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New Species of Rock-Dwelling Cichlid (Pisces: Cichlidae) from Lake Malawi, Africa, with Comments on *Melanochromis vermivorus* Trewavas

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Morphometric and meristic values were obtained from six populations of Lake Malawi fishes purported to belong to the species *Melanochromis vermivorus* Trewavas and compared with data from type material of *M. vermivorus*. Multivariate statistical analysis of the data revealed differences between the type material and the sampled populations with respect to shape and meristic counts. A previously recognized, but undescribed, species, *Melanochromis* sp. "chinyamwezi" (endemic to Chinyamwezi Island), is shown to be conspecific with the supposed *M. vermivorus* populations. We describe a new species of *Melanochromis* based on the above material.

BASED on specimens collected by Cuthbert Christy in 1925–1926, Trewavas (1935) recognized nine genera of Lake Malawi cichlids to be more closely related to each other than to other genera in the lake. All of these genera are strongly lithophilous and are often referred to collectively as mbuna (Fryer, 1959). This group of genera included *Melanochromis*, *Pseudotropheus*, *Petrotilapia*, *Labeotropheus*, *Cyathochromis*, *Christyella* (later recognized as a junior synonym of *Gephyrochromis*), *Labidochromis*, and *Genyochromis* (Trewavas, 1935).

Within the genus *Melanochromis*, Trewavas (1935) described five species: *M. melanopterus* (the type species for the genus), *M. vermivorus*, *M. labrosus*, *M. brevis*, and *M. perspicax*. She originally distinguished *Melanochromis* from *Pseudotropheus* on the basis of reduced size and number of pharyngeal teeth but later refined her definition to include all elongate fishes that possess horizontal stripes, an aggressive temperament, U-shaped tooth bands, and a generalized pharyngeal dentition (Trewavas, 1983). As a result, *P. johanni* Eccles and *P. auratus* (Boulenger) were transferred to *Melanochromis* (Ribbink et al., 1983). Within the genus *Melanochromis*, species are typically differentiated on the basis of adult coloration, size at maturity, depth distribution, and morphology.

Species discrimination among the mbuna, and Lake Malawi cichlids in general, is hampered by the recency of species divergence (1–2 million years) and the limited array of distinctive morphological characters. The taxonomic status of many allopatric populations of ecologically similar color morphs remains unclear. Analysis of morphometric and meristic characters using multivariate statistical techniques has proved useful in separating morphologically similar species (Stauffer and Boltz, 1989; Stauffer, 1991). The purpose of this paper is to examine morphometric and meristic data from several populations identified by Ribbink et al. (1983) as *M. vermivorus*, the type specimens of *M. vermivorus*, and an undescribed species of *Melanochromis* (*M.* sp. "chinyamwezi"; Ribbink et al., 1983) endemic to Chinyamwezi Island.

METHODS

Fishes were collected during March and July 1991 at seven locations (see Table 1) using SCUBA gear and a monofilament net (7 m × 1 m × 1.5 cm). Fishes were fixed in 10% formalin with their fins pinned and preserved in 70% ethanol. Type material of *M. vermivorus* (BMNH-1935.6.14:307–316) was obtained from the Natural History Museum (London) for morphometric and meristic examination. The original species description of *M. vermivorus* (Trewavas, 1935) was based on 25 syntypes. We were only able to examine 20 of these specimens because of the poor quality of three and the disappearance of two specimens. Twenty-two measures and 12 counts consisting of several standard measurements (Barel et al., 1977) and truss measurements (Humphries et al., 1981) were made. 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.

Morphometric and meristic values of purported *M. vermivorus* specimens were compared to those of the type material using sheared principal component analysis (PCA) and factor analysis (Humphries et al., 1981; Bookstein et al., 1985). Sheared PCA quantifies shape differences among populations independent of the

TABLE 1. COLLECTION LOCATIONS AND NUMBER OF SPECIMENS ANALYZED. Museum abbreviations follow Leviton et al. (1985), except MFU is symbol of the Malawi Fisheries Unit. Also shown is location where type material was collected.

