Abstract

A new species of annual killifish, *Nothobranchius nubaensis*, is described based on specimens collected from ephemeral water bodies in central Sudan and south-west Ethiopia. The new species is distinguished from the other members of the *Nothobranchius ugandensis* species group by the following combination of characters: 17-19 dorsal fin rays; 17-19 anal fin rays; 29-30 scales in median lateral series; dorsal and anal fins in males with short filamentous rays; pelvic fins short, tips reaching the anus; orange red head with three distinct oblique bars on the operculum; dorsal fin light blue with a pattern of irregular orange-red spots and elongated yellow spots in distal areas; anal fin yellow, light blue at base, with a pattern of orange-red spots; pelvic fins yellow with a pattern of orange-red spots; pectoral fins orange-red with a light blue margin; caudal fin orange-red with short pale or dark red lines, extending from fin base onto fin rays.

Zusammenfassung

Eine neue Art der einjährigen Killifische: *Nothobranchius nubaensis*, wird auf der Basis von Exemplaren beschrieben, die in kurzzeitigen Wasserlöchern im Zentralsudan und in SW-Athiopen gesammelt wurden. Sie unterscheidet sich von anderen Angehörigen der *Nothobranchius-ugandensis*-Artengruppe durch die folgende Merkmale: 17-19 Rückenflossenstrahlen; 17-19 Afterflossenstrahlen; 29-30 Schuppen in median-lateralen Reihen; die dorsalen und analen Flossen bei Männchen mit kurzen fadenförmigen Flossenstacheln; Bauchflossen kurz, die Spitzen reichen bis zum After; orangeroter Kopf mit drei deutlichen schrägen Streifen auf dem Kiemendeckel; Rückenflosse hellblau mit einem unregelmäßigen Muster orangeroter Flecken und länglichen gelben Flecken im distalen Bereich; Afterflosse gelb, hellblau am Grund, mit einem Muster orangeroter Flecken; Brustflossen gelb mit einem Muster orangeroter Flecken; Brustflossen orangerot mit hellblauem Rand; Schwanzflosse orangerot mit kurzen blassen oder dunkelroten Linien, die sich von der Flossenbasis bis zu den Flossenstrahlen erstrecken.

Résumé

Une nouvelle espèce de killy annuel, *Nothobranchius nubaensis*, est décrite sur base de spécimens collectés dans des poches d’eau temporaires du centre du Soudan et du sud-ouest de l’Éthiopie. La nouvelle espèce se distingue des autres membres du groupe *Nothobranchius ugandensis* par la combinaison des caractéristiques suivantes: 17 à 19 rayons dorsaux; 17 à 19 rayons à l’anal, 29 à 30 écailles dans les rangées latérales médianes; dorsale et anale des mâles avec de courts rayons filamentex; pelviennes courtes, les extrémités touchant l’anus; tête rouge orange avec trois barres obliques nettes sur l’opercule; dorsale bleu clair avec un patron irrégulier de taches rouge-orange; pelviennes jaunes avec un patron de taches rouge orange; pectorales rouge orange avec un liseré bleu clair; caudale rouge orange avec de petites lignes rouges pâles ou foncées s’étendant de la base de la nageoire jusqu’aux rayons.

Sommario

Una nuova specie di killifish annuale, *Nothobranchius nubaensis*, è descritta sulla base di esemplari raccolti in corpi idrici temporanei del Sudan centrale e dell’Etiopia sudoccidentale. La nuova specie si distingue dagli altri membri del complesso di specie *Nothobranchius ugandensis* per la seguente combinazione di caratteri: 17-19 raggi dorsali; 17-19 raggi anali; 29-30 scaglie lungo la serie mediana laterale; pinna dorsale e anale nei maschi con brevi raggi filamentosi; pinne pelviche brevi, con le punte che arrivano fino all’ano; capo roso-arancio con tre distinte barre oblique sull’opercolo; pinna dorsale blu chiaro con un motivo di macchie lineari allungate rosso-arancio e macchie allungate gialle nelle aree distali; pinna anale gialla, blu chiaro alla base, con un motivo di macchie lineari rosso-arancio; pinne pelviche gialle con un motivo di macchie lineari rosso-arancio; pinne pectorali rosso-arancio con una margine blu chiaro; pinna caudale roso-arancio con brevi linee pallide o rosso scuro che si estendono dalla base della pinna fino ai raggi.
INTRODUCTION

*Nothobranchius virgatus* Chambers, 1984 is the only species of *Nothobranchius*, which has been described from Sudan. It was collected in October 2008. From Ethiopia it is known from Gambella, Obela Stream, near the road from Gambela to Gog (J. Friel, pers. comm.).

