Verlag Dr. Friedrich Pfeil
ISSN 0936-9902

Ichthyological Exploration of Freshwaters

An international journal for field-orientated ichthyology

Volume 20
Number 2

Ichthyological Exploration of Freshwaters
An international journal for field-orientated ichthyology

Volume 20 • Number 2 • June 2009
pages 97-192, 48 figs., 17 tabs.

Ichthyological Exploration of Freshwaters is published quarterly

Subscriptions should be addressed to the Publisher:

Verlag Dr. Friedrich Pfeil, Wolfratshauser Str. 27, D–81379 München, Germany
PERSONAL SUBSCRIPTION : EURO 100 per Year/volume - 4 issues (includes surface mail shipping)
INSTITUTIONAL SUBSCRIPTION : EURO 180 per Year/volume - 4 issues (includes surface mail shipping)

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Maurice Kottelat, Route de la Baroche 12, Case postale 57, CH–2952 Cornol, Switzerland

CIP-Titelaufnahme der Deutschen Bibliothek

Ichthyological exploration of freshwaters : an international
journal for field-orientated ichthyology. – München : Pfeil.
Erscheint jährl. viermal. – Aufnahme nach Vol. 1, No. 1 (1990)
ISSN 0936-9902

Vol. 1, No. 1 (1990) –

Printed by Advantage Printpool, Gilching

ISSN 0936-9902
Printed in the European Union

Verlag Dr. Friedrich Pfeil, Wolfratshauser Str. 27, D-81379 München, Germany
Tel. +49-(0)89-7428270 – Fax +49-(0)89-7242772 – E-mail: info@pfeil-verlag.de – www.pfeil-verlag.de

Ichthyol. Explor. Freshwaters, Vol. 20, No. 2, pp. 163-178, 9 figs., 3 tabs., June 2009
 – ISSN 0936-9902

Two new cave-dwelling cichlids of Lake Malaŵi, Africa

Rachel M. Cleaver*, Adrianus F. Konings and Jay R. Stauffer, Jr.***

Six different populations of the Lake Malaŵi cave-dweller *Otopharynx lithobates*, each of them distinguished by differences in the male breeding coloration, were examined. We found that morphometric and meristic data of all populations overlap, and that no significant differences could be found to distinguish them. Morphological data of *Otopharynx walteri* were completely within the range of *O. lithobates* and we regard them as conspecific. Two other cave-dwelling cichlids are described: *Otopharynx spelaeotes*, new species, and *Otopharynx antron*, new species. No geographical variation in the males' breeding colors of these species was observed. *Otopharynx antron* is described from a 20 km stretch of the eastern shore of the lake. It is sympatric with *O. spelaeotes*, but seems to have a more predatory feeding regime. *Stigmatochromis modestus*, another cave-dwelling species, and *Stigmatochromis pleurospilus* are compared to the three cave-dwelling members of *Otopharynx*.

Introduction

Eccles & Trewavas (1989) revised the Malaŵi cichlid genera on the basis of their basic melanin pattern. They defined both *Stigmatochromis* and *Otopharynx* by the possession of a supra-pectoral and a supra-anal spot. In the case of the former the supra-pectoral spot is small and below the upper lateral line while in *Otopharynx* the large supra-pectoral spot is on or below the upper lateral line. In *Stigmatochromis* the vertical bars of the plesiomorphic melanin pattern are present as a series of faint bars. *Stigmatochromis* further differs from *Otopharynx* in jaw structure and dentition; the lower jaw of *Stigmatochromis* extends forward of the tips of the premaxillae which is not the case in *Otopharynx* and in the latter the snout is shorter than the post-orbital part of the head, which is longer or of equal length in *Stigmatochromis* over 60 mm SL (Eccles & Trewavas, 1989).

We found that most of the characters given to distinguish these two genera overlap in various species assigned to either genus by the same authors. The shape, position, and presence of additional components of the basic melanin pattern vary in species of both genera and are not diagnostic. The prognathic lower jaw occurs in members of *Otopharynx* as well, i.e. *O. speciosus* and *O. brooksi* (see Eccles & Trewavas, 1989: 166 and 162, respectively). The purposes of this paper are to synonymize *O. walteri* with *O. lithobates* and to describe two new cave-dwelling species from Lake Malaŵi.

Methods

Fishes were collected in Lake Malaŵi (Fig. 1) by chasing them into a monofilament block net while SCUBA diving. All fishes were anesthetized with clove oil, euthanized in 1 % formalin, pinned in

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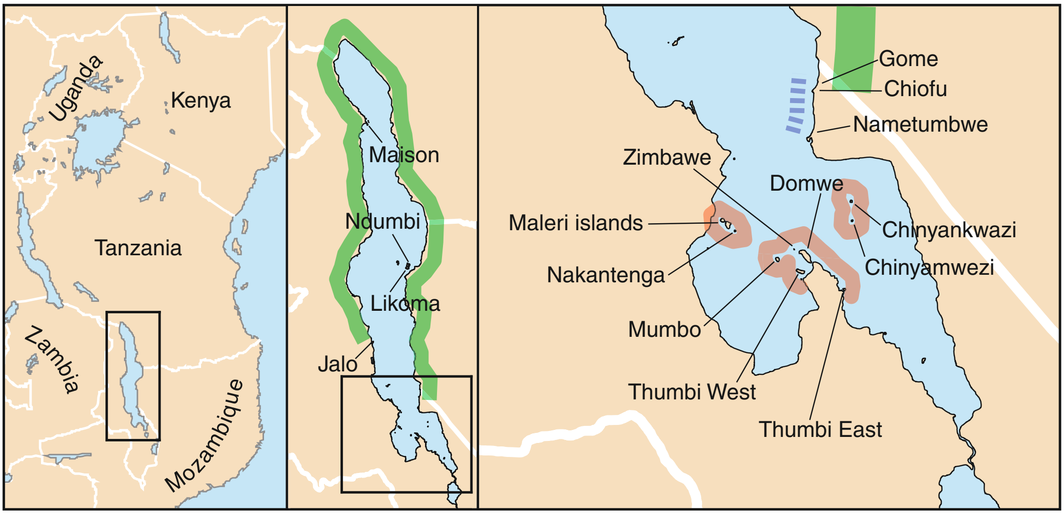

Fig. 1. Map of Lake Malaŵi with localities mentioned in text. Map in center shows distribution of *Otopharynx spelaeotes* and map on right indicates the distribution areas of *O. lithobates* (solid red band), *O. antron* (dashed band), and part of *O. spelaeotes* (solid green band).

trays so that the bodies were flat and the fins erect, preserved in 10 % formalin, and stored in 70 % ethanol. Pigmentation patterns and color were recorded in the field via direct observation, photography, and videography. Counts and measurements follow Stauffer (1991) and Stauffer & Konings (2006). All measurements were taken from the left side of the body with the exception of gill-raker counts, which were taken on the right side. These measurements were then analyzed in SAS using a principal component analysis. Morphometric data were analyzed using a sheared principal component analysis which factors the covariance matrix and restricts size variation to the first principal component (Humphries et al., 1981, Bookstein et al., 1985). Meristic data were analyzed using a principal component analysis in which the correlation matrix was factored. Differences among species were illustrated by plotting the sheared second principal components (SPC2) of the morphometric data against the first principal components (PC1) of the meristic data (Stauffer & Hert, 1992). Institutional abbreviations follow Leviton et al. (1985), except UMBC, University of Malaŵi, Bunda College.

