

Five new species of the genus *Petrotilapia* (Teleostei: Cichlidae), from Lake Malaŵi, Africa

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Most rocky shores of Lake Malaŵi harbor three different members of *Petrotilapia*, each one occurring in its own preferred habitat. None of the known species of *Petrotilapia* has a lake-wide distribution and similar habitats at separate localities harbor sometimes different species. The relationship between the members of each of the three groups is not only reflected in the habitat preference but often also in the basic melanin pattern. The three species groups have been referred to as the *P. tridentiger* group, the *P. nigra* group and the *P. genalutea* group. Five new species from various habitats throughout the lake are described: *P. xanthos*, *P. flaviventris* (both *P. nigra* group), *P. palingnathos* (*P. tridentiger* group), *P. pyrosceles* (*P. genalutea* group), and *P. mumboensis* which is the only species that cannot satisfactorily be assigned to any of these groups.

Introduction

The African Great Lakes, lakes Victoria, Tanganyika, and Malaŵi, all harbor a large number of endemic cichlid fishes (Fryer & Iles, 1972; Coulter, 1991). The fishes in each lake exhibit remarkable diversity in terms of morphology, ecology, and behavior, and this diversity was acquired through independent and explosive adaptive radiation (Danley & Kocher, 2001). Lake Malaŵi is the southernmost of the East African Rift Lakes and harbors about 850 cichlid species of which less than 500 have been described. Allopatric speciation (Fryer & Iles, 1972) and intrinsic isolating mechanisms (McKaye & Stauffer, 1986) are the two most widely proposed driving forces for the speciation events that led to the explosive radiation of the haplochromine cichlids in the Great

Lakes of Africa, with sexual selection as a leading mechanism to the diverse cichlid fauna of Lake Malaŵi (Dominey, 1984; Turner & Burrows, 1995; Deutsch, 1997; Kellogg et al., 2000).

The small, rock-dwelling haplochromine cichlid fishes in Lake Malaŵi are commonly referred to as mbuna. The genus *Petrotilapia* – one of the 13 genera currently recognized within the mbuna – includes five described species, *P. tridentiger* Trewavas, 1935, *P. genalutea* Marsh, 1983, *P. nigra* Marsh, 1983, *P. chrysos* Stauffer & van Snik, 1996 and *P. microgalana* Ruffing, Lambert & Stauffer, 2006, and about a dozen recognized taxa that await description (Ribbink et al., 1983; Konings, 2007). *Petrotilapia* was diagnosed by Trewavas (1935) as having all oral teeth tricuspid and being similar in form to *Petrochromis* from Lake Tanganyika. Subsequently, Marsh (1983)

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Fig. 1. Map of Lake Malaŵi showing distribution of species discussed in text.

modified the generic diagnosis to include cichlids with predominantly tricuspid teeth in the major dentigerous area because there is usually a single or double lateral series of stout unicuspid teeth on both jaws posterior to that area.

Members of the genus *Petrotilapia* are further characterized by broad fleshy lips that are densely covered with slender teeth that are exposed, even when the mouth is closed (Ribbink et al., 1983). The numerous teeth are used to comb the algae on rocks for diatoms and loose algal strands. Species of *Petrotilapia* feed from slanted and vertical slopes at perpendicular angles (Ribbink et al., 1983; Stauffer & Posner, 2006). Most species of *Petrotilapia* inhabit the rocky outcroppings,

where adult males establish territories. Females, juveniles, and non-territorial males are found either singly or in schools throughout the rocky habitat (Ribbink et al., 1983).

The members of *Petrotilapia* can be divided into three habitat-related groups (Konings, 2001), and many rocky shores harbor a species from each group. The three groups are the *P. tridentiger* group, the *P. genalutea* group, and the *P. nigra* group. The members of the *P. tridentiger* group are found mainly in the wave-washed upper rocky habitat. *Petrotilapia genalutea* is the most widespread member of *Petrotilapia* and lives in sediment-rich and intermediate habitats. Only two other species are assigned to the *P. genalutea* group: *P. sp. 'chitande'* and *P. sp. 'orange pelvic'*. The *P. nigra* group is by far the largest, containing more than a dozen species that are strictly bound to rocky environments. Their preference for the somewhat deeper rocky habitats isolates them geographically from neighboring populations.

The three *Petrotilapia* groups can also be identified by female color pattern. The pattern in females of the *P. tridentiger* group consists of vertical bars – which are not, however, always in evidence – on a gray-brown to brown background. Females of the *P. genalutea* group are characterized by two rows of spots on the flank, the lower of which consists of a few large blotches. The background color is white or light gray and the dorsal fin has a black submarginal band. Females of the *P. nigra* group often have a yellow or golden background color and a pattern consisting of two horizontal rows of spots, all more or less the same size (those of the mid-lateral row slightly larger). Often a pattern of vertical bars is superimposed on the two horizontal rows of spots and sometimes the spots merge to form solid horizontal lines.

One of the species that cannot satisfactorily be assigned to any of these three groups, provisionally referred to as *P. 'mumbo blue'* by Ribbink et al. (1983), is described herein. At Thumbi West and Mbenji islands, it shares the habitat with three other species of *Petrotilapia* and it should therefore, perhaps, be considered to constitute a fourth group in the genus.

The most distinctive difference among these species is live coloration. Several studies have recognized the existence of unique color patterns to be a reliable character for distinguishing cichlid species (Barel et al., 1977; Ribbink et al., 1983; Bowers & Stauffer, 1993; Stauffer et al., 1995, 1997b). Most species differ principally by male coloration

and melanin pattern, thus pigmentation remains an important tool for describing cichlid fishes of Lake Malaŵi. The purpose of this paper is to describe five new species of *Petrotilapia*.

Materials and methods

Live fishes were collected by chasing them into a monofilament net while SCUBA diving. Upon collection, the fishes were anaesthetized in clove oil, fixed in 10 % formalin for at least two weeks, then transferred to 70 % ethanol for permanent storage. In addition, detailed field notes on live coloration of the specimens were recorded. All bars from just posterior to the operculum to the origin of the caudal fin are counted, if they originate at the dorsal portion of the flank and extend downward to at least the level of the lower lateral line. Twenty-four measurements and fourteen counts were taken on previously described type material and newly collected populations of *Petrotilapia*. Figure 1 shows the collection sites mentioned. Counts and measurements followed Stauffer (1991, 1994). All morphometric characters were measured in millimeters with digital calipers, between recognizable landmarks. Institutional abbreviations follow Leviton et al. (1985), except UMBC, University of Malaŵi, Bunda College.

Meristic data were analyzed using principal component analysis (PCA) in which the correlation matrix was factored. 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; Stauffer et al., 1997b). 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 (Stauffer et al., 1997b).

Petrotilapia xanthos, new species

(Fig. 2)

Petrotilapia sp. 'hara' Konings, 2007

Holotype. PSU 4757, 130.4 mm SL; Malaŵi: Lake Malaŵi: Gallireya Reef, 10°30.0' S 34°14.1' E; A. F. Konings & J. R. Stauffer, 21 Jan 2007.

Paratypes. PSU 4756, 24, 76.1–124.5 mm SL; same data as for holotype. – PSU 4758, 16, 74.7–122.3 mm SL; same locality; A. F. Konings & J. R. Stauffer, 15 Jun 2008.

