Rivulus staecki, a new killifish (Teleostei: Cyprinodontiformes: Rivulidae) from the upper Rio Negro drainage in southern Venezuela

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Accepted on March 26, 2011.

Published online at www.vertebrate-zoology.de on June 22, 2011.

> Abstract

Rivulus staecki, a new species of the subgenus *Owiyeye*, is described from the upper Rio Negro drainage in southern Venezuela (Estado Amazonas). It differs from the other species of the subgenus by a unique combination of character states: a truncate caudal fin, elongated pelvic fins in males, presence of a 'rivulus spot' in both sexes and 35–38 scales in the longitudinal series.

> Resumen

Rivulus staecki, una nueva especie del subgénero *Owiyeye*, se describe desde la parte superior de la cuenca del Río Negro, sur de Venezuela (Estado Amazonas). Se diferencia de las restantes especies del subgénero por una combinación única de los siguientes caracteres: una aleta caudal truncada, aletas pélvicas alargadas en los machos, la presencia de la 'mancha de rivulus' en ambos sexos y de 35 a 38 escamas en la serie longitudinal.

> Kurzfassung

Rivulus staecki, eine neue Art der Untergattung *Owiyeye,* wird aus dem oberen Rio Negro Flusssystem im südlichen Venezuela (Estado Amazonas) beschrieben. Sie unterscheidet sich von den übrigen Arten der Untergattung durch eine einzigartige Kombination folgender Merkmale: eine gestutzte Schwanzflosse, verlängerte Bauchflossen bei Männchen, einen „Rivulus-Fleck" bei beiden Geschlechtern und 35–38 Schuppen in der Längsreihe.

> Key words

Teleostei, Aplocheiloidei, Rivulidae, Rivulinae, *Rivulus*, taxonomy, new species, Venezuela, Rio Negro.

Introduction

The neotropical killifish genus *Rivulus* Poey, 1860 is the most species rich within the Rivulidae. Currently it contains more than 130 species which are distributed from Middle America in the north to northern Argentina in the south. The centre of the species diversity and phenetic manifoldness of the genus is situated in the Amazon and Orinoco drainages.

The genus is divided into several species groups and formally recognized subgenera (Costa, 2006, 2008a; Huber, 1992). The new species described here is a member of the recently established subgenus *Owiyeye* Costa, 2006. This subgenus currently contains ten species (*R. altivelis*, *R. amanapira*, *R. kirovskyi*, *R. mahdiaensis*, *R. nicoi*, *R. rectocaudatus*, *R. romeri*, *R. tecminae, R. uakti* and *R. uatuman*), which are distributed in the Orinoco and Amazon drainages (Costa, 2006, 2008b; Costa & de Souza, 2009). All these taxa were described within the last three decades, with *Rivulus rectocaudatus* Fels & de Rham, 1981 as the oldest. They are small fish

Fig. 1. Holotype (male) of *R. staecki* spec. nov.

Fig. 2: Largest preserved female paratype of *R. staecki* spec. nov.

usually living in forest creeks, shallow ponds and swamps. According to COSTA (2006) the subgenus *Owiyeye* is a monophyletic unit. Its major diagnostic characters are the transversally arranged frontal scales (S-patterned) and a transverse stripe through the chin (COSTA, 2006).

During a field trip to the state Amazonas in Venezuela WOLFGANG STAECK (Berlin, Germany) collected a new colourful *Rivulus* possessing the diagnostic character states of the subgenus *Owiyeye*. The species was introduced in the aquaristic literature as *Rivulus* spec. "San Carlos de Rio Negro" by STAECK (2006). The purpose of this paper is to provide a formal description of this Killifish.

Material and Methods

Type specimens were fixed in formalin and later transferred into 75 % ethanol. The holotype and some paratypes are deposited in Museo de Zoología, Guanare, Venezuela (MCNG-UNELLEZ), the remaining paratypes are stored in MTD (Senckenberg Naturhistorische Sammlungen Dresden, Museum für Tierkunde, Germany).