In addition to comparing the two new species to their congeners, we also compared them to *Stigmatochromis pleurospilus*, which they superficially resemble, and the cave-dwelling *S. modestus*.

Taxonomic analysis

Otopharynx Regan

Type species. *Tilapia auromarginata* Boulenger.

Diagnosis. Members of *Otopharynx* are characterized by the possession of a supra-pectoral, a supra-anal, and a pre-caudal spot, the first two not extending to the base of the dorsal fin, which distinguish them from species of *Hemitilapia* and *Trematocranus*, and from *Tramitichromis intermedius*, where they do extend to the dorsal-fin base. Often there is a spot or blotch at the nape and a series of small spots along the back at the base of the dorsal fin that distinguish *Otopharynx* from the spotted species of *Copadichromis* in which these characters are missing. *Otopharynx* differs further from *Copadichromis* by a shorter premaxillary pedicel (22-36 % HL vs. 30-43) and from *Stigmatochromis* by a snout that is shorter than the post-orbital head length (which is longer or of equal length in *Stigmatochromis*). The outer teeth of the lower jaw in *Otopharynx* are moderately to strongly developed (unicuspid or bicuspid) and continue posteriorly as a single series (Eccles & Trewavas, 1989).

Fig. 2. Males in breeding coloration of *Otopharynx lithobates* at four different localities. **a,** Thumbi West Island; **b,** Mumbo Island; **c,** Zimbawe Rock; and **d,** Nakantenga Island.

Otopharynx lithobates (Oliver)
(Fig. 2)

Material examined. PSU 4467, 6, 93.2-105.4 mm SL; Malaŵi: Lake Malaŵi: Nakantenga Island, 13°54.920'S 34°38.623'E; Stauffer, 30 Jul 2006. – PSU 4468, 20, 62.5-90.5 mm SL; Malaŵi: Lake Malaŵi: Thumbi West Island, 14°0.961'S 34°48.627'E; Stauffer, 10 Apr 2003. – PSU 4469, 10, 68.3-89.0 mm; PSU 4471, 10, 58.3-97.1 mm SL; Malaŵi: Lake Malaŵi: Mumbo Island, 13°59.504'S 34° 45.374'E; Stauffer, 12 Feb 2004. – PSU 4470, 3, 97.3-107.0 mm SL; Malaŵi: Lake Malaŵi: Chinyamwezi Island, 13°53.310'S 34°57.322'E; Stauffer, 9 Feb 2003. – PSU 4473, 17, 71.0-105.1 mm SL; same data, 15 Apr 2003. – PSU 4472, 10, 73.4-101.6 mm SL; Malaŵi: Lake Malaŵi: Zimbawe Rocks, 13°57.925'S 34°48.189'E; Stauffer, 9 Apr 2003. – PSU 4475, 10, 69.8-97.8 mm SL; same data, 7 Feb 2003. – PSU 4474, 20, 64.3-87.0 mm SL; Malaŵi: Lake Malaŵi: Domwe Island, 13°58.138'S 34°49.037'E; Stauffer, 15 Apr 2003.

Remarks. *Otopharynx walteri* is endemic to the Maleri archipelago (Fig. 1) and was described from the Nakantenga Island population**.** *Otopharynx lithobates* is found around the islands surrounding the Nankumba peninsula and at Chinyankwazi and Chinyamwezi islands (Fig. 1). Although found within a small geographic area, *O. lithobates* displays broad variation in male breeding coloration (Fig. 2). When Konings (1990) described *O. walteri*, the only known locations of *O. lithobates* (regarded as its closest relative) were Thumbi West Island and Thumbi East Island and when specimens of the type localities of either nominal species were compared they showed significant morphological differences (unpubl. obs.). The morphometric and meristic data of *O. walteri* from Nakantenga Island (type locality) overlap with those data for *O. lithobates* from Chinyamwezi Island, Domwe Island, Mumbo Island, Thumbi West Island, and Zimbawe Rock (Table 1). Furthermore, the minimum polygon cluster formed when plotting the SPC2 of the morphometric data against the PC1 of the meristic data of *O. walteri* is completely contained within the minimum polygon cluster of *O. lithobates* (Fig. 3). Therefore, we regard *O. walteri* as a junior synonym of *O. lithobates*.

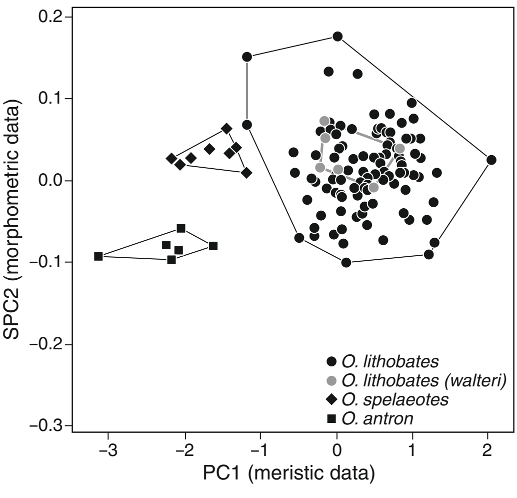

Fig. 3. Plot of sheared second principal component of morphometric data and first principal component of meristic data for cave-dwelling species of *Otopharynx.*

Otopharynx spelaeotes, new species
(Figs. 4, 5a, 6a)

Otopharynx sp. 'cave', Konings, 2007: 156.

Holotype. PSU 4462, 107.1 mm SL; Lake Malaŵi, Likoma Island, Ndumbi Rocks, 12°01.614'S 34° 44.149'E; Stauffer, 14 Mar 2007.

