Description of a New Species in the *Pseudotropheus williamsi* Complex (Teleostei: Cichlidae), from Lake Malawi, Africa

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A new species of the cichlid genus *Pseudotropheus* Regan (Teleostei: Cichlidae), from Lake Malawi is described. The new species is a member of the *Pseudotropheus williamsi* complex from Mbenji Island. *Pseudotropheus williamsi* is the type species of the genus *Pseudotropheus*, which is a polyphyletic grouping of several species of rock-dwelling cichlids from Lake Malawi. In addition to the *P. williamsi* complex, *Pseudotropheus* contains species belonging to the *P. tropheops*, *P. elongatus*, and *Pseudotropheus* aggressive complexes, as well as a group of miscellaneous forms such as *Pseudotropheus fainzilberi*. We predict that *Pseudotropheus* eventually will be restricted taxonomically to include only members of the *P. williamsi* complex, but because of the lack of phylogenetic data on many of the miscellaneous forms (e.g., *P. fainzilberi*) we are currently unable to diagnose *Pseudotropheus* as monophyletic.

FISHES of the family Cichlidae have undergone rapid and extensive radiation in the lakes of East Africa, resulting in as many as 1500 species endemic to Lake Malawi (Stauffer et al., 1997). Trewavas (1935) hypothesized that nine genera (*Cyathochromis, Cynotilapia, Genyochromis, Christyella* (= *Gephyrochromis*), *Labeotropheus, Labidochromis, Melanochromis, Petrotilapia,* and *Pseudotropheus*) were more closely related to each other than to any other genera found in Lake Malawi. Malawian fishermen collectively refer to this group as mbuna (Fryer and Iles, 1972). Subsequently, Oliver and Loiselle (1972) added *Iodotropheus* to this group, and recently Stauffer et al. (1997) delineated *Metriaclima* from *Pseudotropheus*. Both morphologically and genetically, these 11 genera appear to more closely resemble each other than other genera that inhabit the lake (e.g., Ribbink et al., 1983; Moran et al., 1994; Albertson et al., 1999). Although to date there has been no formal taxonomic recognition of this group, they share the following suite of characters: (1) large number of small scales in the nape and chest region; (2) reduction of the left ovary; (3) abrupt transition from large flank scales to small chest scales; and (4) possession of true ocelli (Fryer, 1959).

Pseudotropheus williamsi was originally described by Günther and placed in the genus *Chromis*. Subsequently, Regan (1922:681) designated it as the type species of *Pseudotropheus*, which he diagnosed as follows: "Jaws with several series of teeth anteriorly, the outer bicuspid, the inner small and tricuspid, forming rather broad curved or travsverse bands; upper jaw with a series of conical teeth on each side posteriorly, more or less sharply differentiated, some or all larger than the last bicuspid teeth; lower jaw short and broad, with the lateral margin of the band of teeth incurved, and with a series of teeth on each side behind the band. Dorsal XVI–XIX 8–10. anal III 7–9. Scales denticulate."

The above diagnosis did not distinguish the *P. williamsi* complex, as evidenced by the fact that Regan's new genus also included *Melanochromis auratus* (Boulenger), *Metriaclima zebra* (Boulenger), *Pseudotropheus tropheops tropheops*, and *Pseudotropheus novemfasciatus* (Regan). Trewavas (1984) redescribed *P. williamsi* and Stauffer et al. (1997) diagnosed the complex based on (1) the lack an acutely sloping ethmo-vomerine block found in the subgenus *Tropheops* and the *Pseudotropheus elongatus* complex; and (2) a terminal mouth with a lower jaw that is parallel to a line from the hypural plate to the tip of the snout (Stauffer et al., 1997). Ribbink et al. (1983) recognized eight distinct populations of *P. c.f. williamsi*, but *P. williamsi* is the only described species. The purpose of this paper is to describe a new species of the *P. williamsi* complex from Mbenji Island in Lake Malawi.