Location	Latitude	Longitude	Museum no.	Number ind.
Chinyamwezi Island (CHW)	13°53'S	34°57'E	PSU2563	18
			PSU2564	7
			USNM323586	10
			MFU3	10
Chinyankwazi Island (CHK)	13°50'S	34°58'E	PSU2565	5
			PSU2566	4
			USNM323587	9
			MFU4	9
Domwe Island (DOM)	14°00'S	34°52'E	PSU2567	5
			USNM323588	12
Thumbi East Island (THM)	14°04'S	34°55'E	PSU2568	3
			PSU2569	2
			USNM323589	7
Mitande Rocks (MIT)	14°05'S	34°50'E	PSU2570	8
			PSU2571	2
			PSU2572	5
			USNM323590	16
			MFU5	5
Mumbo Island (MUM)	13°59'S	34°45'E	PSU2573	7
			USNM323591	12
			MFU6	10
Zimbawe Rocks (ZIM)	13°58'S	34°49'E	PSU2574	5
			PSNM323592	12
Nkudzi Point (NKD) (Type Material)	14°11'S	34°59'E	BMNH1935.6.14	20

size of individuals (Reyment et al., 1984). Color notes were made on collected material but could not be compared with the type material because of serious color fading. Species diagnosis and description are based on the holotype and 46 paratypes from Chinyamwezi Island and 137 paratypes collected from six additional locations (Table 1). The large number of paratypes was required to document the variation in color pattern exhibited by geographically isolated populations.

Melanochromis heterochromis n. sp.

Melanochromis "Chinyamwezi," Ribbink et al., 1983:204 (in part); *M. vermivorus*, Ribbink et al., 1983:203 (in part).

Holotype.—PSU2562 (Figs. 1–2), adult male, 83.0 mm, Chinyamwezi Island, Lake Malawi (longitude 34°57'E, latitude 13°53'S), Malawi, Africa, 2–4 m, 13 March 1991. Collected by JRS, field collection number JRS-91-71.

Paratypes.—The collection data and deposition of the paratypes are summarized in Table 1.

Diagnosis.—A cichlid of the genus *Melanochromis* once considered to be *M. vermivorus*, exhibits longitudinal striping and reverse coloration between the sexes, bicuspid teeth, a U-shaped tooth band, and generalized pharyngeal teeth pattern typical of the genus *Melanochromis* (Trewavas, 1935, 1983). It is distinguished from other species of *Melanochromis* based on its relatively deep body and large size. Females resemble *M. parallelus* Burgess and Axelrod in color, but the latter can be distinguished by the whitish caudal fin with black upper and lower border and black pigment distally.

Analysis of morphometric and meristic values indicates differences between *M. heterochromis* and *M. vermivorus* (BMNH 1935.6.14, Nkudzi Point, Lake Malawi; Tables 2–3), which it superficially resembles. *Melanochromis heterochromis* tends to be deeper bodied than is *M. vermivorus* (as indicated by the longer truss measurements) and tends to have a shorter snout. A plot of the first sheared principal component score (shape) and the first factor score (meristics) of *M. heterochromis* and *M. vermivorus* (Fig. 3) reveals no overlap between the two species. Those variables having the highest load-

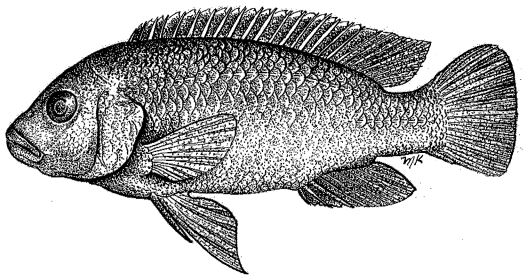

Fig. 1. *Melanochromis heterochromis*, holotype, PSU2562, adult male, 83.0 mm. Drawn to scale.