Paratypes. PSU 4463, 5, 88.2-115.4 mm SL; data as for holotype. – PSU 4464, 1, 117.2 mm SL; Lake Malaŵi, Maison Reef, 10°28.644'S 34°17.730'E; Stauffer & Konings, 24 Jan 2007. – PSU 4465, 1, 112.5 mm SL; Lake Malaŵi, Likoma Island, Ndumbi Rocks; Stauffer, 14 Mar 2007.

Diagnosis. *Otopharynx spelaeotes* has a larger eye (36.1-38.4 % HL) than *Otopharynx auromarginatus* (25.0-30.3 % HL), *O. brooksi* (26.3-29.4 % HL), *O. decorus* (26.3-30.3 % HL), *O. heterodon* (30.3-34.5 % HL), *O. ovatus* (22.7-30.3 % HL), *O. selenurus* (23.3-30.3 % HL), *O. tetraspilus* (25.0-30.3 % HL), *O. speciosus* (22.7-25.0 % HL), and *O. tetrastigma* (25.0-30.3 % HL) (Eccles & Trewavas, 1989). It has fewer lateral-line scales (31-33) than *O. argyrosoma* (34-36) (Eccles & Trewavas, 1989). *Otopharynx spelaeotes* differs from *O. lithobates* by having more teeth in the outer row of the left lower jaw (18-24, mode 22 vs. 13-21, mode 16), fewer gill rakers on the ceratobranchial (11-13, mode 12 vs. 12-17, mode 14) and by the male breeding coloration that includes yellow/orange ocelli on the anal fin and a blue/black dorsal fin with a very narrow white margin with orange/red lappets. The anal fin of the male *O. lithobates* lacks light-colored spots and the dorsal fin has a wide, white/orange margin with lappets of the same color. Males of most populations of *O. lithobates* exhibit a white/orange blaze on the head and nape (often the color is extended into the dorsal fin); such a blaze has never been observed among male *O. spelaeotes*. Females of either species cannot be distinguished by their melanin pattern. *Otopharynx spelaeotes* is distinguished from *O. an-*

Table 1. Morphometric and meristic values of *Otopharynx lithobates* (n = 99) and *Otopharynx walteri* (n = 6) from Nakantenga Island, Malaŵi.

	O. walteri	*O. lithobates*				
	Nakantenga Island (n = 6)	Chinyamwezi Island (n = 19)	Western tip of Domwe Island (n = 20)	Mumbo Island (n = 20)	Thumbi West Island (n = 20)	Zimbawe Rocks (n = 20)
	range	range	range	range	range	range
Standard length, mm	77.1-105.4	71.0-107.0	64.3-87.0	58.3-97.1	62.5-90.5	69.8-101.6
Head length, mm	28.5-37.7	24.4-37.3	22.7-31.7	21.0-32.0	21.2-31.2	23.9-36.4
Percent standard length						
Head length	35.3-36.9	33.4-38.0	34.6-37.9	32.9-37.7	33.9-37.7	33.9-37.7
Snout to dorsal-fin origin	36.7-38.9	35.9-40.4	36.9-40.0	33.7-41.0	35.7-41.3	35.7-40.1
Snout to pelvic-fin origin	41.8-43.8	37.7-43.2	39.8-44.5	39.8-43.6	39.1-45.7	39.2-43.8
Dorsal-fin base length	53.1-56.7	52.9-58.6	51.5-57.4	51.4-56.6	51.6-57.6	52.7-57.6
Anterior dorsal to anterior anal	44.7-49.2	44.5-51.1	30.2-46.0	43.3-47.7	42.4-48.0	44.4-50.0
Anterior dorsal to posterior anal	55.5-60.7	56.4-60.8	53.9-59.9	54.2-58.4	55.0-59.7	55.3-59.9
Posterior dorsal to anterior anal	28.4-30.7	27.1-30.8	24.5-27.2	24.8-30.0	26.1-29.1	26.5-29.7
Posterior dorsal to posterior anal	15.1-15.6	14.1-16.6	12.2-14.6	11.8-15.3	13.5-16.0	13.2-15.5
Posterior dorsal to ventral caudal	17.8-19.5	18.1-20.2	16.0-19.7	16.7-20.3	17.3-19.8	16.9-20.9
Posterior anal to dorsal caudal	20.4-21.6	20.4-23.2	18.9-21.6	18.9-22.8	18.4-23.0	18.9-21.7
Anterior dorsal to pelvic-fin origin	33.3-36.5	30.3-38.7	28.4-33.7	30.6-33.9	30.3-34.2	32.0-36.0
Posterior dorsal to pelvic-fin origin	51.1-53.6	50.1-55.9	40.2-52.5	48.8-54.3	48.7-53.9	50.5-54.5
Caudal-peduncle length	14.5-17.8	13.0-18.1	13.4-17.3	14.5-17.3	13.3-18.3	12.1-16.9
Least caudal-peduncle depth	11.1-12.2	11.3-13.1	9.8-12.1	9.9-12.0	10.7-11.9	10.5-12.4
Percent head length						
Snout length	29.6-33.0	28.4-33.6	25.2-31.5	26.6-33.6	27.4-34.0	27.9-33.3
Postorbital head length	32.3-33.8	33.1-38.2	31.8-37.1	32.4-38.5	31.0-37.0	33.4-37.3
Horizontal eye diameter	34.3-37.3	32.2-38.4	36.3-43.1	34.1-41.0	35.2-42.3	33.0-39.6
Vertical eye diameter	31.3-35.7	28.8-36.7	34.1-41.3	31.9-39.7	32.8-42.1	31.2-37.7
Preorbital depth	13.5-16.4	15.6-19.4	13.1-16.9	11.9-18.0	12.2-19.1	12.7-19.8
Cheek depth	13.7-17.4	13.8-22.3	12.4-19.1	9.4-17.5	13.3-19.1	10.3-19.8
Lower-jaw length	39.1-42.7	32.3-42.0	32.6-40.6	26.9-44.5	28.7-39.7	29.1-43.6
Head depth	66.4-75.0	67.9-89.0	66.3-75.3	64.4-80.2	64.9-80.7	70.7-81.5
Counts						
Dorsal-fin spines	16-17	15-17	16-17	14-18	15-17	16-17
Dorsal-fin rays	8-11	10-12	10-11	10-12	10-11	10-12
Anal-fin spines	3	3	3	3	3	3
Anal-fin rays	8-8	8-9	7-9	7-9	8-9	8-9
Pectoral-fin rays	12-13	13-14	12-14	13-14	12-14	12-14
Pelvic-fin rays	5	5	5	5	5	5
Lateral-line scales	30-32	28-33	27-32	30-32	30-32	29-33
Pored scales posterior of lateral line	2-3	1-4	1-3	1-4	1-3	1-4
Scale rows on cheek	2-3	2-3	3	2-3	2-4	2-4
Gill rakers on first ceratobranchial	13-15	12-15	12-14	12-15	12-17	12-15
Gill rakers on first epibranchial	5	5-6	4-7	4-6	4-7	4-6
Teeth in outer row of left lower jaw	14-19	14-20	14-18	13-18	13-17	14-21
Teeth rows on upper jaw	3-4	4-5	3-4	3-4	3-4	3-4
Teeth rows on lower jaw	3-4	4-5	3-4	3-4	3-4	3-4

Fig. 4. *Otopharynx spelaeotes*, PSU 4462, holotype, 107.1 mm SL; Malaŵi: Lake Malaŵi: Likoma Island: Ndumbi Rocks.

tron by a larger horizontal eye diameter (36.1-38.4 % HL vs. 31.4-34.7), a shallower caudal peduncle (depth 11.7-12.3 % SL vs. 12.4-13.4), and more teeth in the outer row of the left lower jaw (18-24, mode 22 vs. 15-19, mode 15).

