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A new species of *Iodotropheus* (Teleostei: Cichlidae) from Lake Malawi, Africa

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Iodotropheus declivitas, new species, is described from Boadzulu Island, Lake Malawi, Africa. *Iodotropheus sprengerae*, the type species of *Iodotropheus*, was based solely on aquarium-raised specimens thought to have originated from brood stock collected from Boadzulu Island. Subsequently, *I. stuartgranti* was described from the eastern shore of Lake Malawi near the Mozambique border. Analysis of the morphometric and meristic data, however, demonstrate that the type series of *I. sprengerae* is phenotypically more similar to wild-caught specimens from Chinyankwazi and Chinyamwezi islands than it is to wild-caught specimens from Boadzulu Island. The new species is distinguishable from the type series of *I. sprengerae*, wild-caught specimens from Chinyankwazi and Chinyamwezi islands, and from the type series of *I. stuartgranti* based on shape, oral dentition, and pharyngeal-bone dentition.

Introduction

All of the haplochromine rock-dwelling cichlids inhabiting Lake Malawi are endemic; moreover, many of these fishes are restricted to solitary islands or isolated rock outcroppings (Stauffer, 1988; Stauffer & Boltz, 1989). *Iodotropheus* Oliver & Loiselle (type species: *Iodotropheus sprengerae* Oliver & Loiselle) was described as a monotypic genus based on the examination of aquarium-raised specimens (Oliver & Loiselle, 1972). Subsequently, *I. stuartgranti* Konings was described based on specimens from the eastern shore of Lake Malawi between the mouth of the Nsinje River and the Mozambique border (Konings, 1990a). Oliver & Loiselle (1972) reported that *I. sprengerae* was known only from Boadzulu Island, but Ribbink et al. (1983) expanded its known range to include Chinyamwezi and Chinyankwazi islands.

Chinyankwazi (Fig. 1) and Chinyamwezi islands are separated by a few kilometers, but Boadzulu Island is located more than 100 km south of these two islands. Because of the high degree of endemism associated with the islands in the southeast arm of Lake Malawi, I thought it unusual that populations of a single species would be separated by such distances and not occur at any intervening locations. I initially postulated that the distribution of this species could represent relict populations of a more expansive species. Thus, a more detailed examination of these disjunct populations of the putative *I. sprengerae* was initiated. The purpose of this

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Fig. 1. Chinyankwazi Island located in the southeast arm of Lake Malawi.

paper is to describe a new species of *Iodotropheus* from Boadzulu Island, redescribe *I. sprengerae* from wild-caught specimens from Chinyankwazi and Chinyamwezi islands, and provide an artificial key to *Iodotropheus*.

Methods and Materials

Fishes were collected by chasing them into a monofilament net (7 m × 1 m × 1.0 cm mesh) while SCUBA diving. Standard length (SL) is used throughout. External counts and measurements follow Barel et al. (1977) and Stauffer (1991). The posterior simple ray of the anal fin, if present, was not counted, because it shared the same pterygiophore as the last fully developed ray. Morphometric characters were measured with dial calipers that were interfaced with a personal computer. Except for gill-raker counts, which were recorded from the right side, all counts and measurements were made on the left side of the fish. Pored scales in the lower lateral-line, which overlapped with pored scales in the upper lateral-line were not counted. The upper pharyngeal bones of the holotype and 10 paratypes were dissected and the teeth counted as follows: a) number in the dorsal/posterior row left of the median suture; b) number along the left side parallel and adjacent to the median suture; and c) number of transverse rows with the posteriormost tooth adjacent to the median suture counted as the first row. Additionally, 14 measurements on each pharyngeal bone were recorded (Fig. 2).

Fishes were collected from Boadzulu (14°11'S 35°07'E), Chinyamwezi (13°56'S 35°00'E), and Chinyankwazi (13°53'S 35°00'E) islands. These specimens were compared to most of the type material of *I. sprengerae* (BMNH 1971.9.8:5, 1971. 9.8:6-8, USNM 207013, 207015) and the type material of *I. stuartgranti* (BMNH 1990.4.9:35-44). Differences in body shape were analyzed using sheared principal component analysis (SPCA) of the morphometric data (Humphries et al., 1981; Bookstein et al., 1985). Pectoral-fin length and pelvic-fin length were not included in the analysis, because these measurements are dependent on the reproductive stage of the fish. Dorsal-fin base length and lower jaw length were not included because the data were not available for all populations. Meristic data were analyzed using

