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Eight new species of rock-dwelling cichlids of the genus *Melanochromis* (Teleostei: Cichlidae) from Lake Malawi, Africa

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Eight new species of rock-dwelling cichlids belonging to the genus *Melanochromis* from Lake Malawi, Africa, are described. The new species are recognized primarily by their distinctive adult breeding coloration and overall morphology.

Introduction

The cichlid fish species flocks of the African Great Lakes present an unparalleled example of explosive speciation in conjunction with tremendous trophic radiation. Trophic diversification within the rock-dwelling cichlids (mbuna) in Lake Malawi has occurred with limited morphological divergence, resulting in taxonomic and phylogenetic difficulties (Stiassny, 1991). Management and protection of such a diverse assemblage is critical, yet implementation of conservation strategies is hampered by an incomplete taxonomic database and taxonomic uncertainties (Lowe-McConnell, 1993; Reinthal, 1993).

Members of the cichlid genus *Melanochromis* Trewavas, 1935, all of which are endemic to Lake Malawi, are small, elongate fishes that inhabit the rocky littoral zone. The strong lithophilic nature of the rock-dwelling cichlids (mbuna) and their high degree of philopatry has resulted in the restriction of many species to single isolated rocky outcrops (Fryer & Iles, 1972; Ribbink et al., 1983; Stauffer, 1988). The genus *Melanochromis* was originally distinguished from other mbuna genera on the basis of dentition (Trewavas, 1935), but affinities between *Pseudotropheus williamsi* (Gunther, 1893), the type species of the genus *Pseudotropheus* Regan, 1922 and *Melanochromis melanopterus* Trewavas, 1935, the type species of *Melanochromis*, prompted a recent redefinition of the genus by Trewavas (1984). The current definition of *Melanochromis* emphasizes the presence of two horizontal stripes along the flanks, typically in a color that contrasts with the ground color (Trewavas, 1984). Discrimination among species within the genus is typically based on characteristics considered to be important in mate recognition

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Fig. 1. Map of Lake Malawi showing collection locations.

(Ribbink et al., 1983), such as adult breeding coloration, preferred habitat, and behavioral aspects.

There are presently 16 described species within the genus *Melanochromis* (Ribbink et al., 1983; Daget et al., 1991; Bowers & Stauffer, 1993), of which 13 have been commonly observed or reported (Ribbink et al., 1983; Konings, 1990). An additional nine or ten taxa have been recognized as distinct entities, but have not yet been described. Because of the distinctive coloration of these species, many of which are collected and exported for the aquarium trade, the genus is of tremendous economic importance. Therefore, identification of these species is important for monitoring potential impacts of the aquarium trade on population size and distribution. Our purpose, therefore, is to present formal descriptions of eight species of *Melanochromis* from Lake Malawi, Africa.

Material and methods

Fishes were collected within the political boundaries of Malawi (Fig. 1) using SCUBA and a monofilament gill net. Color notes were made on live fish or recently preserved specimens. Holotype illustrations are based on preserved material and color patterns may have faded, therefore, careful attention should be given to the color descriptions. Specimens were then fixed in 10 % formalin with their fins pinned and preserved in 70 % ethanol.

External counts and measurements follow Stauffer (1991) and Barel et al. (1977) and were collected with an accuracy of 0.1 mm using JAVA image analysis software (Jandel Scientific). Standard length (SL) is used throughout except where noted. Scale counts in the lateral line system did not include scales in the overlapping portion of the lower lateral line. Except for gill-raker counts, which were recorded from the right side, all counts and measures were made on the left side of the fish. The number of teeth on the left lower jaw are presented following the method of Stauffer (1991). Morphometric ratios are presented as percent SL or percent head length (HL).

Morphometric data among phenetically similar forms were compared using sheared principal components analysis (SPCA) (Humphries et al., 1981; Bookstein et al., 1985). This technique permits overall comparison of body shape among similar species by reducing the contribution of the size on the second and third components. We used SPCA to factor the covariance matrix of the morphometric data and used principal components analysis (PCA) to factor the correlation matrix of the meristic data (Reyment et al., 1984; Stauffer, 1991). This technique has been used to successfully distinguish among closely related cichlid species (Stauffer & Boltz, 1989; Stauffer, 1991; Stauffer & Hert, 1992; Bowers & Stauffer, 1993; Stauffer et al., 1993). Comparisons among species were conducted by plotting the sheared second principal component (PC) of the morphometric data against the first PC of the meristic data. Multivariate analysis of variance analysis (MANOVA) was conducted to determine if the minimum polygon clusters of the PCA scores of each population were significantly different ($P < 0.05$). Duncan's multiple range test was used when MANOVA indicated that the clusters were significantly different along one axis to determine which populations differed from each other. All statistical analyses were conducted using the Statistical Analysis Software (SAS, Inc., Cary, NC, USA), version 6.08.

Museum abbreviations follow Leviton et al. (1985), except MFU, which is the Malawi Fisheries Unit located at Chancellor College in Zomba, Malawi.

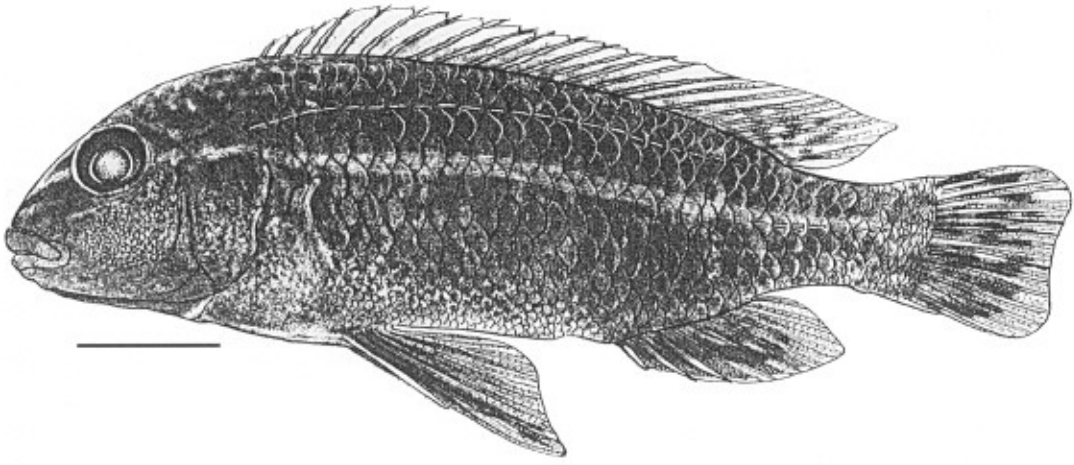

Fig. 2. *Melanochromis dialeptos*, holotype, PSU 2649.1, adult male, 72.0 mm SL, Masinje, Lake Malawi. Scale bar: 10 mm.

Melanochromis dialeptos, new species
(Fig. 2)

Melanochromis auratus (non Boulenger, 1897): Ribbink et al., 1983: 202 (in part).
Melanochromis sp. "dwarf auratus": Konings, 1990: 332

Holotype. PSU 2649.1, adult male, 72.0 mm; Masinje, Lake Malawi (34°51"E, 13°35"S), Malawi, Africa; 10 m; February 1992.

Paratypes. PSU 2649.2, 10 ex., 46.8-62.2 mm; ANSP 175082, 3 ex., 49.7-58.7 mm; USNM 343714, 5 ex., 43.2-51.0 mm; MFU 31, 5 ex., 51.6-79.5 mm; data as for holotype.

Diagnosis. Recognized as a member of the genus *Melanochromis* by the presence of two horizontal stripes along its flanks. The bright yellow ground color of female *M. dialeptos* distinguishes it from other members of the genus, except *Melanochromis auratus* and *Melanochromis simulans* Eccles, 1973. It can be distinguished from *M. simulans* by its shorter lower jaw (20.2-27.0 % HL, vs. 40; Eccles, 1973). *Melanochromis dialeptos* can further be distinguished from *M. auratus* by the presence of black markings throughout the entire caudal fin of females, whereas the black markings in the caudal fin are restricted to the dorsal section in *M. auratus*. Furthermore, the horizontal stripes of *M. dialeptos* are more narrow and the edges more jagged than the stripes of *M. auratus*.

Description. Morphometric and meristic data for *M. dialeptos* from the holotype and 24 paratypes are summarized in Table 1. Body form is elongate with blunt head, jaws isognathous. Teeth in outer rows distinctly bicuspid (cusps symmetrical), with 26-34 teeth in the outer row of the lower jaw that are progressively smaller posteriorly. Inner teeth tricuspid in 3-5 rows on the upper jaw and 2-5 rows on the lower jaw. Lower pharyngeal bone triangular, teeth well spaced with 10-12 teeth along the longest medial series and 32-36 enlarged teeth across the posterior margin.

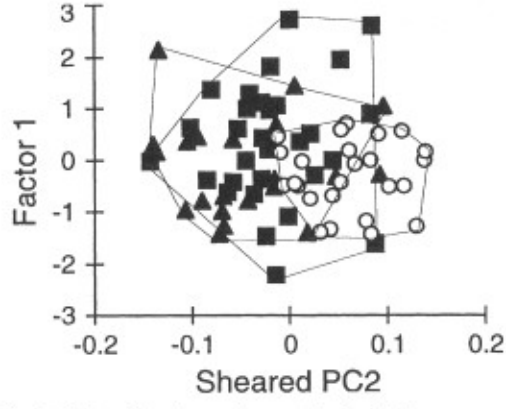

Fig. 3. Plot of the sheared second principal component of the morphometric data against the first principal component of the meristic data for *Melanochromis auratus* from Thumbi East Island (▲), *M. auratus* from Nakantenga Island (■), and *M. dialeptos* from Masinje (○).

Coloration. Males with dark gray-blue ground color with pale blue mid-lateral stripe and an interrupted, pale blue dorso-lateral stripe. Dorsal fin pale yellow with brown flecks in membranes, most males with faint gray submarginal band; white lappets and yellow tips. Caudal fin brown-black with clear flecks throughout, yellow outer margin, ventral margin may also be yellow. Anal fin black with white leading edge, may have yellow submarginal band; one to two yellow ocelli present. Pelvic fins gray with white leading edge and black submarginal band. Pectoral fins pale gray. Head dark gray-blue with two pale blue, interorbital bars.