Description. See Table 2 for morphometric and meristic data. Medium-sized cave-dwelling haplochromine with relatively deep body with greatest body depth at base of eighth or ninth dorsal spine. Dorsal body profile curving downward to caudal peduncle; ventral body profile convex, increasingly tapering from deepest point upward to end of caudal peduncle. Dorsal head profile straight to slightly convex, curving on nape to dorsal fin origin; eye more than double depth preorbital and positioned slightly forward of center of head; snout at 28-37° angle with body axis and prognathous lower jaw with moderately thickened mental knob; teeth on dentary and premaxillae in 2-3 rows with outer rows bicuspid and inner rows tricuspid.

Dorsal fin with 16-17 (mode 17) spines and 10-12 (mode 10) soft rays. Anal fin with 3 spines and 8-10 (mode 9) soft rays. First 4-5 dorsal spines gradually increasing in length posteriorly with first spine about ⅔ length of fifth spine; last 12 spines slightly increasing in length posteriorly with last spine longest; rounded or subacuminate tip, sixth or seventh ray longest, reaching base of caudal fin in females and about halfway to caudal fin in breeding males. Anal spines progressively increasing in length posteriorly; fifth or sixth ray longest, not reaching base of caudal fin in females and to about ¼ to ½ of caudal fin in breeding males. Caudal fin subtruncate to emarginate. Pelvic fin about reaching anal fin in females and reaching about second spine of anal fin in breeding males. Pectoral fin pointed with fourth or fifth ray longest, reaching vertical through base of 14-15th dorsal spine.

Flank scales large; lateral-line scales 31-33 with 2-4 pored scales on caudal fin, and 3 scale rows on cheeks. Gill-rakers on first ceratobranchial 11-13 and on first epibranchial 4-5. Small scales on proximal posterior margins of dorsal and anal fins and on proximal half of caudal fin.

Coloration. Breeding males (Fig. 5a): head dark blue/brown with dark blue/gray throat; cheek blue/gray with purple highlights; operculum blue with black marks and black opercular spot. Center of scales on flank yellow, outlined in blue/silver. Eight black vertical bars along body, three black spots, but absent in some brightly colored males; breast yellow-brown to black with gray markings; belly black. Dorsal fin blue/gray with orange membranes in rayed portion and clear spots, white lappets with orange/red tips. Caudal-fin rays blue/brown; membranes clear with orange spots. Anal fin brown/gray over spinous parts; rayed portion proximal ⅔ brown-gray, distal ⅓ clear membrane with 2-8 yellow ocelli. Pelvic fin black with narrow white/blue leading

Fig. 5. Breeding males of: **a,** *Otopharynx spelaeotes*, approx. 110 mm SL; Tanzania: Lake Malaŵi: Ngwazi; **b,** *O. antron*, approx. 100 mm SL; Malaŵi: Lake Malaŵi: Nametumbwe; and **c,** *Stigmatochromis modestus*, approx. 95 mm SL; Malaŵi: Lake Malaŵi: Nametumbwe.

margin. Pectoral fin with light gray anterior edge; proximal dark brown; distal light brown.

Females (Fig. 6a): head with gray interorbital; cheek pale yellow fading to white ventrally; opercle and preopercle pale yellow. Center of some scales yellow, outlined in silver; a series of black spots just ventral of dorsal fin; three black spots mid-laterally. Dorsal fin clear with yellow spines and rays. Proximal ¾ of caudal fin milky white, distal ¼ clear. Anal fin white proximally fading to clear distally; anterior anal-fin rays pale yellow distally. Pectoral-fin rays white on proximal ¾, clear distally; membranes clear. Pectoral fin clear.

Field observations. *Otopharynx spelaeotes* has a preference for large caves and is therefore often found in rocky habitats that consist of large boulders. Most individuals are seen solitary and often at a depth of more than 10 m. Males in breeding colors always have a territory inside a large cave and hardly ever venture far from it. Foraging individuals are sometimes seen outside caves but always in close contact with the rocky substrate. The mode of feeding consists of scavenging material lying on the rocky substrate of their environment. This often includes the droppings of other fishes, perhaps those of herbivorous fishes which may have some residual nutritional value.

Distribution. *Otopharynx spelaeotes* is known from both the eastern and western shores of Lake Malaŵi in the northern two-thirds of the lake (Fig. 1). Its southernmost point of distribution is at Gome in Malaŵi where it shares the habitat with *O. antron.* Along the western shore, its southernmost point is at Jalo Reef near Nkhotakota. It is nowhere very common, but population densities seem to be higher in the northern part of the lake, where the rocky coast has a steep inclination.

Etymology. The specific epithet, a noun in apposition, is derived from the Greek and means cave dweller.

Remarks. Although the morphometric and meristic data for *O. lithobates* (Table 1) and *O. spelaeotes* (Table 2) overlap for many characters, there is no overlap of the minimum polygon clusters along the first principal component of the meristic data (Fig. 3). The first principal component of the meristic data explained 23 % of variation with number of gill rakers on the outer row of the ceratobranchial (0.42), teeth rows on the lower jaw (0.36), and anal-fin rays (–0.35) having the highest loadings.

Otopharynx antron, new species
(Figs. 5b, 6b, 7)

Stigmatochromis sp. 'modestus eastern', Konings, 2007: 157.

Holotype. PSU 4461.1, 91.9 mm SL; Malaŵi: Lake Malaŵi: Nametumbwe, 13°38.290'S 34°51.334'E; Stauffer & Konings, 25 Jan 2007.

Paratypes. PSU 4461, 5, 69.2-99.4 mm SL; data as for holotype.