On 5 December 2002, live specimens of a red species of *Nothobranchius* were collected by M. Blemmans in Khor Angarko (which is part of the Khor Abu Habl system), South Kordofan, about 21 km south of Dilling and 100 km north of Kadugli (Blemmans 2003). This species was provisionally described as *N. nubaensis* (Blemmans 2003), but this name is not available, for the following reasons: (1) the mention of a “provisional description” may unquestionably be considered to violate ICZN Article 16.1; (2) no type has been designated in the paper, the author rather states “types will be designated…” . Article 16.4.1 of the ICZN clearly requires an “explicit fixation of a holotype, or syntypes”, even if not immediately deposited. The paper mentions several specimens without giving numbers. The name *N. nubaensis* is not a “nomen nudum” as a description is given, but an “anoplonym” according to Dubois (2000).

In November 2005 and November 2006, K. Kardashev and others collected specimens of red coloured *Nothobranchius* in Khor Maada Mulaha, belonging to the Wadi Al Gallah system (Kardashev 2007 a, b). In November 1986, November 1994 and December 2006, A. Golubtsov collected specimens of red coloured *Nothobranchius* near Abobo, Ethiopia. They occurred in seasonal ponds of the Alvero River drainage, White Nile basin. Specimens of these three populations from Sudan and Ethiopia are considered to belong to the same species on the basis of the coloration of males and morphological characters. Here below this annual fish is described as a new species, *Nothobranchius nubaensis*.

MATERIAL AND METHODS
Measurements and counts were taken according to Amiet (1987); except for the addition of the caudal peduncle length, which is measured from the posterior end of the anal fin base to the posterior end of the hypural plate; eye diameter, which is measured between anterior and posterior orbital walls; and snout length, which is measured from the anterior tip of the lower jaw to the anterior edge of the orbital wall. Measurements were taken with digital callipers to the nearest 0.1 mm, partly under a dissecting microscope. All measurements and counts were taken from the left side. All visible rays of the dorsal and anal fins were counted. The counts of scales on the median longitudinal series is the number of scales between the superior junction of the opercular membrane and the hypural plate. The scales on the base of the caudal fin were counted separately. All measurements are presented as percentages of standard length (SL); except of eye diameter and snout length, which are given as percentage of head length (HL). Terminology for the cephalic neuromast series follows Scheel (1968), the frontal squamation following Hoedeman (1958).

Type specimens and additional material is deposited in the following institutions; Musée Royal de l’Afrique Centrale, Tervuren, Belgium (MRAC); Natural History Museum, London, UK (BMNH); Muséum National d’Histoire Naturelle, Paris, France (MNHN); Zoological Museum, Moscow State University, Moscow, Russia (ZMM); South African Institute for Aquatic Biodiversity, Grahamstown, South Africa (SAIAB); and, Museo Civico di Storia Naturale “G. Doria”, Genova, Italy (MSNG).

Comparative material is listed in Blache & Miton (1960), Chambers (1984, Rahad el Fula population), and Wildekamp (1995). Further collections examined include: Stefano Valdesalici private collection: *Nothobranchius robustus*, 4 males, 31.7-36.3 mm SL, Uganda, Kalisizo 0°33’S 31°36’E; *N. rubroreticulatus*, 2 males, 34.3-36.9 mm SL, Tchad, Zakouma National Park 10°50’N 19°38’E; *N. ugandensis*, 1 male, 47.3 mm SL, Uganda, Butiaba 01°53’N 31°24’E; 1 male, 43.7 mm SL, Uganda, Busesa 00°30’N 33°31’ E.

