*Zootaxa* 2738: 1–25 (2011)
www.mapress.com/zootaxa/


**Article**

ISSN 1175-5326 (print edition)
**ZOOTAXA**
ISSN 1175-5334 (online edition)

# Descriptions of five new species in the genus *Metriaclima* (Teleostei: Cichlidae) from Lake Malawi, Africa

PATRICK J. CICCOTTO[1], ADRIANUS KONINGS[2] & JAY R. STAUFFER, JR.[3]

[1]*Department of Biological Sciences, University of Maryland Baltimore County, Baltimore MD, 21250, USA. E-mail: c76@umbc.edu*

[2]*Cichlid Press, El Paso, TX, 79913, USA. E-mail: info@cichlidpress.com*

[3]*School of Forest Resources, The Pennsylvania University, University Park, PA 16802, USA. E-mail: vc5@psu.edu*

## Abstract

Five new species of rock-dwelling cichlids from Lake Malawi are described. All five species phenotypically resemble *Metriaclima aurora* based on the absence of a black band in the dorsal fin and occupying the rock-sand interface of the lake. Differences in overall shape, meristics, and coloration distinguish these new species from each other and from previously described species within this group. The new species *Metriaclima glaucos, M. mossambicus, M. nkhunguensis,* and *M. xanthos* originate from the Mozambique coast of the lake, while *M. sciasma* is restricted to Tanzanian waters.

**Key words:** Cichlids, Lake Malawi, *Metriaclima*

## Introduction

The rock-dwelling haplochromine cichlids of Lake Malawi, collectively referred to as mbuna, are a diverse group of fishes consisting of twelve genera. The mbuna genus *Metriaclima* was originally described by Stauffer *et al.* (1997) to accommodate species in the *Pseudotropheus zebra* complex (Ribbink *et al.* 1983). The characters of the genus *Metriaclima* that distinguish it from other mbuna genera include a moderately-sloped ethmo-vomerine block with a swollen rostral tip, the presence of bicuspid teeth in the anterior portion of the outer row of both jaws, the lower jaw at a 45° angle to a line from the tip of the snout to the middle of the caudal peduncle (Stauffer *et al.* 1997), the lower jaw is often slightly longer and thicker than the upper jaw, a large part of the upper dental arcade is normally exposed when the mouth is closed, the tips of the teeth in the premaxilla and dentary are in a V-shaped line with the anteriormost in upper and lower jaw furthest apart, the placement of the bicuspid teeth in the outer row along the sides of the jaws does not follow the contour of the jaw bone, and the jaws are abducted to a near 180° angle during feeding so that the body is aligned at a perpendicular angle to the substrate to remove diatoms and loose algal strands from algae attached to the substrate (Konings & Stauffer 2006).

In addition to expanding the diagnosis of *Metriaclima*, Konings & Stauffer (2006) recognized three phenotypically similar assemblages within the genus: 1. a Blue-Black barred group associated with *M. zebra*, 2. a Black Dorsal group associated with *M. flavifemina*, and 3. an Aurora group associated with *M. aurora*. Both the Black Dorsal group and the Aurora group are found in the intermediate habitat along the coast of Lake Malawi, where the transition between rocks and sand occurs and are distinguished from one another by the presence or absence of a black band in the dorsal fins of males (Konings 2001). Males hold territories mainly over the sand near rocks and excavate beneath rocks to construct their spawning burrow. These species are most commonly found at depths of 3–20 m. The members of the Aurora group are characterized by their habitat preference (sand-rock interface), the absence of a black submarginal band in the dorsal fin, and by a light brown coloration of most females exhibiting no (or only faintly present) vertical bars and a yellow margin in the dorsal, anal, and caudal fins. Five described species were initially recognized as part of the Aurora group: *Metriaclima aurora, M. chrysomallos, M. benetos, M. hajomaylandi,* and *M. barlowi* (see Konings & Stauffer 2006), while putative members were recognized at several localities along the eastern shore of Lake Malawi in Malawi, Mozambique, and Tanzania (Fig. 1).