Diagnosis. *Otopharynx antron* has a larger eye (31.4-34.7 % HL; Table 2) than *O. auromarginatus* (25.0-30.3 % HL), *O. brooksi* (26.3-29.4 % HL), *O. decorus* (26.3-30.3 % HL), *O. ovatus* (22.7-30.3 % HL), *O. selenurus* (23.3-30.3 % HL), *O. tetraspilus* (25.0-30.3 % HL), *O. speciosus* (22.7-25.0 % HL), and *O. tetrastigma* (25.0-30.3 % HL) (Eccles & Trewavas, 1989). It has fewer lateral-line scales (29-31) than *O. argyrosoma* (34-36) (Eccles & Trewavas, 1989). *Otopharynx antron* has a larger lower-jaw length (41.3-47.8 % HL) than *O. heterodon* (35.7-40.0 % HL). *Otopharynx antron* is distinguished from *O. spelaeotes* and *O. lithobates* by its primarily unicuspid teeth in the outer rows of the oral jaws, by its smaller horizontal eye diameter (31.4-34.7 % HL vs. 36.1-38.4 in *O. spelaeotes* and 32.2-43.1 in *O. lithobates*), by a deeper caudal peduncle (12.4-13.4 % SL vs. 11.7-12.3 in *O. spelaeotes* and 9.8-13.1 in *O. lithobates*), and additionally from *O. spelaeotes* by having fewer teeth in the outer row of the left lower jaw (15-19, mode 15 vs. 18-24, mode 22).

Description. See Table 2 for morphometric and meristic data. Small to medium-sized cave-dwelling haplochromine with relatively deep body with greatest body depth at base of seventh or eighth dorsal spine. Dorsal body profile continuously curving between nape and caudal peduncle; ventral body profile convex, increasingly tapering from deepest point upward to end of caudal peduncle. Dorsal head profile straight to slightly concave between tip of snout and nape, convex on nape to dorsal fin origin; eye about double depth preorbital and positioned with about ¾ in anterior half of head; snout at 35-40° angle with body axis and slightly prognathous lower jaw (isognathous in some specimens) with moderately thickened mental knob; gape moderately oblique; teeth on dentary and premaxillae in 2-3 rows with outer rows mostly unicuspid with some bicuspid, and inner rows unicuspid.

Dorsal fin with 16-17 (mode 17) spines and 9-10 (mode 9) soft rays. Anal fin with 3 spines and 8-9 (mode 9) soft rays. First 4-5 dorsal spines gradually increasing in length posteriorly with first spine about ½ length of fifth spine; last 12 spines slightly increasing in length posteriorly

Table 2. Morphometric and meristic values of *Otopharynx spelaeotes* (n = 8) from Ndumbi Rocks, Likoma Island, Malaŵi (n = 7) and from Maison Reef, Malaŵi (n = 1), and of *Otopharynx antron* (n = 6) from Nametumbwe, Malaŵi. Ranges include holotypes.

	Otopharynx spelaeotes		*Otopharynx antron*	
	holotype	range	holotype	range
Standard length, mm	107.1	88.3-117.2	91.9	69.2-99.4
Head length, mm	38.6	31.4-41.6	33.2	25.5-36.9
Percent standard length				
Head length	36.0	34.8-36.6	36.1	36.1-37.2
Snout to dorsal-fin origin	36.8	36.8-40.9	38.9	37.9-40.4
Snout to pelvic-fin origin	43.3	41.0-43.5	43.1	42.5-44.8
Dorsal-fin base length	53.2	52.6-55.9	58.3	55.2-58.3
Anterior dorsal to anterior anal	45.7	42.9-49.0	51.7	48.0-51.7
Anterior dorsal to posterior anal	56.5	55.7-59.7	62.0	58.8-61.9
Posterior dorsal to anterior anal	27.6	27.6-30.4	32.1	30.5-32.1
Posterior dorsal to posterior anal	14.4	14.3-15.8	16.5	15.2-16.6
Posterior dorsal to ventral caudal	17.9	17.8-19.5	17.6	16.9-18.7
Posterior anal to dorsal caudal	20.7	20.0-21.7	21.6	20.0-21.6
Anterior dorsal to pelvic-fin origin	31.5	31.2-37.4	39.1	35.5-39.2
Posterior dorsal to pelvic-fin origin	51.1	50.0-52.7	55.8	52.6-57.2
Caudal-peduncle length	13.5	13.2-15.6	12.6	12.4-13.6
Least caudal-peduncle depth	11.8	11.7-12.3	13.4	12.4-13.4
Percent head length				
Snout length	28.3	28.2-29.9	30.7	29.1-30.7
Postorbital head length	34.0	33.3-39.2	38.3	37.2-39.1
Horizontal eye diameter	37.6	36.1-38.4	31.9	31.4-34.7
Vertical eye diameter	33.2	33.0-37.0	30.4	30.4-34.2
Preorbital depth	13.4	13.0-15.7	16.1	14.9-17.4
Cheek depth	14.7	14.7-18.2	21.7	16.0-21.7
Lower-jaw length	44.2	42.1-44.3	41.3	41.3-47.8
Head depth	72.3	69.7-77.1	89.4	80.1-89.4
Counts				
Dorsal-fin spines	17	16-17	17	16-17
Dorsal-fin rays	10	10-12	9	9-10
Anal-fin spines	3	3	3	3-4
Anal-fin rays	9	8-10	9	8-9
Pectoral-fin rays	13	13-14	13	13
Pelvic-fin rays	5	5	5	5
Lateral-line scales	33	31-33	30	29-31
Pored scales posterior to lateral line	2	2-4	2	1-3
Scale rows on cheek	3	3	4	3-4
Gill rakers on first ceratobranchial	12	11-13	11	10-11
Gill rakers on first epibranchial	5	4-5	4	4
Teeth in outer row of left lower jaw	22	18-24	17	15-19
Teeth rows on upper jaw	2	2-3	3	2-3
Teeth rows on lower jaw	2	2-3	3	2-3

Fig. 6. Females of: **a,** *Otopharynx spelaeotes*, approx. 90 mm SL; Malawi: Lake Malaŵi: Maison Reef; **b,** *O. antron*, PSU 4461, 69.2 mm SL; Malaŵi: Lake Malaŵi: Nametumbwe; and **c,** *Stigmatochromis modestus*, approx. 70 mm SL; Mozambique: Lake Malaŵi: Londo.