Diagnosis. The absence of a dark submarginal band in the dorsal fin distinguishes *P. xanthos* from *P. microgalana*, *P. genalutea*, *P. nigra*, *P. chrysos*, *P. mumboensis*, and *P. pyrosceles* which have such a band. Adult males of *P. xanthos* are yellow, which distinguishes them from *P. tridentiger*, which are light blue with dark blue bars. Adult males of *P. xanthos* are also distinct from those of *P. flaviventris*, and *P. palingnathos*. Males of *P. flaviventris* are yellow on ventral and mid flank with scales outlined in blue; the dorsal one-third is blue to gray with yellow and orange highlights; cheeks and throat yellow to orange. Adult male (and female) *P. palingnathos* have distinctly retrognathous jaws and can thus be distinguished from those of *P. xanthos*. Females of *P. xanthos* are light brown, which distinguishes them from those of *P. tridentiger*, which are brown, from *P. chrysos* and *P. microgalana*, which are golden yellow, from those of *P. flaviventris*, which are yellow brown with interrupted black stripes and fading to dark brown dorsally. The melanin pattern in females of *P. xanthos* have both horizontal and vertical elements, which distinguishes them from those of *P. chrysos*, which lack a distinct melanin pattern and are completely yellow, and from *P. microgalana* and *P. flaviventris*, which have no vertical elements in their melanin pattern.

Description. Morphometric and meristic data in Table 1. Body depth at origin of dorsal fin 32.3–39.2 % SL. Dorsal head profile concave between snout tip and interorbital. Horizontal and vertical eye diameters 29.8–35.5 % HL and 30.1–36.9 % HL, respectively; preorbital depth 22.6–28.3 % HL. Snout 33.4–38.6 % HL. Isognathous jaws and thickened lips. Teeth on lower jaw in 10–17 rows with outer and inner rows tricuspid. Dorsal fin with XVII–XVIII (mode XVIII) spines and 6–10 (mode 9) rays. Anal fin with III spines and 7–8 (mode 8) rays. First dorsal-fin spine about half length of eighth spine. Caudal fin subtruncate to emarginate. Depressed pelvic fin not reaching anal fin in females, reaching second to third anal spine in males. Pectoral fin round and paddle-shaped. Flank scales large, ctenoid; cheek with 2–5 rows of scales. Lateral line with 29–31 pored scales.

Coloration. Live males with gold head and green opercular spot. Flank and breast gold with white to pale yellow belly, gold dorsal fin; caudal fin with gold rays and blue membranes. Anal fin proximal $\frac{1}{4}$ yellow, distal $\frac{3}{4}$ blue to gray with 1–5 yellow ocelli. Pelvic fin with light blue to white anterior margin, gold to clear posteriorly. Pectoral fin with gold rays and clear membranes.

Females with brown head; white to light

brown throat, and purple highlights on cheek; black opercle spot with green highlights. Flank light brown with 5–8 dark brown bars and narrow horizontal mid-lateral and dorso-lateral stripe, and light brown breast and white belly. Dorsal spines and rays clear, membranes clear with brown spot between spines and black spots between rays. Proximal half of caudal fin brown, distal half light gray and membranes with light

Table 1. Morphometric and meristic values of *Petrotilapia xanthos* (N=40; PSU 4756, 4757, 4758). Ranges include holotype.

	holotype	mean	SD	range
Standard length (mm)	130.4	104.2	15.2	74.7–130.4
Head length (mm)	39.0	32.0	4.3	23.6–39.0
Percent standard length				
Body depth	35.6	35.1	1.5	32.3–39.2
Snout to dorsal-fin origin	31.7	31.7	1.0	29.9–33.8
Snout to pelvic-fin origin	39.8	39.1	1.2	37.1–42.0
Dorsal-fin base length	63.1	60.9	1.3	58.8–63.9
Anterior dorsal to anterior anal	55.0	54.1	1.5	50.5–57.0
Anterior dorsal to posterior anal	64.8	64.2	1.1	62.0–67.2
Posterior dorsal to anterior anal	32.1	32.5	1.1	30.5–34.3
Posterior dorsal to posterior anal	16.5	16.4	0.7	15.3–17.9
Posterior dorsal to ventral caudal	17.8	18.3	0.6	17.1–20.2
Posterior anal to dorsal caudal	18.8	19.4	0.5	18.6–20.9
Anterior dorsal to pelvic fin origin	40.2	38.6	1.6	34.4–42.1
Posterior dorsal to pelvic fin origin	60.9	59.7	1.5	55.7–62.7
Caudal peduncle depth	14.6	14.7	0.8	13.1–17.0
Least caudal peduncle depth	13.5	13.3	0.4	12.7–14.3
Percent head length				
Snout length	37.8	35.8	1.5	33.4–38.6
Postorbital head length	38.8	37.6	0.9	35.5–38.9
Horizontal eye diameter	29.8	32.6	1.4	29.8–35.5
Vertical eye diameter	30.1	33.0	1.3	30.1–36.9
Head depth	92.5	86.7	5.0	77.0–96.3
Preorbital depth	26.8	25.7	1.4	22.6–28.3
Cheek depth	25.9	24.6	2.1	15.8–28.8
Lower jaw length	34.0	33.7	1.6	29.1–36.7
Counts				
		mode	% frequency	range
Dorsal-fin spines	18	18	72.5	17–19
Dorsal-fin rays	9	9	80.0	6–10
Anal-fin spines	3	3	100.0	3
Anal-fin rays	9	8	70.0	7–9
Pelvic-fin rays	5	5	100.0	5
Pectoral-fin rays	14	14	67.5	12–14
Lateral line scales	30	31	50.0	29–31
Pored scales posterior to hypural plate	1	2	62.5	0–3
Scale rows on cheek	4	4	72.5	2–5
Gillrakers on first ceratobranchial	10	11	50.0	10–12
Gillrakers on first epibranchial	3	3	95.0	2–3
Teeth on outer row of left lower jaw	19	14	20.0	10–19
Teeth rows on upper jaw	15	13	30.0	9–16
Teeth rows on lower jaw	16	14	30.0	10–17

gray spots. Proximal $\frac{3}{4}$ of anal fin dark brown, distal $\frac{1}{4}$ clear, anal fin membranes with narrow orange margin and 1–3 small faint orange ocelli. Pelvic and pectoral fins clear.

Preserved males with yellow to light brown head, black opercle, and yellow to brown throat; flank yellow with sometimes 7–8 light brown vertical bars and yellow breast and belly. Dorsal, caudal, anal, and pectoral fins faint yellow. Pelvic

fin yellow with yellow to clear membranes. Preserved females with dark to light brown head, black opercle, and yellow throat. Flank light brown to yellow with two horizontal dark stripes and 5–8 dark bars; breast and belly yellow to whitish.

Distribution. *Petrotilapia xanthos* is only known from the type locality, Gallireya Reef, Malawi (Fig. 1).

Table 2. Morphometric and meristic values of *Petrotilapia flaviventris* (N=18; PSU 4759, 4760). Ranges include holotype.

	holotype	mean	SD	range
Standard length (mm)	110.9	94.1	14.2	68.0–111.2
Head length (mm)	36.2	30.5	4.5	21.6–36.2
Percent standard length				
Body depth	38.5	37.6	0.8	36.3–39.0
Snout to dorsal-fin origin	33.7	33.3	0.8	32.1–34.9
Snout to pelvic-fin origin	42.1	40.9	1.2	37.4–42.9
Dorsal-fin base length	63.5	61.2	1.5	57.9–63.5
Anterior dorsal to anterior anal	55.8	55.5	1.1	52.7–57.0
Anterior dorsal to posterior anal	66.2	64.9	1.3	61.6–66.4
Posterior dorsal to anterior anal	32.5	31.2	0.7	29.9–32.7
Posterior dorsal to posterior anal	16.4	15.7	0.6	13.7–16.5
Posterior dorsal to ventral caudal	17.5	17.1	0.4	16.1–17.8
Posterior anal to dorsal caudal	18.3	18.3	0.5	17.4–19.3
Anterior dorsal to pelvic fin origin	41.5	41.1	0.9	38.5–41.6
Posterior dorsal to pelvic fin origin	59.7	40.4	1.6	56.7–62.1
Caudal peduncle depth	12.7	12.3	0.6	11.4–13.7
Least caudal peduncle depth	13.7	12.9	0.3	12.4–13.7
Percent head length				
Snout length	38.6	37.2	1.8	32.6–39.9
Postorbital head length	39.0	37.6	1.1	35.5–40.1
Horizontal eye diameter	29.7	30.5	1.7	28.0–34.7
Vertical eye diameter	30.7	31.3	1.5	28.6–33.7
Head depth	93.2	90.6	1.0	86.9–94.8
Preorbital depth	26.9	26.2	2.4	24.2–28.6
Cheek depth	26.2	25.6	1.7	22.4–29.9
Lower jaw length	34.3	34.7	1.0	33.0–36.4
Counts				
Dorsal-fin spines	18	18	66.7	17–19
Dorsal-fin rays	9	9	77.8	8–9
Anal-fin spines	3	3	100.0	3
Anal-fin rays	8	8	88.9	7–8
Pelvic-fin rays	5	5	100.0	5
Pectoral-fin rays	14	14	61.1	13–14
Lateral line scales	30	30	61.1	30–31
Pored scales posterior to hypural plate	1	2	77.9	1–2
Scale rows on cheek	4	4	88.9	3–4
Gillrakers on first ceratobranchial	11	10	83.3	10–11
Gillrakers on first epibranchial	2	3	72.2	2–3
Teeth on outer row of left lower jaw	14	13	27.8	10–18
Teeth rows on upper jaw	14	14	27.8	10–17
Teeth rows on lower jaw	16	13	22.2	11–18