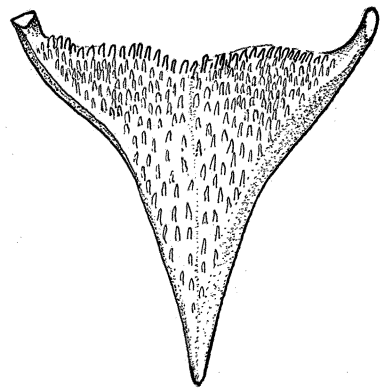

Fig. 2. Dorsal view of the lower pharyngeal bone of *Melanochromis heterochromis*, PSU2562, adult male, 83.0 mm. Magnified 7 times.

ings on the sheared second principal component are snout length and head depth (Table 4). Number of dorsal-fin spines and teeth rows on the lower jaw have the highest loadings on the first factor score and gillrakers on the first ceratobranchial, pectoral-fin rays, and number of teeth in the outer row of the left lower jaw load high on the second factor score (Table 4). *Melanochromis heterochromis* has more dorsal-fin spines than does *M. vermivorus* ($\bar{x}$ = 18.0 vs 16.6), fewer gillrakers on the first ceratobranchial arch ($\bar{x}$ = 8.91 vs 10.5), more bicuspid teeth (13.1 vs 11.2), and more teeth rows on the upper/lower jaw ($\bar{x}$ = 4.78/4.36 vs 3.10/3.05).

Description.—This description is based on the holotype from Chinyamwezi Island (Figs. 1–2) and 183 paratypes from seven geographically isolated populations. Morphometric ratios and meristic values are given in Tables 2 and 3. The jaws isognathous (Fig. 1); teeth on lower jaw in 4–6 poorly defined rows, those on premaxilla in 4–6 poorly defined rows; teeth in inner rows tricuspid; teeth in outer rows bicuspid with 7–9 unicuspid teeth posteriorly; 15 bicuspid teeth in outer row of left lower jaw of holotype (10–17 in paratypes). Teeth of lower pharyngeal bone (Fig. 2) well spaced with 10–11 teeth along the longest medial series and 34 enlarged teeth across the posterior margin. No data were collected on ecology or habitat utilization of the populations examined, but all fishes were collected over similarly sized rocks at approximately the same depths (10–20 m) at the seven locations.

Fins.—Dorsal fin with 18 spines and nine rays in holotype (17–19 spines and 7–9 rays in paratypes). Pectoral fins with 14 rays in holotype (10–14 in paratypes); anal fin with three spines and seven rays in holotype (three spines and 6–8 rays in paratypes).

Gill-rakers.—Rakers well separated and short, decreasing in size of from upper to lower part of the ceratobranchial. Holotype with three gillrakers on epibranchial (2–4 in paratypes), one in articulation of epibranchial and ceratobranchial, and nine on ceratobranchial (8–10 in paratypes).

Squamation.—Holotype with 32 scales in lateral-line series (29–33 in paratypes) and four cheek-scale rows (4–6 in paratypes).

Coloration.—Body coloration in adult specimens varies among populations, although coloration within a population is fairly constant. The following description is based on the holotype and 45 paratopotypes.

Males.—Dark blue-black ground color with faint blue midlateral and dorsolateral stripes. Dorsal fin pale brown with black submarginal band and orange lappets; trailing edge of the soft-rayed region of the fin orange. Caudal fin black with orange outer margin. Anal fin black with or-

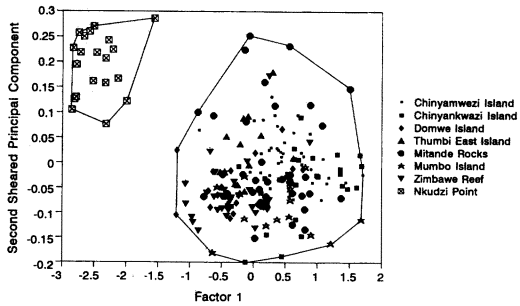

Fig. 3. Plot of sheared second principal component (morphometric data) and first factor score (meristic data) of *Melanochromis heterochromis* and *M. vermivorus* (Nkudzi Point).