Examined material of *Rivulus staecki* is listed under the species account. Morphometric data are obtained as described by HUBER (1992). According to this procedure we and other authors (e. g. THOMERSON & TAPHORN 1992; THOMERSON *et al*. 1992) use the snout tip as the most anterior point of reference for the standard length (SL). COSTA (e. g. 2004, 2006), however, used the middle of the posterior limit of the depression between the upper jaw and the neurocranium (see COSTA, 1988, 1995). Thus, the proportional data provided in his papers (e. g. COSTA, 2004, 2006) are comparable only to a certain extent with those published by others. Measurements were made with an electronic digital calliper reading to the nearest tenth of a millimetre. All ratios are expressed as percentages of standard length. Counts were made under a dissecting microscope; fin-ray counts were made with light transmitted through the fins. As counting the number of fin rays is not without difficulties, it may happen that the very minute first rays of anal, dorsal and caudal fin are overlooked. Values for a potassium hydroxide cleared and alizarin stained (c&s) specimen are indicated by an asterisk after counts. Terminology

Table 1. Morphometric values for six males (24.1–28.9 mm SL) and two females (19.4–19.6 mm SL) from the type series of *Rivulus staecki*. max = highest value, min = lowest value, mean = arithmetric mean.

	males			females	
	min	max	mean	min	max
Body depth	19.0	21.5	19.6	18.4	20.1
Caudal peduncle depth	12.9	15.3	14.2	13.9	14.1
Predorsal length	68.8	73.2	70.8	68.0	70.9
Prepelvic length	50.9	55.9	53.3	52.6	53.1
Preanal length	59.1	64.2	61.1	60.3	62.2
Length of dorsal fin base	9.1	11.2	10.2	9.9	10.3
Length of anal fin base	16.1	19.9	18.3	16.3	16.5
Caudal fin length	24.7	28.0	26.7	26.5	26.8
Pectoral fin length	19.4	22.1	20.7	19.0	19.1
Pelvic fin length	20.8	25.4	22.4	10.2	10.8
Head length	24.4	25.7	25.1	25.5	25.8
Eye diameter	7.5	9.0	8.3	8.6	8.9

for the arrangement of frontal scales follows HUBER (1992), terminology for the cephalic neuromast series COSTA (2001). Nomenclature of colour patterns and shapes is according to HUBER (1992).

Rivulus staecki spec. nov.

Figs. 1–5, Table 1

Holotype. MCNG-UNELLEZ 56350, male 28.4 mm SL; Venezuela, Estado Amazonas, Rio Negro drainage, pond close to village Arigua, about 20 km south of San Carlos de Rio Negro (approx. 1° 50′N, 67° 02′ W); *leg*. W. STAECK, Febr. 2006.
Paratypes. MCNG-UNELLEZ 56351, 1 female, 19.4 mm SL; same data as holotype. MTD F 32344–32348, MTD F 32397–32400, 9, 15.5–28.9 mm; same data as holotype. Collection of the author, 1 male (c&s), 28.4 mm SL; same data as holotype.

Diagnosis. *Rivulus staecki* is a member of the subgenus *Owiyeye*. Similar to *R. altivelis*, *R. nicoi*, *R. tecminae*, *R. uakti* and distinguished from the remaining congeners by having long pelvic fins (pelvic-fin length up to about 25 % of SL, reaching the middle of anal-fin base in males versus pelvic fin short, reaching anterior portion of anal-fin base). It is distinguished from the other species of the subgenus (except for *R. amanapira*, *R. rectocaudatus* and *R. tecminae*) by a truncate caudal fin in males (versus round, subtruncate, spatula- or lyre-shaped caudal fin). It differs from *R. altivelis, R. amanapira, R. rectocaudatus* and *R. tecminae* by having fewer scales in the longitudinal series (35–38 versus 41–44 in *R. altivelis,* 48–49 in *R. amanapira* and 38–43 in *R. rectocaudatus* and *R. tecminae*) and from *R. nicoi* and *R. uakti* by having more scales (35–38 versus 26–29 in *R. nicoi* and 32–33 in *R. uakti*).

