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Description of a new species of *Petrotilapia* (Teleostei: Cichlidae), from Lake Malaŵi, Africa

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Abstract.—A new species of *Petrotilapia* from the Nkhata Bay region of Lake Malaŵi is described. The black submarginal band in the dorsal fin distinguishes it from *Petrotilapia tridentiger* Trewavas and *Petrotilapia chrysos* Stauffer & van Snik, which lack this band. The bright blue color of the males distinguishes it from males of *Petrotilapia genalutea* Marsh, which have a dull blue ground color and orange flanks, and males of *Petrotilapia nigra* Marsh, which are predominately black with 7–10 gray/brown bars. A plot of the sheared second principal components of the morphometric data and the first principal components of the meristic data further support that these latter three species are distinct. Females of the new species are light beige to whitish laterally with 5–7 faint brown vertical bars. Juveniles are bright yellow. The new species is sympatric with *P. genalutea* and *P. tridentiger*, but underwater observations show preferences for different habitats and assortative mating among these sympatric species.

Fishes of the family Cichlidae have undergone rapid and extensive radiation in the lakes of East Africa, resulting in as many as 850 species endemic to Lake Malaŵi (Konings 2001). Malaŵian fishermen collectively refer to the group of rock-dwelling cichlids as mbuna (Fryer & Iles 1972). The genus *Petrotilapia* contains the largest species of mbuna. They are easily recognized by their broad lips that are densely covered with slender teeth that are visible even when the mouth is closed (Konings 1990). The numerous teeth are used to comb algae for food. Most species of *Petrotilapia* inhabit the rocky outcroppings, where adult males establish territories. Females, juveniles, and non territorial males are found either singularly or in schools throughout the rocky habitat.

The genus *Petrotilapia* was originally thought to be a single polymorphic species, *Petrotilapia tridentiger* Trewavas, which was diagnosed as having all tricuspid teeth, that are visible when the mouth is closed (Trewavas 1935). Subsequently, (Marsh 1983) described two new species from Monkey Bay, *Petrotilapia genalutea* Marsh and *Petrotilapia nigra* Marsh and modified the generic diagnosis to include cichlids with predominantly tricuspid teeth, noting that all specimens he examined had some distinctly unicuspid teeth (Marsh 1983). He distinguished *P. genalutea, P. nigra*, and *P. tridentiger* using differences in behavior, biology, coloration, and observations of assortative mating (Marsh et al. 1981). With the description of *Petrotilapia chrysos* Stauffer & van Snik, which is endemic to Chinyankwazi and Chinyamwezi islands (Stauffer & van Snik 1996), there are now four described species in the genus; however, there are probably an additional 13 species that are currently undescribed (Ribbink et al. 1983, Konings 1990). In the Nkhata Bay region, *P.*

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tridentiger, P. genalutea, and three different color forms, small blues, browns, and a smaller yellow form have been observed (Konings 1990). The purpose of this paper is to describe a new species of *Petrotilapia* from Nkhata Bay that includes all three color forms.

Materials and Methods

Adult fishes were collected while SCUBA diving, by chasing them into a monofilament net. The fish were anesthetized, pinned, and immediately fixed in 10% formalin. Counts and measurements follow Barel et al. (1977) and Stauffer (1991, 1994) with the following modification. Head depth was measured from the hyoid symphysis to the top of the head (jaws not extended) at a 90° angle to the horizontal body axis. Following abbreviations are used in the tables: ADAA—anterior insertion of dorsal fin to anterior insertion of anal fin; ADPA—anterior insertion of dorsal fin to posterior insertion of anal fin; PDAA—posterior insertion of dorsal fin to anterior insertion of anal fin; PDPA—posterior insertion of dorsal fin to posterior insertion of anal fin; PDVC—posterior insertion of dorsal fin to ventral portion of caudal fin; PADC—posterior insertion of anal fin to dorsal portion of caudal fin; ADP2—anterior insertion of dorsal fin to insertion of pelvic fin; PDP2—posterior insertion of dorsal fin to insertion of pelvic fin. Institutional abbreviations follow (Leviton et al. 1985), except UMBC, University of Malaŵi, Bunda College.

Morphometric data were analyzed using sheared principal component analysis (SPCA), which factors the covariance matrix and restricts size variation to the first principal component (Humphries et al. 1981, Bookstein et al. 1985). Meristic data were analyzed using principal component analysis (PCA) in which the correlation matrix was factored. Comparisons among species were illustrated by plotting the sheared second principal component of the morphometric data against the first principal component of the meristic data.

Petrotilapia microgalana, new species
Fig. 1

Holotype.—PSU 3389, adult male, 103.7 mm SL, Nkhata Bay, Lake Malaŵi, Malaŵi, Africa, 14 March, 1995.