Fig. 2. *Petrotilapia xanthos*, Malaŵi: Lake Malaŵi: Gallireya Reef; **a**, PSU 4757, holotype, 130.4 mm SL, adult male; **b**, adult male; **c**, adult female.

Etymology. The name *xanthos*, from the Greek, meaning yellow referring to the yellow breeding color of males. A noun in apposition.

Petrotilapia flaviventris, new species
(Fig. 3)

Petrotilapia ‘yellow ventral’ Ribbink et al., 1983

Holotype. PSU 4760, 110.9 mm SL; Malaŵi: Chizumulu Island: Same Bay, 12°00.6'S 34°36.9'E; S. M. Grant, A. F. Konings & J. R. Stauffer, 21 Feb 2006.

Paratypes. PSU 4759, 17, 68.0–111.2 mm SL; same data as for holotype.

Diagnosis. Absence of a dark submarginal band in the dorsal fin distinguishes *P. flaviventris* from males of *P. microgalana*, *P. genalutea*, *P. nigra*, *P. chrysos*, *P. mumboensis*, and *P. pyrosceles*, which have such a band. Adult males of *P. flaviventris* are yellow on ventral and mid flank with scales outlined in blue; the dorsal one-third is blue to gray with yellow and orange highlights; cheeks and throat are yellow to orange. Males of *P. tridentiger* are light blue with dark blue bars; while those of *P. xanthos* are yellow. Adult male (and female) *P. palingnathos* have distinctly retrognathous jaws and can thus be distinguished from those of *P. flaviventris*. Females of *P. flaviventris* are yellow brown with interrupted black horizontal stripes and with a background coloration fading to dark brown dorsally, which distin-



Fig. 3. *Petrotilapia flaviventris*, Malaŵi: Lake Malaŵi: Chizumulu Island; a, PSU 4760, holotype, 110.9 mm SL, adult male; Same Bay; b, adult male; Mkanila Bay; c, adult female; Mkanila Bay.

guishes them from those of *P. tridentiger*, which are brown and from *P. chrysos* and *P. microgalana*, which are golden yellow. Females of *P. flaviventris* are further distinguished from those of *P. xanthos*, which are light brown.

Description. Morphometric and meristic data in Table 2. Body depth at origin of dorsal fin between 36.3–39.0 % SL. Dorsal head profile concave between snout tip and interorbital. Horizontal and vertical eye diameters 28.0–34.7 % HL and 28.6–33.7 % HL, respectively; preorbital depth 24.2–28.6 % HL. Snout 32.6–39.9 % HL. Isognathous jaws and thickened lips. Teeth on lower jaw in 10–18 rows with outer row and inner rows tricuspid. Dorsal fin with XVII–XIX (mode XVIII) spines and 8–9 (mode 9) rays. Anal fin with III spines and 7–8 (mode 8) rays. First dorsal-fin spine less

than half length of eighth spine. Caudal fin subtruncate to emarginate. Depressed pelvic fin not reaching anal fin in females, reaching first anal spine in males. Pectoral fin round and paddle-shaped. Flank scales large, ctenoid; cheek with 3–4 rows of scales. Lateral line with 30–31 pored scales.

Coloration. Live males with yellow cheek, ventral preopercle, opercle, and throat; preopercle and opercle with blue highlights; interorbital dark blue. Flank blue and yellow; ventral one-third yellow, mid one-third yellow with scales outlined in blue and yellow highlights; breast and belly yellow. Dorsal fin yellow and blue with blue membranes. Caudal fin with blue rays and yellow membranes. Anal-fin spines and membranes blue/black, anterior rays blue/black, posterior

rays blue with 1–5 ocelli, anal-fin membrane blue and black. Pelvic fin yellow with blue leading edge. Pectoral fin with yellow rays and clear membranes.

Live females with dark brown head, black opercle with blue green highlights and gray throat. Flank yellow brown with interrupted black stripes with 8–9 faint vertical bars, and fading to dark brown dorsally. Breast and belly light gray. Dorsal-fin spines brown, proximal two-thirds of membranes brown, distal one-third light blue; gray brown lappets, and membranes of rays with brown spots. Caudal fin with brown rays and blue gray membranes. Proximal two-thirds light brown, distal one-third clear without ocelli. Membranes of first two rays of pelvic fin yellow brown, remaining membranes clear. Pectoral fin with brown rays and clear membranes.

Preserved males with brown head, light brown cheek, black opercle, and light brown to yellow throat. Flank of ventral and mid-side light brown to yellowish and scales outlined in brown with 6 faint brown vertical bars. Flank dorsally dark brown with dark spots; belly and breast light brown to white. Dorsal fin light brown to white with clear spines, rays, and membranes; dorsal fin without black submarginal band. Caudal-fin rays light brown with clear membranes. Anal fin light brown with dark rays and spines with dark leading edge. Pelvic fin light brown with clear spine, rays, and membranes. Pectoral fin with light brown rays and clear membranes.

Preserved females with dark brown head, black opercle, brown cheek, and brown to light brown throat. Flank brown with mid-lateral and dorso-lateral row of dark blotches and 8–9 black bars; belly yellow to whitish, breast brown to yellow. Dorsal fin light brown with clear membranes and without submarginal band; brown spots on rays. Caudal fin with gray rays, clear membranes, and black blotches. Anal fin with brown rays and spines with clear membranes. Pectoral fin with light brown rays, clear membranes. Pelvic fin with brown spine and anterior rays; posterior rays and membranes clear.

Distribution. *Petrotilapia flaviventris* is found at Chizumulu Island. Konings (2007) reports the presence of *P. flaviventris* between Mbweca, Mozambique, and Undu Point, Tanzania (Fig. 1).

Etymology. The name *flaviventris*, from *flavus* (Latin), meaning yellow and *venter* (Latin), mean-

ing the underside or belly, referring to the yellow color on the ventral side of this species. A noun in apposition.

Petrotilapia palingnathos, new species
(Fig. 4)

Petrotilapia ‘retrognathous’ Ribbink et al., 1983

Holotype. PSU 4767, 118.0 mm SL; Malaŵi: Chizumulu Island: Same Bay, 12°01.6' S 34°37.7' E; J. R. Stauffer & A. F. Konings, 21 Feb 2006.

Paratypes. PSU 4766, 5, 96.3–117.7 mm SL; same data as for holotype.

Diagnosis. Adult male and female *P. palingnathos* have distinctly retrognathous jaws and can thus be distinguished from all other members of *Petrotilapia*. Furthermore, the absence of a dark submarginal band in the dorsal fin distinguishes *P. palingnathos* from *P. microgalana*, *P. genalutea*, *P. nigra*, *P. chrysos*, *P. mumboensis*, and *P. pyrosceles*, which have such a band. Adult males of *P. palingnathos* are dark gray with orange markings and scales outlined in blue with orange cheek and a blue gular area, which distinguishes them from *P. tridentiger*, which are light blue with dark blue bars, and from males of *P. xanthos* which are yellow, while those of *P. flaviventris* are yellow on ventral and mid-sides with scales outlined in blue.