TABLE 2. MORPHOMETRIC AND MERISTIC MEASURES OF *Melanochromis heterochromis*. Mean, standard deviation (SD), and range include holotype and 183 paratypes.

Character	Holotype	Mean	SD	Range
Standard length (mm, SL)	83.0	69.3	8.8	54.0–96.8
Head length (mm, HL)	28.3	22.3	3.4	16.0–32.1
Percent head length				
Snout length (SNL)	35.2	37.0	3.4	29.5–47.4
Postorbital head length (POHL)	50.9	47.8	2.8	39.5–58.8
Horizontal eye diameter (HED)	20.6	25.1	3.4	15.5–32.6
Vertical eye diameter (VED)	23.8	26.1	3.4	14.5–33.7
Preorbital depth (PRE)	27.0	30.0	3.3	18.5–40.9
Cheek depth (CD)	31.4	35.5	3.7	27.1–42.7
Head depth (HD)	88.5	93.8	5.9	79.8–1.10
Percent standard length				
Head length (HL)	34.1	32.0	1.9	24.3–37.7
Snout to dorsal-fin origin (SND)	36.9	37.0	2.0	32.7–46.5
Snout to pelvic-fin origin (SNP2)	39.5	39.2	2.8	32.8–46.5
Dorsal-fin base length (DFBL)	63.5	59.6	2.8	49.1–73.3
Anterior dorsal to anterior anal (ADAA)	54.4	51.5	2.9	43.3–66.9
Posterior dorsal to posterior anal (PDPA)	17.1	15.8	1.1	12.1–19.9
Anterior dorsal to posterior anal (ADPA)	66.0	62.6	2.9	54.3–78.0
Posterior dorsal to anterior anal (PDAA)	30.8	29.7	1.7	24.2–35.5
Posterior dorsal to ventral caudal (PDVC)	18.7	17.9	1.3	14.7–22.7
Posterior anal to dorsal caudal (PADC)	18.2	18.7	1.6	14.9–23.4
Anterior dorsal to pelvic-fin origin (ADP2)	38.8	35.9	2.1	31.6–43.4
Posterior dorsal to pelvic-fin origin (PDP2)	65.5	56.5	3.4	50.0–73.5
Pelvic-fin length (P2L)	24.0	22.8	2.1	16.9–30.5
Pectoral-fin length (P1L)	28.4	25.2	2.8	19.5–32.5
Meristics				
Dorsal-fin spines (DS)	18	18.0	0.4	17–19
Dorsal-fin rays (DS)	9	8.1	0.5	7–9
Anal-fin rays (AR)	7	6.9	0.4	6–8
Pectoral-fin rays (P1R)	14	12.9	0.6	10–14
Lateral-line scales (LLS)	32	30.7	0.8	29–33
Pored scales posterior to lateral line (PLLS)	0	1.3	0.7	0–3
Cheek scales (CS)	4	4.7	0.6	4–6
Gillrakers on first ceratobranchial (GRU)	3	2.7	0.6	2–4
Gillrakers on first epibranchial (GRL)	9	8.9	0.6	8–10
Teeth in outer row of left lower jaw (TLLJ)	15	13.1	1.6	10–17
Teeth rows on upper jaw (TRU)	5	4.8	0.6	4–6
Teeth rows on lower jaw (TRL)	4	4.6	0.6	4–6

ange leading edge, 2–4 orange egg-dummies. Pelvic fins black with light blue leading edge. Pectoral fins black.

Females.—Dusky brown ground color with dark brown midlateral and dorsolateral stripes that extended onto head; one faint brown interorbital bar. Dorsal fin clear with black submarginal band and orange lappets; trailing edge clear. Caudal fin brown, clear distally with flecks of black and faint orange edge. Anal fin orange with black outer margin; no egg-dummies. Pelvic fins yellow with black leading edges and orange outer margins. Pectoral fins completely orange.