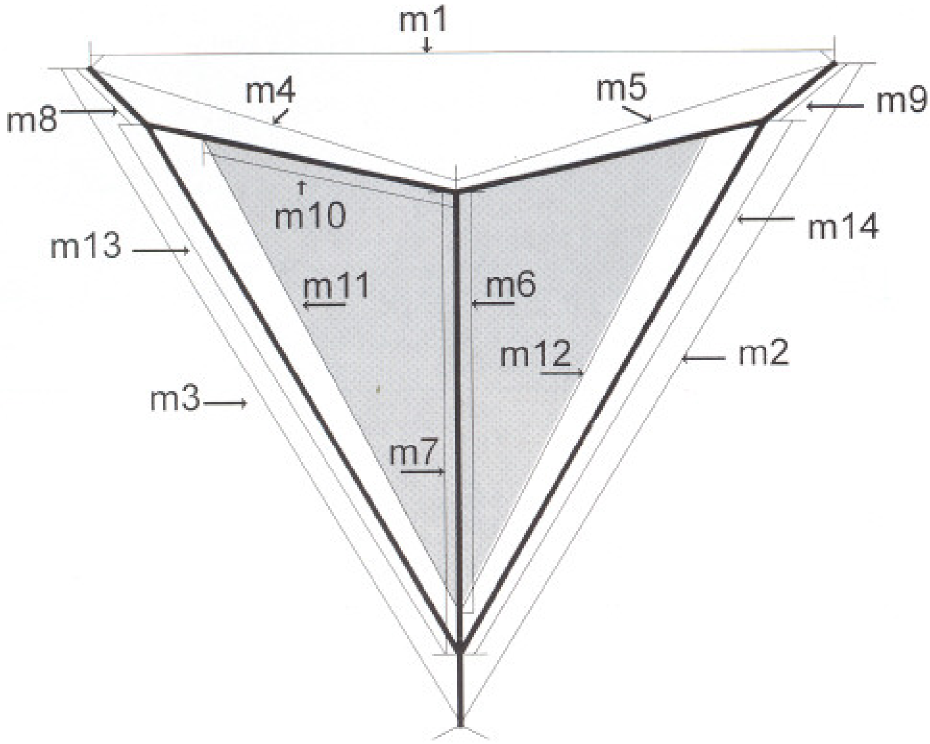

Fig. 2. Schematic representation of the lower pharyngeal bone, showing the measurements that were recorded. Shaded area denotes dentigerous portion of the bone.

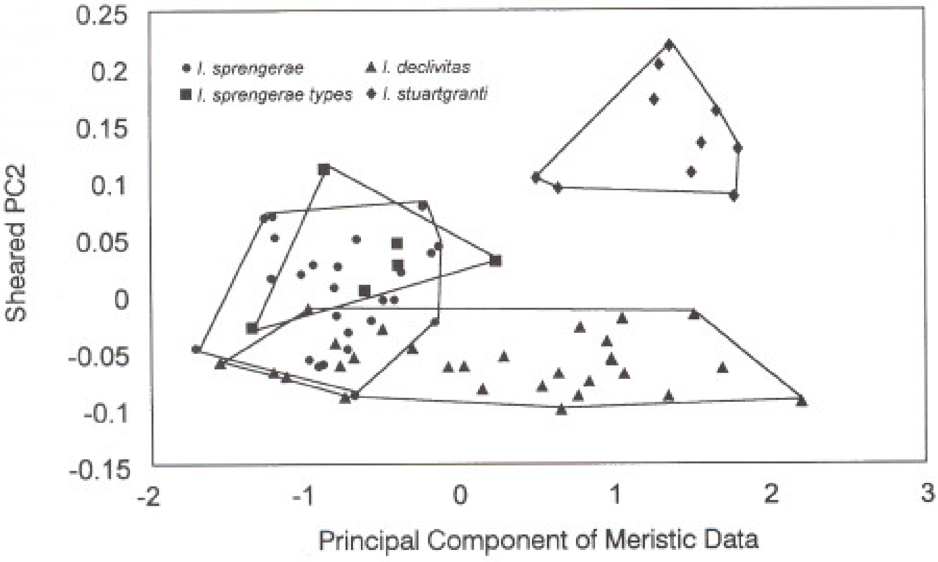

Fig. 3. Plot of individual sheared second principal component scores (morphometric data) and first principal component scores (meristic data) of body morphology of *Iodotropheus* species, *I. declivitas* (Boadzulu Island population), wild-caught *I. sprengerae* (Chinyankwazi and Chinyamwezi islands), type series of *I. sprengerae*, and type series of *I. stuartgranti*.

principal component analysis (PCA). Shape of the lower pharyngeal bones was analyzed using a sheared principal component analysis and tooth formula on the lower pharyngeal bones was examined using principal component analysis. The correlation matrix was factored in all principal components analysis of meristic data, while the covariance matrix was factored in the calculation of all sheared principal components of the morphometric data. Differences among populations were illustrated by plotting the sheared second principal component of the morphometric data against the first principal component of the meristic data (Stauffer & Hert, 1992).

Table 1. Morphometric and meristic characters of *Iodotropheus declivitas* (n=30). Mean, standard deviation and range includes holotype.

	holotype	mean	standard dev.	range
Standard length, mm	63.7	59.3	3.6	50.6-65.1
Head length, mm	21.3	20.0	1.1	17.3-21.5
Percents of standard length				
Head length	33.4	33.7	0.9	31.6-35.6
Snout to dorsal-fin origin	36.0	37.9	2.1	33.5-42.1
Snout to pelvic-fin origin	40.1	39.3	1.6	35.3-41.7
Caudal-peduncle length	12.9	13.8	1.2	11.0-16.0
Least caudal-peduncle depth	12.8	12.7	0.5	11.6-13.7
Pectoral-fin length	25.3	25.8	1.8	23.2-32.3
Pelvic-fin length	35.2	32.9	4.5	24.4-45.0
Dorsal-fin base length	63.0	61.1	2.3	56.4-66.3
Anterior dorsal to anterior anal	50.4	53.2	2.1	48.8-59.0
Posterior dorsal to posterior anal	15.4	16.0	0.8	14.7-17.6
Anterior dorsal to posterior anal	66.2	64.5	2.0	59.7-68.8
Posterior dorsal to anterior anal	31.9	30.8	1.2	28.6-33.7
Posterior dorsal to ventral caudal	15.9	17.3	1.1	15.3-20.2
Posterior anal to dorsal caudal	18.5	19.5	0.9	17.9-21.0
Anterior dorsal to pelvic-fin origin	37.0	37.4	1.8	33.8-41.7
Posterior dorsal to pelvic-fin origin	56.3	56.6	1.5	53.2-59.6
Percents of head length				
Horizontal eye diameter	30.7	31.5	1.6	26.7-36.3
Vertical eye diameter	31.2	32.2	1.4	30.1-37.0
Snout length	32.8	33.9	2.1	30.0-38.3
Postorbital head length	44.4	40.6	1.5	37.6-44.4
Preorbital depth	19.2	18.1	1.2	15.7-20.4
Lower-jaw length	40.0	33.6	2.2	29.3-40.0
Cheek depth	37.0	33.2	1.9	28.4-37.0
Head depth	91.5	97.5	4.6	86.7-105.0
Counts	holotype	mode	% freq.	range
Lateral-line scales	31	31	63.3	29-32
Pored scales posterior to lateral line	0	2	56.7	0-3
Scale rows on cheek	3	3	90.0	3-4
Dorsal-fin spines	17	17	46.7	15-18
Dorsal-fin rays	9	9	60.0	8-10
Anal-fin rays	7	7	56.7	6-7
Pectoral-fin rays	13	13	80.0	13-14
Gill rakers on first ceratobranchial	8	8	70.0	7-10
Gill rakers on first epibranchial	2	2	86.7	2-3
Teeth in outer row of left lower jaw	6	6	53.3	5-9
Teeth rows on upper	3/0	4.0	60.0	3-4
Teeth rows on lower jaw	3	4.0	56.7	3-4