Description. See Table 1 for morphometric data. Males larger than females, largest male 28.9 mm SL (largest preseved female 19.6 mm SL). Dorsal profile slightly convex from snout to end of dorsal-fin base, approximately straight on caudal peduncle. Ventral profile convex on head, almost straight from anterior portion of venter to end of anal-fin base, nearly straight on caudal peduncle. Body slender, subcylindrical anteriorly, slightly deeper than wide, to compressed posteriorly. Highest body depth at level of pelvic-fin base. Posterior tip of dorsal and anal fins rounded in both sexes. Dorsal and anal fin round or slightly pointes in males. Caudal fin truncate in males, rounded in females. Pectoral fin rounded. Tip of pelvic fin reaching between base of 5th and 7th anal-fin ray in males, and between base of 1st and 3rd anal-fin ray in females. Dorsal-fin origin on vertical between base of 8th and 10th anal-fin ray. Dorsal-fin rays 8*–9; anal-fin rays 13*–14; caudal fin rays 26*; pectoral-fin rays 13*; pelvic fin rays 6*.

Scales small, cycloid. Body and head entirely scaled. Frontal squamation S-patterned. Few scales on caudal-fin base; no scales on dorsal and anal fin. Frontal squamation scales arranged in a transverse pattern, each scale with posterior margin exposed. Longitudinal series of scales 35–38. Contact organs on male flank. No contact organs on fin rays. Cephalic neuromasts: supraorbital 3+3. Lateral line interrupted. Six branchiostegal rays. Gill-rakers on first branchial arch 1+7–8. Minute dermosphenotic present. Caudal skeleton symmetric; hypural forms two plates, separated by a median gap; single epural narrow, loosely connected with last neural spine at its base; parhypural autogenous, thin, stick like. Total vertebrae 31*.

Colouration in alcohol. Male (Fig. 1): Body side light brown with dark brown stripes, ventrally irregular and interrupted by light dashes. Dorsum uniform dark brown, venter light, whitish. Side of head dark brown, dorsal part darker, branchiostegal area light grey. Dorsal fin light grey with dark grey irregular dots. Caudal fin grey with dark brownish or grey elongated interradial dots or short strokes; ventral margin with a broad light band; dark blotch on dorsal portion of caudal fin base. Anal fin light grey at base, distally darker with blackish marginal band. Pelvic fin dark grey with dark blackish border. Pelvic fin light grey.

Female (Fig. 2): Body and head sides brownish with dark brown stripes, ventrally irregular and interrupted by light strokes. Dorsum darker, venter light-

Fig. 3. *Rivulus staecki* spec. nov., live adult male (from type locality) of approx. 28 mm SL in aquarium. Not preserved, no type specimen. Caudal fin partly demaged.

Fig. 4. *Rivulus staecki* spec. nov., live adult female (from type locality) of approx. 24 mm SL in aquarium. Not preserved, no type specimen. Caudal fin dorso-ventrally compressed.

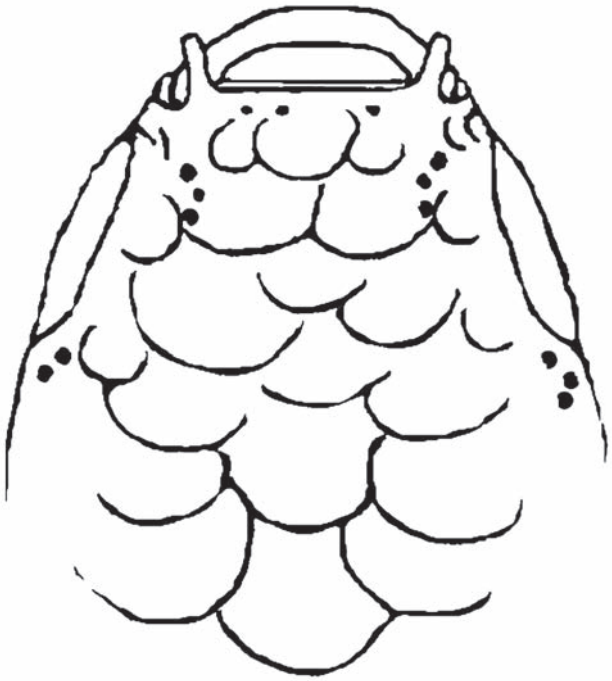

Fig. 5. Diagrammatic representation of the frontal squamation in *R. staecki* spec. nov.

er. Dorsal- and caudal fin light grey with dark grey irregularly arranged interradial dots. Dark blotch on dorsal portion of caudal fin base. Anal fin grey, at base lighter, distally darker. Pelvic fins grey with dark grey border. Pectoral fins light grey.