Description. Morphometric and meristic data in Table 3. Body depth at origin of dorsal fin 38.0–38.9 % SL. Dorsal head profile concave between snout tip and interorbital. Horizontal and vertical eye diameters 23.6–26.2 % HL and 25.6–27.7 % HL, respectively; preorbital depth 24.9–30.8 % HL. Snout length 40.5–44.5 % HL. Retrognathous jaws and thickened lips. Teeth on lower jaw in 18–26 rows with outer and inner rows tricuspid. Dorsal fin with XVII–XVIII (mode XVIII) spines and 8–10 (mode 9) rays. Anal fin with III spines and 7–8 (mode 8) rays. First dorsal-fin spine less than half length of eighth spine. Caudal fin subtruncate to emarginate. Depressed pelvic fin reaching first ray in males. Pectoral fin round and paddle-shaped. Flank scales large, ctenoid; cheek with 4 rows of scales. Lateral line with 30–31 pored scales.

Coloration. Live males with orange cheek and preorbital, preopercle, and opercle orange with blue highlights; throat blue; interorbital dark gray with light blue bar. Flank dark gray with scales outlined in blue, and with some orange markings, with 8–10 faint vertical dark gray bars. Dorsal spines dark blue/gray; blue membrane with orange markings. Caudal fin with blue rays and orange membranes. Anal fin with faint orange

cast and 1–3 yellow ocelli. Pelvic fin with yellow to clear membranes and white to light blue leading edge. Pectoral fins with brown rays and clear membranes.

Live coloration for female *P. palingnathos* absent; following description of females from photos in natural habitat. Females with overall orange brown color and 8–10 dark brown vertical bars; dark brown opercle; throat, breast, and belly yellow.

Table 3. Morphometric and meristic values of *Petrotilapia palingnathos* (N=6; PSU 4766, 4767). Ranges include holotype.

	holotype	mean	SD	range
Standard length (mm)	118.0	111.5	8.3	96.3–118.0
Head length (mm)	37.7	36.3	2.3	32.4–38.4
Percent standard length				
Body depth	38.0	38.6	0.3	38.0–38.9
Snout to dorsal-fin origin	34.1	35.1	0.8	34.1–36.2
Snout to pelvic-fin origin	41.0	40.5	0.9	38.8–41.2
Dorsal-fin base length	61.5	61.3	1.2	58.9–62.5
Anterior dorsal to anterior anal	56.3	55.6	0.3	55.1–56.3
Anterior dorsal to posterior anal	65.4	65.1	0.9	63.5–66.4
Posterior dorsal to anterior anal	30.6	30.4	0.4	29.4–30.7
Posterior dorsal to posterior anal	16.0	16.2	0.5	15.3–16.7
Posterior dorsal to ventral caudal	18.5	18.1	0.5	17.5–18.7
Posterior anal to dorsal caudal	19.4	19.3	0.2	18.8–19.6
Anterior dorsal to pelvic fin origin	39.0	39.8	1.0	38.5–41.2
Posterior dorsal to pelvic fin origin	55.9	57.0	1.0	55.9–58.5
Caudal peduncle depth	17.6	15.0	1.4	13.8–17.6
Least caudal peduncle depth	13.7	13.9	0.2	13.7–14.1
Percent head length				
Snout length	40.5	41.9	1.4	40.5–44.5
Postorbital head length	34.6	36.5	1.4	34.6–38.8
Horizontal eye diameter	24.8	24.9	0.9	23.6–26.2
Vertical eye diameter	25.6	26.2	0.8	25.6–27.7
Head depth	92.6	91.0	2.4	88.5–94.8
Preorbital depth	24.9	27.6	2.3	24.9–30.8
Cheek depth	25.8	26.6	0.9	25.2–27.6
Lower jaw length	35.2	34.0	1.3	31.5–35.2
Counts				
Dorsal-fin spines	18	18	66.7	17–18
Dorsal-fin rays	9	9	50.0	8–10
Anal-fin spines	3	3	100.0	3
Anal-fin rays	8	8	66.7	7–8
Pelvic-fin rays	5	5	100.0	5
Pectoral-fin rays	14	14	66.7	14–15
Lateral line scales	31	31	66.7	30–31
Pored scales posterior to hypural plate	2	1	50.0	1–2
Scale rows on cheek	4	4	100.0	4
Gillrakers on first ceratobranchial	10	10	83.3	9–10
Gillrakers on first epibranchial	2	2	100.0	2
Teeth on outer row of left lower jaw	25	20	33.3	19–25
Teeth rows on upper jaw	21	17	33.3	16–21
Teeth rows on lower jaw	26	26	33.3	18–26



Fig. 4. *Petrotilapia palingnathos*, Malaŵi: Lake Malaŵi: Chizumulu Island; **a**, PSU 4767, holotype, 118.0 mm SL, adult male; Same Bay; **b**, adult male; Mkanila Bay; **c**, adult female; Same Bay.

low to orange. Dorsal fin without black submarginal band; spines and rays brown with orange lappets and clear membranes. Pelvic fin brown with blue leading edge and clear membranes. Pectoral fin with brown rays and clear membranes.

Preserved males with brown head, black opercle, and light brown throat. Flank dark brown and without bars; belly and breast brown. Dorsal fin without black submarginal band; spines, rays, and membranes gray. Caudal fin with dark brown rays and brown membranes. Anal fin light brown with 1–3 light brown ocelli; membranes light brown. Pelvic fin with light brown spine and rays; membranes clear. Pectoral fin with light brown rays and clear membranes. No preserved female specimens.

Distribution. *Petrotilapia palingnathos* occurs at Chizumulu Island. Konings (2007) reports this

species' presence at Taiwanese Reef as well (Fig. 1). It is normally found in the shallow but not wave-washed habitat.

Etymology. The name *palingnathos*, from the Greek *pálin*, meaning back or backwards, and *gnáthos*, meaning mouth or jaw, referring to the shorter lower jaw. A noun in apposition.

***Petrotilapia mumboensis*, new species**
(Fig. 5)

Petrotilapia 'mumbo blue' Ribbink et al., 1983

Holotype. PSU 4765, 106.1 mm SL; Malaŵi: Mumbo Island, 13°59.5'S 34°45.4'E; A. F. Konings, J. R. Stauffer, and S.M. Grant, 8 Feb 2003.

Paratypes. PSU 4764, 8, 86.1–105.7 mm SL; same



Fig. 5. *Petrotilapia mumboensis*, Malaŵi: Lake Malaŵi: Mumbo Island; a, PSU 4765, holotype, 106.1 mm SL, adult male; b, adult male; c, adult female (mouthbrooding).

data as for holotype. – PSU 4763, 9, 78.9–105.5 mm SL; Malaŵi: Mumbo Island, 13°59.5' S 34°45.4' E; J. R. Stauffer and S.M. Grant, 15 Apr 2003. – PSU 4748, 1, 127.2 mm SL; Malaŵi: Thumbi West Island, 14°0.9' S 34°48.3' E; A. F. Konings and J. R. Stauffer, 7 Feb 2003. – PSU 4747, 16, 80.2–120.6 mm SL; Malaŵi: Thumbi West Island; J.R. Stauffer, 28 Jan 2000. – PSU 4746, 4, 103.4–127.2 mm SL; Malaŵi: Thumbi West Island, 14°0.8' S 34°48.3' E; A. F. Konings and J. R. Stauffer, 7 Feb 2003.