Geographically, male ground color varies from dark blue (e.g., Thumbi East Island) to light brown (e.g., Chinyamwezi Island) with pale blue to brown midlateral and dorsolateral stripes that are sometimes indistinct (e.g., Chinyankwazi Island). Dorsal-fin coloration varies from pale blue to clear, and a dark submarginal band is often present (e.g., Mitande Rocks, Domwe Island), although variable within populations. Some populations have orange-red trailing edges to the dorsal and caudal fins (e.g., Chiny-

TABLE 3. MORPHOMETRIC AND MERISTIC MEASURES FOR SEVEN POPULATIONS OF *Melanochromis heterochromis* AND *Melanochromis vermivorus* (NKD) SYNTYPES. Means (standard deviation) are shown. Population abbreviations are as shown in Table 1 and character abbreviations are as in Table 2.

Measure	CHW	CHK	DOM	THM	MIT	MUM	ZIM	NKD
SL	79.7	65.6	60.3	60.6	66.3	63.8	77.7	68.7
	(6.4)	(5.4)	(4.1)	(2.6)	(3.0)	(3.9)	(6.1)	(6.1)
HL	26.3	19.9	20.2	19.1	20.8	20.3	25.3	24.9
	(2.5)	(1.9)	(1.5)	(1.4)	(1.6)	(1.5)	(1.9)	(2.7)
Percent head length								
SNL	37.6	37.3	34.6	39.0	38.3	34.6	37.4	44.6
	(3.1)	(3.5)	(2.6)	(2.3)	(3.4)	(2.8)	(2.9)	(3.4)
POHL	47.6	49.0	45.4	49.1	47.5	48.8	46.4	45.0
	(2.4)	(2.0)	(2.4)	(3.0)	(2.9)	(3.0)	(1.6)	(2.2)
HED	23.0	25.6	27.1	23.5	24.7	26.0	27.5	21.2
	(2.4)	(3.5)	(2.8)	(2.9)	(4.2)	(2.3)	(2.2)	(2.3)
VED	23.8	26.6	27.6	26.3	25.1	27.7	29.5	20.6
	(2.2)	(2.6)	(2.4)	(3.5)	(4.2)	(2.1)	(2.1)	(1.9)
PRE	29.9	31.9	27.6	30.7	30.9	28.4	30.6	32.1
	(2.6)	(4.0)	(3.0)	(3.8)	(2.6)	(2.7)	(4.3)	(2.6)
CD	33.9	36.3	36.3	38.0	34.7	35.0	38.1	35.2
	(2.7)	(3.6)	(2.6)	(2.5)	(3.1)	(3.2)	(2.7)	(3.9)
HD	88.5	97.6	93.3	94.0	93.9	96.0	98.3	83.0
	(4.5)	(5.9)	(3.7)	(4.5)	(5.6)	(4.1)	(5.1)	(3.9)
Percent standard length								
HL	33.0	31.5	33.4	31.5	31.4	31.7	32.6	36.3
	(1.6)	(2.3)	(1.0)	(1.5)	(1.2)	(1.3)	(1.4)	(2.1)
SND	37.2	36.0	37.8	38.7	36.8	36.6	36.9	40.4
	(1.8)	(2.5)	(1.7)	(2.3)	(2.2)	(1.3)	(1.6)	(1.7)
SNP2	38.9	37.6	39.6	40.3	39.7	40.5	38.1	45.2
	(2.5)	(2.6)	(2.2)	(2.3)	(2.9)	(2.3)	(2.8)	(3.3)
DFBL	59.8	61.5	59.3	56.7	58.5	59.5	61.0	54.4
	(1.9)	(3.9)	(2.2)	(3.9)	(2.4)	(1.6)	(1.5)	(2.5)
ADAA	51.6	52.9	50.9	49.2	49.7	52.2	53.7	48.2
	(1.8)	(4.8)	(1.8)	(3.1)	(2.2)	(1.5)	(1.3)	(2.1)
ADPA	15.3	15.8	16.3	15.8	15.4	16.4	17.0	14.1
	(1.0)	(1.6)	(0.8)	(0.9)	(0.9)	(0.7)	(0.9)	(1.1)
PDAA	62.8	64.6	61.3	60.2	61.2	63.3	64.4	59.7
	(1.7)	(4.7)	(1.9)	(3.6)	(2.1)	(1.4)	(1.3)	(2.8)
PDPA	29.7	29.5	29.8	29.3	29.5	29.6	30.5	27.4
	(2.0)	(2.3)	(1.6)	(1.4)	(1.0)	(1.0)	(1.3)	(1.6)
PDVC	17.3	18.2	17.5	18.4	18.0	18.5	18.2	17.0
	(1.1)	(1.9)	(1.1)	(0.9)	(1.3)	(0.9)	(1.1)	(1.5)
PADC	17.7	18.7	20.0	18.6	18.9	19.0	19.5	16.3
	(1.4)	(1.8)	(0.7)	(1.4)	(1.5)	(1.1)	(0.8)	(1.3)
PDP2	35.4	35.4	36.8	35.8	35.1	36.9	37.6	33.9
	(1.9)	(2.6)	(1.7)	(1.9)	(1.5)	(1.6)	(2.0)	(1.7)
ADP2	57.3	59.4	55.6	53.8	54.9	55.3	57.9	53.8
	(2.6)	(5.1)	(2.5)	(2.3)	(2.5)	(2.0)	(2.1)	(2.7)
P2L	22.5	23.6	21.4	22.0	22.7	23.9	23.3	21.2
	(1.9)	(2.5)	(2.4)	(2.3)	(2.0)	(1.7)	(1.5)	(1.9)
P1L	26.4	25.5	22.1	25.1	25.0	24.9	24.9	25.2
	(2.6)	(2.9)	(2.1)	(2.7)	(2.5)	(2.1)	(2.4)	(2.1)
Meristics								
DS	18.1	18.0	17.8	17.7	18.0	17.9	18.1	16.6
	(0.5)	(0.3)	(0.4)	(0.5)	(0.3)	(0.4)	(0.2)	(0.5)
DR	8.2	7.8	7.6	8.3	8.4	8.1	8.1	7.7
	(0.5)	(0.4)	(0.5)	(0.5)	(0.5)	(0.3)	(0.3)	(0.8)