Fig. 7. *Otopharynx antron*, PSU 4461.1, holotype, 91.9 mm SL; Malaŵi: Lake Malaŵi: Nametumbwe.

with last spine longest; acuminate tip in breeding males or subacuminate in females, fifth or sixth ray longest, reaching ¼ of caudal fin in females and about halfway caudal fin in breeding males. Anal spines progressively increasing in length posteriorly; fourth or fifth ray longest, not reaching base of caudal fin in females and to about ¼ to ½ of caudal fin in breeding males. Caudal fin subtruncate to emarginate. Pelvic fin not reaching anal fin in females and reaching about second spine of anal fin in breeding males. Pectoral fin with acuminate tip with fourth or fifth ray longest, reaching vertical through base 14-15th dorsal spine.

Flank scales large; lateral-line scales 29-31 with 1-3 pored scales on caudal fin, and 3-4 scale rows on cheeks. Gill-rakers on first ceratobranchial 10-11 and on first epibranchial 4. Small scales on proximal posterior margins of dorsal and anal fins and on proximal ¾ of caudal fin.

Coloration. Breeding males (Fig. 5b): head blue with green highlights and black throat; operculum blue with green marks and black opercular spot, absent in some territorial males. Breast black; belly gray. Scales outlined in blue with brown center, green highlights throughout; 8-9 black vertical bars along body. Dorsal fin bright blue with orange membranes in rayed portion; white/blue lappets with red tips. Caudal fin with blue/gray rays and orange membrane. Anterior half of anal fin black/blue, posterior half orange/red with 3-7 yellow ocelli in distal margin. Pelvic fin black with white/blue leading edge and dark gray membrane. Pectoral fin with gray rays and clear membranes.

Females (Fig. 6b): head brown with dark brown snout and throat; operculum light brown with gray and green highlights; flank brown with 8 dark brown bars, large supra-pectoral spot mostly below upper lateral line and supra-anal spot across lower lateral line; caudal peduncle dark brown; breast dark brown; belly gray. Dorsal fin brown, white lappets with red tips. Caudal fin with brown rays and clear membranes. Anal fin brown with narrow yellow/orange margin. Pelvic fin light gray with darker leading margin. Pectoral fin with brown rays and clear membranes.

Field observations. *Otopharynx antron* has only sporadically been observed while SCUBA diving. The population at Nametumbwe (Fig. 1) consists mainly of breeding individuals in a mixed sand-rock habitat at a depth of approximately 10-15 m. Males in breeding color defend small caves with a sandy bottom mostly against conspecific males. The distance between territorial males varied between 4-10 meters. At the other localities where *O. antron* has been sighted (Gome and Chiofu), solitary individuals were encountered at depths of 35-60 meters. We were unable to observe feeding traits during the few encounters of non-breeding individuals but the sparse, primarily unicuspid teeth suggest a diet of larger invertebrates or even fish.

Distribution. *Otopharynx antron* has thus far only been encountered along the eastern shore between Gome and Nametumbwe (Fig. 1), a stretch of about 20 km, but because it has a very low population density and is mostly found in very deep water (for SCUBA divers) it may actually have a wider distribution along the eastern shore north of Gome and into Mozambique waters.

Etymology. The specific epithet, a noun in apposition, is derived from the Greek word *antron*, which means cave or cavity.

Stigmatochromis Eccles & Trewavas

Type species. *Haplochromis woodi* Regan.

Diagnosis. *Stigmatochromis* is characterized by a supra-pectoral, a supra-anal, and a pre-caudal spots; the first two spots do not extend to the base of the dorsal fin, which distinguish *Stigmatochromis* from *Hemitilapia*, *Trematocranus*, and *Tramitichromis intermedius*, in which these spots extend to the dorsal-fin base. The presence of a spot or blotch at the nape and a series of small spots along the back at the base of the dorsal fin distinguish *Stigmatochromis* from the spotted species of *Copadichromis*, in which these spots are absent. Species of *Stigmatochromis* over 60 mm SL differ from those of *Otopharynx* by a snout that is longer or about as long as the post-orbital head length, while the snout in *Otopharynx* is always shorter. *Stigmatochromis* is further characterized by a prognathous lower jaw and by numerous unicuspid teeth in the outer series of the oral jaws. In three of the four species (not in *S. pleurospilus*) there are 50 to 74 teeth in the outer row of the upper jaw (Eccles & Trewavas, 1989).

Remarks. The holotype of *S. pleurospilus* (Fig. 8) is a specimen of barely 40 mm SL and does not comply with the diagnosis of the genus. Eccles & Trewavas (1989) comment that the type may be a juvenile of one of the other species in the genus, and they have placed it in *Stigmatochromis* on the basis of its melanin pattern. Snoeks & Hanssens (2004) suggest that *S. pleurospilus* is a valid species that may not exceed 10 cm SL and kept it in this genus which would then require an adjustment to its diagnosis (see discussion).

Stigmatochromis modestus (Günther)
(Figs. 5c, 6c)

Material examined. BMNH 1893 1.17.5, holotype, 120.0 mm SL; Lake Malaŵi; Williams, 1891. – PSU 4466, 6, 67.3-124.1 mm SL; Malaŵi: Lake Malaŵi: Nametumbwe, 13° 38.290' S, 34° 51.334' E; Stauffer & Konings, 25 Jan 2007.

Description. See Table 3 for morphometric and meristic data. Medium-sized cave-dwelling haplochromine characterized by dark coloration (blue in breeding males and dark brown in others) with relatively elongate body with greatest body depth at base of second or third dorsal spine. Dorsal body profile slightly convex between nape and last dorsal spine, then abruptly tapering towards caudal peduncle along soft dorsal; ventral body profile slightly convex, increasingly tapering from pelvic fin upward to caudal peduncle. Dorsal head profile straight to slightly concave between tip of snout and nape, convex on nape to dorsal-fin origin; eye about 1½ depth preorbital and positioned about center of head. Snout at 30-35° angle with body axis. Prognathous lower jaw; gape moderately oblique (about 30°) and premaxillary pedicels almost reaching between eyes; teeth on dentary in 2-3 rows and on premaxillae in 3-4 rows with outer and inner rows unicuspid.

Dorsal fin with 16-17 (mode 16) spines and 10-12 (mode 11) soft rays. Anal fin with 3 spines and 8-10 (mode 9) soft rays. First 5-6 dorsal spines gradually increasing in length posteriorly with first spine about ⅓ length of sixth spine; last 10 spines slightly increasing in length posteriorly with last spine longest; subacuminate tip in breeding males or rounded in females, sixth or seventh ray longest, reaching about ¼ length of caudal fin in breeding males and just reaching base of caudal fin in females. Anal fin with subacuminate (males) or rounded (females) tip, fifth or sixth ray longest, not reaching base of caudal fin in females and to about ¼ of caudal fin in breeding males. Caudal fin subtruncate to emarginate. Pelvic fin reaching about second or third spine of anal fin in males, not reaching anal fin in females. Pectoral fin with subacuminate tip with fourth ray longest, reaching vertical through base 11-12th dorsal spine.