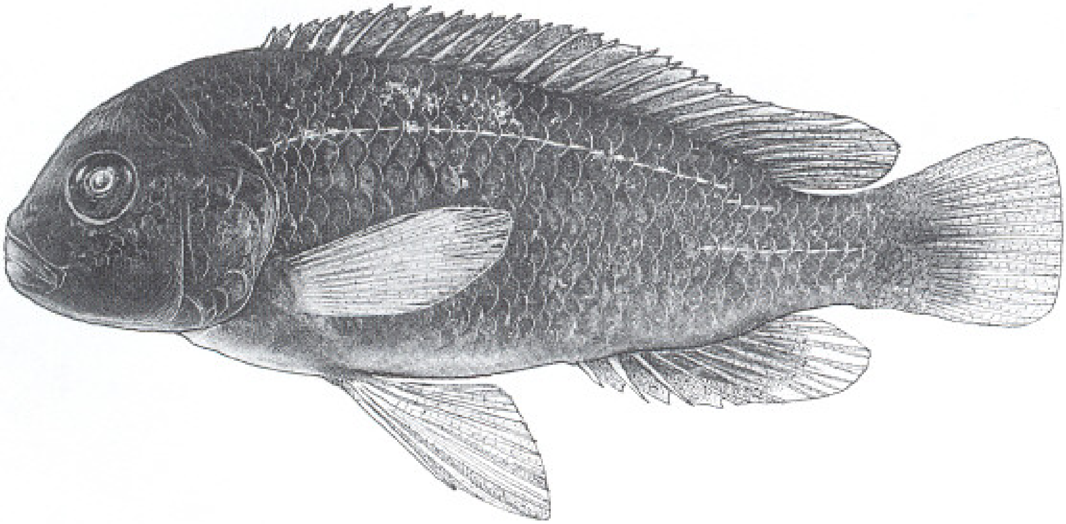

Fig. 4. *Iodotropheus declivitas*, PSU 2723, 63.7 mm SL, from Boadzulu Island, Lake Malawi.

A MANOVA was used to determine if the clusters formed by the minimum polygons of the PCA scores of each population were significantly different ($p < 0.05$). Institutional abbreviations follow Leviton et al. (1985), except where noted.

Results

A plot of the second sheared principal component (morphometric data) against the first principal component (meristic data) demonstrated that the cluster formed by the data for *I. stuartgranti* did not overlap with those formed by data from the other populations (Fig. 3). The cluster formed by the Chinyamwezi and Chinyankwazi islands' populations overlapped slightly with that formed by the Boadzulu Island's population. A multivariate analysis of variance (MANOVA) indicated that these two clusters formed by the minimum polygons of the PCA scores were significantly different from each other ($p < 0.05$). The data for the cluster of the type series of *I. sprengerae* were more closely aligned with the cluster formed by the Chinyamwezi and Chinyankwazi islands' populations and not the population from Boadzulu Island; thus I concluded that the population inhabiting Boadzulu Island represented a new species, which is clearly distinct from both *I. sprengerae* and *I. stuartgranti.*

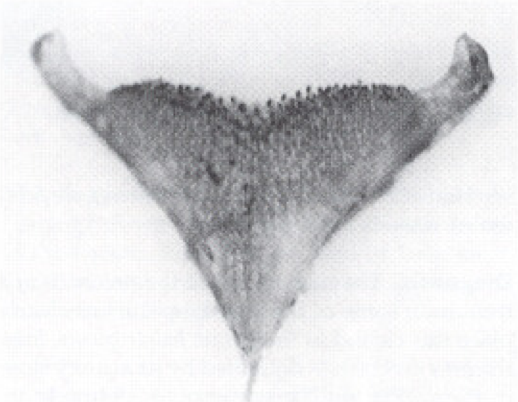

Fig. 5. Lower pharyngeal bone of the type specimen of *Iodotropheus declivitas*, PSU 2723.

Iodotropheus declivitas, new species
(Fig. 4)

Iodotropheus sprengerae, Ribbink et al., 1983: 241 (in part); Konings, 1990b: 270 (in part).

Holotype. PSU 2723, adult male, 63.7 mm, Boadzulu Island, Lake Malawi, Africa, 2-4 m, 1991 (Figs. 4 and 5).

Paratypes. PSU 2725, 15 (56.6-64.1 mm); USNM 331699, 9 (54.3-63.7 mm); MFU 6 (Malawi Fisher-

Fig. 6. *Iodotropheus declivitas* at Boadzulu Island.

ies Unit), 5 (58.0-64.1 mm); 21 males and 8 females, data as for holotype.