*Nothobranchius nubaensis* n. sp.
(Figs 1-6, Table I)

*Nothobranchius nubaensis* Blemmans, 2003 (anoplonym)

Holotype: MRAC 2008-05-P-1, male, 42.9 mm SL; Sudan: Angarko, 21 km south of Dilling and
100 km north of Kadugli, 11°53′05.23″N 29°42′31.82″E, Marc Bellemans, 5 December 2002. Collected with hand net and preserved after living for about six months in aquaria.

**Paratypes** (collected with holotype): MRAC 2008-05-P-2, 1 male, 43.9 mm SL; MRAC 2008-05-P-3-4, 2 females, 28.1-33.2 mm SL; MSNG 54286, 1 male, 40.8 mm SL; MNHN 2008-1140-1141-1179, 3 males, 38.4-45.8 mm SL; SAIAB 80410, 1 male, 36.5 mm SL; BMNH 2008.4.2.11-12, 1 male, 45.1 mm SL, 1 female, 33.1 mm SL.

**None-type material:** SAIAB 80411, 1 male, 49 mm SL, Sudan: Maada Mulaha, 11°09′40.5″N 40°19′44.1″E, Kiril Kardasheva and Plamen Ivanov, 22 November 2005, collected with large hand nets and preserved in the field; SAIAB 80412, 1 female, 40.8 mm SL, BMNH 2008.4.2.13-14, 1 male, 47.1 mm SL, 1 female, 39.8 mm SL, same data as SAIAB 80411; ZMMGU P22009, 3 males, 38.4-49.9 mm SL, Ethiopia: Alvero River drainage, 7 km S of the southern end of the Alvero Dam, 7°47′N 34°25′E, altitude about 500 m, Alexander Golubtsov, 4 December 2006, collected with large nets and preserved in the field.

**Diagnosis:** *Nothobranchius nubaensis* can be distinguished from all other species of the genus by the following combination of characters: 17-19 dorsal fin rays; 17-19 anal fin rays; 29-30 scales in median lateral series; dorsal and anal fin with short filamentous rays in males; pelvic fins short, tips reaching the anus; orange-red head with 3 distinct oblique bars on the operculum; dorsal fin light blue with a pattern of irregular orange-red spots and elongated yellow spots in distal areas; anal fin yellow, light blue at base, with a pattern of orange-red spots; pelvic fins yellow with a pattern of orange-red spots; pectoral fins orange-red with a light blue margin; caudal fin orange-red, with short pale or dark red lines extending from fin base onto fin rays.

**Description:** Morphometric measurements are given in Table I. Robust, deep bodied *Nothobranchius* with rounded snout; terminal mouth directed upward; dorsal fin rays 17-19; anal fin rays 17-19; scales in median lateral series 29-30 + 2-3 on caudal fin base; cephalic squamation pattern variable; anterior neuromast series of 'open' type; central series in shallow groove with low lobes and with 3 neuromasts; posterior cephalic neuromast series curved with 3 neuromasts; preopercular neuromast system in open groove, distal ridge overlapping opercle slightly; one neuromast on each scale of median longitudinal series.

Maximum observed length 49.9 mm SL in males; body deep and moderately compressed; dorsal profile slightly concave to nearly straight on head, convex from nape to end of dorsal fin base; ventral profile convex, slightly concave on caudal peduncle posterior to dorsal and anal fins; maximum body height occurring at the base of the pelvic fins; dorsal and anal fins shallow and rounded, tips with short filamentous rays; dorsal and anal fins with papillate contact organs, distributed over fin rays; pelvic fins short, tips reaching the anus; caudal fin subtrunate; branchiostegal membrane projecting from opercle, distal edge slightly wrinkled.

Female smaller than male, maximum observed size 40.8 mm SL; body less compressed and less deep than in males; dorsal fin rounded; anal fin triangu-
lar with rounded tip; anal fin positioned more posterior; short snout and narrower caudal peduncle than in males; opercular membrane not projecting from opercle.