Diagnosis. The dark submarginal band in the spinous part of the dorsal fin of both male and female distinguishes *P. mumboensis* from *P. tridentiger*, *P. xanthos*, *P. flaviventris*, and *P. palingnathos*, which lack such a band. Males of *P. mumboensis* are light blue with 8–10 dark blue vertical bars,

light blue cheek, and a light blue to gray gular region, which distinguishes it from *P. genalutea*, *P. nigra*, *P. chrysos*, *P. microgalana*, and *P. pyrosceolos*. *Petrotilapia genalutea* are dull gray-blue with 5–7 black vertical bars with orange-yellow cheek and a black throat. Males of *P. nigra* and *P. chrysos* are predominantly blue-black with 7–10 gray/brown bars, have a dark blue cheek, and a black throat. Males of *P. microgalana* are bright blue with 5–7 faint black vertical bars, and have a light blue cheek and a yellow throat while those of *P. pyrosceolos* are blue with bronze highlights and have a red pelvic fin. Females of *P. mumboensis* are gray-brown to light brown with a conspicuous black submarginal band in the dorsal fin and are distinguished from those of *P. genalutea*, *P. nigra*, *P. chrysos*, and *P. microgalana* by the lack of hori-

zontal elements in the pigmentation pattern on the flank and from females of *P. pyroscelos*, which are brown with faint blue and yellow highlights and often have dorso-lateral series of faint spots.

Description. Morphometric and meristic data in Table 4. Body depth at origin of dorsal fin 36.3–42.5 % SL. Dorsal head profile concave between snout tip and interorbital; large males with small

hump at interorbital. Horizontal and vertical eye diameters 23.4–30.2 % HL and 24.7–31.5 % HL, respectively; preorbital depth 20.0–28.5 % HL. Snout 32.3–42.8 % HL. Isognathous jaws and thickened lips. Teeth on lower jaw in 9–21 rows with teeth in outer and inner rows tricuspid. Dorsal fin with XVI–XVIII (mode XVII) spines and 8–10 (mode 9) rays. Anal fin with III spines and 7–9 (mode 8) rays. First dorsal-fin spine less

Table 4. Morphometric and meristic values of *Petrotilapia mumboensis* (N=39; PSU 4746, 4747, 4748, 4763, 4764, 4765). Ranges include holotype.

	holotype	mean	SD	range
Standard length (mm)	106.1	100.9	12.5	78.9–127.2
Head length (mm)	36.9	34.0	3.6	27.6–40.0
Percent standard length				
Body depth	42.0	39.2	1.4	36.3–42.5
Snout to dorsal-fin origin	35.9	35.0	1.1	32.5–36.9
Snout to pelvic-fin origin	40.7	40.1	1.9	33.6–44.3
Dorsal-fin base length	63.6	61.8	1.5	59.5–64.9
Anterior dorsal to anterior anal	58.0	54.9	4.2	30.3–58.4
Anterior dorsal to posterior anal	67.9	66.2	1.4	64.1–69.4
Posterior dorsal to anterior anal	34.9	32.9	1.3	30.3–35.1
Posterior dorsal to posterior anal	17.0	16.9	0.7	15.4–18.3
Posterior dorsal to ventral caudal	18.0	18.2	0.6	17.0–19.4
Posterior anal to dorsal caudal	18.7	18.9	0.6	17.4–20.0
Anterior dorsal to pelvic fin origin	44.1	41.1	1.3	38.3–44.1
Posterior dorsal to pelvic fin origin	61.6	59.4	1.4	57.1–62.7
Caudal peduncle depth	12.2	12.3	0.9	10.0–14.1
Least caudal peduncle depth	15.5	14.6	0.6	13.6–15.7
Percent head length				
Snout length	37.0	38.7	2.4	32.3–42.8
Postorbital head length	39.5	39.9	1.3	36.5–43.0
Horizontal eye diameter	26.7	27.3	1.6	23.4–30.2
Vertical eye diameter	27.5	28.1	1.6	24.7–31.5
Head depth	94.0	92.2	6.0	80.8–111.7
Preorbital depth	23.7	24.7	2.6	20.0–28.5
Cheek depth	27.4	27.2	2.3	22.4–33.0
Lower jaw length	37.2	34.9	1.7	30.6–37.4
Counts				
Dorsal-fin spines	18	17	84.6	16–18
Dorsal-fin rays	8	9	79.5	8–10
Anal-fin spines	3	3	100.0	3
Anal-fin rays	8	8	89.7	7–9
Pelvic-fin rays	5	5	100.0	5
Pectoral-fin rays	14	14	82.1	13–15
Lateral line scales	29	29	64.1	29–31
Pored scales posterior to hypural plate	1	2	82.1	1–2
Scale rows on cheek	4	4	74.4	3–5
Gillrakers on first ceratobranchial	10	10	71.8	9–12
Gillrakers on first epibranchial	3	3	69.2	2–3
Teeth on outer row of left lower jaw	19	16	18.0	10–27
Teeth rows on upper jaw	21	13	23.1	9–21
Teeth rows on lower jaw	9	14	18.0	9–21

than half length of ninth spine. Caudal fin subtruncate to emarginate. Depressed pelvic fin not reaching anal fin in most females and reaching to second anal-fin spine in males. Pectoral fin round and paddle-shaped. Flank scales large, ctenoid; cheek with 3–5 rows of scales. Lateral line with 29–31 pored scales.

Coloration. Live males with dark blue/gray head and two light blue interorbital bars, opercle and pre-opercle light blue and black opercular spot; throat light blue/gray. Flank blue/green with 8–10 dark blue bars; breast and belly white with black/gray markings. Caudal peduncle dark blue/gray. Dorsal fin with broad black submarginal band. Proximal $\frac{1}{4}$ of dorsal fin light blue, lappets light blue with orange tips. Caudal fin with gray rays, orange tips, and light blue membranes. Anal fin blue/gray with black spinous portion, and broad black marginal bar over rayed portion; 2–6 dark orange ocelli on anal fin. Pelvic fin light blue with white leading edge; first two rays of fin and membrane black, rest of membranes clear. Pectoral fin with gray rays and clear membranes.

Live females with brown head and gray throat. Flank brown with light brown to white belly, dark gray breast, and 8–10 faint dark vertical bars. Anal fin black with 1–4 small orange ocelli. Pelvic, pectoral, caudal, and dorsal fins as in males.

Preserved males with dark brown head, brown opercle, and brown throat. Flank dark brown to gray with 8–10 faint dark vertical bars, white to gray belly, and dark brown breast. Dorsal fin light brown to dark, with broad submarginal black band; dorsal fin membranes light brown. Caudal fin brown to gray with light brown membranes. Anal fin gray with black marginal band over spines and first ray; spines black with dark brown rays and light brown membranes. Pelvic fin light brown with black spine; light brown membranes and black marginal band over spines and first ray. Pectoral fin light brown with clear membranes.

Preserved females with dark brown head, brown opercle, and yellow to light brown throat. Flank brown with 8–10 vertical bars, yellow to light brown breast, and light brown belly. Dorsal fin light brown with broad submarginal band and light brown membranes. Caudal fin brown with light brown membranes. Anal fin light brown to gray, light brown membranes, and black spines with submarginal band. Pelvic fin gray to white;

black spine with first three rays dark and last two rays white to gray. Pectoral fin dark gray with clear membranes.

Distribution. *Petrotilapia mumboensis* occurs at Mumbo, Thumbi West, and Mbenji islands, Malaŵi (Fig. 1).

Etymology. The name *mumboensis* is in reference to Mumbo Island, Malaŵi where this species is very common and from where the holotype was collected. An adjective.

Petrotilapia pyrosceles, new species

(Fig. 6)

Petrotilapia ‘orange pelvic’ Ribbink et al., 1983

Holotype. PSU 4753, 107.2 mm SL, adult male; Malaŵi: Chizumulu Island: Mkanila Bay, 12°0.57' S 34°36.9' E; S. M. Grant, A. F. Konings & J. R. Stauffer, 21 Jan 2003.