Females with pale yellow or white belly with three or four thin, jagged edged, white horizontal stripes ventrad. A thin, white mid-lateral stripe with a black band that runs along its center extends from caudal fin onto head. A thin, white dorso-lateral stripe with a black stripe running down its center. Dorsal fin white with black submarginal band, white lappets and yellow tips. In some specimens, an interrupted brown stripe may be present along the insertion of the dorsal fin. Caudal fin yellow with black vermiculations distributed evenly throughout the upper and lower

Table 1. Morphometric ratios and meristics for *Melanochromis dialeptos* (n=25). Summary values include holotype.

	holotype	mean	SD	range
Standard length (mm)	72.0	56.5	8.5	43.2-79.5
Head length (mm)	21.0	17.1	2.5	13.3-25.3
Percent head length				
Snout length	40.0	38.2	2.6	33.2-42.8
Postorbital head length	49.8	49.3	2.6	42.9-54.2
Horizontal eye diameter	26.8	25.2	2.2	20.4-30.6
Vertical eye diameter	25.7	25.8	2.2	20.3-31.7
Preorbital depth	36.4	29.9	2.7	24.3-36.4
Cheek depth	40.1	36.1	3.0	29.1-40.7
Lower jaw length	25.1	24.0	1.7	20.2-27.0
Percent standard length				
Head length	29.2	30.3	1.5	28.0-34.1
Head depth	26.9	25.9	1.3	23.1-28.6
Body depth	30.5	29.5	1.5	27.2-33.0
Snout to dorsal-fin origin	34.3	35.5	1.4	32.8-38.7
Snout to pelvic-fin origin	32.1	33.4	1.6	29.3-37.7
Dorsal-fin base length	61.3	57.8	2.1	53.1-63.5
Anterior of dorsal-fin to anterior of anal-fin	51.9	47.5	2.8	49.2-51.9
Posterior of dorsal-fin to posterior of anal-fin	14.3	13.6	1.0	11.8-15.4
Anterior of dorsal-fin to posterior of anal-fin	63.7	59.3	2.2	54.2-64.0
Posterior of dorsal-fin to anterior of anal-fin	27.9	26.5	1.5	24.0-29.8
Posterior of dorsal-fin to ventral of caudal-fin	17.1	16.3	1.2	14.2-19.5
Posterior of anal-fin to dorsal of caudal-fin	17.9	18.0	1.4	14.2-20.1
Anterior of dorsal-fin to pelvic-fin origin	20.0	20.6	1.2	18.0-22.9
Posterior of dorsal-fin to pelvic-fin origin	56.0	54.4	2.1	49.9-58.8

	holotype	mode	% freq.	range
Dorsal-fin spines	18	18	68.0	18-19
Dorsal-fin rays	8	8	72.0	7-8
Anal-fin rays	7	7	100	7-7
Pectoral-fin rays	13	13	64.0	12-14
Lateral-line scales	31	30	60.0	30-32
Pored scales posterior to lateral line	2	2	68.0	1-2
Cheek scales	4	4	100	4-4
Gill-rakers on first ceratobranchial	2	3	52.0	2-3
Gill-rakers on first epibranchial	8	8	60.0	7-9
Teeth in outer row of left lower jaw	14	15	32.0	13-17
Teeth rows on upper jaw	5	5	48	4-6
Teeth rows on lower jaw	4	4	76	3-6

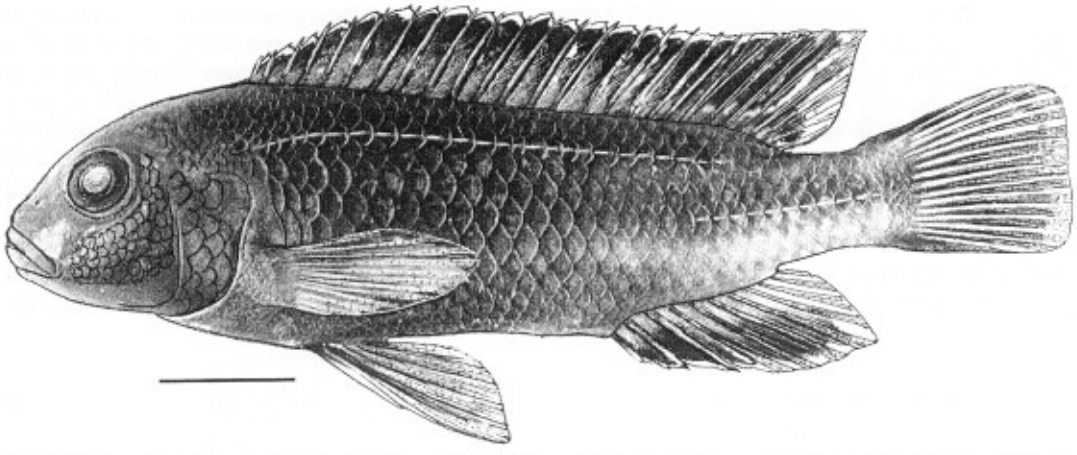

Fig. 4. *Melanochromis cyaneorhabdos*, holotype, PSU 2650.1, adult male, 65.0 mm SL, Likoma Island, Lake Malawi. Scale bar: 10 mm.

portions of the fin. Central margin of the caudal fin may be yellow. Anal fin yellow with white leading edge and black submarginal band, may have white band along insertion; one faint yellow ocelli present. Pelvic fins white with black leading edge and yellow submarginal band. Pectoral fins clear with brown flecks in interray membrane. Head yellow-brown with two faint black interorbital bars.

Distribution. *Melanochromis dialeptos* is endemic to the rocky habitats near Masinje, on the southeastern shore of Lake Malawi. It occurs over all rocky habitats including the intermediate zone (Konings, 1990) and feeds primarily on loose attached algae (Ribbink et al., 1983).

Etymology. From the Greek *dialeptos*, a noun in apposition meaning very small, in reference to the diminutive stature of the species.

Remarks. Although easily distinguished from *M. auratus* on the basis of color pattern, *M. dialeptos* closely resembles *M. auratus* morphologically. In a comparison of two populations of *M. auratus* from Thumbi East Island (TE) and Nakantenga Island (N) with *M. dialeptos*, a plot of the sheared second PC of the morphometric data against the first PC of the meristic data revealed substantial overlap (Fig. 3). However, the minimum polygon cluster formed by *M. dialeptos* was shown to be significantly (Wilks' Lambda = 0.0001; Duncan's Multiple Range Test, $P < 0.05$) different along the sheared second PC than those formed by the two populations of *M. auratus*, which were not significantly different than each other. Variables with the highest loadings on the sheared second PC were postorbital head length (0.336), horizontal eye diameter (-0.515), vertical eye diameter (-0.326), and lower jaw length (0.471), while those having the highest values on the first PC of the meristic data were dorsal rays (0.334) and number of teeth in outer row of left lower jaw (0.303).

Melanochromis cyaneorhabdos, new species
(Fig. 4)

Melanochromis "maingano": Ribbink et al., 1983: 207.

Holotype. PSU 2650.1, adult male, 65.0 mm; Likoma Island (Mbako Point), Lake Malawi (34°45"E 12°02"S), Malawi, Africa; 5 m; February 1992.

Paratypes. PSU 2650.2, 6 ex., 60.7-75.2 mm; ANSP 175083, 4 ex., 57.8-70.0 mm; data as for holotype. - USNM 343715, 8 ex., 54.0-69.1 mm; MFU 32, 8 ex., 59.3-68.0 mm; Likoma Island (Membe Point), Lake Malawi (34°35"E 12°04"S), Malawi, Africa; 10 m; February 1992.

Diagnosis. An elongate cichlid recognized as a member of the genus *Melanochromis* by the presence of two horizontal stripes along its flanks. *Melanochromis cyaneorhabdos* may be distinguished from other members of the genus, except *Melan-*

ochromis johannii Eccles, 1973, by the dark navy-blue ground color with a pale blue stripe running from the dorsal region of the caudal fin to the interorbital bar and a pale blue stripe running from the ventral region of the caudal fin to the pectoral region. Breeding *M. cyaneorhabdos* males tend to have an overall bluish hue, whereas *M. johannii* males tend to be almost black rather than blue. *Melanochromis cyaneorhabdos* tends to have more gill rakers on the first epibranchial (9-11) than does *M. johannii* (8-9; Eccles, 1973).

Description. Morphometric and meristic data for *M. cyaneorhabdos* from the holotype and 26 paratypes collected at Mbako and Membe Points off Likoma island are summarized in Table 2. Body form is elongate and moderately compressed, jaws isognathous. Teeth in outer row distinctly bicuspid (cusps asymmetrical), with 22-32 teeth in the outer row of the lower jaw that are progressively smaller posteriorly. Inner teeth tricuspid in 3-5 irregular rows on the upper jaw and 2-4 irregular rows on the lower jaw. Lower pharyn-

Table 2. Morphometric ratios and meristics for *Melanochromis cyaneorhabdos* (n=27). Summary values include holotype.

	holotype	mean	SD	range
Standard length (mm)	65.0	63.7	5.8	54.0-75.2
Head length (mm)	21.2	17.5	2.2	14.0-22.7
Percent head length				
Snout length	27.0	36.3	4.0	26.9-45.6
Postorbital head length	43.8	50.0	3.5	40.1-56.0
Horizontal eye diameter	20.8	28.3	3.3	20.8-34.1
Vertical eye diameter	24.8	30.6	3.5	24.5-37.6
Preorbital depth	28.1	31.2	3.7	24.2-37.2
Cheek depth	28.9	37.7	3.2	28.9-44.9
Lower jaw length	26.3	26.0	2.5	22.7-29.3
Percent standard length				
Head length	32.7	27.4	1.8	24.4-32.7
Head depth	25.1	25.9	1.0	24.2-27.6
Body depth	29.2	30.2	0.8	28.7-31.6
Snout to dorsal-fin origin	31.3	33.1	1.1	30.6-35.1
Snout to pelvic-fin origin	30.2	31.0	2.1	27.6-35.7
Dorsal-fin base length	62.2	60.3	2.5	55.4-64.1
Anterior of dorsal-fin to anterior of anal-fin	50.2	48.9	1.7	45.1-51.6
Posterior of dorsal-fin to posterior of anal-fin	13.3	13.8	0.9	11.6-15.4
Anterior of dorsal-fin to posterior of anal-fin	64.0	61.9	1.9	58.7-65.3
Posterior of dorsal-fin to anterior of anal-fin	28.7	27.6	1.6	23.7-30.0
Posterior of dorsal-fin to ventral of caudal-fin	15.2	16.6	1.0	14.8-18.7
Posterior of anal-fin to dorsal of caudal-fin	17.3	17.7	0.9	16.2-19.8
Anterior of dorsal-fin to pelvic-fin origin	21.4	21.1	1.3	18.7-23.3
Posterior of dorsal-fin to pelvic-fin origin	59.5	57.9	2.3	52.9-61.3

	holotype	mode	% freq.	range
Dorsal-fin spines	18	18	92.6	18-19
Dorsal-fin rays	7	8	85.1	7-9
Anal-fin rays	7	7	100	7-7
Pectoral-fin rays	13	13	92.6	12-13
Lateral-line scales	31	31	51.8	29-32
Pored scales posterior to lateral line	1	1	55.6	0-2
Cheek scales	4	4	66.7	4-5
Gill-rakers on first ceratobranchial	2	3	66.7	2-4
Gill-rakers on first epibranchial	9	9	55.6	9-11
Teeth in outer row of left lower jaw	14	13	48.1	11-16
Teeth rows on upper jaw	5	5	66.7	4-6
Teeth rows on lower jaw	4	4	85.2	3-5

geal bone triangular, teeth well spaced, 10-11 teeth along the longest medial series and 34-40 enlarged teeth across the posterior margin.