Color in life: Male (Figs 1-3): body and head scales light blue with broad orange-red margin, creating a reticulated pattern on body; almost completely orange-red on head; lips, snout, throat, frontal and superior portion of head all orange-red; opercular region with three distinct oblique bars on the operculum, extending from the eye to the upper part of the head; branchiostegal membrane orange-red with light blue rim; dorsal fin light blue with broad dark red reticulation, forming approximately horizontal arch-like stripes, broad border with interrupted red pattern; some elongated yellow spots in distal areas; anal fin yellow, light blue at base, with pattern of large orange-red spots; spots in the middle of the fin dark red, distal spots orange-red; caudal fin orange-red with pale or dark red lines extending from base onto fin rays, some specimens having a faint dark red marginal band; pelvic fins yellow with orange-red spots, spots near base dark red; pectoral fins orange-red with light blue margin, some specimens with yellow spots and short dark or pale red lines extending onto fin rays; iris golden, with faint black vertical bar through center of eye.

Figure 2. Adult male of Nothobranchius nubaensis (not preserved) from Khor Maada Mulaha. Photo by K. Kardashev.

Color in alcohol: Male (Fig. 5): body scales light brown to whitish, almost all scales with distinct red margin; dorsal and anal fins light brown to whitish with a pattern red spots; caudal fin of a light pale red; pelvic fins light brown to whitish with red spots near base; pectoral fins of a light pale red; iris bluish.

Female (Fig. 4): body pale olive-brown, lighter brown to silvery ventrally; unpaired and paired fins hyaline; iris golden, with faint black vertical bar through center of eye.

Distribution (Fig. 7): Populations have been found scattered over a large area. Two groups of localities can be distinguished: (1) Khor Angarko (in South Kordofan around the foothills of the Nuba Mountains) and the area near Khor Maada Mulaha (in the plains of West Kordofan) in Sudan; (2) near Abobo (Gambella Region) in Ethiopia.

Habitat (Figs 8-10): The specimens of Nothobranchius nubaensis described here were found in residual pools of seasonal rivers (called “Khor”) and rainwater filled depressions (Bellemans 2003, Kardashev 2007 a, b). All populations of Nothobranchius in central Sudan and south-west Ethiopia undergo important annual fluctuations in abundance and extent of distribution area. In Khor Angarko, N. nubaensis was the only fish species present in 2002. During successive surveys at the same collection site during the post-rain period in 2005 and 2006 no specimens of N. nubaensis were found, not even in the mud collected from the residual pools (M. B.).

In Khor Maada Mulaha Nothobranchius virgatus and N. aff. rubroreticulatus were found in in the...
same locality in 1998 and 1999 (Bellemans 2000) and in 2004 (J. Bulterman pers. comm.). In 2005 and 2006 *N. virgatus*, *N. nubaensis* and *Protopterus* sp. (probably *Protopterus annectens* Owen, 1939) were found in the same locality, but not a single specimen of *N. aff. rubroreticulatus*. In this locality all males *Notothobranchius nubaensis* were collected at the surface near rocks. Almost all females were collected in about 2 to 2.5 m deep water. No aquatic vegetation was present, with only dry grass along the shores. The water was brown, slightly turbid, with a pH of 7.8-8.2. At 12:30 h the temperature was 22°C, at 1 m below the water surface. The air temperature was 42°C. The bottom substrate of these habitats was brown-black clay (K.K.). In Ethiopia, there are two seasonal ponds near Abobo where *Notothobranchius nubaensis* is known to occur, both belonging to the Alvero river drainage (White Nile basin).

In late November 1994, two males and three females of *Notothobranchius* were collected from a swamp-like pond at the land divide between the Alvero and Gilo rivers (the latter river seems to be a tributary of the Pibor River, affluent of Sobat, affluent of White Nile). The pond was muddy and covered with dense macrophyte vegetation. The *Protopterus* sp. larvae were sampled simultaneously with the *Notothobranchius* specimens. Based on the anecdotal information from the local Anuak people, the pond is never connected to any river system; it is
filled with rain water. The same pond was re-sampled on 4 December 2006. No *Protopterus* were found. New villages and cultivated lands appeared in the vicinity of the pond, which became a source of drinking water for the nearest settlement located about 2.5 km to the north.

