It is distinguished from all *Fundulopanchax* species by its unique male coloration of a red longitudinal band on the middle of the sides versus no red band, with the exception of *F. amieti*, *F. avichang*, *F. deltaensis* and some individual specimens of *F. ndianus*, *F. puerzli* and *F. spoorenbergi*. It is distinguished from all *Fundulopanchax* species, except *F. ndianus* and some specimens of *F. puerzli*, by a red ventral band from the pelvic fins to the lower caudal fin base. *F. kamdemi* is distinguished from the latter species and most other *Fundulopanchax* except *F. spoorenbergi* by the coloration of the unpaired fins as given below. Females can be distinguished

from its congeners by the presence of an orange-red margin at the dorsal fin and a narrow red band at the base of the anal fin.

Description. See Figures 2–4 for general appearance and Table 1 for morphometric data of the type specimens.



FIGURE 2. *Fundulopanchax kamdemi*; Male; Korup National Park; approximately 45 mm SL, (not preserved). Photograph by W. Eigelshofen.



FIGURE 3. *Fundulopanchax kamdemi*; Female; Korup National Park; approximately 40 mm SL, (not preserved). Photograph by W. Eigelshofen.

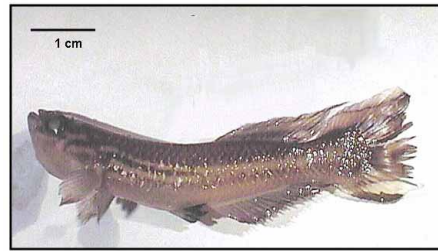


FIGURE 4. *Fundulopanchax kamdemi*; Korup National Park; Holotype, MRAC A2-003-P-0001. Photograph by D. Adriaens.

Fundulopanchax of large size. Dorsal-fin origin distinctly behind mid-length of body and just behind anal fin origin. Dorsal fin 15–18 rays, anal fin 16–19 rays. Scales on mid-longitudinal series 34–38 plus 3 or 4 on caudal fin base, most with shallow pit in centre, not connected to underlying neuromast system. Transverse rows of scales above pelvic fin 10–11; scale rows around caudal peduncle 16. Supra-orbital squamation G-pattern, with two H-scales. Anterior and central cephalic neuromast systems separated, consisting of two shallow grooves, lined with low lobes. Posterior cephalic neuromast system, consisting of 3 neuromasts, in an open curved groove, with both ends angled to approximately 90°. Preopercular neuromast system tubular with six exposing pores.

TABLE 1. Morphometric characters of *Fundulopanchax kamdemi* new species, expressed in percentages of standard length. Standard length in mm. Mean and SD figures for males include holo- and paratypes.

	holotype male	Paratype males X (n=13) (range)	SD	Paratype females X (n=13) (range)	SD
Standard length	50.0	43.5–73.0		40.0–61.7	
Body depth	21.0	17.8–21.7	20.7	17.8–23.3	21.5
Body width	10.4	10.1–12.6	11.3	11.4–17.2	14.0
Head length	26.4	23.9–28.9	26.6	22.1–28.7	26.3
Eye diameter	7.2	7.2–13.1	8.2	7.6–12.3	9.0
Interorbital width	12.2	7.4–12.7	11.9	7.6–12.7	11.5
Snout length	5.2	5.8–8.3	7.1	5.2–8.7	7.1
Pre-dorsal length	60.8	57.9–63.4	61.3	55.9–65.4	61.9
Pre-anal length	57.6	54.2–60.7	58.5	51.7–63.5	59.4
Pre-ventral length	48.0	44.1–49.3	46.9	46.0–51.4	47.5
Dorsal fin base	23.0	19.2–24.1	22.3	17.3–22.0	19.5
Anal fin base	24.6	21.0–25.6	23.1	16.3–25.5	18.7
Caudal length	20.0	18.3–22.4	20.7	19.3–24.0	20.8
Caudal depth	11.8	9.8–12.7	11.4	9.9–12.7	10.8

Males. Up to 73.0 mm SL. Body laterally compressed. Dorsal profile nearly straight. No distinct transition between head and body. Dorsal and anal fin trapezoid, pointed at distal end. Dorsal and anal fin rays slightly projecting from fin membrane. Both fins covered with a thin layer of epidermal tissue. No visible papillae on dorsal and anal fin rays. Opercular membrane slightly projecting posteriorly, distal edge smooth or only slightly wrinkled.