Diagnosis. The rust color and the presence of a frenum in some of the largest specimens clearly place this cichlid in the genus *Iodotropheus*. *Iodotropheus declivitas* is delimited by its acutely sloping head (Fig. 4). The presence of 5-9 (mode=6) teeth in the outer row of the left lower jaw of *Iodotropheus declivitas* distinguishes it from *I. stuartgranti*, which has 8-10 (mode=9). The greater number of teeth on the lower pharyngeal bone of *I. declivitas* distinguishes it from *I. sprengerae*; in the posterior row, 15-20 versus 12-16; median row, 8-13 versus 7-9; and the transverse row, 7-9 versus 5-6.

Description. Jaws isognathous (Fig. 4); teeth on jaws in 3-4 rows; majority of teeth in outer rows bicuspid, those in inner rows tricuspid; 6 teeth in outer row of left lower jaw of holotype, 5-9 in paratypes. Dorsal fin with 17 spines in the holotype and 15-18 in paratypes; dorsal-fin rays 9 in holotype and 8-10 in paratypes. Pectoral fins with 13 rays in holotype and 13-14 in paratypes; anal fin with 3 spines and 7 rays in holotype and 16 paratypes, with 3 spines and 6 rays in remaining 12 paratypes; caudal fin emarginate (Fig. 4, Table 1). Lower pharyngeal bone of holotype triangular in outline (Fig. 5); pharyngeal teeth in left posterior/dorsal row of holotype 20 (10 paratypes 15-20), those in left median row of holotype 13 (10 paratypes 8-13), and those in left transverse row of holotype 9 (10 paratypes 7-9). Scales along side ctenoid; holotype with 31 pored lateral-line scales, paratypes with 29-32; pored scales posterior to hypural plate 0-3 (Table 1). Twenty-six specimens, including holotype, with 3 scale rows on cheek, remaining 3 paratypes with 4. First gill arch with 7-10 gill rakers on the ceratobranchial, 2-3 on the epibranchial, and 1 between the epibranchial and ceratobranchial. Fifteen specimens, including the holotype, with only bicuspid teeth in the outer row of the upper and lower jaws, 1 with only unicuspid teeth, and 13 with both bicuspid and unicuspid teeth. Although the holotype and 21 paratypes exhibited no evidence of a frenum, three paratypes possessed a distinct frenum, and four paratypes had a partially developed frenum.

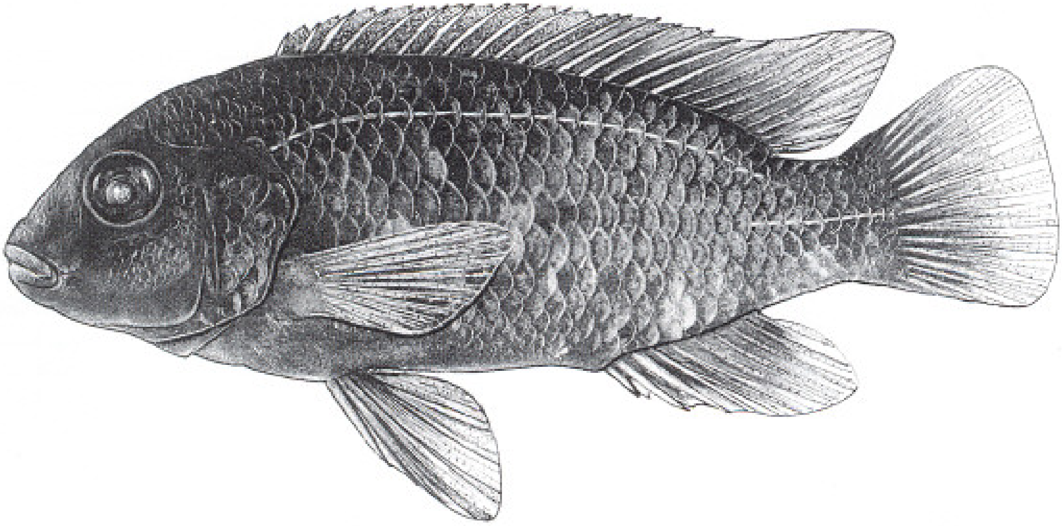

Fig. 7. *Iodotropheus sprengerae*, PSU 2721, 70.6 mm SL, from Chinyankwazi Island, Lake Malawi.

Overall body coloration of males dark red/brown dorsally fading to lighter rust color ventrally (Fig. 6); breeding males will sometimes develop a blue hue laterally (see color photo in Konings, 1990b: 283); majority of lateral scales with purple spots; dorsal fin red/brown with orange lappets and a blue membrane is present in some specimens; caudal-fin rays red/brown, membranes blue; anal fin red/brown with orange edge distally and 2-3 yellow/orange ocelli; pelvic fins brown with white leading edges with some specimens having a thin black submarginal band. Head red/brown with a faint purple opercular spot in some individuals. Females colored similarly, but less intensely; ocelli absent from anal fin of some females; when present, they are pale yellow and located on distal portion of the fin.

Distribution. *Iodotropheus declivitas* appears to be restricted to Boadzulu Island, and the immediately surrounding rock reefs in the southeast arm of Lake Malawi. This species was not observed at other localities in numerous diving expeditions throughout the southeast arm of Lake Malawi over the past 10 years; however Konings (1990b) reported a population at Makakola Reef, which is located approximately 500 meters south of Boadzulu Island. Observations by Oliver & Loiselle (1972) indicated that specimens of *Iodotropheus* observed at Boadzulu Island were most abundant at depths greater than 10 m; however, all of specimens reported herein were captured at depths of 1-8 m.

Etymology. The name *declivitas*, from the Greek, meaning 'downward slope', was chosen to reflect the acute sloping of the head of *I. declivitas* (Fig. 4) as compared to *I. sprengerae* (Fig. 7); treated as a noun in apposition.