Coloration. We observed no variation in coloration between the two populations from Membe and Mbako Points. Males and females with dark navy-blue ground color. Iridescent pale blue stripe running from the dorsal region of the caudal fin to the interorbital bar and a pale blue stripe running from the ventral region of the caudal fin to the pectoral region. Dorsal fin black with a thin, often interrupted, submarginal, iridescent pale blue stripe extending along base; white lappets, and orange tips. Caudal fin black with pale blue interray membranes and white edges. Anal fin black, white leading edge with two to four yellow ocelli in a clear hyaline region in both males and females. Pelvic fins black with light blue leading edges. Pectoral fins black. Head black with two iridescent pale blue interorbital bars. Although all females we collected exhibited male coloration, Konings (1990) has reported that male coloration in females held in aquaria over several generations may fade to yellow.

Distribution. *Melanochromis cyaneorhabdos* is endemic to Likoma Island, between Mbako Point and Membe Point, and is commonly observed over small to medium sized rocks between 5 and 10 m. It typically feeds on zooplankton and epibenthic invertebrates (Ribbink et al., 1983).

Etymology. From the Greek *cyaneorhabdos*, a noun in apposition meaning blue stripe, in reference to the blue horizontal stripes in adults.

Remarks. Comparison of morphometric and meristic data from *M. cyaneorhabdos* and *M. johannii* resulted in separation of the two species along the first PC of the meristic data when plotted against the sheared second PC (Fig. 5). The minimum polygon clusters formed by the two species were shown to be significantly (Wilks' Lambda = 0.0001; Duncan's Multiple Range Test, $P < 0.05$) different along the first PC of the meristic data. Variables with the highest loadings on the first PC of the meristic data were number of gill rakers on the first ceratobranchial (0.274), number of gill rakers on the first epibranchial (0.334), and number of teeth in outer row of left lower jaw (0.361), while those having the highest values on the sheared second PC were snout length (0.531), vertical eye diameter (-0.303), horizontal eye diameter (-0.329), preorbital depth (0.397), and lower jaw length (0.303).

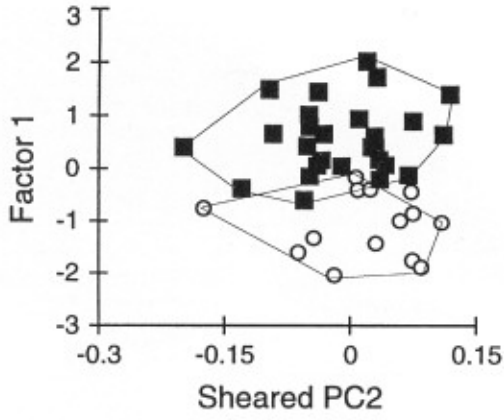

Fig. 5. Plot of the sheared second principal component of the morphometric data against the first principal component of the meristic data for *Melanochromis johannii* from Masinje (○) and *M. cyaneorhabdos* from Likoma Island (■).

Melanochromis elastodema, new species
(Figs. 6-7)

Melanochromis "red": Ribbink et al., 1983: 206.
Melanochromis sp. "chisumulu johannii": Konings, 1990: 332.

Holotype. PSU 2651.1, adult male, 67.3 mm SL; Chisumulu Island (Liwello Bay), Lake Malawi (34°37"E 12°02"S), Malawi, Africa; 5-8 m; February 1992.

Paratypes. PSU 2651.2, 8 ex., 59.6-66.0 mm; ANSP 175084, 5 ex., 55.5-65.1 mm; USNM 343716, 5 ex., 48.6-61.6 mm; MFU 33, 4 ex., 43.9-49.7 mm; data as for holotype.

Diagnosis. An elongate cichlid recognized as a member of the genus *Melanochromis* by the presence of two horizontal stripes along its flanks. *Melanochromis elastodema* may be distinguished from other members of the genus by a pale blue abbreviated or absent dorso-lateral stripe and a pale blue interrupted mid-lateral stripe in males. Males *M. elastodema* resemble *M. perileucos*, but may be distinguished by their dark blue or almost black caudal peduncle, compared with the

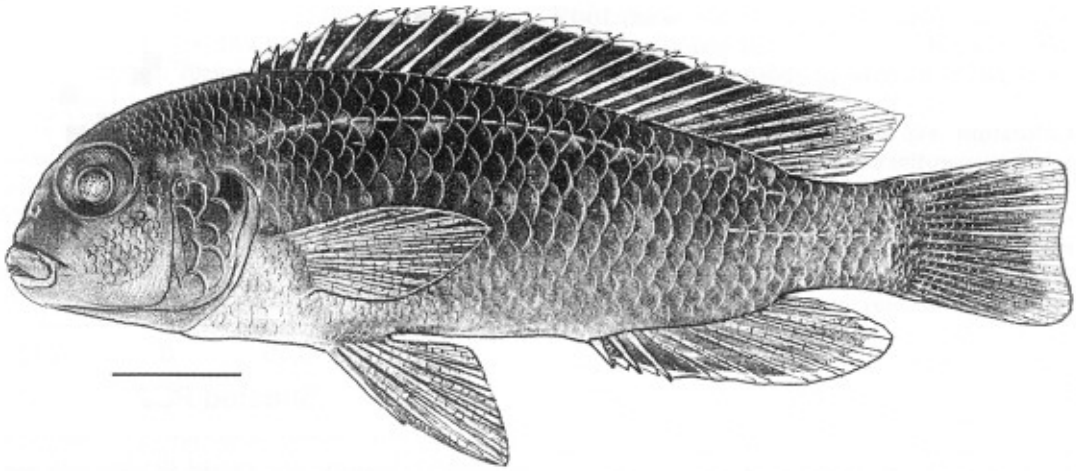

Fig. 6. *Melanochromis elastodema*, holotype, PSU 2651.1, adult male, 67.3 mm SL, Chisumulu Island, Lake Malawi. Scale bar: 10 mm.

more typical light blue caudal peduncle of *M. perileucos*. Females are difficult to distinguish from female *M. johannii*.

Description. Morphometric and meristic data for *M. elastodema* from the holotype and 22 paratypes are summarized in Table 3. Body form elongate and moderately compressed with blunt head, and lower jaw slightly shorter than upper jaw. Teeth in outer rows distinctly bicuspid (cusps almost symmetric), with 18-24 teeth in the outer row of the lower jaw that are progressively smaller posteriorly. Inner teeth tricuspid in 3-5 rows on the upper jaw and 2-4 rows on the lower jaw. Lower pharyngeal bone triangular, with 10-11 teeth along the longest medial series and 32-40 enlarged teeth across the posterior margin.

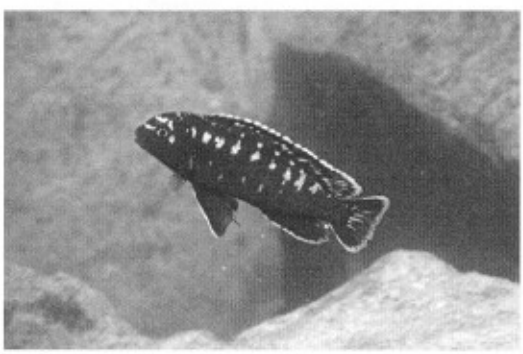

Fig. 7. *Melanochromis elastodema*, Mitande Rocks, Thumbi West Island, Lake Malawi.

Coloration. Males with dark blue-black ground color with iridescent blue dorso-medial stripe, often interrupted into 9-10 spots. Blue mid-ventral stripe often faint, interrupted, or missing. May have an interrupted iridescent blue stripe along the insertion of the dorsal fin, that extends into the base of the dorsal fin. Dorsal fin dark blue-black with white lappets and yellow tips. Caudal fin black with pale blue interray membranes and pale blue outer edge that may be tipped with orange in some individuals. Anal fin black with white leading edge and two to three

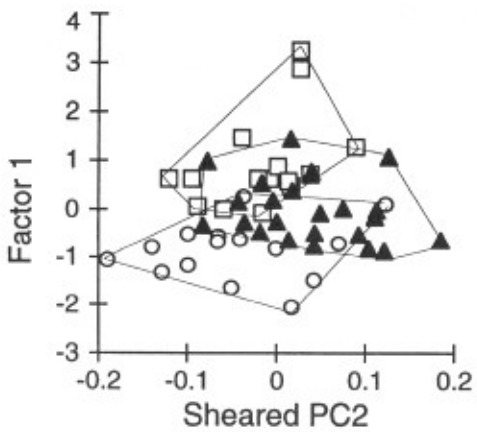

Fig. 8. Plot of the sheared second principal component of the morphometric data against the first principal component of the meristic data for *Melanochromis johannii* from Masinje (○), *M. elastodema* from Chisumulu Island (□), and *M. perileucos* from Likoma Island (▲).

yellow ocelli. Pectoral fins black with white leading edges. Pelvic fins gray-black. Head dark blue with two iridescent interorbital bars.

Females uniformly reddish-gold, some may have faint brown vertical bars along body. No ocelli on anal fin.