Many small and hair like, probably epithelial, papillae at the distal margin of the scales in the mid-longi-

tudinal and lower scale row at caudal peduncle, beginning above the anal fin. This phenomena was also described for *F. ndianus* (Scheel, 1968), *F. puerzli* (Radda & Scheel, 1974) and *F. amieti* (Radda, 1976). Scheel (1968) described it ctenoid spines at some scales. In the descriptions of *F. puerzli* and *F. amieti* these were named ctenii or 'Kontaktorgane' (contact organs) (Radda, 1976; Radda & Scheel, 1974). Similar structures were observed by us in *F. fallax* (Ahl, 1935) and *F. traudeae* (Radda, 1971). These hair like structures seem to be of a similar origin as the ctenii on the distal margin of the scales on the species mentioned above. They can vary in appearance from short and stout (*F. ndianus*) to long and hair like (*F. fallax*, *F. amieti* and *F. kamdemi* sp. nov.). It is to note that not all individuals of a species show these structures (Scheel, 1990, and own observation), which makes it difficult to draw conclusions about its distribution in the different *Fundulopanchax* species groups. The origin and function of these structures is not known and will be subject of a future study. It is thought that they play a role during spawning like the fin and scale papillae in the genus *Nothobranchius*.

Females. Up to 61.7 mm SL. Body less laterally compressed and deeper than male. Dorsal profile straight. Dorsal and anal fin trapezoid, tip rounded. Caudal fin rounded. No epidermal tissue present on dorsal and anal fins. Opercular membrane not projecting posteriorly. No papillae at the body scales.

Coloration. Males (Fig.2) Live specimen. Dorsal brown to red-brown. Sides dominated by a bright red longitudinal band, extending from upper opercle junction to caudal fin base. On anterior part of body this band may be interrupted, as in Fig. 2. On anterior part of sides a short red band or series of red spots usually below longitudinal band. Body coloration above red band reflective green to blue-green. Below band reflective light blue. Red-brown of dorsal area usually separated from the green on sides by a series of red spots. A further red band, following lower body profile, from pelvic fins to caudal fin base. Upper part of the head brown, opercle reflective green. Throat and lower part of the head light blue. On opercle three parallel oblique red streaks. Under eye a red band and a further red band just below the lower lip. Lobes lining supra-orbital neuromast systems red. Lower part of dorsal fin reflective green-blue with series of red dots at base. Dorsal fin margin yellow-green separated from green-blue by a red band. Anal fin light blue. At the base a red band. Anal fin margin dark red. Caudal fin reflective green-blue to light blue. On central part an irregular pattern of red flame-like stripes parallel to the rays. One or two flames originating from end of red body band. Upper caudal fin margin yellow-green, separated from central part by a red band. Upper caudal fin margin ending in a long extension. Lower edge of caudal fin dark red, separated from central part by a white, light blue or in some specimen yellow band. Pelvic fins light blue with red margin. Pectoral fins transparent light blue with red sub-terminal band and light blue edge.

Females (Fig. 3) Live specimen. Body coloration generally grey-brown to yellow-brown. Upper part of sides with light green cast. Lower part of sides with light blue. On middle of sides a series of red spots. On anterior part of body a second series of red spots below it. Lower part of the sides, ventrum and throat pale orange. Lower half of dorsal fin reflective green with some red spots at base. Upper half of dorsal fin orange-red. Basal part of anal fin light blue with red horizontal band. Remaining part of anal fin pale yellow with red edge. Caudal fin transparent pale green-yellow. Upper part and upper edge of caudal fin orange-red with some red spots at base. Pelvic fins orange. Pectoral fins hyaline.