TABLE 3. CONTINUED.

Measure	CHW	CHK	DOM	THM	MIT	MUM	ZIM	NKD
AR	7.0	6.7	6.9	7.0	6.9	7.1	6.9	7.0
	(0.2)	(0.5)	(0.2)	(0.0)	(0.5)	(0.4)	(0.3)	(0.3)
P1R	13.3	13.0	12.6	12.3	12.7	12.7	13.0	13.3
	(0.5)	(0.3)	(0.5)	(0.9)	(0.6)	(0.5)	(0.2)	(0.5)
LLS	30.7	30.7	30.4	31.1	30.7	30.7	30.5	29.6
	(0.7)	(0.7)	(0.7)	(1.0)	(0.8)	(1.0)	(0.5)	(0.5)
PLLS	1.5	1.1	1.3	1.1	1.3	1.4	1.1	1.0
	(0.7)	(0.7)	(0.7)	(0.9)	(0.7)	(0.7)	(0.7)	(0.7)
CS	4.8	4.8	4.1	4.7	5.2	4.3	4.2	4.3
	(0.5)	(0.6)	(0.3)	(0.5)	(0.6)	(0.5)	(0.4)	(0.5)
GRU	3.2	2.8	2.5	2.3	2.5	2.3	2.5	3.3
	(0.5)	(0.6)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.6)
GRL	9.1	8.8	8.8	8.3	9.1	8.9	8.3	10.5
	(0.6)	(0.5)	(0.6)	(0.6)	(0.6)	(0.4)	(0.5)	(0.5)
TLLJ	14.7	14.1	11.5	11.8	12.7	12.1	12.3	11.2
	(0.8)	(1.8)	(0.6)	(1.0)	(1.4)	(0.9)	(0.7)	(1.1)
TRU	5.0	5.2	4.5	4.7	4.7	4.3	4.9	3.1
	(0.4)	(0.6)	(0.5)	(0.5)	(0.6)	(0.6)	(0.8)	(0.3)
TRL	4.2	4.8	4.3	4.2	4.4	4.1	4.7	3.0
	(0.5)	(0.6)	(0.5)	(0.4)	(0.7)	(0.4)	(0.6)	(0.2)