Paratypes. PSU 4752, 21, 71.9–103.6 mm SL; same data as for holotype. – PSU 4754, 7, 77.2–100.8 mm SL; Malaŵi: Chizumulu Island: Same Bay, 12°1.6' S 34°37.7' E; J. R. Stauffer & A. F. Konings, 21 Feb 2006.

Diagnosis. The dark submarginal band in the spinous part of the dorsal fin of both male and female distinguishes *P. pyrosceles* from *P. tridentiger*, *P. xanthos*, *P. flaviventris*, and *P. palingnathos*, which lack such a band. Males of *P. pyrosceles* have blue and bronze ground color with 7–9 gray vertical bars, whitish to gray throat and purple cheek, which distinguishes it from *P. genalutea*, *P. nigra*, *P. chrysos*, *P. microgalana* and *P. mumboensis*. Males of *P. genalutea* are dull gray-blue with 5–7 black vertical bars, have an orange-yellow cheek, and a black throat. Males of *P. nigra* and *P. chrysos* are predominantly blue-black with 7–10 gray/brown bars, have a dark blue cheek, and a black throat. Males of *P. microgalana* are bright blue with 5–7 faint black vertical bars, and have a light blue cheek and a yellow throat, while those of *P. mumboensis* are blue with 8 dark blue vertical bars, light blue cheeks, and a light blue to gray gular region. Females of *P. pyrosceles* are brown with faint blue and yellow highlights with a conspicuous black submarginal band in the dorsal fin. Females of *P. pyrosceles* are distinguished

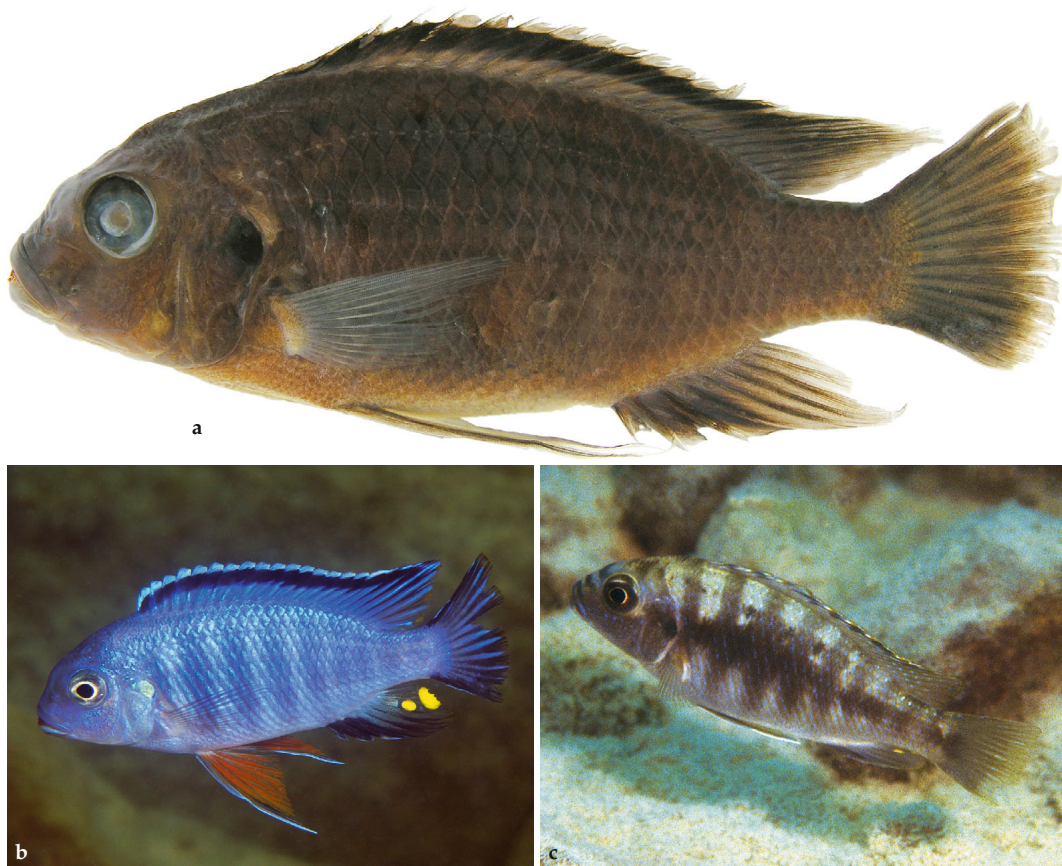


Fig. 6. *Petrotilapia pyrosceles*, Malaŵi: Lake Malaŵi: Chizumulu Island; **a**, PSU 4753, holotype, 107.2 mm SL, adult male; Mkanila Bay; **b**, adult male; Same Bay; **c**, adult female; Mkanila Bay.

from those of *P. genalutea*, *P. nigra*, *P. chrysos*, and *P. microgalana* by the brown to gray ground color on the flank which is beige or yellow in the other species and are distinguished from females of *P. mumboensis* which lack any horizontal elements of the flank's pigmentation pattern.

Description. Morphometric and meristic data in Table 5. Body depth at origin of dorsal fin 32.1–37.6 % SL. Dorsal head profile concave between snout tip and interorbital region. Horizontal and vertical eye diameters 28.9–35.9 % HL and 31.1–35.9 % HL respectively; preorbital depth 22.2–28.6 % HL. Snout length 33.5–39.9 % HL. Isognathous jaws and thickened lips. Teeth on lower jaw in 10–18 rows with outer row and inner rows tricuspid. Dorsal fin with XVII–XVIX (mode XVII) spines and 8–10 (mode 9) rays. Anal fin with III spines and 7–8 (mode 8) rays. First dorsal-fin

spine less than half length of tenth spine. Caudal fin subtruncate to emarginate. Depressed pelvic fin not reaching anal fin in most females and to first or second anal-fin spine in males. Pectoral fin round and paddle-shaped. Flank scales large, ctenoid; cheek with 3–5 rows of scales. Lateral line with 29–33 pored scales.

Coloration. Live males with dark gray interorbital region, no interorbital bar; cheek, preorbital, opercle, and pre-opercle blue with purple highlights and dark gray opercular spot; throat whitish to gray. Flank blue with bronze highlights and 7–9 dark gray to blue bars; breast and belly whitish to gray. Dorsal fin blue with broad black submarginal band and light blue lappets. Caudal fin with dark gray rays and blue membranes. Anal spines and membranes black, rays black to gray and with clear membranes and 1–2 yellow

ocelli. Pelvic fin orange with white leading edge. Pectoral fin with dark blue rays and clear membranes.

Live females with brown head; blue and green highlights on cheek, black opercle spot and white throat. Flank brown with faint blue and yellow highlights with often vague series of midlateral and dorso-lateral spots, and 7-9 vertical bars; scales outlined in blue; pale yellow breast with

white belly. Anal fin with gray rays, clear membranes, and 3 yellow ocelli. Dorsal fin with brown spines and rays; black submarginal band, yellow and light blue lappets with brown tips. Caudal fin with gray rays and clear membranes. Pelvic fin with white to light blue leading edge. Pectoral fin with brown rays and clear membranes.