Distribution. *Melanochromis elastodema* was endemic to the southwestern region of Chisumulu Island, but has been introduced at Madimba Bay (Likoma Island), at Nkhata Bay, and at Thumbi West Island (Konings, 1990; Ribbink et al., 1983). We have observed this species over large rocks and slabs at depths ranging from 5 to 12 m. It reportedly feeds on filamentous algae (Ribbink et al., 1983).

Etymology. From the Greek *elastodema*, a noun in apposition meaning broken stripe, in reference to the broken horizontal stripe in males.

Remarks. Comparison of morphometric and meristic data from *M. elastodema*, *M. johannii*, and *M. perileucos* resulted in some overlap among the minimum polygon clusters formed when the sheared second PC of the morphometric data

Table 3. Morphometric ratios and meristics for *Melanochromis elastodema* (n=23). Summary values include holotype.

	holotype	mean	SD	range
Standard length (mm)	67.3	57.9	12.1	47.9-67.3
Head length (mm)	17.8	16.9	12.0	12.6-20.2
Percent head length				
Snout length	42.3	38.6	3.3	30.6-43.3
Postorbital head length	51.3	50.8	3.3	44.4-57.6
Horizontal eye diameter	29.0	27.0	2.5	23.0-33.3
Vertical eye diameter	33.3	28.8	3.2	23.2-34.3
Preorbital depth	31.8	30.3	3.1	24.6-34.5
Cheek depth	43.3	37.9	2.2	33.7-43.3
Lower jaw length	28.2	26.2	2.8	22.5-29.1
Percent standard length				
Head length	26.4	29.2	1.5	26.4-32.4
Head depth	27.2	26.8	1.0	25.1-29.1
Body depth	28.6	28.9	0.9	27.4-30.5
Snout to dorsal-fin origin	34.9	35.4	1.4	32.6-39.6
Snout to pelvic-fin origin	31.7	32.5	2.0	27.7-36.4
Dorsal-fin base length	63.3	58.0	3.3	51.4-63.4
Anterior of dorsal-fin to anterior of anal-fin	50.4	48.0	2.5	43.1-52.1
Posterior of dorsal-fin to posterior of anal-fin	13.6	13.7	0.7	12.1-14.6
Anterior of dorsal-fin to posterior of anal-fin	66.4	61.0	2.8	55.1-66.4
Posterior of dorsal-fin to anterior of anal-fin	30.0	27.0	1.8	23.1-30.2
Posterior of dorsal-fin to ventral of caudal-fin	17.0	17.2	1.2	14.7-20.5
Posterior of anal-fin to dorsal of caudal-fin	15.9	17.8	1.5	15.5-21.3
Anterior of dorsal-fin to pelvic-fin origin	21.5	21.1	1.1	18.8-23.7
Posterior of dorsal-fin to pelvic-fin origin	58.1	56.1	2.5	51.9-60.4

	holotype	mode	% freq.	range
Dorsal-fin spines	18	18	100	18-18
Dorsal-fin rays	9	8	78.3	7-9
Anal-fin rays	7	7	100	7-7
Pectoral-fin rays	12	13	65.2	12-13
Lateral-line scales	31	30	52.3	30-32
Pored scales posterior to lateral line	1	1	56.5	0-2
Cheek scales	4	4	100	4-4
Gill-rakers on first ceratobranchial	3	2	56.5	2-3
Gill-rakers on first epibranchial	9	8	56.5	8-10
Teeth in outer row of left lower jaw	10	12	39.1	9-12
Teeth rows on upper jaw	4	5	56.5	4-6
Teeth rows on lower jaw	4	4	70.0	3-5

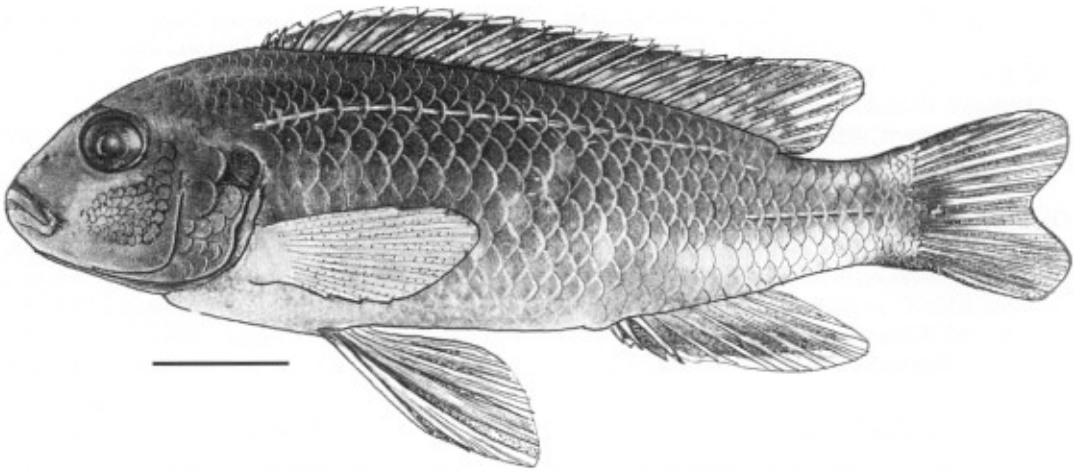

Fig. 9. *Melanochromis perileucos*, holotype, PSU 2652.1, adult male, 71.1 mm SL, Likoma Island. Scale bar: 10 mm.

was plotted against the first PC of the meristic data (Fig. 8). The minimum polygon clusters formed by the three species, however, were shown to be significantly (Wilks' Lambda=0.0001; Duncan's Multiple Range Test, $P<0.05$) different along the first PC of the meristic data. Variables with the highest loadings on the first PC of the meristic data were dorsal spines (0.352) and number of gill rakers on the first epibranchial (0.420), while those having the highest loadings on the sheared second PC were snout length (0.589), preorbital depth (0.361), and body depth (0.489).

Melanochromis perileucos, new species
(Fig. 9)

Melanochromis "black+white johannii": Ribbink et al., 1983: 206.

Holotype. PSU 2652.1, adult male, 71.1 mm SL; Likoma Island (Membe Point), Lake Malawi (34°45"E 12°04"S), Malawi, Africa; 5-8 m; February 1992.

Paratypes. PSU 2652.2, 5 ex., 64.1-75.2 mm; ANSP 175085, 3 ex., 63.2-70.1 mm; USNM 343717, 3 ex., 58.6-64.2 mm; MFU 34, 3 ex., 58.5-80.0 mm; data as for holotype.

Diagnosis. An elongate cichlid recognized as a member of the genus *Melanochromis* by the presence of two horizontal stripes along its flanks. *Melanochromis perileucos* may be distinguished from other members of the genus, except *M. elastodema*, by its faded, often interrupted, horizontal stripes in males. It may be distinguished from *M. elastodema* by its pale blue caudal peduncle compared with the dark blue or almost black caudal peduncle of *M. elastodema*. *Melanochromis perileucos* is the only *Melanochromis* in which females may be white.

Description. Morphometric and meristic data for *M. perileucos* from the holotype and 14 paratypes are summarized in Table 4. Body form is elongate and slightly compressed, lower jaw slightly shorter than upper jaw. Teeth in outer rows distinctly bicuspid (cusps slightly asymmetric), with 24-28 teeth in the outer row of the lower jaw that are progressively smaller posteriorly. Inner rows of teeth tricuspid in 4-5 irregular rows on upper jaw and 3-5 irregular rows on lower jaw. Lower pharyngeal bone triangular, teeth crowded with 10-11 teeth along the longest medial series and 34-38 enlarged teeth across the posterior margin.

Coloration. Males with brilliant deep blue ground color. Pale blue, wide, mid-ventral stripe along ventral margin of body, interrupted anteriorly and becoming a solid stripe posteriorly. May have an interrupted blue stripe extending laterally from dorsal base of caudal fin anteriorly in the position where the dorso-medial stripe would be located. Dorsal fin black with white lappets and two distinct ocelli on clear posterior margin. Caudal fin pale blue with black spines and white outer margin. Anal fin black with white

leading and trailing edges and two yellow ocelli. Pelvic fins black with white leading edges. Pectoral fins pale gray. Head dark blue, may have two pale blue interorbital bars.

Females with pale yellow or typically white ground color with faint, wide dark mid-lateral stripe and a thinner, faint dorso-lateral stripe. Dorsal fin black with white lappets. Caudal fin pale yellow with black dorsal and ventral margins. Anal fin and pelvic fins dark gray with white leading edges, single yellow ocelli on anal fin. Pectoral fins gray. Head pale yellow with two dark gray interorbital bars.

Distribution. *Melanochromis perileucos* was endemic to the eastern region of Likoma Island, but has been introduced at Thumbi West Island and Otter Point (Ribbink et al., 1983). We have observed *M. perileucos* over the rock-sand interface as well as purely rocky habitats. It feeds on attached algae, in the sand substrata, and on plankton (Ribbink et al., 1983).

Etymology. From the Greek *perileucos*, a noun in apposition meaning white-edged, in reference to the dorsal-fin color pattern in adult males.