Iodotropheus sprengerae Oliver & Loiselle
(Fig. 7)

Material examined. BMNH 1971.9.8:5 (holotype), BMNH 1971.9.8:6-8 (3 paratypes), USNM 207013 (1 paratype), USNM 207015 (1 paratype), PSU 2722 (4 male specimens from Chinyamwezi Island), PSU 2720, PSU 2721, (21 specimens, 6 females, 15 males) from Chinyankwazi Island).

Description. The following description is based on the wild-caught specimens. Jaws isognathous (Fig. 7); teeth on jaws in 3-4 rows; majority of teeth in outer rows unicuspid, those in inner rows tricuspid; 3-8 (mode=7) in the outer row of left lower jaw (Table 2). Dorsal fins with 16-18 spines and 8-9 rays; anal fin with 3 spines and 6-8 rays; caudal fin emarginate (Fig. 7). Lower pha-

Table 2. Mean, standard deviation, and range of morphometric and meristic characters of *Iodotropheus sprengerae*.

	type series (n=6) aquaria-raised			wild caught fishes (n=25) Chinyamwezi & Chinyankwazi islands		
	mean	standard dev.	range	mean	standard dev.	range
Standard length, mm	64.6	15.6	44.3-78.6	63.9	6.3	52.4-75.1
Head length, mm	20.7	4.51	14.7-25	21.4	1.8	17.7-24.5
Percents of standard length						
Head length	32.2	1.1	30.6-33.7	33.4	1.0	31.6-35.5
Snout to dorsal-fin origin	34.1	0.8	33.2-35.5	37.7	1.8	34.4-41.6
Snout to pelvic-fin origin	35.3	5.9	27.9-41.3	40.8	1.7	38.2-43.8
Caudal-peduncle length	13.0	0.8	11.7-13.9	13.1	1.0	10.8-15.0
Least caudal-peduncle depth	12.6	0.6	11.7-13.2	13.7	0.9	11.6-15.0
Pectoral-fin length	24.7	1.9	22.2-27.2	25.5	1.7	21.4-28.6
Pelvic-fin length	25.8	4.4	18.2-29.6	31.3	4.0	24.0-39.2
Dorsal-fin base length	–	–	–	61.0	1.9	55.7-63.7
Anterior dorsal to anterior anal	52.4	3.2	48.1-55.7	52.7	2.4	47.5-55.6
Posterior dorsal to posterior anal	16.4	1.1	15.3-17.9	16.6	1.1	14.5-18.9
Anterior dorsal to posterior anal	65.9	2.5	62.7-68.7	64.5	1.9	59.4-67.8
Posterior dorsal to anterior anal	31.8	1.4	30.4-34.3	31.5	1.3	29.0-34.0
Posterior dorsal to ventral caudal	17.2	0.7	16.3-18.3	17.1	0.8	15.7-18.6
Posterior anal to dorsal caudal	18.6	0.6	17.8-19.4	19.7	1.3	17.4-22.1
Anterior dorsal to pelvic-fin origin	33.4	1.9	30.9-35.8	36.3	2.4	30.8-40.1
Posterior dorsal to pelvic-fin origin	57.7	1.6	55.6-59.8	55.8	1.9	52.2-59.1
Percents of head length						
Horizontal eye diameter	28.3	1.2	27.0-29.9	30.9	1.4	28.0-33.7
Vertical eye diameter	28.2	1.7	25.6-30.6	30.9	1.5	27.7-33.4
Snout length	34.9	2.9	31.6-38.8	33.6	2.8	28.9-40.6
Postorbital head length	45.5	1.7	43.1-47.0	41.0	1.2	38.8-45.3
Preorbital depth	19.2	3.0	15.0-22.8	19.2	1.6	16.5-21.4
Lower-jaw length	–	–	–	35.3	2.4	30.0-40.7
Cheek depth	29.7	6.4	21.8-36.6	29.7	4.2	23.6-35.9
Head depth	95.6	6.1	86.8-101.3	98.6	5.4	85.5-107.4
Counts	mode	% freq.	range	mode	% freq.	range
Lateral-line scales	31	66.7	30-32	30	52.0	29-32
Pored scales posterior to lateral line	1	66.7	0-1	1	60.0	0-2
Scale rows on cheek	4	83.3	3-4	3	56.0	3-4
Dorsal-fin spines	17	66.7	17-18	17	72.0	16-18
Dorsal-fin rays	9	66.7	8-9	9	52.0	8-9
Anal-fin rays	7	66.7	6-7	6	60.0	6-8
Type Series (n=6)						
Pectoral-fin rays	13	83.3	13-14	13	96.0	13-14
Gill rakers on first ceratobranchial	8	50.0	8-9	8	40.0	7-9
Gill rakers on first epibranchial	2.0	100	2	2	84.0	1-3
Teeth in outer row of left lower jaw	8	50	5-8	7	28.0	3-8
Teeth rows on upper jaw	3.0	100	3	3	92.0	3-4
Teeth rows on lower jaw	3.0	100	3	3	88.0	3-4

ryngeal bone of holotype triangular in outline (Fig. 8); range of pharyngeal teeth of 10 specimens fromChinyankwazi Island in left posterior row 12-16, left median row 7-9, and left transverse row 5-6. The shape of the pharyngeal bones of 10 *I. sprengerae* did not differ from the shape of the pharyngeal bones of 10 *I. declivitas* (Table 3); however the first principal component of the tooth counts did delimit these two species (Fig. 9). The first factor score explained 80 % of the observed variance with the variable loadings of transverse teeth, posterior/dorsal teeth, and median teeth being 0.59, 0.57 and 0.56 respectively. Scales along side ctenoid with 29-32 lateral line scales, 0-2 pored scales posterior to hypural plate, and 3-4 scale rows on cheek. First gill arch with 7-9 gill rakers on the ceratobranchial, 1-3 on epibranchial, and one between the epibranchial and ceratobranchial (Table 2). Thirteen specimens with only unicuspid teeth in the outer row of the upper and lower jaws, and 12 with both unicuspid and bicuspid teeth. Eight individuals with no evidence of a frenum; 17 with either a distinct frenum or a developing frenum.