Preserved males with dark brown head, black opercle, brown cheek, and yellowish to light

Table 5. Morphometric and meristic values of *Petrotilapia pyrosceles* (N = 28; PSU 4752, 4753, 4754). Ranges include holotype.

	holotype	mean	SD	range
Standard length (mm)	107.2	92.3	8.8	71.9-106.1
Head length (mm)	33.1	29.0	2.6	23.2-33.5
Percent standard length				
Body depth	34.5	35.0	1.1	32.1-37.6
Snout to dorsal-fin origin	32.4	33.7	1.4	31.0-36.1
Snout to pelvic-fin origin	40.6	39.2	1.1	37.2-41.3
Dorsal-fin base length	59.6	60.6	1.4	57.9-62.8
Anterior dorsal to anterior anal	54.1	53.4	1.1	50.5-55.4
Anterior dorsal to posterior anal	63.9	63.5	1.3	60.7-65.6
Posterior dorsal to anterior anal	30.8	30.0	0.9	27.9-31.7
Posterior dorsal to posterior anal	16.3	15.2	0.6	14.1-16.5
Posterior dorsal to ventral caudal	18.1	17.8	0.7	15.9-19.3
Posterior anal to dorsal caudal	19.2	19.0	0.8	17.1-20.5
Anterior dorsal to pelvic fin origin	37.4	37.5	1.2	34.1-39.9
Posterior dorsal to pelvic fin origin	56.0	57.0	1.5	53.6-59.1
Caudal peduncle depth	15.4	14.2	1.1	11.6-16.3
Least caudal peduncle depth	13.2	12.8	0.4	11.9-16.3
Percent head length				
Snout length	38.6	36.3	1.7	33.5-39.9
Postorbital head length	37.4	35.9	1.0	33.6-37.7
Horizontal eye diameter	31.5	32.3	1.5	28.9-35.9
Vertical eye diameter	32.6	33.7	1.0	31.1-35.9
Head depth	85.3	84.5	5.0	74.0-93.3
Preorbital depth	28.2	25.3	1.5	22.2-28.6
Cheek depth	26.6	23.8	1.5	20.6-26.6
Lower jaw length	36.8	35.7	2.2	29.2-38.6
Counts				
		mode	% frequency	range
Dorsal-fin spines	18	18	64.3	17-19
Dorsal-fin rays	9	9	71.4	8-10
Anal-fin spines	3	3	100.0	3
Anal-fin rays	7	8	67.9	7-8
Pelvic-fin rays	5	5	100.0	5
Pectoral-fin rays	14	14	57.1	12-15
Lateral line scales	30	31	46.4	29-33
Pored scales posterior to hypural plate	2	2	64.3	1-2
Scale rows on cheek	4	4	78.6	3-5
Gillrakers on first ceratobranchial	11	10	53.6	8-11
Gillrakers on first epibranchial	3	3	89.3	2-3
Teeth on outer row of left lower jaw	13	14	25.0	9-20
Teeth rows on upper jaw	14	12	28.6	10-18
Teeth rows on lower jaw	15	13	28.6	10-18

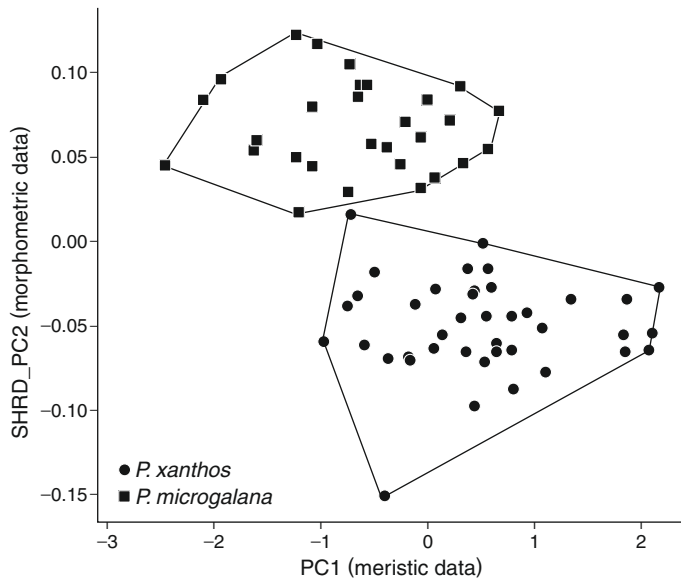


Fig. 7. Plot of second sheared principal component (morphometric data) and first factor scores (meristic data) of *Petrotilapia xanthos* (N=40; PSU 4757, PSU 4756, PSU 4758) and *P. microgalana* (N=29; PSU 3389, PSU 3390; UMBC 003; AMNH 238686 (Nkhata Bay), PSU 3453 (Mbowe Island), PSU 4755 (Kakusa)).

brown throat. Flank dark brown; faint dark vertical bars, white belly, and brown breast. Dorsal fin with black submarginal band, gray membranes, and gray to brown spines and rays. Caudal fin with dark gray rays and gray membranes. Anal-fin spines and membranes black, rays black to gray with clear membranes. Pelvic-fin spine and first three rays gray with clear membranes, posterior rays and membranes clear. Pectoral fin with gray rays and clear membranes. Preserved females with brown head, black opercle, brown cheek, and a yellowish to brown throat. Flank brown with blotches and faint vertical bars; breast yellow, belly white to yellow. Dorsal fin with black submarginal band, gray spines and membranes; rays with brown spots. Caudal fin with brown to gray rays and clear membranes. Anal fin with gray to brown spines with brown to clear membranes. Pelvic spines and first two rays dark with dark to clear membranes. Pectoral fin with gray rays and clear membranes.

Distribution. *Petrotilapia pyrosceles* is only known from the type locality, Chizumulu Island, Lake Malaŵi (Fig. 1).

Etymology. The name *pyrosceles* is from the Greek *pyros*, meaning fire, and *skelos*, meaning leg, refer-

ring to the pelvic fins of males that have the color of fire. A noun in apposition.

Discussion

The presence of predominantly tricuspid teeth in the major dentigerous area of the upper and lower jaws and a single or double lateral series of unicuspid teeth posterior to this broad band places all the new species in the genus *Petrotilapia*. The most distinctive difference between the known species of *Petrotilapia* is the live coloration, in particular that of territorial males. There is rarely a single morphological characteristic that can reliably distinguish even sympatric species of this genus, but combinations of several characters usually resulted in complete separation of the examined specimens. For this reason we have based our diagnoses of the five new species mainly on color patterns and on observations in the natural habitat to exclude the possibility that some of the new taxa are mere morphs of a polymorphic species (Ribbink et al., 1983; Konings, 2007).

Konings (2001) divided the members of the genus *Petrotilapia* into three groups with a representative of each group found at most rocky shores

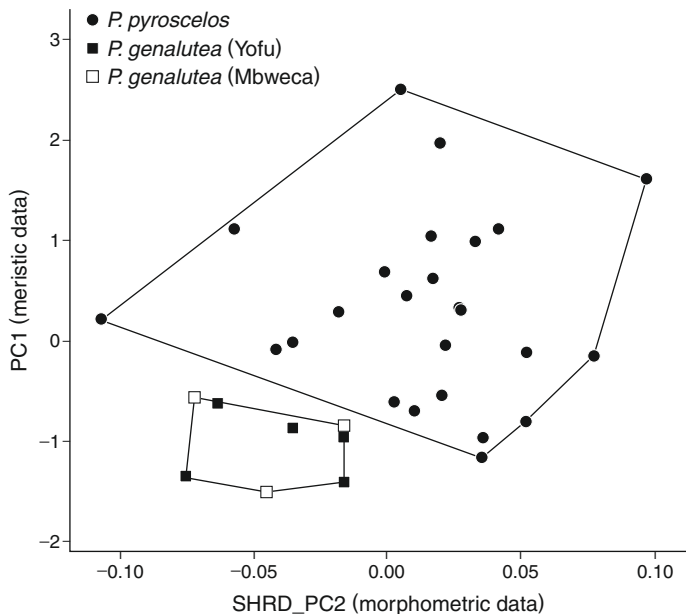


Fig. 8. Plot of second sheared principal component (morphometric data) and first factor scores (meristic data) of *Petrotilapia pyroscelos* from Mkanila Bay and Same Bay, Chizumulu Island (N=28; PSU 4753, PSU 4752, PSU 4754), *P. genalutea* from Mbweca Rocks (N=3; PSU 4750); *P. genalutea* from Yofu Bay (N=5; PSU 4749).

around the lake. He referred to these groups as the *P. tridentiger*, the *P. genalutea*, and the *P. nigra* group based upon the habitat they occupy and also on the basic melanin patterns visible in females and juveniles. Members of the *P. tridentiger* group are mainly found in the wave-washed upper rocky habitats. The melanin pattern consists of vertical bars, although not always distinctly evident, on a gray-brown to brown-black ground coloration. There is no dark submarginal band in the dorsal fin. Members of this group are *P. tridentiger*, *P. palingnathos*, and the undescribed *P. sp.* 'yellow chin'. Members of the *P. genalutea* group inhabit the sediment-rich and intermediate habitats. The melanin pattern is characterized by two rows of spots on the flank, with the lower row consisting of a few large blotches. The background color is very light and the dorsal fin has a black submarginal band. Members of this group are *P. genalutea*, *P. pyroscelos*, and the undescribed *P. sp.* 'chitande'. Members of the *P. nigra* group inhabit the deeper rocky environments. The melanin pattern consists of two horizontal rows (mid-lateral and dorso-lateral) of dots of about equal size or sometimes fused to form a solid band. A pattern of vertical bars is sometimes superimposed on the two horizontal rows of spots,

but such bars may not always be distinct. Some species have a black sub-marginal band in the dorsal fin but the distinction of membership of this group is based mainly on the pattern on the flank where often both horizontal and vertical elements are present, and on habitat preference. Members of this group are (not including undescribed species) *P. nigra*, *P. chrysos*, *P. microgalana*, *P. flaviventris*, and *P. xanthos*.