Table 4. Morphometric ratios and meristics for *Melanochromis perileucos* (n=15). Summary values include holotype.

	holotype	mean	SD	range
Standard length (mm)	71.1	68.2	9.7	58.5-80.0
Head length (mm)	20.8	19.4	1.7	16.8-21.9
Percent head length				
Snout length	35.4	35.6	2.6	29.6-38.1
Postorbital head length	50.5	49.5	2.6	44.9-53.6
Horizontal eye diameter	27.0	28.5	3.5	22.2-34.4
Vertical eye diameter	27.1	29.1	3.7	21.4-35.6
Preorbital depth	26.9	9.2	3.3	22.1-35.8
Cheek depth	45.1	41.7	2.8	38.0-46.6
Lower jaw length	30.6	29.0	1.8	26.2-31.4
Percent standard length				
Head length	29.2	28.5	1.5	26.2-31.9
Head depth	25.9	25.9	0.7	24.9-27.2
Body depth	27.3	8.6	1.1	26.6-30.9
Snout to dorsal-fin origin	30.4	34.0	1.6	30.4-36.5
Snout to pelvic-fin origin	32.6	32.0	1.8	28.2-36.2
Dorsal-fin base length	61.8	60.0	2.3	55.7-63.3
Anterior of dorsal-fin to anterior of anal-fin	46.9	48.2	1.5	45.0-50.5
Posterior of dorsal-fin to posterior of anal-fin	12.8	13.8	0.8	12.7-15.7
Anterior of dorsal-fin to posterior of anal-fin	63.8	61.9	2.6	59.4-65.3
Posterior of dorsal-fin to anterior of anal-fin	28.8	27.7	1.6	24.2-31.5
Posterior of dorsal-fin to ventral of caudal-fin	16.8	16.3	1.8	14.2-18.0
Posterior of anal-fin to dorsal of caudal-fin	17.1	17.8	1.0	14.8-19.9
Anterior of dorsal-fin to pelvic-fin origin	21.8	21.0	1.5	17.5-23.8
Posterior of dorsal-fin to pelvic-fin origin	55.9	57.1	1.6	52.8-62.4

	holotype	mode	% freq.	range
Dorsal-fin spines	18	18	80.0	18-19
Dorsal-fin rays	8	8	80.0	7-8
Anal-fin rays	7	7	100	7-7
Pectoral-fin rays	13	13	80.0	12-13
Lateral-line scales	31	31	66.7	30-32
Pored scales posterior to lateral line	1	1	60.0	1-2
Cheek scales	4	4	100	4-4
Gill-rakers on first ceratobranchial	3	3	53.3	2-3
Gill-rakers on first epibranchial	9	9	60.0	9-10
Teeth in outer row of left lower jaw	12	13	60.0	12-14
Teeth rows on upper jaw	5	5	60.0	4-5
Teeth rows on lower jaw	4	4	73.3	3-5

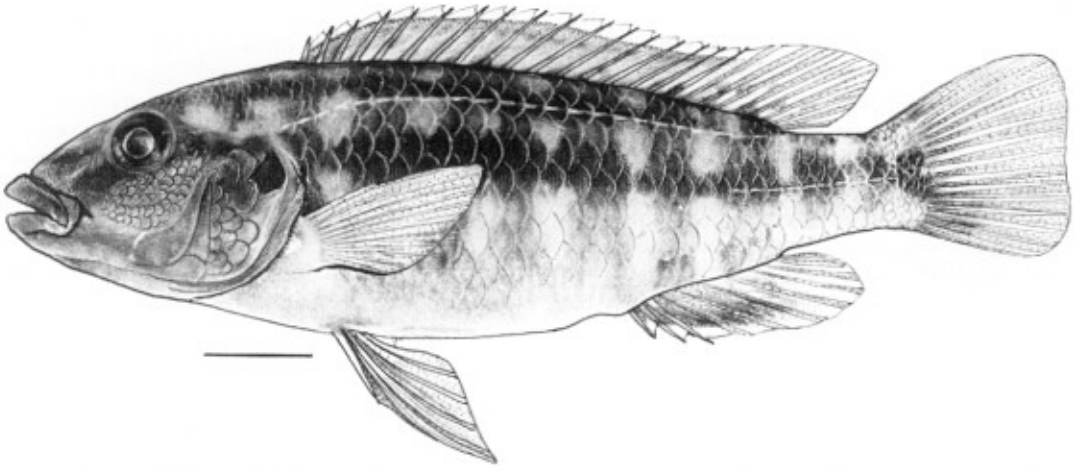

Fig. 10. *Melanochromis baliodigma*, holotype, PSU 2653.1, adult male, 61.9 mm SL, Membe Island, Lake Malawi. Scale bar: 10 mm.

Remarks. Comparison of morphometric and meristic data from *M. perileucos*, *M. johannii*, and *M. elastodema* resulted in some overlap among the minimum polygon clusters formed when the sheared second PC of the morphometric data was plotted against the first PC of the meristic data (Fig. 8). The minimum polygon clusters formed by the three species, however, were shown to be significantly (Wilks' Lambda = 0.0001; Duncan's Multiple Range Test, $P < 0.05$) different along the first PC of the meristic data. Variables with the highest loadings on the first PC of the meristic data were dorsal spines (0.352) and number of gill rakers on the first epibranchial (0.420), while those having the highest loadings on the sheared second PC were snout length (0.589), preorbital depth (0.361), and body depth (0.489).

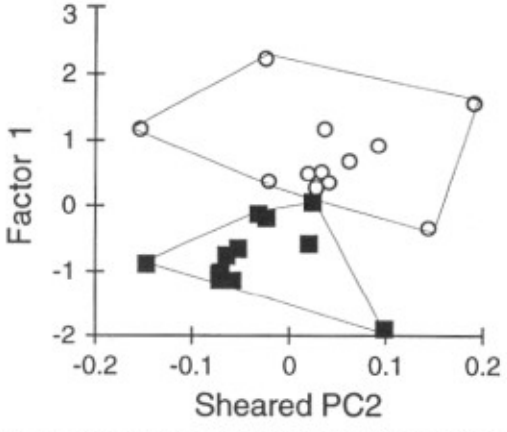

Fig. 11. Plot of the sheared second principal component of the morphometric data against the first principal component of the meristic data for *Melanochromis baliodigma* from Membe Island (○) and *M. xanthodigma* from Masinje (■).

Melanochromis baliodigma, new species
(Fig. 10)

Melanochromis "blotch": Ribbink et al., 1983: 204 (in part).

Holotype. PSU 2563.1, adult male, 61.9 mm SL; Membe Island, Lake Malawi (34°37"E 12°03"S), Malawi, Africa; 5 m; February 1992.

Paratypes. PSU 2563.2, 4 ex., 52.1-66.6 mm; ANSP 175086, 2 ex., 52.0, 58.0 mm; USNM 343718, 3 ex., 57.0-73.3 mm; and MFU 35, 2 ex., 63.8, 65.6 mm; data as for holotype.

Diagnosis. An elongate cichlid with a pointed snout recognized as a member of the genus *Melanochromis* by the presence of two horizontal stripes along its flanks. *Melanochromis baliodigma* may be distinguished from other members of the genus, except *M. xanthodigma*, by the presence of seven to nine brown vertical bars overlain by two dark horizontal stripes. The presence of two to four yellow ocelli on its anal fin distinguishes it from *M. xanthodigma*, which possess five to seven yellow ocelli on its anal fin. In addition, the vertical

brown bars in *M. baliodigma* tend to be thinner than those in *M. xanthodigma*.

Description. Morphometric and meristic data for *M. baliodigma* from the holotype and 11 paratypes are summarized in Table 5. Body form is elongate and moderately compressed, jaws isognathous. Teeth in outer rows distinctly bicuspid (cusps asymmetric), with 20-26 bicuspid teeth in the outer row of the lower jaw that are progressively smaller posteriorly. Inner teeth tricuspid, in 1-2 rows on the upper and lower jaws. Lower pharyngeal bone triangular, teeth not crowded with 10-11 teeth along the longest medial series and 20-24 enlarged, uncrowded teeth across the posterior margin.

Coloration. Males and females with light brown or pale yellow ground color and seven to nine brown vertical bars. A dark brown stripe extending from the eye to the basal region of the caudal fin and a dark brown stripe extending from occipital region to posterior of dorsal fin. Dorsal fin yellow-white with brown rays. Caudal fin brown, yellow distally with white edges. Anal fin brown to yellow with dark brown leading edge; clear

Table 5. Morphometric ratios and meristics for *Melanochromis baliodigma* (n=12). Summary values include holotype.

	holotype	mean	SD	range
Standard length (mm)	61.9	60.5	6.4	52.0-73.3
Head length (mm)	17.9	19.4	2.4	16.5-23.7
Percent head length				
Snout length	34.8	36.9	5.1	30.3-45.3
Postorbital head length	52.7	48.3	3.2	44.2-53.2
Horizontal eye diameter	24.8	25.8	3.3	19.3-31.5
Vertical eye diameter	28.5	27.7	3.0	23.0-34.3
Preorbital depth	26.9	26.5	3.8	19.0-32.3
Cheek depth	31.7	32.0	2.8	28.0-37.5
Lower jaw length	39.3	37.1	2.5	34.1-39.3
Percent standard length				
Head length	29.0	32.0	1.6	28.9-34.9
Head depth	24.2	27.3	1.5	22.9-27.3
Body depth	26.9	27.4	1.6	25.0-29.3
Snout to dorsal-fin origin	34.1	37.2	2.0	33.1-39.7
Snout to pelvic-fin origin	34.3	35.3	2.4	29.8-39.7
Dorsal-fin base length	60.5	55.6	2.6	51.9-60.6
Anterior of dorsal-fin to anterior of anal-fin	48.5	46.4	2.4	41.9-50.3
Posterior of dorsal-fin to posterior of anal-fin	15.4	14.3	0.8	13.4-15.7
Anterior of dorsal-fin to posterior of anal-fin	60.3	58.2	1.5	55.7-60.3
Posterior of dorsal-fin to anterior of anal-fin	28.5	25.8	1.6	23.8-28.5
Posterior of dorsal-fin to ventral of caudal-fin	16.7	16.9	0.8	15.4-18.1
Posterior of anal-fin to dorsal of caudal-fin	18.7	17.1	1.1	15.4-19.0
Anterior of dorsal-fin to pelvic-fin origin	22.5	21.0	1.8	18.0-24.3
Posterior of dorsal-fin to pelvic-fin origin	56.0	53.9	2.3	50.0-57.1

	holotype	mode	% freq.	range
Dorsal-fin spines	17	17	91.7	17-18
Dorsal-fin rays	8	8	91.7	7-8
Anal-fin rays	7	7	100	7-7
Pectoral-fin rays	13	13	91.7	13-14
Lateral-line scales	30	30	83.3	29-31
Pored scales posterior to lateral line	2	2	75.0	1-2
Cheek scales	4	4	50.0	4-5
Gill-rakers on first ceratobranchial	3	3	91.7	2-3
Gill-rakers on first epibranchial	7	7	58.3	7-9
Teeth in outer row of left lower jaw	10	11	50.0	10-13
Teeth rows on upper jaw	3	3	75.0	2-3
Teeth rows on lower jaw	2	2	50.0	2-3

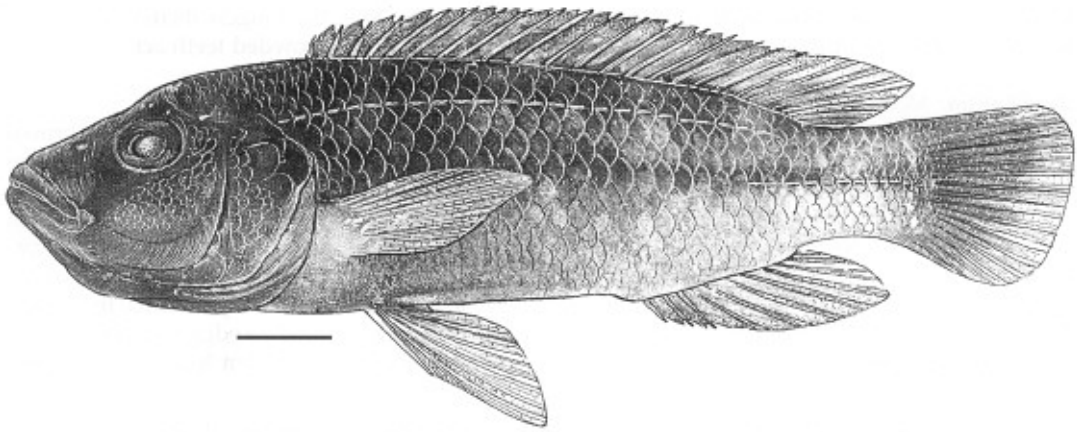

Fig. 12. *Melanochromis xanthodigma*, holotype. PSU 2656.1, adult male, 81.6 mm SL, Masinje, Lake Malawi. Scale bar: 10 mm.

distally with two to four yellow ocelli present in both males and females. Pelvic fins brown with white anterior margins; yellow distally. Pectoral fins dull yellow with scattered gray melanophores. Forehead ivory with two brown interorbital bars.