MATERIALS AND METHODS

Adult fishes were collected by chasing them into a monofilament net while SCUBA diving. All measurements were made with dial calipers interfaced directly with a computer. External counts and measurements followed Barel et al. (1977) and Stauffer (1991) except that head depth was taken along the vertical through the posterior edge of the midpoint of the branchiostegal. The number of scales in the lateral line series excludes scales in the overlapping portion of the lower and upper lateral lines; pored scales located posterior to the hypural plate were recorded separately. Except for gill
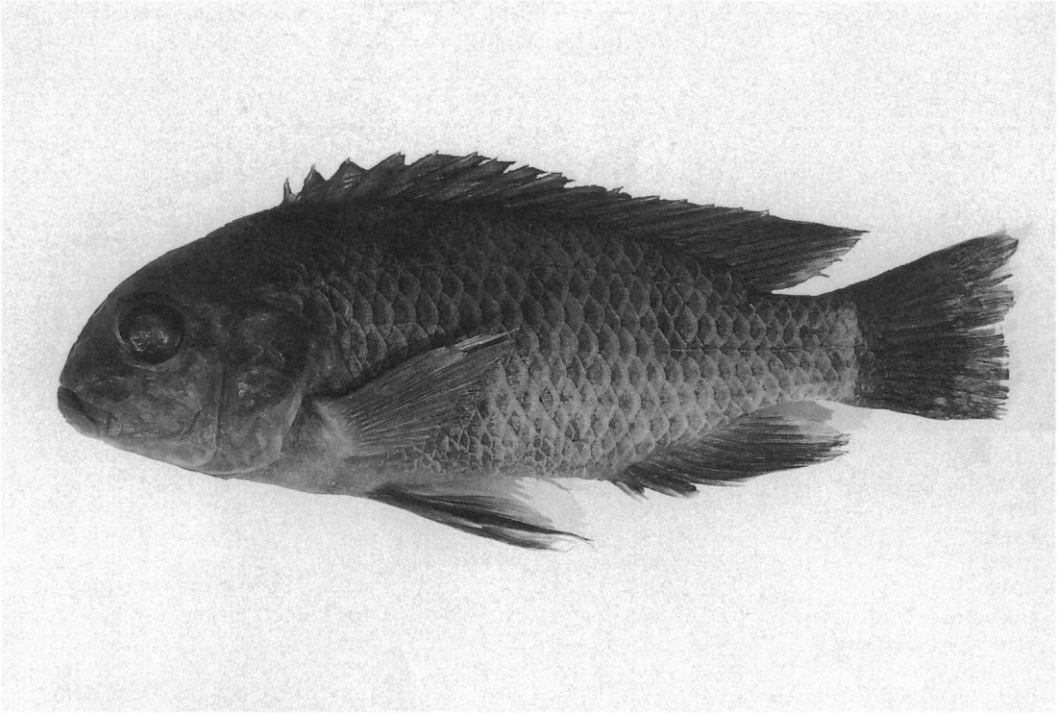
Fig. 1. Holotype (PSU 3380) of *Pseudotropheus galanos.*

raker meristics, all counts and measurements were made on the left side.

Differences in body shape of 10 individuals of the new species and the holotype of *P. williamsi* were analyzed using sheared principal component analysis (SPCA) of the morphometric data (Humphries et al., 1981; Bookstein et al., 1985). Meristic data were analyzed using principal component analysis (PCA) of the correlation matrix.

Pseudotropheus galanos n. sp.
Figure 1

Holotype.—PSU 3380, adult male, 87.4 mm SL, Mbenji Island, Lake Malawi, Malawi, Africa, 10 March, 1996.

Paratypes.—PSU 3379, 6 (69.9–88.1 mm SL); UMBC (University of Malawi, Bunda College) 0001, 3 (70.3–83.5 mm SL); data as for holotype.

Diagnosis.—The absence of an acutely sloped ethmo-vomerine block and a lower jaw that is parallel to a line from the tip of the snout to the hypural plate clearly places this species in the *P. williamsi* complex. The head depth of *P. galanos* (88.7–99.4% HL) is smaller than that of

P. williamsi (102% HL; Table 1). *Pseudotropheus galanos* has a larger eye (vertical eye diameter 27.3–32.2% HL) than *P. williamsi* (25.5% HL). Similarly, the body depth as reflected in PDPA, ADPA, and ADP2 (Table 2) was greater in *P. williamsi* than in *P. galanos* (Table 1). The holotype of *P. williamsi* had three rows of teeth on the lower jaw and eight dorsal fin rays, whereas the mode of the number of teeth rows on the lower jaw and dorsal fin rays in *P. galanos* was four (40.0%) and nine (50.0%), respectively (Table 3).