Petrotilapia xanthos was compared to *P. microgalana*, geographically the nearest member of the *P. nigra* group. *Petrotilapia microgalana* was originally described from Nkhata Bay, Malaŵi (Ruffing et al., 2006) and is characterized by a melanin pattern consisting of two horizontal rows of dots of about the same size with the mid-lateral row slightly larger. Males have a black submarginal band in the dorsal fin and non-breeding females have a yellow ground color. Some populations (i.e., at Kakusa and Charo, Malaŵi) of a form previously known as *P. 'ruarwe'* (Ribbink et al., 1983) are indistinguishable from that of *P. microgalana* in that the females are yellow and males have a black submarginal band in the dorsal. Males of other populations of *P. 'ruarwe'* (i.e. at Mbowe Island and Ruarwe, Malaŵi) lack such a black submarginal band. There was no obvious

difference in habitat preference among these populations when compared to *P. microgalana* from Nkhata Bay. We compared the morphological data of specimens of *P. 'ruarwe'* from Kakusa and Mbowe Island (Fig. 1) with those of *P. microgalana* in a principle component analysis and found that there was no distinction discernable between any of the three populations. We therefore consider *P. 'ruarwe'* conspecific with *P. microgalana*. We pooled all three sets of data of *P. microgalana* and compared them with those of *P. xanthos* by plotting the second sheared principal components of the morphological data and first principal component of the meristic data (Fig. 7). Size accounted for 92.3 % of the observed variance and the second principal component accounted for 3.5 %. Variables with the highest loadings on the sheared second principal components were caudal peduncle length (-0.47), cheek depth (0.45), and lower jaw length (0.35). The first principal component of the meristic data explained 22.6 % of the total variance. Variables with the highest loadings on the first principal component are teeth rows on the upper jaw (0.52), number of teeth on the outer row of the left side of lower jaw (0.52), and teeth rows on the lower jaw (0.50). The minimum polygon cluster formed by the meristic and morphometric data for *P. xanthos* was distinct from the cluster formed by the data for *P. microgalana* (Fig. 7).

Petrotilapia pyrosceles is endemic to Chizumulu Island where it is commonly encountered in the shallow wave-washed rocky areas (Ribbink et al., 1983). As well as in habitat preference and in morphology it resembles *P. genalutea*, which is absent from Chizumulu Island, and it is therefore included in the *P. genalutea* group. We compared the morphological and meristic data of specimens of *P. genalutea* from geographically nearby populations, i.e., Yofu Bay, Likoma Island and Mbweca Rocks in Mozambique (Fig. 1) with those of *P. pyrosceles* and found no overlap of the clusters of either species (Fig. 8). Size accounted for 90.0 % of the observed variance and the second principal component accounted for 3.1 %. Variables with the highest loadings on the sheared second principal components were preorbital depth (0.59), lower jaw length (0.40), and snout length (0.36). The first principal component of the meristic data explained 20.5 % of the total variance. Variables with the highest loadings on the first principal component are teeth rows on the upper jaw (0.56), teeth rows on the upper jaw (0.56), and pored

scales posterior to the hypural plate (0.38). The separation of the clusters, however, is marginal and may show some overlap if more specimens of *P. genalutea* could have been compared. On the other hand, when the male breeding coloration of *P. genalutea* is considered throughout its wide range we found very little variation. The noticeable difference in male breeding coloration between *P. pyrosceles* and *P. genalutea* of neighboring Likoma Island convinced us that these constitute two different species.

Petrotilapia mumboensis has a habitat preference indistinguishable from that of members of the *P. tridentiger* group and it occurs at Mumbo, Thumbi West, and Mbenji islands. *Petrotilapia mumboensis* may be the 'replacement' for *P. tridentiger* at Mumbo Island, where the latter is absent, but unlike that species, both males and females have a dark submarginal band in the dorsal fin. At the other two islands, however, *P. mumboensis* shares the habitat with *P. tridentiger* (Thumbi West) or with *P. 'yellow chin'* (Mbenji). Although the latter species may be a geographical variant of *P. tridentiger* (there were no specimens available to test this theory) the fact remains that four different *Petrotilapia* occur at these two islands. The other species at Thumbi West are *P. nigra* and *P. genalutea* and at Mbenji *P. genalutea* and the undescribed species *P. 'fuscous'*, a member of the *P. nigra* group. At Likoma Island an undescribed form, *P. 'likoma barred'* (Ribbink et al., 1983), lives in the upper wave-washed upper rocky habitat and would have been regarded a member of the *P. tridentiger* group if it would not exhibit a black submarginal band in the dorsal. At Taiwanese Reef, north of Chizumulu Island, only two *Petrotilapia* species have been found. One is *P. palinathos* a member of the *P. tridentiger* group and the other is *P. 'likoma barred'*. *P. tridentiger* is absent from either island and from Taiwanese Reef. Perhaps both *P. 'likoma barred'* and *P. mumboensis* form a fourth group which is restricted in its distribution to islands and reefs.

Artificial key to *Petrotilapia*

Apart from the retrognathous mouth of *P. palinathos* all other characters that distinguish the ten described species of *Petrotilapia* were taken from the color pattern of live territorial males. The ranges of all examined morphological characters overlap between species, even among

sympatric species, and are therefore inadequate to differentiate between the species of this genus. The adult females of four of the five species of the *P. nigra* group are impossible to distinguish; the females of the fifth species, *P. chrysos*, are yellow.

- 1 - Mouth retrognathous.
.....*P. palingnathos*
- Mouth terminal.
.....2
- 2 - Flank of adult male black, blue, or blue and yellow.
.....3
- Flank of adult male entirely gold-yellow.
.....*P. xanthos*
- 3 - Absence of a dark submarginal band in dorsal fin.
.....4
- Presence of a dark submarginal band in dorsal fin.
.....6
- 4 - Pelvic fin of adult male blue.
.....*P. tridentiger*
- Pelvic fin of adult male yellow.
.....5
- 5 - Lower half head in adult male yellow.
.....*P. flaviventris*
- Lower half head in adult male blue.
.....*P. microgalana* (in part)
- 6 - Anal fin of adult male without black band.
.....*P. microgalana* (in part)
- Anal fin of adult male with broad black band.
.....7
- 7 - Cheek of adult male with yellow/orange pigment.
.....*P. genalutea*
- Cheek of adult male blue or black.
.....8
- 8 - Pelvic fin of adult male orange/red.
.....*P. pyrosceles*
- Pelvic fin of adult male black or blue.
.....9

- 9 - Throat of adult male light blue.
.....*P. mumboensis*
- Throat of adult male black.
.....10
- 10 - Dorsal fin of adult male with white submarginal band and yellow lappets.
.....*P. nigra*
- Dorsal fin of adult male with white submarginal band and white lappets.
.....*P. chrysos*

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