Distribution. *Melanochromis baliodigma* is endemic to the rocky areas off Membe Island, just south of Chisumulu Island, and is typically found at intermediate depths over the rock-sand interface (Ribbink et al., 1983). *Melanochromis baliodigma* appears to be an opportunistic feeder, eating smaller fish and catfish eggs (Konings, 1990).

Etymology. From the Greek *baliodigma*, a noun in apposition meaning spotted pattern, in reference to the predominant adult color pattern.

Remarks. Because of the similarity in color pattern between *M. baliodigma* and *M. xanthodigma*, morphometric and meristic data from these two species were compared. In a plot of the sheared second PC of the morphometric data against the first PC of the meristic data, there was slight overlapped between the minimum polygon clusters formed by the two species (Fig. 11). The minimum polygons formed by the two species, however, were shown to be significantly (Wilks' Lambda = 0.0001; Duncan's Multiple Range Test, $P < 0.05$) different along both axes. Variables with the highest loadings on the sheared second PC were snout length (0.317), lower jaw length (0.249), and body depth (0.797), while those having the highest values on the first PC of the meristic data were dorsal spines (0.274), lateral line scales (0.258) and number of teeth in outer row of left lower jaw (0.243).

Melanochromis xanthodigma, new species
(Fig. 12)

Melanochromis "blotch": Ribbink et al., 1983: 204 (in part).

Holotype. PSU 2656.1, adult male, 81.6 mm SL; Masinje, Lake Malawi (34°51"E 13°35"S), Malawi, Africa; 5 m; February 1992.

Paratypes. PSU 2656.1, 4 ex., 58.0-82.9 mm; ANSP 175087, 2 ex., 71.1, 77.9 mm; USNM 343719, 3 ex., 76.8-85.5 mm; MFU 36, 2 ex., 78.3, 79.7 mm; data as for holotype.

Diagnosis. An elongate cichlid with a pointed snout recognized as a member of the genus *Melanochromis* by the presence of two horizontal stripes along its flanks. *Melanochromis xanthodigma* can be distinguished from other members in the genus, except *M. baliodigma*, by seven to nine brown vertical bars overlain by two dark brown longitudinal stripes. It is distinguished from *M. baliodigma* by the presence of five to seven yellow ocelli on the anal fin versus two to four yellow ocelli on the anal fin of *M. baliodigma*. The ground color of *M. xanthodigma* tends to be a more intense compared to the light brown or pale yellow ground color of *M. baliodigma*.

Description. Morphometric and meristic data for *M. xanthodigma* from the holotype and 11 paratypes are summarized in Table 6. Body form is elongate and slightly compressed, jaws isognathous. Teeth in outer rows distinctly bicuspid (cusps slightly asymmetric), with 20-26 bicuspid teeth in the outer row of the lower jaw that are progressively smaller posteriorly. Inner teeth tricuspid in 2 rows on the upper jaw and 1-2 rows on the lower jaw. Lower pharyngeal bone triangular, teeth uncrowded with 10-11 teeth along the longest medial series and 32-34 enlarged teeth across the posterior margin.

Coloration. Males and females with dull yellow ground color. Two rows of bright yellow blotches extending mid- and dorso-laterally formed by the presence of seven to nine vertical brown bars and two horizontal brown stripes which extend from the eye to the basal region of the caudal fin and from the occipital region to posterior of dorsal fin. Dorsal fin bright yellow with brown rays. Caudal fin brown with yellow outer margin. Anal fin brown to yellow with dark brown leading edge, clear distally with five to seven yellow ocelli in both males and females. Pelvic fins brown with white leading edges and yellow distally.

Table 6. Morphometric ratios and meristics for *Melanochromis xanthodigma* (n=12). Summary values include holotype.

	holotype	mean	SD	range
Standard length (mm)	81.6	76.4	8.1	58.0-85.5
Head length (mm)	25.9	23.9	2.7	18.9-26.9
Percent head length				
Snout length	37.9	39.4	2.3	37.0-44.6
Postorbital head length	44.6	46.4	3.6	43.5-55.1
Horizontal eye diameter	23.8	25.2	2.3	22.8-30.6
Vertical eye diameter	23.5	26.4	2.4	22.5-30.2
Preorbital depth	32.7	29.8	4.2	24.5-40.7
Cheek depth	35.6	32.7	2.9	28.1-37.5
Lower jaw length	43.5	39.1	3.3	35.5-43.5
Percent standard length				
Head length	31.8	31.3	1.7	28.6-34.7
Head depth	27.6	25.8	1.4	23.4-27.9
Body depth	29.1	28.1	1.2	27.4-31.1
Snout to dorsal-fin origin	35.3	36.7	1.9	34.2-40.9
Snout to pelvic-fin origin	35.6	35.3	2.4	29.8-39.7
Dorsal-fin base length	58.8	56.0	3.1	50.4-59.6
Anterior of dorsal-fin to anterior of anal-fin	47.4	45.6	2.8	40.1-49.7
Posterior of dorsal-fin to posterior of anal-fin	13.9	13.9	0.8	12.5-15.0
Anterior of dorsal-fin to posterior of anal-fin	58.8	58.1	2.9	51.8-62.2
Posterior of dorsal-fin to anterior of anal-fin	28.1	27.0	1.9	23.8-30.3
Posterior of dorsal-fin to ventral of caudal-fin	15.2	17.2	1.6	14.9-19.8
Posterior of anal-fin to dorsal of caudal-fin	17.6	17.5	0.9	15.9-18.9
Anterior dorsal-fin to pelvic-fin origin	20.7	20.3	1.1	18.1-21.6
Posterior dorsal-fin to pelvic-fin origin	56.9	53.5	3.0	48.1-57.7

	holotype	mode	% freq.	range
Dorsal-fin spines	18	18	91.7	18-19
Dorsal-fin rays	8	8	100	8-8
Anal-fin rays	7	7	100	7-7
Pectoral-fin rays	13	13	66.7	13-14
Lateral-line scales	31	30	50.0	30-33
Pored scales posterior to lateral line	3	2	75.0	1-3
Cheek scales	5	5	83.3	4-5
Gill-rakers on first ceratobranchial	3	3	66.7	3-4
Gill-rakers on first epibranchial	8	8	100	8-8
Teeth in outer row of left lower jaw	12	10	41.7	10-13
Teeth rows on upper jaw	3	3	100	3-3
Teeth rows on lower jaw	3	3	75.0	2-3

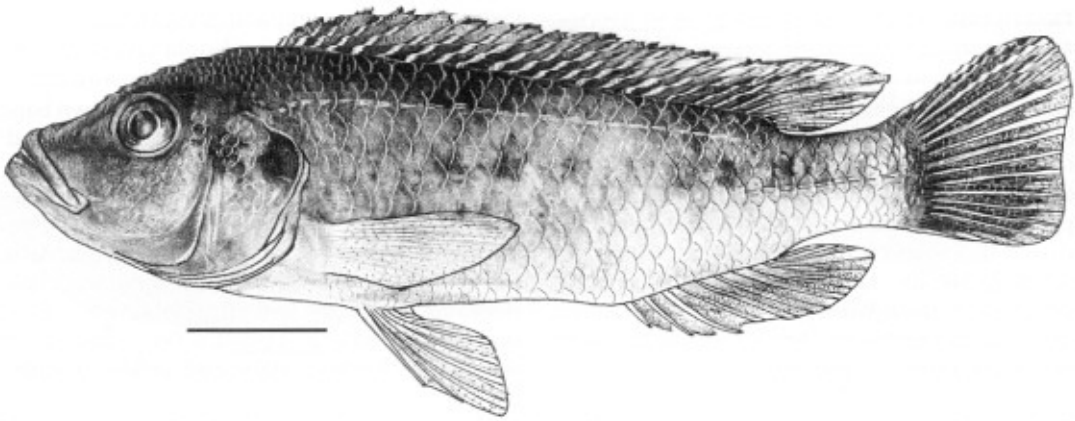

Fig. 13. *Melanochromis benetos*, holotype, PSU 2654.1, adult male, 91.3 mm SL, Mpanga Rocks, Lake Malawi. Scale bar: 10 mm.

Pectoral fins yellow-gray. Forehead yellow with two brown interorbital bars.

Distribution. *Melanochromis xanthodigma* is restricted to the rocky reefs at Masinje. The species is an opportunistic feeder and is commonly found in crevices and caves at depths around 20 m (Konings, 1990).

Etymology. From the Greek *xanthodigma*, a noun in apposition meaning yellow pattern, in reference to coloration in adults.

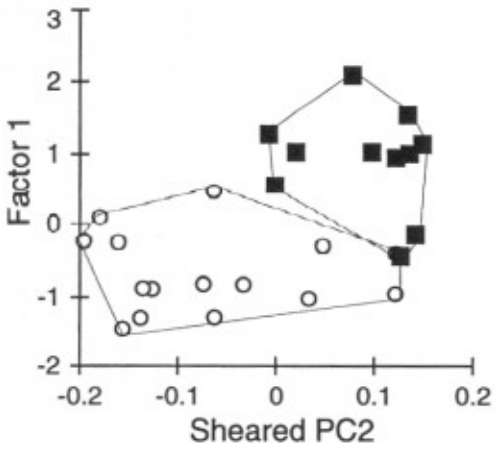

Fig. 14. Plot of the sheared second principal component of the morphometric data against the first principal component of the meristic data for *Melanochromis benetos* from Mpanga Rocks (○) and *M. lepidiadaptes* from Makanjila Point (■).