In the other pond, in late November 1986, about 25 km W of Abobo (now 15 km W of a dam) 7°54’N 34°20’E, altitude about 430 m, only one female of *Nothobranchius* was sampled from the pan-like pond in the flood plain of the Alvero River (a tributary of the Baro River, affluent of Sobat, affluent of White Nile). The pond had a light clay bed and no dense macrophyte vegetation. Judging from the fish species composition (occurring together with the only *Nothobranchius* specimen), i.e. small *Barbus* sp., *Ctenopoma* sp., *Neolebias* sp., *Aplocheilichthys* (? , possibly *Micropanchax*), the pond was connected to the river during the rainy season. When we tried to re-sample the pond in early January 1987, no fish was found there; the water temperature was about 43°C; it was a watering place of elephants (judging from foot prints). The pond was never re-sampled until present (A. G.).

**Etymology:** The new species is named after type locality, which lies in the Nuba mountains.

**Discussion:** Based on the known distribution, on the coloration of males and on morphology, *Nothobranchius nubaensis* can be grouped in the *Nothobranchius ugandensis* species group, which is defined here. This clade includes *N. ugandensis* Wildekamp, 1995, an undescribed species of *Nothobranchius* “Lake Victoria” (see comments in Wildekamp 1990: 199, 1996: 147, and pictures in Seegers 1997: 82-83) and *N. nubaensis*, which is described here. Synapomorphies to define this group are: male coloration consisting of light blue scales with a large irregularly reticulated pattern on body, forming oblique bars in vivid red color, vivid red coloration on the head and in dorsal areas, yellow to yellowish anal fin, large vivid red spot pattern on dorsal and anal fins, red caudal fin of subtruncated shape; relatively deep body (up to 38% of SL); moderately compressed, and rounded head; dorsal profile of

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**Fig. 5.** *Nothobranchius nubaensis*, MRAC 2008-05-P-1, holotype, 42.9 mm SL, male. Photo by S. Valdesalici.

**Fig. 6.** *Nothobranchius nubaensis*, MRAC 2008-05-P-3, paratype, 33.2 mm SL, female. Photo by S. Valdesalici.
head slightly concave to nearly straight, convex from nape to end of dorsal fin base; variable cephalic squamation.

Male *N. nubaensis* differ from a similarly red male morph of *N. ugandensis* by coloration of the whole body (orange-red broad scales margin *vs.* narrow red scale margins) and head (almost completely orange-red *vs.* red on lips and superior part only); dorsal fin spots pattern (broad and arranged in horizontal row *vs.* small spots, sometime arranged in thin lines extending onto fin rays); anal fin spot pattern (broad *vs.* absent or if present, few and arranged in lines extending to fin rays); pectoral fin color (red *vs.* hyaline). Males and females with relatively a reduced number of scales in the longitudinal series (29-30 *vs.* 28-33), modally less deep body in males (25.9-34.0

![Geographical distribution map](image_url)

**Fig. 7.** Geographical distribution of *Nothobranchius nubaensis* (asterisk; type locality: open asterisk), *Nothobranchius virgatus* (circle) and *N. aff. rubroreticulatus* (orange squares) (black squares are cities with their names). Drawing by S. Valdesalici.
vs. 25.0-37.3% of SL) and females (21.4-30.4 vs. 22.4-34.0% SL); dorsal fin positioned more anterior in males (54.4-61.8 vs. 54.5-65.2% of SL) and females (57.8-61.4 vs. 57.0-66.5% of SL); origin of pelvic fins relatively more anterior in males (44.0-54.9 vs. 47.2-57.0% of SL); shorter head in males (26.3-33.6 vs. 26.6-36.8% of SL) and females (25.6-33.9 vs. 27.6-37.8% of SL); body scales (without ctenii vs. with ctenii), ctenii structures on operculum (absent vs. present).