Preserved in ethanol. Males (Fig. 4). Pale white-yellow band distinctly present on mid-lateral body. Longitudinal band separates dark grey-brown dorso-lateral part of body from yellow-grey ventro-lateral part. Anterior part of mid-lateral band usually consisting of two parallel horizontal lines, in some specimens represented by series of dots. The two parallel horizontal lines fuse to one band above middle of anal fin base. Upper part of head grey-brown, lower part and throat pale yellow. Opercle with 2 to 3 parallel pale white-yellow oblique bars. Dorsal fin semi-transparent grey. A purple band runs from the middle of the first dorsal fin ray to the pointed distal end separating the light grey margin from the rest of the fin. In most specimens the purple band is forked, its lower branch reaching distal dorsal fin base. At base of dorsal fin two or three purple spots. Anal fin with pale yellow band at base, followed by a pale grey part and black to dark brown margin. In

some individuals the black to dark brown band may be followed by a grey-white margin. Caudal fin purple-brown. The white-yellow body band continues in the caudal fin and ends in the upper extension. Upper caudal fin margin as dorsal fin margin. From lower part of caudal fin base a pale yellow band runs obliquely upward to about half-way along the fin. From there it runs downward, parallel to fin rays, to the lower caudal fin extension. Fin part below band purple-brown followed by grey-white submargin and black to dark brown margin.

Females. Uniform grey-brown on body and sides. Vague band of light grey-yellow spots running from the upper opercle to the caudal fin base. All fins uniformly semi-transparent grey.

Distribution. *Fundulopanchax kamdemi* is known from a limited number of localities, all within the Korup National Park. It was mentioned as *Aphyosemion* sp. 01 (cf. *A. cameronense*) in McGregor Reid (1989) from the Akpa-Yafe River and the upper Nidian River, in southern Korup only. This was confirmed by comparing the specimens, deposited by Kamdem Toham, as *Aphyosemion* sp. (KORUP 01) in the collection of the Museum for Central Africa, Tervuren, Belgium. He found them in the swampy parts that edge the small creeks under the cover of the forest in the southern Korup close to the Science camp (Kamdem Toham, 1992). Additionally the three collection localities, studied by the first author, confirmed the presence of the new species in the southern part of the Park only. Presence in the adjacent Oban National Park at the Nigerian side of the border may be possible but could not be confirmed as no collections of cyprinodontiform fishes are known from there. Other cyprinodontiform species found in sympatry with *F. kamdemi* are *F. marmoratus*, *Epiplatys infrafasciatus* (Günther, 1866) (= *E. sexfasciatus* in McGregor Reid, 1989 and Kamdem Toham, 1992), *Aphyosemion (Chromaphyosemion) bivittatum*, *A. calliurum* and *Aplocheilichthys spilauchen*. All have a larger distribution and are also known from localities outside the park.

Ecology. According to Kamdem Toham (1992) the species generally lives in the shallow swampy pools at the edge of small creeks under forest cover. These pools, up to 35 cm in depth, are partly covered with a layer of fallen leaves under which the fishes in the pools take cover.

Additional ecological information was collected by the first author. The presence of *F. kamdemi* was also recorded from small forest streams connected with swampy pools. Streams and pools are heavily shaded by peripheral vegetation and their bottom is covered by decaying leaves, branches and logs. Both the streams and pools contain clear water during the rainy season and brown tinged during the dry season. Water depths ranged during the seasons from 2 to 48.3 cm. Water temperature was measured between 20.9 and 23.8° C, the pH between 5.0 and 7.5. Water hardness varied between 0.6 and 1 DH, conductivity between 10 and 21 µS/cm and the total dissolved oxygen between 0.9 and 5.5 mg/l. Stomach contents of *F. kamdemi* indicated an insectivorous behavior and consisted of ants, crickets, beetles, spiders and cockroaches, with a predominance of ants. In the wild, maturity was observed in the months of November to January. These shallow pools dry out periodically, suggesting an annual mode of reproduction. The first observations on the breeding biology of *F. kamdemi* were carried out in captivity by K.-H. Lüke, Bochum and W. Eigelshofen, Sprockhövel, both Germany indicate that its annual mode of reproduction is facultative. Embryological development has not been studied.