Overall body coloration of males rust/orange with blue/purple markings. Dorsal fin rust/orange proximally, distally purple/lavender; caudal-fin rays rust/orange; anal fin rust/orange with 2 yellow/orange ocelli; pelvic fins rust/orange with yellow edge. Head rust/orange with a faint purple opercular spot in some individuals. Females colored similarly, but not as intensely; ocelli absent from anal fin of some females; when present, they are pale yellow and located on distal portion of the fin.

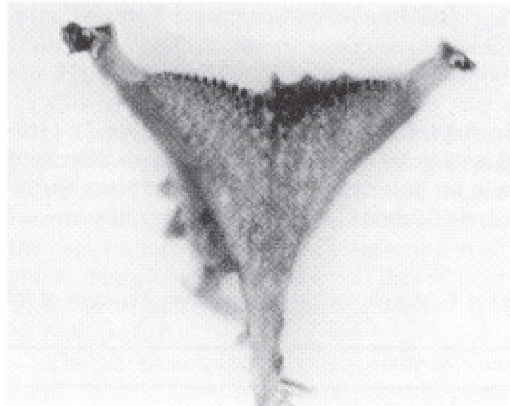

Fig. 8. Lower pharyngeal bone of *Iodotropheus sprengerae*, PSU 2721, 70.6 mm SL.

Distribution. *Iodotropheus sprengerae* appears to be restricted to the rock outcroppings surrounding Chinyamwezi and Chinyankwazi islands.

Table 3. Mean, standard deviation, and range of pharyngeal tooth measurements for *Iodotropheus sprengerae* and *Iodotropheus declivitus*. See Figure 2 for schematic of measurements.

	Iodotropheus sprengerae (n = 10)			*Iodotropheus declivitus* (n = 10)		
measurements	mean	standard dev.	range	mean	standard dev.	range
M1	5.6	0.4	5.1-6.4	5.4	0.5	4.7-6.5
M2	6.2	0.5	5.7-7.1	5.9	0.6	5.1-7.1
M3	6.0	0.5	5.4-7.2	5.8	0.7	4.9-7.0
M4	2.9	0.3	2.7-3.2	2.9	0.3	2.4-3.3
M5	3.0	0.2	2.6-3.5	2.8	0.3	2.2-3.4
M6	3.5	0.4	2.8-4.0	3.3	0.4	2.6-4.0
M7	4.6	0.5	3.9-5.6	4.4	0.5	3.6-5.4
M8	0.8	0.2	0.6-1.1	0.9	0.1	0.7-1.1
M9	1.0	0.1	0.8-1.2	0.9	0.1	0.8-1.1
M10	4.4	0.2	4.0-4.7	4.1	0.4	3.6-4.9
M11	4.3	0.3	3.7-4.8	4.1	0.4	3.3-4.7
M12	4.4	0.3	4.0-4.7	4.2	0.4	3.5-4.9
M13	5.2	0.5	4.5-6.2	5.0	0.6	4.1-6.0
M14	5.3	0.4	4.9-6.1	5.2	0.5	4.3-6.1

Iodotropheus stuartgranti Konings

Material examined. BMNH 1990-4-9:35-44.

Description. Jaws isognathous (Table 4); teeth on jaws in 3-4 rows; both unicuspid and bicuspid teeth on outer rows, those in inner rows tricuspid; 8-10 (mode=9.0) teeth in the outer row of left lower jaw. Konings (1990a) records 4-6 tooth rows on the upper jaw and 5-8 on the lower jaw in an irregular series. For the purposes of this study, incomplete rows were not counted. Dorsal fins with 15-17 spines and 8-9 rays; anal fin with 3 spines and 6-7 rays; caudal fin emarginate. Lateral scales ctenoid with 30-32 lateral-line scales, 0-2 pored scales posterior to hypural

Table 4. Morphometric and meristic characters of *Iodotropheus stuartgranti* (n=10; BMNH 1990-4-9:35-44).

	mean	standard dev.	range
Standard length, mm	67.8	11.4	46.7-81.7
Head length, mm	20.6	4.8	12.8-25.5
Percents of standard length			
Head length	30.2	3.7	23.2-33.8
Snout to dorsal-fin origin	34.8	1.4	33.3-37.3
Snout to pelvic-fin origin	41.4	0.8	40.4-43.0
Caudal-peduncle length	14.7	1.0	12.8-16.1
Least caudal-peduncle depth	12.1	0.6	11.1-13.1
Pectoral-fin length	22.5	1.3	19.9-23.9
Pelvic-fin length	24.3	3.4	16.7-28.7
Anterior dorsal to anterior anal	49.8	1.6	47.3-51.9
Posterior dorsal to posterior anal	16.6	3.5	14.6-23.2
Anterior dorsal to posterior anal	62.3	1.3	60.7-65.1
Posterior dorsal to anterior anal	29.7	1.5	27.7-32.1
Posterior dorsal to ventral caudal	17.5	0.8	16.1-18.7
Posterior anal to dorsal caudal	20.6	1.1	19.3-21.9
Anterior dorsal to pelvic-fin origin	33.8	1.8	31.2-37.8
Posterior dorsal to pelvic-fin origin	52.9	1.2	51.1-55.4
Percents of head length			
Horizontal eye diameter	30.6	6.4	25.1-42.4
Vertical eye diameter	29.9	6.2	23.7-42.4
Snout length	40.2	5.6	33.5-53.1
Postorbital head length	42.9	6.1	39.2-54.7
Preorbital depth	20.4	2.8	17.1-25.8
Cheek depth	26.3	4.4	19.6-36.4
Head depth	98.0	16.2	72.6-126.5
Counts	**mode**	**% freq.**	**range**
Lateral-line scales	31	50.0	30-32
Pored scales posterior to lateral line	2	80.0	0-2
Scale rows on cheek	4	90.0	3-4
Dorsal-fin spines	16	60.0	15-17
Dorsal-fin rays	9	80.0	8-9
Anal-fin rays	7	90.0	6-7
Pectoral-fin rays	13	90.0	13-14
Gill rakers on first ceratobranchial	8	50.0	7-10
Gill rakers on first epibranchial	2	70.0	2-3
Teeth in outer row of left lower jaw	9	80.0	8-10
Teeth rows on upper jaw	4	90.0	3-4
Teeth rows on lower jaw	4	90.0	3-4