Remarks. Morphometric and meristic data from *M. xanthodigma* and *M. baliodigma* were compared using SPCA. In a plot of the sheared second PC of the morphometric data against the first PC of the meristic data, there was slight overlapped between the minimum polygon clusters formed by the two species (Fig. 11). The minimum polygons formed by the two species, however, were shown to be significantly (Wilks' Lambda =0.0001; Duncan's Multiple Range Test, $P<0.05$) different along both axes. Variables with the highest loadings on the second sheared PC were snout length (0.317), lower jaw length (0.249), and body depth (0.797), while those having the highest values on the first PC of the meristic data were dorsal spines (0.274), lateral line scales (0.258) and teeth in outer row of left lower jaw (0.243).

Melanochromis benetos, new species
(Fig. 13)

Melanochromis "blue": Ribbink et al., 1983: 207

Holotype. PSU 2654.1, adult male, 91.3 mm SL; Mpanga Rocks, Lake Malawi (34°15"E 10°24"S), Malawi, Africa; 10 m; February 1992.

Paratypes. PSU 2654.2, 3 ex., 61.9-74.4 mm; ANSP 175088, 2 ex., 63.1, 68.0 mm; USNM 343720, 3 ex., 62.6-87.2 mm; MFU 37, 2 ex., 62.2, 74.7 mm; data as for holotype.

Diagnosis. An elongate cichlid with a pointed snout recognized as a member of the genus *Melanochromis* by the presence of two horizontal stripes

along the flanks in females, and weak but sometimes absent horizontal stripes along the flanks in males. *Melanochromis benetos* can be distinguished from other members of the genus by its light blue-gray ground color and faint brown longitudinal stripes. It superficially resembles *M. lepidiadaptes*, but possesses a longer snout (35.5-50.1 % HL, vs. 31.4-39.5) and more teeth in the outer row of the lower jaw (30-36, vs. 24-28).

Description. Morphometric and meristic data for *M. benetos* from the holotype and ten paratypes are summarized in Table 7. Body form is slightly compressed and elongate, lips slightly hypertrophied, jaws isognathous. Teeth in the outer rows distinctly bicuspid (cusps slightly asymmetric), with 30-36 teeth in the outer row of the lower jaw that are progressively smaller posteriorly. Inner teeth bicuspid, in 2-3 rows on upper jaw and 1-2 rows on lower jaw. Lower pharyngeal bone triangular, teeth uncrowded, 10-11 teeth along the longest medial series and 32-40 enlarged teeth across the posterior margin.

Coloration. Males with light blue-gray ground color and faint brown, interrupted mid- and dor-

Table 7. Morphometric ratios and meristics for *Melanochromis benetos* (n=11). Summary values include holotype.

	holotype	mean	SD	range
Standard length (mm)	91.3	70.4	10.4	61.9-91.3
Head length (mm)	27.1	20.6	3.4	17.5-27.1
Percent head length				
Snout length	41.6	42.6	4.2	35.5-50.1
Postorbital head length	53.4	48.9	2.8	44.1-53.4
Horizontal eye diameter	17.3	24.6	4.2	17.1-31.7
Vertical eye diameter	20.4	26.5	4.0	20.4-33.0
Preorbital depth	29.6	27.8	3.7	22.7-33.0
Cheek depth	29.6	33.5	2.5	29.6-37.0
Lower jaw length	39.1	40.0	1.5	38.6-42.2
Percent standard length				
Head length	29.6	29.1	0.9	28.3-31.4
Head depth	26.1	25.2	0.8	24.0-26.2
Body depth	28.7	28.4	1.1	26.7-30.8
Snout to dorsal-fin origin	31.8	33.5	2.0	31.8-38.8
Snout to pelvic-fin origin	34.1	33.7	1.1	32.2-36.2
Dorsal-fin base length	57.3	56.2	2.5	50.6-59.7
Anterior of dorsal-fin to anterior of anal-fin	49.1	47.1	3.1	41.7-51.3
Posterior of dorsal-fin to posterior of anal-fin	13.7	14.3	1.9	12.0-19.2
Anterior of dorsal-fin to posterior of anal-fin	63.3	59.9	3.7	54.0-64.0
Posterior of dorsal-fin to anterior of anal-fin	28.3	26.8	1.0	25.3-28.3
Posterior of dorsal-fin to ventral of caudal-fin	18.0	18.5	2.0	16.2-23.3
Posterior of anal-fin to dorsal of caudal-fin	17.1	18.1	1.1	15.3-19.3
Anterior of dorsal-fin to pelvic-fin origin	24.6	22.5	1.3	20.3-24.6
Posterior dorsal-fin to pelvic-fin origin	56.5	54.0	2.5	50.6-57.6
	holotype	mode	% freq.	range
Dorsal-fin spines	17	17	54.5	17-18
Dorsal-fin rays	7	8	81.8	7-8
Anal-fin rays	7	7	100	7-7
Pectoral-fin rays	14	14	90.9	13-14
Lateral-line scales	31	31	54.5	30-32
Pored scales posterior to lateral line	2	2	72.7	1-2
Cheek scales	5	5	63.6	4-5
Gill-rakers on first ceratobranchial	2	2	72.7	2-3
Gill-rakers on first epibranchial	9	9	81.2	8-9
Teeth in outer row of left lower jaw	18	15	36.4	15-18
Teeth rows on upper jaw	4	3	90.9	3-4
Teeth rows on lower jaw	3	3	72.7	2-3

suprlateral stripes. Dorsal fin blue-gray with orange lappets and clear flecks on membranes. Brown or black flecks on posterior, distal margin of dorsal fin; may be coalesced into a prominent dorsal fin spot. Caudal fin pale blue with dark brown ventral and dorsal distal borders, and orange outer margin. Anal fin blue-gray, white leading edge, dark gray submarginal band, and two to three yellow ocelli. Pelvic fins gray with dark gray submarginal bands and white leading edges. Pectoral fins gray. Head blue-gray, no interorbital bars, dark brown opercular spot. Gular region pale orange.

Females similar in color to males, but overall ground color a paler brownish-blue with interrupted dark brown, mid- and dorso-lateral stripes. Two to three yellow ocelli on the anal fin.

Distribution. We collected *M. benetos* at Mpanga Rocks near Chilumba. Ribbink et al. (1983) observed *M. benetos* at Likoma Island and along the northwestern coast between Nkhata Bay and Chilumba, typically over the rock-sand interface, sand, and rocky habitats. *Melanochromis benetos* is an opportunistic feeder, but primarily feeds on small fishes (Konings, 1989).

Table 8. Morphometric ratios and meristics for *Melanochromis lepidiadaptes* (n=15). Summary values include holotype.

	holotype	mean	SD	range
Standard length (mm)	73.1	74.0	7.3	62.9-87.2
Head length (mm)	21.5	23.6	2.0	19.8-26.2
Percent head length				
Snout length	38.1	36.8	2.7	31.4-39.5
Postorbital head length	52.1	47.8	2.9	41.8-52.1
Horizontal eye diameter	20.7	23.8	1.6	20.7-26.2
Vertical eye diameter	24.3	24.3	1.7	21.8-27.4
Preorbital depth	30.4	31.8	2.5	26.9-35.6
Cheek depth	35.5	32.8	2.7	28.9-37.1
Lower jaw length	36.5	36.8	2.6	32.2-40.1
Percent standard length				
Head length	29.4	31.9	2.5	28.4-36.4
Head depth	25.5	26.6	1.1	25.2-28.3
Body depth	28.7	28.9	1.1	27.3-31.0
Snout to dorsal-fin origin	35.1	36.3	1.5	33.9-38.6
Snout to pelvic-fin origin	31.4	35.5	2.9	31.4-39.6
Dorsal-fin base length	58.2	54.8	2.2	51.0-58.2
Anterior of dorsal-fin to anterior of anal-fin	49.5	46.2	2.1	43.7-51.1
Posterior of dorsal-fin to posterior of anal-fin	14.0	14.3	1.1	12.9-17.4
Anterior of dorsal-fin to posterior of anal-fin	58.8	57.0	2.4	52.0-60.4
Posterior of dorsal-fin to anterior of anal-fin	27.3	26.4	0.9	25.1-28.1
Posterior of dorsal-fin to ventral of caudal-fin	15.5	17.0	1.1	15.5-19.7
Posterior of anal-fin to dorsal of caudal-fin	19.9	18.8	1.2	16.9-20.6
Anterior of dorsal-fin to pelvic-fin origin	22.6	20.9	1.3	18.7-23.9
Posterior of dorsal-fin to pelvic-fin origin	57.8	52.3	3.0	48.1-57.8

	holotype	mode	% freq.	range
Dorsal-fin spines	17	18	73.3	17-18
Dorsal-fin rays	9	8	80.0	8-9
Anal-fin rays	7	7	100	7-7
Pectoral-fin rays	13	13	73.3	13-14
Lateral-line scales	30	31	53.3	30-32
Pored scales posterior to lateral line	2	2	60.0	1-3
Cheek scales	4	4	53.3	4-5
Gill-rakers on first ceratobranchial	3	3	93.4	3-4
Gill-rakers on first epibranchial	9	9	80.0	8-9
Teeth in outer row of left lower jaw	14	12	80.0	12-14
Teeth rows on upper jaw	2	2	53.3	2-3
Teeth rows on lower jaw	2	2	66.7	2-3

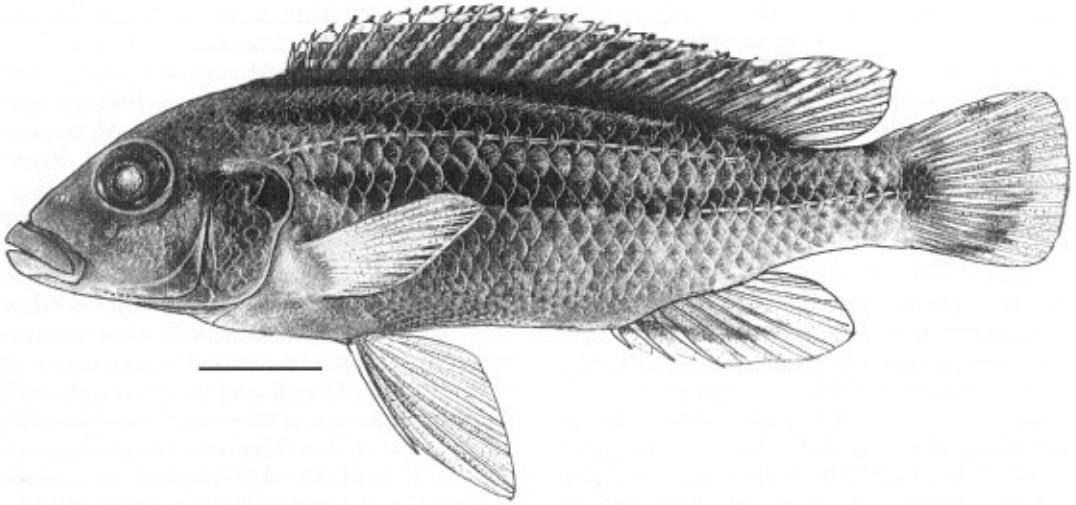

Fig. 15. *Melanochromis lepidiadaptes*, holotype, PSU 2655.1, adult male, 73.1 mm SL, Makanjila Point, Lake Malawi. Scale bar: 10 mm.