Paratypes.—PSU 3390, 13 (80.4–114.3 mm SL); UMBC (University of Malaŵi, Bunda College) 0003, 3 (92.9–101.7 mm SL); AMNH 238686, 5 (86.4–102.9 mm SL) data as for holotype.

Diagnosis.—The presence of predominately tricuspid teeth in both the upper and lower jaws that are visible when the mouth is closed clearly places *P. microgalana* in the genus *Petrotilapia*. Pigmentation and color patterns of *P. microgalana* distinguish it from all described species of *Petrotilapia*. The black submarginal band in the dorsal fin (Fig. 1) distinguishes *P. microgalana* from *P. tridentiger* and *P. chrysos*. Males of *P. microgalana* have a bright blue ground color along the flanks with 5–7 faint black vertical bars and a blue head. Males of *P. genalutea* have a dull blue ground color laterally with orange color along the flanks, 5–7 black vertical bars, and orange/yellow cheeks, while males of *P. nigra* are predominately black with 7–10 gray/brown vertical bars.

Description.—Morphometric and meristic data are shown in Table 1. Jaws isognathus (Fig. 1); 6–10 rows of teeth in upper and 5–10 rows in lower jaw; most teeth in outer and inner rows tricuspid. Pectoral fins of holotype with 13 rays and 12–14 in paratypes. Scales along lateral side ctenoid; holotype with 32 lateral-line scales; paratypes with 32–33; pored scales posterior to hypural plate 1–2. Three to four scale rows on cheek. Gill rakers on first ceratobranchial 10–11 with 3 on the epibranchial.

Lateral body coloration of territorial males blue with 5–7 faint black vertical

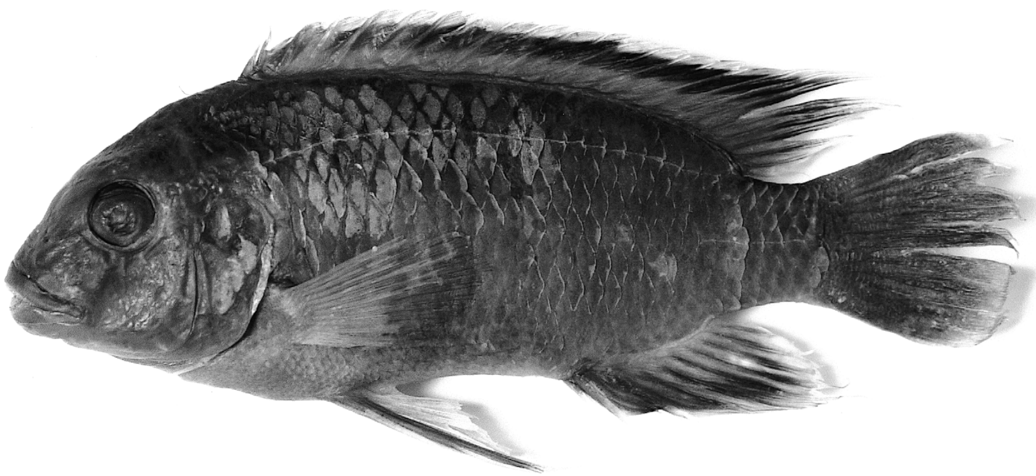

Fig. 1. *Petrotilapia microgalana* holotype, PSU 3389, 103.7 mm SL, Nkhata Bay, Lake Malaŵi, Malaŵi, Africa.

bars. Chest and belly yellow or orange. Head blue with one broad black interorbital bar, black opercle spot, and faint yellowish orange gular region with micromelanophores. Proximal two-thirds of dorsal fin gray with black submarginal band, light blue lappets, and orange tips. Caudal fin with blue membrane, gray rays, and orange tips. Anal fin clear with micromelanophores and 3 orange ocelli. Pelvic and pectoral fins gray with pale blue leading edge. Females with light brown to bright gold lateral body coloration with 5–7 faint brown vertical bars below dorsal fin and series of dark brown blotches running mid-laterally along body. Juveniles bright yellow.

Distribution.—All type specimens were collected from Nkhata Bay, Lake Malaŵi. Konings (1990) postulates the distribution for this species ranges from Bandawe Point to Cape Manulo, a distance of some 84 km along the west coast of Lake Malaŵi.