plate, and 3-4 scale rows on cheek. First gill arch with 7-10 gill rakers on the ceratobranchial, 2-3 on epibranchial, and one between the epibranchial and ceratobranchial. Since no specimens were collected by the author, live color notes are not available, but see Konings (1990b: 267) for color photograph. As many as 7 ocelli are present on the anal fin.

Distribution. *Iodotropheus stuartgranti* inhabits the eastern coast of the Lake Malawi between the border of the Nsinje River and the Mozambique border (Konnings, 1990a).

Discussion

Iodotropheus currently is comprised of three species with disjunct distributions. All of the *Iodotropheus* species have a similar red/brown ground color. Moreover, some specimens in all populations have a well-developed frenum, or are in the process of developing one. Finally, certain specimens in all of the populations have unicuspid teeth in the outer rows of the upper and lower jaws. Whether tooth formation is under genetic control or a result of wear, as suggested by Oliver & Loiselle (1972), is unclear.

Clusters of each of the *Iodotropheus* species were formed by plotting the sheared second principal component of the morphometric data versus the first principal component of the meristic data (Fig. 3). There was no overlap between the clusters formed by *I. declivitas* and *I. stuartgranti*. The clusters formed by *I. declivitas* and *I. sprengerae* were significantly different (MANOVA; $p<0.05$).

The first principal component of the morphometric data is interpreted as a size component and the sheared components represent shape, independent of size (Humphries et al., 1981; Bookstein et al., 1985). Size accounts for 78.7 % of the observed variance of the PCA calculated using external measurements and the second principal component accounts for 7.4 %. The variables that have the highest loadings on the sheared second principal component are cheek depth, the caudal-peduncle length, the vertical eye diameter, distance between the posterior anal-fin insertion to the dorsal portion of the caudal fin, and distance between the posterior dorsal-fin insertion to posterior anal-fin insertion (Table 5). The first principal component of the meristic data explained 44.6 % of the total variance. The variables having the highest loadings on the first principal component are number of teeth rows on the upper and lower jaws, the

Table 5. Variable loadings on size and the second sheared principal components (shape factors) for *Iodotropheus declivitas, I. sprengerae*, and *I. stuartgranti*.

characters	size	sheared PC2
Standard length	0.204	0.133
Head length	0.207	-0.083
Snout length	0.233	0.167
Postorbital head length	0.194	0.034
Horizontal eye diameter	0.144	-0.161
Vertical eye diameter	0.144	-0.262
Preorbital depth	0.263	0.102
Cheek depth	0.313	-0.745
Head depth	0.232	-0.164
Snout to dorsal-fin origin	0.195	-0.007
Snout to pelvic-fin origin	0.256	0.154
Least caudal-peduncle depth	0.234	0.041
Caudal-peduncle length	0.178	0.290
Anterior dorsal to anterior anal	0.232	0.024
Anterior dorsal to posterior anal	0.223	0.067
Posterior dorsal to anterior anal	0.210	0.090
Posterior dorsal to posterior anal	0.194	0.222
Posterior dorsal to ventral caudal	0.220	0.146
Posterior anal to dorsal caudal	0.202	0.233
Posterior dorsal to pelvic-fin origin	0.204	0.043
Anterior dorsal to pelvic-fin origin	0.233	-0.086

Table 6. Standardized scoring coefficients on meristic data for *Iodotropheus declivitas, I. sprengerae*, and *I. stuartgranti*.

	Factor 1
Dorsal-fin spines	-0.194
Dorsal-fin rays	0.177
Anal-fin rays	0.155
Pectoral-fin rays	0.103
Lateral-line scales	0.025
Pored scales posterior to lateral line	0.130
Scale rows on cheek	0.010
Gill rakers on first ceratobranchial	0.021
Gill rakers on first epibranchial	0.096
Teeth in outer row of left lower jaw	0.208
Teeth rows on upper jaw	0.283
Teeth rows on lower jaw	0.247
Tooth forms (1 = unicuspid, 2 = bicuspid, 3 = both)	0.125