Colouration in life. Male (Fig. 3): Dorsum dark brownish, venter whitish to yellowish. Body sides metallic green, with irregular red stripes, stripes dorsally more regular, ventrally irregular and interrupted. Opercular region metallic greenish with brown or reddish reticulated dots. Ventral part of head silvery whitish. Upper jaw brown, lower jaw dark brown or dark grey. Iris light brown to yellow with golden or greenish iridescence. Dorsal fin reddish brown with metallic greenish dots. Anal fin reddish brown with metallic greenish irregular dots or strokes and dark marginal band. Caudal fin dark grey with iridescent greenish interradial strokes and broad bright yellowish or orange ventral stripe. Black blotch on dorsal portion of caudal fin base ('rivulus-spot'). Pelvic fins dark grey with metallic greenish border. Pectoral fins pale grey.

Female (Fig. 4): Dorsum brown, with dark brown dots, venter whitish. Body sides light brownish with pale olive irregular stripes, which are caudally and ventrally interrupted. Opercular region pale golden with brown spots. Ventral surface of head white. Lower jaw dark brown or brownish grey. Iris light brown to yellow. Dorsal and anal fin light brown or grey with brown dots. Caudal fin light brown with brown dots. Black vertically elongated oval spot on dorsal portion of caudal-fin base ('rivulus-spot'). Pelvic and pectoral fins yellowish.

Distribution and habitat. Known only from the type locality, a pond in Rio the Negro basin, about 20 km south of San Carlos de Rio Negro at the village Darigua (Amazonas, Venezuela). The water at the collecting site was clear, of light brownish colour and very acid (pH 4.4). Its temperature was 25.4 °C and its electric conductivity < 10 µS/cm.

Etymology. The species is named in honour of WOLFGANG STAECK (Berlin, Germany), former president of the Deutsche Cichliden-Gesellschaft and collector of the type specimens, to acknowledge his commitment to South American freshwater fishes and his contributions to the taxonomy of the fish families Rivulidae and Cichlidae.

Discussion

The subgenus *Owiyeye* is defined by transversally arranged frontal scales appearing as an S-patterned squamation (Fig. 5) and a transverse stripe through chin (COSTA, 2006). The new species *R. staecki* possesses

these character states and hence fits the characteristics of this subgenus. Costa (2006) mentioned the lack of the dermosphenotic (sixth infraorbital bone) as a possible apomorphic character of *Owiyeye*. However, the osteology has not been studied in all species of the subgenus yet. Since a minute dermosphenotic is present in *R. staecki*, we consider this character as polymorphic in *Owiyeye* and not as an apomorphy of this subgenus. The presence of a minute dermosphenotic is used as a diagnostic character state for the Rivulidae by Costa (1998). Hence, the presence of it is a plesiomorphic character state for *Rivulus*.

An S-patterned frontal squamation and a transverse stripe through chin also occur in the two species of the subgenus *Anablepsoides* (see Costa, 2006). *Rivulus staecki*, however, is readily distinguishable from both species of this subgenus (*R. atratus* and *R. ornatus*; for *R. obscrus* is treated as a synonym of *R. ornatus* by Costa, 2006) by its truncate caudal fin (round in *Anablesoides*), higher number of dorsal- (> 7 in *R. staecki* versus < 8 in *R. atratus* and *R. ornatus*) and anal-fin rays (> 12 in *R. staecki* versus < 12 in *R. atratus* and *R. ornatus*) and more scales in the longitudinal series (> 34 in *R. staecki* versus < 33 in species of *Anablepsoides*).