Discussion

We compared the holotype and 21 paratypes of *P. microgalana* with the other two species of *Petrotilapia*, which contain a black submarginal band in the dorsal fin, *P. genalutea* (PSU 3456 (n = 10); paratypes BMNH 1981.2.2 (n = 5); holotype BMNH 1981.2.2:221) and *P. nigra* (PSU 3455 (n = 5) and PSU 3458 (n = 5) holotype BMNH 81.2.2:206). We could not find a single morphometric or meristic character that did not overlap among these three species (Table 1). Although we did not clear and stain the specimens, we did dissect some of the lower pharyngeal bones and found no differences. It should be noted that many tooth characters in these fishes are phenotypically plastic and, thus, may not provide reliable evidence even if differences were observed (Stauffer & Gray 2004). *Petrotilapia microgalana* is distinct from other *Petrotilapia* species that have a black submarginal band in the dorsal fin. The plot of the sheared second principal components of the morphometric data versus the first principal components of the meristic data shows that *P. microgalana* is clearly distinct from *P. genalutea* and *P. nigra* (Fig. 2), in that the minimum polygon cluster formed by individuals of *P. microgalana* does not overlap with the clusters formed by either *P. genalutea* nor *P. nigra*. Size accounts for 85% and the second principal component accounts for 3.5% of the total

Table 1.—Morphometric and meristic values of *Petrotilapia microgalana* ($n = 22$), *Petrotilapia genalutea* (6), and *Petrotilapia nigra* (10) collected from Nkhata Bay, Lake Malaŵi, Malaŵi, Africa. Mean for *P. microgalana* includes holotype. See Materials and Methods for explanation of abbreviations.

	Petrotilapia microgalana				*Petrotilapia genalutea*		*Petrotilapia nigra*	
Variable	Holotype	$\bar{X}$	*SD*	Range	$\bar{X}$	Range	$\bar{X}$	Range
Standard length, mm	103.7	95.4	8.2	80.4–114.3	111.5	90.4–120.6	107.7	91.8–117.3
Head length, mm	33.4	29.7	3.2	23.1–36.7	33.7	26.9–36.5	33.7	27.1–37.5
Percent standard length								
Head length	32.2	31.0	0.9	28.7–32.5	30.2	28.9–31.6	31.3	29.5–32.4
Snout to dorsal-fin origin	37.5	34.4	1.3	32.2–37.5	32.4	31.3–34.1	32.9	30.5–34.6
Snout to pelvic-fin origin	42.1	39.4	1.7	36.6–42.2	38.6	36.0–40.9	38.4	36.8–41.0
Dorsal-fin base length	59.8	61.6	1.3	59.5–63.9	61.9	58.2–64.1	61.4	59.2–64.6
ADAA	51.7	54.3	1.3	51.7–56.8	54.6	51.8–57.0	55.0	53.7–56.4
ADPA	61.7	65.0	1.4	61.7–67.6	65.0	61.5–67.3	65.6	64.2–67.3
PDAA	30.6	32.2	1.1	29.6–34.6	32.3	30.4–34.2	31.6	31.0–32.6
PDPA	15.1	16.4	0.7	15.1–17.9	16.1	15.2–17.1	15.5	9.1–17.0
PADC	19.6	20.7	0.8	19.2–22.3	20.9	19.9–22.0	20.1	18.9–21.5
PDVC	17.6	18.6	0.5	17.6–19.6	18.5	17.9–19.1	18.0	17.2–18.9
PDP2	56.2	57.0	1.4	54.1–59.4	57.9	56.3–60.8	58.0	56.1–60.6
ADP2	38.3	37.1	1.6	33.5–39.7	36.4	34.0–38.2	36.8	34.9–38.4
Caudal peduncle length	13.8	14.2	0.9	12.2–16.3	14.8	11.8–16.4	13.6	12.2–14.7
Least caudal peduncle depth	14.1	13.8	0.9	12.9–14.8	13.6	13.0–14.3	13.7	12.9–14.4
Percent head length								
Snout length	39.6	38.9	0.3	33.4–45.5	37.3	34.4–42.1	40.2	37.4–41.6
Postorbital head length	40.0	38.6	1.7	35.1–41.1	38.6	35.1–41.7	38.7	37.0–39.9
Horizontal eye diameter	30.7	30.1	3.0	27.5–33.5	31.4	27.4–34.5	29.0	27.3–32.3
Vertical eye diameter	28.7	30.2	1.8	25.4–32.9	32.0	28.3–35.2	28.9	26.4–32.0
Head depth	72.4	74.0	5.7	64.4–82.7	72.5	61.6–81.7	77.0	69.7–84.1
Preorbital depth	24.1	23.0	1.8	19.7–26.4	24.1	22.1–28.2	24.1	22.7–25.5
Cheek depth	28.0	27.3	2.3	21.8–32.5	27.9	25.3–33.5	26.2	22.0–29.2
Lower jaw length	36.2	34.4	2.3	32.0–3-7.5	35.6	30.5–41.2	33.1	29.7–36.0
Counts		Mode	Frequency	Range	X	Range	X	Range
Dorsal-fin spines	17	17	59	17–19	18	17–19	18	17–18
Dorsal-fin rays	9	9	63.4	9–10	9	9–10	9	8–10
Anal-fin spines	3	3	100	—	3	—	3	—
Anal-fin rays	8	8	60	7–8	8	8–9	8	7–9
Pelvic-fin rays	5	5	100	—	5	—	5	—
Pectoral-fin rays	13	13	50	12–14	14	13–14	13	13–14
Lateral line scales	33	32	54	32–33	30	29–33	30	30–32
Pored scales post. lat line	2	2	95	1–2	2	0–2	2	0–2
Scale rows cheek	4	3	68	3–4	4	3–4	3	—
Gill rakers 1st ceratobranchial	11	10	77	10–11	10	9–11	9–10	9–11
Gill rakers 1st epibranchial	3	3	100	—	3	2–3	3	2–3
Teeth outer left lower jaw	11	13	41	9–15	19	12–21	18	14–18
Teeth rows upper jaw	6	6	59	6–10	11	7–13	13	8–13
Teeth rows lower jaw	8	7/8	27	5–10	11	9–17	18	14–18