Description.—Jaws isognathous; teeth on jaws in 3–5 rows; majority of teeth in outer rows bicuspid; 13 teeth in outer row of left lower jaw of holotype, 11–14 in paratypes. Dorsal fin with 16 spines in the holotype and 16–17 in paratypes; dorsal fin rays 8–10. Pectoral fin rays 14; anal fin rays 8. Lower pharyngeal bone triangular in outline. Scales along flank ctenoid; holotype with 31 lateral line scales, 31–33 in paratypes. First ceratobranchial rakers 9–11, first epibranchial rakers 2–3, 1 between epibranchial and ceratobranchial (Table 3).

One-third of lateral dorsal portion of trunk of males with green ground color and blue highlights; ventral two-thirds blue with orange highlights; six faint vertical bars; belly white with

TABLE 1. MORPHOMETRIC VALUES OF *Pseudotropheus williamsi* AND *Pseudotropheus galanos*. Summary statistics ($n = 10$) include the holotype.

Counts	P. williamsi Holotype	P. galanos Holotype	Mean	Standard Deviation	Range
Standard length, mm	84.8	87.4	80.3	6.6	69.9–88.1
Head length, mm	27.9	30.8	26.9	2.3	23.2–30.8
Percent of standard length					
Head length	32.9	35.2	33.6	0.9	32.5–35.2
Snout to dorsal fin origin	36.5	37.2	37.5	0.9	36.4–39.4
Snout to pelvic fin origin	41.2	39.2	39.8	1.2	38.3–41.4
Pectoral fin length	22.4	25.4	24.5	0.9	23.3–25.6
Pelvic fin length	24.1	30.4	25.8	2.1	23.4–30.4
Dorsal fin base length	60.2	60.0	58.1	1.2	56.3–60.0
ADAA	54.7	51.9	50.7	0.9	49.5–52.1
PDPA	16.6	14.8	14.7	1.0	13.1–16.2
ADPA	64.8	62.9	61.7	1.1	59.6–63.4
PDAA	30.0	29.5	29.3	0.9	27.7–30.4
PDVC	19.1	18.3	17.3	0.7	16.3–18.3
PADC	19.9	18.7	19.4	0.5	18.6–20.2
ADP2	36.5	36.1	34.0	1.0	32.3–36.1
PDP2	49.7	54.7	53.6	1.2	51.0–54.8
Horizontal eye diameter	28.6	26.9	30.8	1.9	26.9–33.1
Vertical eye diameter	25.5	27.3	30.2	1.4	27.3–32.2
Snout length	40.8	43.8	42.5	2.2	39.7–47.6
Postorbital head length	41.2	40.6	41.8	0.7	40.6–42.5
Preorbital depth	20.1	22.7	22.4	1.3	20.7–24.5
Lower-jaw length	40.5	39.4	37.7	2.4	34.9–41.9
Cheek depth	27.8	28.3	27.3	0.9	25.6–28.4
Head depth	102.0	95.0	95.7	3.2	88.7–99.4

faint orange highlights. Head orange/brown with prominent dark green spot on posterior portion of the opercle. Ventral edge of cheek outlined in fluorescent blue; cheek with orange/brown and blue highlights. One flourescent green interorbital bar. Gular region yellow. Dorsal fin orange with black submarginal band. Caudal fin rays black; membranes yellow with blue highlights. Anal fin rays black; membranes between rays transparent with micromelanophores and four orange ocelli. Pelvic fin leading edge light blue; first two rays and membranes black; posterior rays and membranes clear with orange spots. Pectoral fin rays gray with clear membranes.

Females green laterally with blue highlights; black midlateral band and second black band between midlateral band and dorsal fin. Belly white with yellow and blue highlights. Color of head similar to that of male. Dorsal fin brown with dark gray submarginal band. Caudal fin gray; anal fin gray with no ocelli. Leading edge of pelvic fin light blue; first two rays and membranes black; remainder clear with orange highlights. Pectoral fins with gray rays and clear membranes.

The plot of the sheared second principal component of the morphological data versus the first principal component of the meristic data shows that there is no overlap between the type of *P. williamsi* with *P. galanos* (Fig. 2). The first principal component of the morphometric data is interpreted as a size component and the sheared components as shape, independent of size (Humphries et al., 1981; Bookstein et al., 1985). Size accounts for 85% of the observed variance and the second principal component accounts for 6%. The variables that had the highest loadings on the sheared second principal component are preorbital depth, vertical eye diameter, PDPA, and horizontal eye diameter (Table 4). The first principal component of the meristic data explains 27% of the total variance. The variables with the highest loading on the first principal component are teeth rows on the lower jaw, teeth rows on upper jaw, and number of dorsal fin rays (Table 5).