The cyprinodontiform fish fauna of the Korup National park. The cyprinodont fauna of the Korup National Park and its surroundings is diverse. The collections made by McGregor Reid and Kamdem Toham (specimens collected by the latter are in the collection of the Museum for Central Africa, Tervuren, Belgium) included species of five different genera (e.g. *Epiplatys*, *Aplocheilichthys*, *Aphyosemion*, *Fundulopanchax* and *Procatopus*). McGregor Reid (1989) distinguished, based on male coloration, four different phenotypes of the genus *Procatopus* and Kamdem Toham (1992) distinguished two. Based on Van der Zee, Woeltjes and Wildekamp (in press) two *Procatopus* species occur in the vicinity of the Korup National Park, *P. aberrans* Ahl, 1927 and *P. similis* Ahl, 1927. Both are variable in male coloration at the population level, but *P. aberrans* generally is restricted to the soils of basement crystalline origin and *P. similis* to soils of sedimentary origin. In the areas surrounding the park, in Nigeria as well as in Cameroon, the occurrence of *Aphyosemion*

calliurum, *A. (Chromaphyosemion) cf. splendopleure* (Brüning, 1929), *F. sjoestedti* (Lönnerberg, 1895), *F. marmoratus*, *F. scheeli* (Radda, 1970), *F. ndianus*. (Berkenkamp, 1976) and *E. grahami* (Boulenger, 1911), have been demonstrated (Huber, 2000; Radda & Pürzl, 1982; Wildekamp, 1993, 1996).

Etymology. Named for Andre Kamdem Toham of the World Wildlife Fund's Central African Rainforest Project (CARPE) and a collector of this new species.

Discussion

The tubular preopercular neuromast system of this new species has six exposing pores, indicating that it is a representative of the *Fundulopanchax/Aphyosemion*-group within the family Nothobranchiidae of the cyprinodontiform suborder Aplocheiloidei. The additional diagnostic characters, with the exception of otolith morphology which was not studied, given in Van der Zee & Wildekamp (1994), all fit to *F. kamdemi* which is therefore attributed to the genus *Fundulopanchax*.

The male color pattern of the adult *F. kamdemi* is dominated by the red longitudinal band on the sides. This character is shared by two other *Fundulopanchax* species, *F. amieti* (see Seegers, 1997) and *F. avichang* Malumbres & Castello, 2001, and can also be found in most male specimens of the Dibamba, Cameroon, population of *F. puerzli* (see Amiet, 1987) and individuals of *F. spoorenbergi*. In *F. kamdemi* a second red band runs parallel to the lower body profile, a character shared only by *F. ndianus*. With the exception of *F. avichang* all species mentioned share all distinguishing characters for the genus *Fundulopanchax* mentioned in Van der Zee and Wildekamp (1994) and all are robust species of large (= 55 mm SL) size. *Fundulopanchax avichang* differs from the above mentioned species by its small size (less than 40 mm SL), low number of circumcaudal scales (12–13 vs. 16) and elliptical caudal fin in males (vs. extensions at the upper and lower corner). The second red line on the lower body profile is not a unique derived character since, beside its presence in *Fundulopanchax* (e.g. *F. avichang* and *F. amieti*), it is found in some species of the related genus *Aphyosemion* (e.g. *A. ferranti* (Boulenger, 1910), *A. labarrei* Poll, 1951, *A. louessense* (Pellegrin, 1931), and populations of *A. cameronense* (Boulenger, 1903)).

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