amwezi Island, Zimbawe Reef). Females of most populations have 1–3 orange egg dummies, although the presence of egg dummies is not consistent within a population.

Etymology.—The name was chosen to reflect the geographic variation in the color pattern of this species.

DISCUSSION

Differences in morphometric and meristic measures between *M. vermivorus* type material (Trewavas, 1935) and six populations identified by Ribbink et al. (1983) as *M. vermivorus* (see Table 2) were demonstrated. Based on these results, we have described a new species, *M. heterochromis*, which includes the six populations of presumed *M. vermivorus* and a population at Chinyamwezi Island originally thought to be a distinct species (Ribbink et al., 1983). It is possible that shape differences between *M. heterochromis* and *M. vermivorus* may be artifactual, due to shrinkage of the older, preserved type material, but meristic data, which should be unaffected by age and preservation, support the distinction between the two species. In general, *M. heterochromis* tends to have more dorsal spines and dorsal rays than *M. vermivorus*. Teeth rows in the upper and lower jaws tend to be poorly defined and more numerous in *M. heterochromis* than in *M. vermivorus*, and *M. vermivorus* tends to have more gillrakers on both the first epibranchial and the first ceratobranchial bones. The pharyngeal bone of *M. vermivorus* appears to differ from that of *M. heterochromis*, based on a drawing of the lower pharyngeal bone in the original species description (Trewavas, 1935; p. 78, fig. 4c). The pharyngeal bone of *M. vermivorus* has 12 teeth along the longest medial series and 24 teeth across the posterior margin, compared with 10 and 34, respectively, in *M. heterochromis*.

Although we did not collect all of the populations identified by Ribbink et al. (1983) as *M. vermivorus*, we do not believe that the differences observed between *M. heterochromis* and the *M. vermivorus* type material are a result of clinal variation or that differences represent a phyletic change within the *M. vermivorus* lineage. Unfortunately, we could not compare *M. vermivorus* type material with topotypes to directly examine the temporal effect on phenotypes. Stauffer and Hert (1992), however, compared type material of *Pseudotropheus aurora* Burgess collected in 1976, with topotypes collected in 1989 and found no significant difference ($P < 0.05$) between the two groups when they plotted the sheared second principal component (shape) against the first factor score (meristics).

The type material of *M. vermivorus* was collected at Nkudzi Point (Trewavas, 1935), located in the southeastern arm of Lake Malawi approximately 3 km south of Mazinzi Reef and

TABLE 4. VARIABLE LOADINGS ON SIZE AND THE FIRST TWO SHEARED PRINCIPAL COMPONENTS (SHAPE) FOR *Melanochromis heterochromis* (n = 184) AND *Melanochromis vermivoris* (n = 20). Also shown are the principal component scores for the meristic measures. Loadings < ±0.01 are not shown (*).