Etymology.—The name *galanos*, from the Greek meaning blue, was chosen based on the presence of blue highlights along the lateral sides of both males and females.

TABLE 2. DEFINITION OF ABBREVIATIONS FOR SELECTED
MORPHOMETRICS.

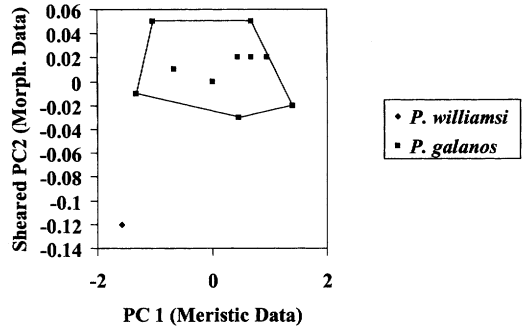| Abbreviation	Definition
ADAA	Distance between anterior insertion of dorsal fin to anterior insertion of anal fin.
PDPA	Distance between posterior insertion of dorsal fin to posterior insertion of anal fin.
ADPA	Distance between anterior insertion of dorsal fin to posterior insertion of anal fin.
PDAA	Distance between posterior insertion of dorsal fin to anterior insertion of anal fin.
PDVC	Distance between posterior insertion of dorsal fin to ventral insertion of caudal fin.
PADC	Distance between posterior insertion of anal fin to dorsal insertion of caudal fin.
ADP2	Distance between anterior insertion of dorsal fin to anterior insertion of pelvic fin.
PDP2	Distance between posterior insertion of dorsal fin to anterior insertion of pelvic fin.

Fig. 2. Plot of the sheared second principal component (morphometric data) and the first principal component (meristic data) for *Pseudotropheus galanos* and the holotype of *Pseudotropheus williamsi*.

DISCUSSION

Günther (1893), based on a single specimen (BMNH 1893.1.17.6), originally described *P. williamsi* in the genus *Chromis*. The type locality is listed simply as Lake Nyasa. Ribbink et al. (1983) recognized eight distinct populations of *Pseudotropheus* c.f. *williamsi* based on color patterns but did not postulate as to which populations represented the species described by Günther (1893). Konings (1995) suggested that the type specimen of *P. williamsi* might have come from the population that inhabits the northeastern coast of Likoma Island. It is obvious that detailed morphological, genetic, and behavioral data are needed to determine the relationships of the many undescribed species of *Pseudotropheus*. In cases where the type series consists of only one or two individuals, the details of the type locality are lacking, and when comprehensive color notes were not recorded, it may be impossible to identify the range of many of these previously described species.

The existence of only a single specimen of *P. williamsi*, prohibits us from accounting for intraspecific variation, when comparing the SPCA2 score of *P. williamsi* to the minimum polygon cluster formed by the type series of *P. galanos*

TABLE 3. MERISTIC VALUES OF *Pseudotropheus williamsi* AND *Pseudotropheus galanos*. Summary statistics ($n = 10$) include the holotype.

Counts	P. williamsi Holotype	P. galanos Holotype	Mode	% Freq.	Range
Lateral line scales	31	31	31	50	31–33
Pored scales posterior to lateral line	0	2	2	40	0–2
Scale rows on cheek	4	4	4	60	3–4
Dorsal fin spines	17	16	17	80	16–17
Dorsal fin rays	8	9	9	50	8–10
Anal fin spines	3	3	3	100	3–3
Anal fin rays	8	8	8	100	8–8
Pectoral fin rays	14	14	14	100	14–14
Pelvic fin rays	5	5	5	100	5–5
Gill rakers on first ceratobranchial	10	9	10	60	9–11
Gill raker on first epibranchial	3	2	2	60	2–3
Teeth in outer row of left lower jaw	11	13	13	40	11–14
Teeth rows on upper jaw	3	5	5	40	3–5
Teeth rows on lower jaw	3	5	4	40	3–5

TABLE 4. VARIABLE LOADINGS ON THE SIZE PRINCIPAL COMPONENTS AND SECOND PRINCIPAL COMPONENTS (SHAPE FACTOR) OF THE MORPHOMETRIC DATA FOR *Pseudotropheus williamsi* ($n = 1$) AND *Pseudotropheus galanos* ($n = 10$).