variation. Variables with the highest loadings on the sheared second principal component in decreasing order of importance are snout length, caudal peduncle length, and head depth. The first principal component of the meristic data explains 56.6% of the variance. Variables with the highest standardized scoring coefficients

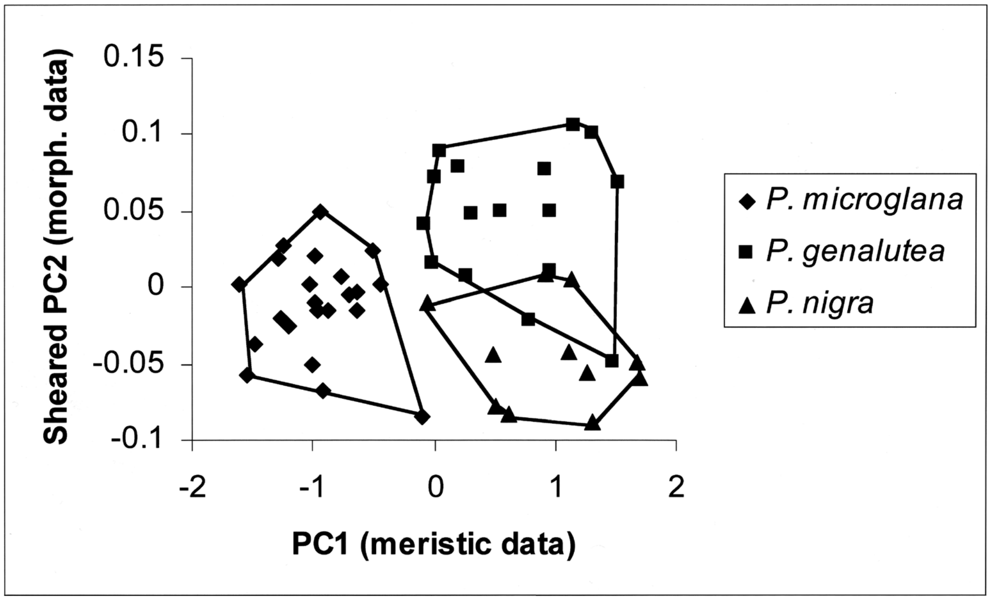

Fig. 2. Plot of the first principal component of the meristic data and the second sheared principal component of the morphometric data of *Petrotilapia microgalana, Petrotilapia genalutea*, and *Petrotilapia nigra*.

on the first principal component in decreasing order are teeth rows on the lower jaw, teeth rows on the upper jaw, number of teeth on the left lower jaw, and number of gill-rakers on the outer ceratobranchial.

Unique color patterns among cichlids, especially the males, are recognized as sufficient to diagnose valid species (Barlow 1974, Barel et al. 1977, Stauffer et al. 1995). Pigmentation and color patters of *P. microgalana* distinguish it from all described species of *Petrotilapia*. The juveniles of this species, which are found at shallower depths, appear bright yellow, which resemble females and juveniles of *P. chrysos*; however, *P. chrysos* lacks the submarginal band in the dorsal fin, which is present in juveniles, adult females, and adult males of *P. microgalana*. Neither of the sympatric species, *P. tridentiger* or *P. genalutea*, have juveniles that are yellow. Additionally, multivariate analysis demonstrated that *P. microgalana* is distinguished from other congeners (i.e., *P. genalutea* and *P. nigra*), which possess this band in the dorsal fin. Our recognition of three distinct species at Nkhata Bay (i.e., *P. tridentiger, P. genalutea*, and *P. microgalana*) is further supported by differences in preferred depths among the three species (Konings 1990), with *P. microgalana* occurring deeper than the other two species and observations documenting assortative mating of the three species (Marsh et al. 1981).

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