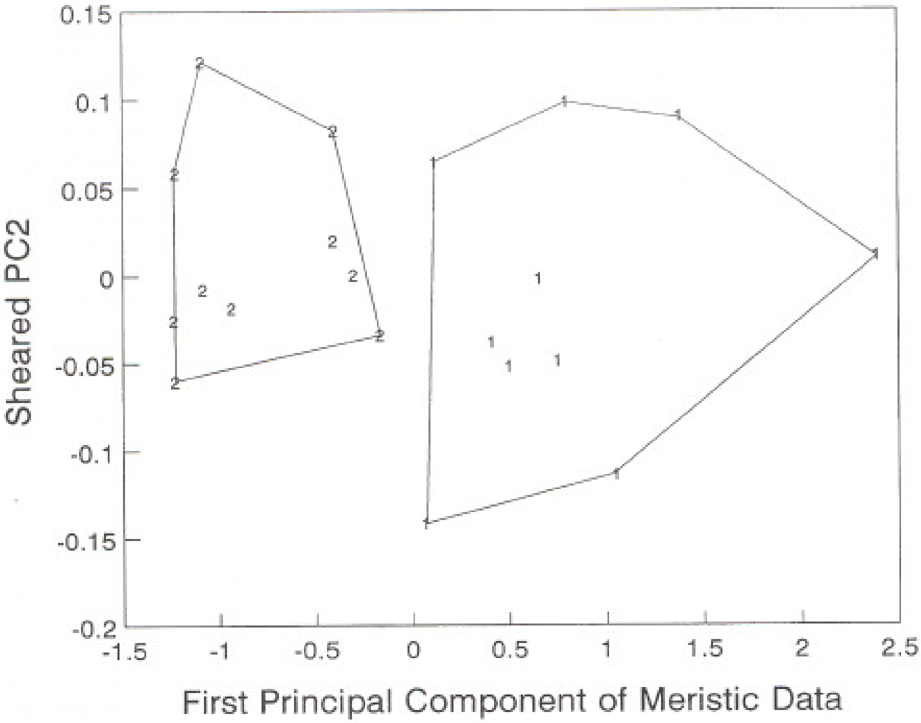

Fig. 9. Plot of individual sheared second principal component scores (morphometric data) and the first principal component scores (meristic data) of the lower pharyngeal bones of *Iodotropheus declivitas* (1, PSU 2725) and *I. sprengerae* (2, PSU 2720, PSU 2721).

number of teeth in outer row of left lower jaw, and the number of dorsal-fin spines (Table 6).

Iodotropheus declivitas (Table 1) is clearly morphologically distinct from *I. stuartgranti* (Table 4; Fig. 3). *Iodotropheus declivitas* and *I. sprengerae* are distinguished by morphology (Fig. 3) and by the dentition pattern on the pharyngeal bone (Fig. 9). *Iodotropheus sprengerae* (n=10) has fewer teeth on its pharyngeal bone than *I. declivitas* (n=10); in the posterior row, 12-16 versus 15-20, lateral row, 7-9 versus 8-13, and the transverse row, 5-6 versus 7-9. These two species are additionally distinguished on the basis of jaw dentition. All of the *I. sprengerae* examined have some unicuspid teeth on the outer row of either the upper or lowerjaw, and 52 % had no bicuspid teeth; by contrast, 50 % of *I. declivitas* possessed only bicuspid teeth, and only one specimen lacked any bicuspid teeth.

In the original description of *I. sprengerae*, Oliver & Loiselle (1972) state that this species had only been collected from Boadzulu Island. Only in the acknowledgments section do they state that the entire type series was comprised of aquarium-raised specimens donated by aquarists from Manhattan Beach, California; Los Gatos, California; and Virginia Beach, Virginia. A single specimen from unknown origin from Atlanta, Georgia was also included. The morphometric and meristic data undoubtedly demonstrate that this type series is phenetically more similar to populations from Chinyamwezi and Chinyankwazi islands than with the population from Boadzulu Island. Interviews with Stuart Grant, an exporter of ornamental fishes from Lake Malawi, reveal that the principal exporter of Malawian fishes in the early 1970's was collecting fishes at Chinyamwezi, Chinyankwazi, and Boadzulu islands. One of the authors (Oliver) of the original description dove at Boadzulu and observed *Iodotropheus* species, but no collections were made; thus it was assumed that these fish were *I. sprengerae* (Loiselle, pers. comm.). In fact, at the time of the description the presence of other populations of *Iodotropheus* species was not known by the authors (Loiselle, pers. comm.). It is most probable that some of the original brood stock of the type material came from Chinyamwezi and/or Chinyankwazi islands.

Morphological descriptions of aquarium-raised specimens are problematical because of the plasticity of haplochromine cichlids (Stauffer et al., in press). As noted by Konings (1990a: 123), *Iodotropheus* species in situ rarely, if ever, 'showed a frenum as distinctly as drawn in the original description (Oliver & Loiselle, 1972: 314, Fig. 4).' In aquaria, specimens develop a frenum only when they are held extended periods of time. The propensity for developing a frenum appears to have a genetic component; of the numerous specimens of *Pseudotropheus* cf. *zebra*, *Petrotilapia* spp., and *Melanochromis* spp. held and bred in my laboratory for several generations, none have shown signs of frenum development.

In order to preserve the name *I. sprengerae*, and hence the generic name *Iodotropheus*, I have petitioned the International Commission on Zoological Nomenclature to use their plenary powers to declare the current type collection invalid, because the specimens are from aquarium-raised fish whose geneology is not known and designate a neotype from the wild-caught specimens from Chinyankwazi Island.

Artificial key to the species of *Iodotropheus*

Iodotropheus is comprised of three species found in the southern end of Lake Malawi. Some individuals from all populations have a well-developed frenum. The presence of a frenum is weakly correlated with standard length, thus may be size-related. None of the other endemic Lake Malawi cichlid genera contain individuals with a frenum. All members of the genus have a rust/orange ground color. It is hypothesized that more species will be described that belong to this genus, especially as the Mozambique shoreline is more adequately sampled.

1. - Nine or more teeth on the left side of the lower jaw.
   .... *I. stuartgranti*

   - Less than nine teeth on the left side of the lower jaw.
   2

2. - Number of teeth in posterior row of lower pharyngeal bone 15-20, median row 8-13, and transverse row 7-9; majority of teeth in outer row of lower jar in most specimens bicuspid.
   .... *I. declivitas*

   - Number of teeth in posterior row of lower pharyngeal bone 12-16, median row 7-9, and transverse row 5-6; majority of teeth in outer row of lower jaw unicuspid.
   .... *I. sprengerae*

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