	Size	PC$_2$
Standard length	0.20	0.01
Head length	0.20	0.10
Snout length	0.23	0.23
Post orbital head length	0.18	0.12
Horizontal eye diameter	0.08	0.24
Vertical eye diameter	0.09	0.48
Head depth	0.23	-0.13
Preorbital depth	0.21	0.49
Cheek depth	0.21	0.15
Lower jaw length	0.31	-0.07
Snout to dorsal fin origin	0.17	0.10
Snout to pelvic fin origin	0.18	-0.13
Dorsal fin base length	0.24	-0.02
ADAA	0.25	-0.18
ADPA	0.23	-0.07
PDAA	0.22	-0.00
PDPA	0.26	-0.41
PDVC	0.27	-0.23
PADC	0.22	-0.02
PDP2	0.22	0.22
ADP2	0.25	-0.17

TABLE 5. VARIABLE LOADINGS ON THE FIRST PRINCIPAL COMPONENT OF THE MERISTIC DATA FOR *Pseudotropheus williamsi* AND *Pseudotropheus galanos*.

	PC$_1$
Dorsal spines	-0.04
Dorsal rays	0.48
Anal spines	0.00
Anal rays	0.00
Pelvic rays	0.00
Pectoral rays	0.00
Lateral line scales	0.17
Pored scales posterior to lateral line	0.18
Cheek scales	0.13
Gill rakers on first ceratobranchial	0.08
Gill rakers on first epibranchial	-0.05
Teeth in outer row of left lower jaw	0.19
Teeth rows on upper jaw	0.57
Teeth rows on lower jaw	0.57

(Fig. 2). Nevertheless, the fact that the variation within *P. galanos* is smaller than the variation between the two species, corroborates our hypothesis that these two forms are heterospecific.

Within the mbuna, *Pseudotropheus* is the most diverse and widespread genus, and is most certainly polyphyletic. Recently, Stauffer et al. (1997) diagnosed a new genus, *Metriaclima* based on the following two apomorphic characters of the skull: (1) moderately sloped ethmo-vomerine block; and (2) a swollen rostral tip of the neurocranium compared to other *Pseudotropheus* species. The choice of *Metriaclima* as the new generic name was confounded because Meyer and Foerster (1984) had earlier proposed the name *Maylandia* as a subgenus of *Pseudotropheus*, with *Pseudotropheus greshakei* as the type species. The use of *Maylandia* as a proposed subgenus of *Pseudotropheus* was not accompanied by either a diagnosis or a description; thus *Maylandia* is a nomen nudum (Stauffer et al., 1997; Konings and Geerts, 1999).

In addition to the *P. williamsi* complex, *Pseudotropheus* now contains species belonging to the subgenus *Tropheops* (Trewavas, 1984), *P. elongatus* complex, *P.* "aggressive" complex, and *P.* "miscellaneous" group (Ribbink et al., 1983) as well as *P. fainzilberi*. Both the *P. elongatus* com-

plex and the members of the subgenus *Tropheops* possess an acutely sloped ethmo-vomerine block (Stauffer et al., 1997). Reinthal (1990) showed that at least one member of the *P. elongatus* complex (*P. elongatus* "greenback") had one of the smallest supraoccipital crests relative to neurocranial length, but whether this character held for other members of the complex was not discussed. The *P. aggressive* species (e.g., *P. minutus* Fryer) and the *P. miscellaneous* group (e.g., *Pseudotropheus socolofi* Johnson), as designated by Ribbink et al. (1983), lack any apparent common morphological character; however, in all of the specimens that we examined, their mouth was elevated approximately 10–20° above a line parallel to one hypothetically drawn from the hypural plate to the tip of the snout. The placement of *P. fainzilberi* is problematic. Although it superficially resembles *M. zebra*, as do many *Cynotilapia* spp., its mouth shape and teeth position more closely resemble *Petrotilapa* species (Staeck, 1976; Stauffer et al., 1997). Reinthal (1993) treated all of these groups as genera, with the exception of *P. fainzilberi* in his distribution analysis. Thus, *Pseudotropheus* is certainly a polyphyletic genus and we hypothesize that eventually members of the *P. tropheops*, *P. elongatus*, and *P. aggressive* complexes will be placed in separate genera, based on apomorhic morphological characters. We also predict that *Pseudotropheus* will only contain members of the *P. williamsi* complex, but because of the lack of phylogenetic data on many of the groups, we are currently unable to diagnose monophyletic groups into which all species currently included in *Pseudotropheus* should be placed.

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