Rivulus staecki resembles *R. tecminae* (probably the most closely related species), distributed both in the upper Rio Orinoco and in the upper Rio Negro basin (Thomerson *et al*., 1992; Costa, 2006). *Rivulus tecminae*, however, differs from *R. staecki* by a higher number of scales in the longitudinal series (35–38, mode 36 in *R. staecki* versus 38–43, mode 40 in *R. tecminae*) and by complete stripes on body flanks (versus interrupted stripes on flanks in *R. staecki*). *Rivulus amanapira* Costa (2004) is another species of *Owiyeye* also described from the upper Rio Negro drainage (type locality São Gabriel da Cachoeira, Brazil). It shares with *R. staecki* the possession of a 'rivulus spot' in the dorsal part of the caudal fin base in both sexes and a truncate caudal fin in adult males. *Rivulus staecki* differs from *R. amanapira* by a longer pelvic fin length (> 20 % of SL in males and >10 % in females of *R. staecki* versus < 10 % in *R. amanapira*), a lower number of scales in the longitudinal series (35–38 in *R. staecki* versus 48–49 in *R. amanapira*), a lower number of caudal fin rays (25–26 in *R. staecki* versus 28–30 in *R. amanapira*) and the broad yellow stripe on the ventral margin of the caudal fin (versus entire marginal region of caudal fin yellowish with narrow reddish line both on dorsal and ventral margins; see Costa, 2004, 2006).

Differences in the colour pattern of males of rivulins often are the main or even the sole criterion for species recognition and discrimination (Huber, 1992; Costa, 2006). Observable variation in colour pattern within *Rivulus* species (discussion in Schindler & Etzel, 2008) and variability caused by mood or environmental influences (Huber, 1992), however, prompt questions about the reliability of differentiation and species limits based only on differences in colour patterns. *Rivulus staecki* can be delimitated from its relatives both by a combination of meristic character states and differences in the colour patterns. This makes it more likely that it represents a genetically different unit and an independent lineage in the sense of the evolutionary species concept as re-defined by Wiley (1978).

Based on field observations on the ecology of *Rivulus* species from the Amazon drainage Costa (2006) introduced the hypothesis that species of different clades occupy distinct habitats or distinguishable microhabitats. The preferred habitats of the species of the subgenus *Owiyeye* are shallow temporary or permanent ponds in the tropical forest area. The type locality of *R. staecki* is described by Staeck (2006, personal communication) as a riparian biotope and hence similar to those habitats known for the other species of *Owiyeye*. This supports the hypothesis of divergent ecological specializations during the evolution of this subgenus (Costa, 2006).

In its current concept the genus taxon *Rivulus* is phylogenetically only weakly supported (Costa, 2006). Based on molecular data it is found to be paraphyletic (Hrbek & Larson, 1999) or even polyphyletic (Vermeulen & Hrbek, 2005). Within *Rivulus*, however, there are several species assemblages which are recognized as well supported monophyletic subgenera (Huber, 1999; Costa, 2006, 2008a). The ambivalence between several monophyletic subgenera within a genus *Rivulus*, which is in a phylogenetical sense probably not a natural unit, raises the question about lifting up these subgenera (or some of them) to genus level. But at present no robust comprehensive phylogenetic analysis based on different kinds of character sets is available. Furthermore, subgenera has the advantage that they are optional parts of the scientific names and not in need to be cited. Therefore it seems a good compromise to use subgenera for the classification. This is why we include the new species in the established genus *Rivulus* instead of using one of the subgenera as a genus. Further phylogenetic studies have to verify whether *Rivulus* is a natural monophyletic assemblage or whether it has to be split into separate genera.

Acknowledgements

We are much indebted to Wolfgang Staeck (Berlin, Germany) for sending us the specimens and providing information

and photographs. Many thanks to OTTO CASTILLO and OSCAR JOSE LEÓN MATA (MCNG-UNELLEZ) and AXEL ZARSKE (MTD) for depositing the material in their institutes.

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