Measure	Size	PC2	PC3
Sheared principal components—morphometrics			
Standard length	0.181	*	*
Head length	0.197	0.189	−0.115
Snout length	0.242	0.527	*
Postorbital head length	0.195	0.162	*
Horizontal eye diameter	0.190	−0.254	−0.615
Vertical eye diameter	0.187	−0.341	−0.451
Head depth	0.293	0.407	*
Preorbital depth	0.258	0.130	−0.276
Cheek depth	0.207	*	*
Snout to dorsal-fin origin	0.190	0.145	*
Snout to pelvic-fin origin	0.187	0.188	*
Dorsal-fin base length	0.199	−0.141	*
Anterior dorsal to anterior anal	0.201	−0.125	*
Anterior dorsal to posterior anal	0.208	−0.284	0.400
Posterior dorsal to anterior anal	0.196	*	*
Posterior dorsal to posterior anal	0.214	*	0.142
Posterior dorsal to ventral caudal	0.165	−0.113	0.106
Posterior anal to dorsal caudal	0.212	−0.221	*
Posterior dorsal to pelvic-fin origin	0.218	*	*
Anterior dorsal to pelvic-fin origin	0.209	*	0.122
Pelvic-fin length	0.231	−01.59	*
Pectoral-fin length	0.265	*	0.239
Principal Components—Meristics			
Dorsal-fin spines	—	0.408	*
Dorsal-fin rays	—	*	*
Anal-fin rays	—	−0.189	−0.244
Pectoral-fin rays	—	*	0.459
Lateral-line scales	—	0.255	−0.113
Pored scales posterior to lateral line	—	0.103	*
Cheek scales	—	0.204	0.341
Gillrakers on first ceratobranchial	—	*	0.511
Gillrakers on first epibranchial	—	−0.314	0.322
Teeth in outer row of left lower jaw	—	0.355	0.434
Teeth rows on upper jaw	—	0.305	*
Teeth rows on lower jaw	—	0.435	−0.195

3 km north of Mpandi Island. During an extensive survey of Lake Malawi mbuna, Ribbink et al. (1983) did not collect *M. vermivorus* at any of these localities. In addition, no *M. vermivorus* were found at Nkudzi Point during extensive collecting by one of the authors (JRS) from 1989–91. The only species of *Melanochromis* collected at Nkudzi were *M. auratus*, *M.* cf. *brevis*, and *M. melanopterus*, suggesting the population on which the original species description of *M. vermivorus* was based has either been extirpated or the locality in the original description of *M. vermivorus* was inaccurate. Additional populations of *M. vermivorus* may exist in Lake Malawi, but either have not been collected or have been identified incorrectly.

The population of *M. heterochromis* from Chinyamwezi Island used as type material was previously referred to as an undescribed species of *Melanochromis* considered closely related to *M. vermivorus* (Ribbink, et al. 1983; Koning, 1990). Based on our analyses, we believe the Chinyamwezi population to be conspecific with the other populations of *M. heterochromis* we examined (Table 3; Fig. 3). Ribbink et al. (1983) based their distinction of *M.* sp. "chinyamwezi" from *M. vermivorus* on coloration, although they indicated that the species were similar behav-

iorally and ecologically. Our analyses have shown that geographically isolated populations of *M. heterochromis* exhibit a range in coloration but do not differ with respect to shape, and, therefore, taxonomic classification of these allopatric populations presents a problem. Geographic variation in color may represent the early stages of allopatric speciation (Lewis, 1982), but this is difficult to prove. Some investigators hypothesize that coloration is the limiting factor in mate selection and that color morphs of morphologically similar populations should be elevated to species status (Johnson, 1975). Several mbuna species, initially distinguished by unique color patterns, have recently been formally described (McKaye and Stauffer, 1986; Stauffer, 1988; Stauffer and Boltz, 1989); however, in all cases, these new species were also discernable by shape and/or meristic differences from species they superficially resembled. In the absence of direct observation of assortative mating and until a better understanding of the genetic control of coloration and color patterns is obtained, morphologically similar populations that differ slightly in coloration (as in *M. heterochromis*) should be considered conspecific.

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