Etymology. From the Greek *benetos*, a noun in apposition meaning blue, in reference to the coloration of adult males.

Remarks. In a plot of the sheared second PC of the morphometric data against the first PC of the meristic data, there was slight overlap between the minimum polygon clusters formed by *M. benetos* and *M. lepidiadaptes* (Fig. 14). The minimum polygons formed by the two species, however, were shown to be significantly (Wilks' Lambda = 0.0001; Duncan's Multiple Range Test, $P < 0.05$) different along both axes. Variables with the highest loadings on the sheared second PC were preorbital depth (-0.468) and snout length (-0.530), while those having the highest values on the first PC of the meristic data were dorsal rays (-0.237), pectoral fin rays (0.294) and number of teeth in outer row of left lower jaw (0.301).

Melanochromis lepidiadaptes, new species
(Fig. 15)

Melanochromis "lepidophage": Ribbink et al., 1983: 204.

Holotype. PSU 2655.1, adult male, 73.1 mm SL; Makanjila Point, Lake Malawi (34°51'E 13°45'S), Malawi, Africa; 2-4 m; February 1992.

Paratypes. PSU 2655.2, 5 ex., 72.0-87.2 mm; ANSP 175089, 3 ex., 68.5-74.8 mm; USNM 343721, 3 ex., 69.2-81.0 mm; MFU 38, 3 ex., 65.2-72.2 mm; data as for holotype.

Diagnosis. An elongate cichlid with a pointed snout recognized as a member of the genus *Melanochromis* by the presence of two horizontal stripes along its flanks. *Melanochromis lepidiadaptes* may be distinguished from other members of the genus by its silvery-blue color and prominent, black caudal spot. *Melanochromis lepidiadaptes* may be distinguished from *M. benetos*, which it superficially resembles, by it shorter snout (31.4-39.5 % HL, vs. 35.5-50.1) and the fewer number of teeth in the outer row of the lower jaw (24-28, vs. 30-36).

Description. Morphometric and meristic data for *M. lepidiadaptes* from the holotype and 14 paratypes are summarized in Table 8. Body form is slightly compressed and elongate, head sharply pointed, jaws isognathous. Teeth in outer rows distinctly bicuspid (cusps asymmetric), with 24-28 teeth in the outer row of the lower jaw that are progressively smaller posteriorly. Inner teeth tricuspid, in 1-2 rows on the upper and lower jaws. Lower pharyngeal bone triangular, teeth well spaced with 10-11 teeth along the longest medial series and 32-34 enlarged teeth across the posterior margin.

Coloration. Males with light blue ground color with silvery sheen, belly darker. Black mid-lateral stripe extending from eye to caudal fin with a prominent caudal spot, and a black dorso-lateral stripe extending from occipital region to posterior ventral region of dorsal fin. A third interrupted black stripe may be present along the base of the dorsal fin. Dorsal fin dusky blue-gray with white lappets and orange tips; three yellow spots on trailing edge. Caudal fin dark gray at base, pale blue distally; upper and lower borders black with white edges. Anal fin dusky blue with dark gray submarginal band and white leading edge with three or four yellow ocelli in both males and females. Pelvic fins dusky blue with dark gray submarginal bands and white leading edges. Pectoral fins clear. Head blue-gray with dark blue opercular spot, gular pale gray. Females similar to males but with an overall dull gray-blue ground color.

All of the specimens we examined (n=15) exhibited the typical horizontal striping of the genus *Melanochromis*, and our description matches the fish pictured as *M.* "lepidophage" by Ribbink et al. (1983: 221, pl. 9f). Konings (1990), however, has suggested that breeding males could be confused with *M. benetos*, since the horizontal striping in *M. lepidiadaptes* may fade and the blue ground color intensify during breeding (Konings, 1990: 337).

Distribution. *Melanochromis lepidiadaptes* is endemic to the rocky areas off Makanjila Point, on the southeastern shore of Lake Malawi, and is often found in the shallow intermediate zone (Ribbink et al., 1983). It feeds in packs, primarily on the scales of other fishes (Ribbink et al., 1983).

Etymology. From the Greek *lepidiadaptes*, a noun in apposition meaning scale eater, in reference the mode of feeding in this species.

Discussion

The eight new species descriptions presented brings the total number of described species of *Melanochromis* to 24: *M. auratus* (Boulenger, 1897), *M. baliodigma*, *M. benetos*, *M. labrosus* Trewavas, 1935, *M. lepidiadaptes*, *M. brevis* Trewavas, 1935, *M. chipoke* Johnson, 1975, *M. cyaneorhabdos*, *M. dialeptos*, *M. elastodema*, *M. heterochromis* Bowers & Stauffer, 1993, *M. interruptus* Johnson, 1975, *M. jounjohnsonae* (Johnson, 1974), *M. johannii* (Eccles, 1973), *M. loriae* Johnson, 1975, *M. melanopterus* Trewavas, 1935, *M. mellitus* Johnson, 1976, *M. parallelus* Burgess & Axelrod, 1976, *M. perileucos*, *M. perspicax* Trewavas, 1935, *M. robustus* Johnson, 1985, *M. simulans* Eccles, 1973, *M. vermivorus* Trewavas, 1935, and *M. xanthodigma*.

Ribbink et al. (1983) referred to two other undescribed species, *Melanochromis* "slab", which resembles *M. melanopterus*, and *Melanochromis* "brown", which they report has having been rarely collected at Chinyankwazi and Chinyamwezi Islands. We have compared populations of *M.* "slab" from Mbenji and Maleri islands with several populations of *M. melanopterus* (unpubl.), and concluded that there was not enough evidence to treat the *M.* "slab" populations as a distinct species. It is anticipated that additional species of *Melanochromis* will be found along the Mozambique coast, which until recently has not been well surveyed.

Discrimination among species of mbuna relies heavily on coloration of breeding adults, since morphological variation is often limited. This was evident among species of *Melanochromis*, since our results indicated substantial overlap in both morphometric and meristic data among species. All species could be readily distinguished, however, based on unique adult coloration and color patterns. Furthermore, multivariate analysis supported differences among the morphologically similar species. For example, examination of morphometric and meristic data among three closely related species, *M. elastodema*, *M. perileucos*, and *M. johannii*, suggested that morphologically they were quite similar. The minimum polygon clusters formed by plotting the sheared second PC of the morphometric data and the first PC of the meristic data, however, indicated that all three species could be shown to be significantly different ($P < 0.05$). Many of the parameters which contributed to the separation of these species (e.g., snout length, preorbital depth, number of gill rakers on the first epibranchial arch) were associated with head shape and feeding, which suggest that these species may be utilizing their food resource (predominantly attached algae) differently (Reinthal, 1990). Recent work suggests that there are species-specific differences in the way that species feed on attached algae, specifically the angle at which they graze the substrate, and these differences in feeding angle are reflected in variation in morphometrics associated with

the jaw and head region (Stauffer et al., 1995).

Differences in adult coloration among geographically isolated populations may represent clinal differences within a species, especially if several genetically contiguous populations exist. When color variation among populations is disjunct, however, it may represent reproductively distinct species or incipient species. Recent molecular data (Moran & Kornfield, 1995) provides evidence for an even greater degree of philopatry within the mbuna than previously suggested. This, in conjunction with the tendency for mbuna not to swim over open water or sandy stretches shoreline (Fryer & Iles, 1972; Ribbink et al., 1983), has probably contributed to the evolution of narrowly endemic species, some of which are restricted to a single, rocky outcrop.

This appears to be the case with the two similarly colored species, *M. baliodigma*, endemic to Membe Island, and *M. xanthodigma*, endemic to Masinje on the southeastern shore and approximately 200 km away from Membe Island. Because of their unique color pattern, it is unlikely that related populations have been collected elsewhere in the lake and misidentified. It is possible, however, that some isolated populations exist along the parts of the Mozambique shore that have not been sampled. We contend, however, that the two described species would remain reproductively isolated if they coexisted sympatrically, in part because of the differences in the number of ocelli on the anal fin, which have been suggested to be important in mate choice in mbuna (Hert, 1989; Goldschmidt & de Visser, 1990). These two species also exhibit behavioral differences in habitat preference. *Melanochromis baliodigma* lives over intermediate habitat at depths of 3-10 m and has infrequently been observed over sandy substrate (Ribbink et al., 1983). *Melanochromis xanthodigma*, on the other hand, tends to hide in caves and crevices at depths down to 20 m (Konings, 1990). Taxonomic problems such as this is not limited to *Melanochromis*, and in his revision of the genus *Labidochromis*, Lewis (1982: 262) concluded that "The decision as to whether anatomically similar but differently colored members of geographically distinct populations are considered as species, subspecies, or geographical races rests with the researcher".

It is probable that the genus *Melanochromis* is polyphyletic, although suitable criteria for splitting the genus have yet to be identified. Some of the described species have not been collected since they were originally described (e.g., *M. melitus*, *M. interruptus*) or have questionable generic affinities (e.g., *M. brevis*, *M. perspicax*, *M. labrosus*). These species must be collected and reexamined to complete our understanding of the relationships within the genus *Melanochromis*.

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