Among other species of Notobranchius occurring in the area, male N. nubaensis differ from male N. virgatus (found in the same habitat in Khor Maada Mulaha) by the coloration pattern of the whole body (broad orange-red scale margins vs. thin red scale margins, forming about 10-16 oblique bars) and head (almost completely orange red vs. light blue with narrow red scale margins); anal fin spot pattern and coloration (yellow, light blue at base, with pattern of large orange-red spots, spots in the middle of fin dark red, distal spots orange-red vs. light blue with red spots forming 6-8 curved lines and a broad margin); pectoral fin color (red vs. hyaline); caudal fin coloration (red vs. light blue with a black margin followed by a submarginal white band and a faint black vertical bar in the inner region); and females color pattern (hyaline without particular pattern vs. with faint oblique bars); more dorsal-fin rays in males and in females (17-19 vs. 13-16); more anal-fin rays in males and females (17-19 vs. 14-16); modally less deep caudal peduncle in males (11.7-15.4 vs. 14.3-16.4% SL); dorsal fin positioned more anterior in males (54.4-61.8 vs. 59.0-62.8% of SL); shorter head in males (26.3-33.6 vs. 31.4-35.7% of SL); pelvic fin shorter (tips reaching the anus vs. tips reaching anal fin).

Male N. nubaensis differ from male N. robustus by coloration of the whole body (light blue with broad orange-red scale margins vs. completely red to red-brown); dorsal and anal fin pattern (spotted vs. plain red); pectoral fin coloration (red vs. hyaline); males and females with more dorsal-fin rays (17-19 vs. 14-16); shorter head in males (26.3-33.6 vs. 29.2-38.8% of SL); different shape of head and snout (rounded vs. pointed).

Male N nubaensis differ from male N. rubroreticulatus by coloration of the whole body (broad orange-red scale margins vs. red broad scale margins forming a reticulated irregular pattern) and head (almost completely orange-red vs. light blue with narrow red scale margins); dorsal fin spot pattern (broad and arranged in horizontal rows vs. spots near the fin base, arranged in an irregular horizontal line, spots in the median part arranged in broad lines extending onto fin rays, light blue submarginal band and broad black margin); anal fin coloration and spot pattern (yellow, light blue at base, with pattern of large orange-red spots, spots in the median part dark red, distal spots orange red vs. light blue with a series of red spots near the base forming a broad irregular horizontal line, spots in the median part arranged in broad red lines extending onto fin rays, light blue submarginal band and broad black margin); pectoral fin color (red vs. hyaline); caudal fin coloration (red vs. light blue with a pattern of broad red lines extending onto fin rays, light blue submarginal band and broad black margin); deeper body in males (26.3-34.0 vs. 25.4-29.7% of SL); anal fin positioned more posteriorly in males (56.5-65.7 vs. 55.1-59.3% of SL); shorter head in female (25.6-33.9 vs. 32.4-37.2% of SL); different shape of head and snout (rounded vs. pointed).

The present disjunct distribution pattern of N. nubaensis, similar to that of N. virgatus can be explained by the dynamics of the changing rain pat-

Fig. 8. Sudan: Angarko; type locality of Notobranchius nubaensis. Photo by M. Bellemans.
tern and climatic conditions over the vast plains of central and southern Sudan and SW Ethiopia (see also Lévêque 1990). The higher water levels of the Nile in the past and the presence of a fossil embankment surrounding a pre-historic lake south of Khartoum, suggest a more continuous and permanent connection between the presently known populations of \( N.\ nubaensis \) (and \( N.\ virgatus \)), as reported in Chambers (1984), Hoelzmann et al. (2000) and Leblanc et al. (2006).

A comparison of the samples did not reveal any apparent differences in morphometry, color pattern or meristics among populations. Determining the full extent of the distribution of \( N.\ nubaensis \) will require additional collections.

Fig. 9. Sudan: Khor Maada Mulaha. Photo by K. Kardashev.

Fig. 10. Ethiopia: Alvero River drainage, 7 km S of the southern end of the Alvero Dam (pond after intensive sampling). Photo by A. Golubtsov.
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Notobranchius nubaensis (Cyprinodontiformes: Notobranchiidae) a new annual killfish from Sudan and Ethiopia