Flank scales large; lateral-line scales 30-31 with 0-2 pored scales on caudal fin, and 3 scale rows on cheeks. Gill-rakers on first ceratobranchial 10-12 and on first epibranchial 4-5. Small scales on proximal ¾ of caudal fin.

Coloration. Breeding males (Fig. 5c): head blue with orange highlights and blue throat; operculum blue with orange markings; breast and belly orange/brown; scales outlined in blue with yellow/orange center; 8-9 dark vertical bars along body. Dorsal fin blue with yellow/orange membranes in trailing portion; white lappets with red tips. Caudal fin with gray/blue rays and yellow

Table 3. Morphometric and meristic values of *Stigmatochromis modestus* (n = 7) and *Stigmatochromis pleurospilus* (n = 1).

	S. modestus			*S. pleurospilus*
	holotype	mean	range	holotype
Standard length, mm	120.0	93.6	67.3-124.1	40.3
Head length, mm	45.2	34.7	26.6-47.6	13.5
Percent standard length				
Head length	37.7	38.8	37.7-39.8	33.5
Snout to dorsal-fin origin	39.6	41.2	39.2-43.2	36.1
Snout to pelvic-fin origin	42.2	44.8	42.2-46.9	39.4
Dorsal-fin base length	51.4	51.9	49.5-53.3	53.0
Anterior dorsal to anterior anal	45.1	43.8	42.0-45.9	43.4
Anterior dorsal to posterior anal	55.9	55.4	53.6-57.2	56.5
Posterior dorsal to anterior anal	27.6	27.3	25.9-28.0	27.5
Posterior dorsal to posterior anal	15.0	14.4	13.9-15.0	14.3
Posterior dorsal to ventral caudal	18.2	17.6	15.8-19.1	18.1
Posterior anal to dorsal caudal	18.7	19.3	18.5-21.7	21.1
Anterior dorsal to pelvic-fin origin	31.9	32.2	30.3-33.8	27.5
Posterior dorsal to pelvic-fin origin	48.1	49.0	47.2-50.7	46.4
Caudal-peduncle length	12.9	13.4	12.8-14.5	17.0
Least caudal-peduncle depth	12.2	11.8	11.4-12.3	10.7
Percent head length				
Snout length	37.4	35.5	33.5-37.4	20.7
Postorbital head length	38.5	35.9	33.3-38.6	35.8
Horizontal eye diameter	27.9	30.2	26.7-33.8	42.6
Vertical eye diameter	25.6	27.5	23.6-31.1	36.7
Preorbital depth	22.9	19.3	17.1-22.9	14.9
Cheek depth	24.8	20.4	17.5-24.8	15.9
Lower-jaw length	48.3	46.4	45.2-48.3	37.0
Head depth	69.0	66.9	63.3-70.0	73.5
Counts		mode	range	
Dorsal-fin spines	17	16	16-17	15
Dorsal-fin rays	11	11	10-12	12
Anal-fin spines	3	3	3	3
Anal-fin rays	9	9	8-10	9
Pectoral-fin rays	13	13	12-13	14
Pelvic-fin rays	5	5	5	5
Lateral-line scales	29	30	29-31	29
Pored scales posterior to lateral line	1	2	0-2	1
Scale rows on cheek.	3	3	3	3
Gill rakers on first ceratobranchial	11	11	10-12	9
Gill rakers on first epibranchial	3	4	3-5	3
Teeth in outer row of left lower jaw	28	27	24-28	17
Teeth rows on upper jaw	3	3	3-4	4
Teeth rows on lower jaw	3	3	2-3	3

Fig. 8. *Stigmatochromis pleurospilus*, BMNH 1935.6.14.1475, holotype, 40.3 mm SL; Tanzania: Lake Malaŵi: Lupembe Sandbank.

membranes. Anal fin orange/red with 4-12 dark-haloed, white/blue spots along margin and in trailing part. Pelvic fin orange/red with black anterior margin and white/blue leading edge. Pectoral fin with gray rays and clear membranes.

Females (Fig. 6c): head, body, and unpaired fins dark brown with slightly darker supra-pectoral and supra-anal spots. Dorsal fin with light brown/white lappets with red tips. Anal fin brown with narrow yellow/orange margin. Pelvic fin dark brown. Pectoral fin with brown rays and clear membranes.

Field observations. *Stigmatochromis modestus* is a very secretive piscivore but can be rather common in some rocky habitats. The color of females and non-breeding males – completely dark brown – matches perfectly the shadows in recesses and caves between and underneath rocks. *Stigmatochromis modestus* commonly lurks in such caves and probably waits until its prey (juvenile mbuna) enters the hideaway. Breeding males appear to "cluster" in a small area of the rocky habitat – usually at depths of more than 10 meters – each defending his spawning site, which is a cave or a place beneath an overhanging rock. During the breeding period, the male appears to refrain from feeding and stays at the entrance of his cave all the time. Aquarium observations suggest that spawning takes place on a rock inside the cave. Fry-guarding females have not been observed.

Distribution. *Stigmatochromis modestus* has a lake-wide distribution.

Stigmatochromis pleurospilus (Trewavas)
(Fig. 8)

Material examined. BMNH 1935.6.14.1475, holotype, 40.3 mm SL; Tanzania: Lupembe Sandbank; Christy, 1925-26.

Description. Known only from immature holotype. Teeth on dentary in 4 and on premaxillary in 3 rows with outer rows bicuspid. Gill rakers on first ceratobranchial 9 and on first epibranchial 3. Lateral-line scales 29 with 1 pored scale on caudal fin and 3 rows on cheeks. Additional morphometric and meristic data in Table 3.

Remarks. In the above diagnoses, the new species are distinguished from *Otopharynx* species. *Stigmatochromis modestus* is a cave dweller and the juvenile *S. pleurospilus* superficially resembles the new species, therefore they are delimited from the new species as follows. *Otopharynx spelaeotes* is distinguished from *S. modestus* by fewer teeth in the outer row of the left lower jaw (18-24 vs. 24-28) and by its shorter head length (34.8-36.6 % SL vs. 37.8-39.8). *Otopharynx spelaeotes* has a larger horizontal eye diameter (36.1-38.4 % HL) than *S. modestus* (26.7-33.8 % HL) and a smaller horizontal eye diameter than *S. pleurospilus* (42.6 % HL). *Otopharynx antron* is distinguished from *S. modestus* by a longer dorsal-fin base length (55.2-58.3 % SL vs. 49.5-53.3), by a deeper body as expressed in the distance between the origins of the dorsal and pelvic fins (35.5-39.2 % SL vs. 30.3-33.8), by a shorter head length (36.1-37.2 % SL vs. 37.8-39.8), by fewer teeth in the outer row of the left lower jaw (15-19 vs. 24-28), and by a snout that is shorter than the post-orbital length while in *S. modestus* the snout is about as long as the post-orbital length. *Otopharynx antron* differs from *S. pleurospilus* by a smaller horizontal eye diameter (31.4-34.7 % HL vs. 42.6) and by a longer head length (36.1-37.2 % SL vs. 33.5).

Discussion

The basic melanin patterns of Malaŵi cichlids play an important role in the genus-level classification. Most genera suggested by Eccles & Trewavas (1989) were diagnosed mainly on such patterns and have generally been accepted by subsequent workers. Nevertheless, the diagnostic pattern in species of *Otopharynx* and *Stigmatochromis* is very similar and we were unable to distinguish between these two genera basing our criteria solely on melanin patterns. The habitus of at least three of the four species currently in *Stigmatochromis* is that of a piscivorous predator and based on melanin pattern and habitus we initially regarded *O. antron* to be a member of *Stigmatochromis*. *Stigmatochromis* is now diagnosed by two main characteristics: a long snout equal in length or longer than the post-orbital head length and numerous, relatively small, unicuspid teeth in the outer series of the oral jaws. The holotype and only known specimen of *S. pleurospilus* does not comply with this diagnosis and we agree with Eccles & Trewavas (1989) that it probably represents a juvenile of another species in the genus. We have no doubt that the type is a juvenile specimen which is not only suggested by the relatively large eye, but also by its overall size. The smallest known adult haplochromine with a melanin pattern of three spots is perhaps *Otopharynx heterodon* which has an adult size range of 68-103 mm SL (Eccles & Trewavas, 1989). Even among the small, rock-dwelling haplochromines (mbuna) very few have an adult size of less than 40 mm SL. Snoeks & Hanssens (2004) state to have rediscovered *S. pleurospilus*, but judging from the photograph published with their account we find that their specimens probably represent *O. spelaeotes*. We were unable to "match" the type of *S. pleurospilus* to *O. spelaeotes* or to any other cave-dwelling species examined in this work. We therefore do not agree with Snoeks & Hanssens (2004) that *S. pleurospilus* is a small species, possibly conspecific with *O. spelaeotes*.

Because of similarities in the basic melanin pattern and in general morphology we chose to compare the two new species to two rock-dwelling species of *Stigmatochromis* and also to the enigmatic *S. pleurospilus*. When we compared *S. modestus*, a cave-dwelling species of *Stigmatochromis*, with the two new species of *Otopharynx*, several characters were distinctly different. For example, *S. modestus* is distinguished from *O. spelaeotes* and *O. antron* by the numerous, small unicuspid teeth in the outer row of the left lower jaw (24-28 vs. 15-24), by a longer snout (33.5-36.1 % HL vs. 29.1-30.7), and by a longer head (37.8-39.8 % SL vs. 34.8-37.2). When the sheared second principal components of the morphometric data are plotted against the principal component of the meristic data, *O. antron* and *O. spelaeotes* group closer to each other than to the two species of *Stigmatochromis* to which they are compared (Fig. 9).

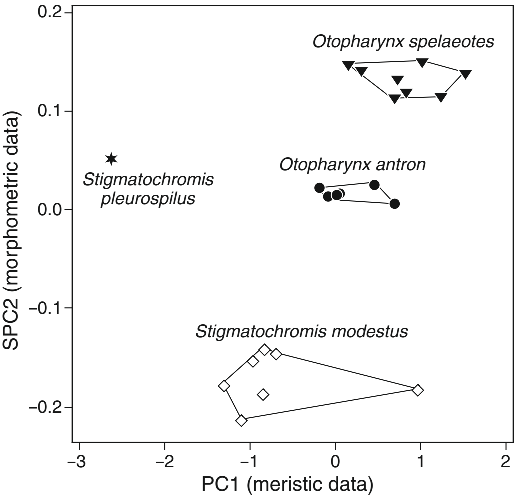

Fig. 9. Plot of sheared second principal component of morphometric data and first principal component of meristic data for *Otopharynx spelaeotes*, *O. antron*, *Stigmatochromis modestus* and *S. pleurospilus*.

Within the genus *Otopharynx*, *O. spelaeotes* is probably most closely related to *O. lithobates* as both seem to have, albeit allopatrically, similar habitat requirements and morphologically they are almost indistinguishable. The meristic differences (Fig. 3) and the observation that no discernable geographical variants could be located in the vast distribution of *O. spelaeotes* convinced us that it indeed represents a species different from *O. lithobates*. Nowhere could we find *O. lithobates* sympatric with *O. spelaeotes* or *O. antron*, but the latter two species are sympatric at Gome, where both are represented in very small numbers. On the other hand, *O. lithobates* appears to be a much more variable species, both morphologically as well as in male breeding coloration, while it has a much more restricted distribution in the southern part of the lake. We have synonymized *O. walteri* and regard it as a population of *O. lithobates*.

The three species of *Otopharynx* discussed herein and *S. modestus* use caves as their primary shelter and foraging site. While *S. modestus* is a piscivore, hunting small mbuna in the dark recesses of the rocky habitat, *O. lithobates* and *O. spelaeotes* feed on morsels and particles – often droppings of other fish including the cave-dwelling catfish *Bagrus meridionalis* – that they locate on the rocky substrate. The feeding strategy of *O. antron* could not be ascertained, but regarding its relatively large mouth set with rather large unicuspid teeth we suspect it to be much more of a predator rather than a scavenger.

Acknowledgments

The authors wish to thank the government of Malaŵi for providing the necessary permits to collect fishes and the late Stuart Grant for providing transport on the lake. Fishes were collected and processed under the research permit issued to the Molecular Biology and Ecology Research Unit (MBERU), University of Malaŵi and the approval of the Animal Use and Care Committee at Pennsylvania State University (IACUC #16945; 00R084). Partial funding was provided by the NSF/NIH joint program in ecology of infectious diseases (DEB-0224958).

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Received 30 April 2008
Revised 2 April 2009
Accepted 16 June 2009

Ichthyological Exploration of Freshwaters

An international journal for field-orientated ichthyology

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Ichthyological Exploration of Freshwaters

An international journal for field-orientated ichthyology

Volume 20 • Number 2 • June 2009

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Cover photograph:
Ellopostoma mystax (photograph by Jörg Bohlen)
Jörg Bohlen and Vendula Šlechtová
(this volume pp. 157-162)

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