*Accepted by J. Friel: 15 Dec. 2010; published: 12 Jan. 2011*

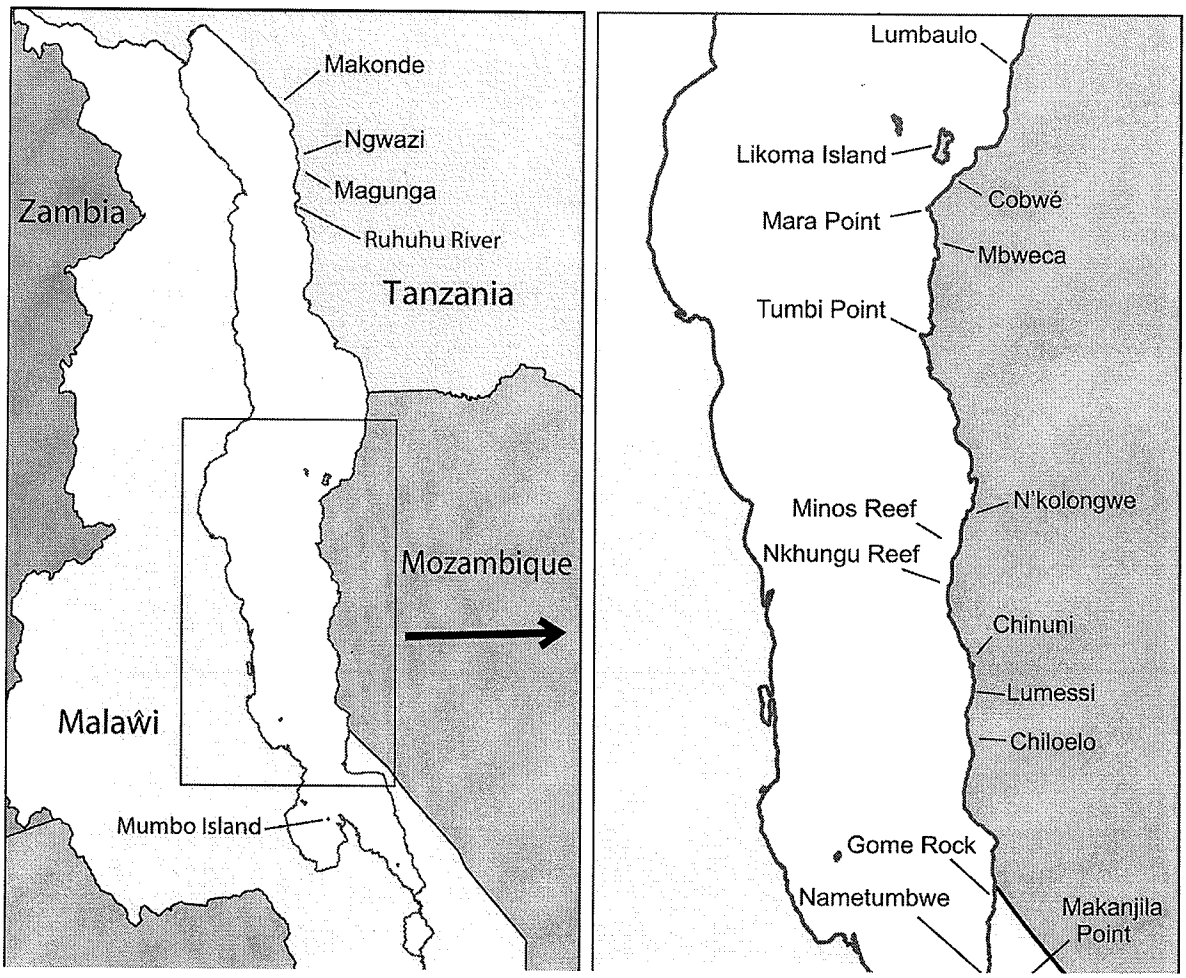


**FIGURE 1.** Map of Lake Malawi showing the locations of species discussed throughout the text.

Species in the genus *Metriaclima*, as well as species of other mbuna genera, are often differentiated based on coloration and morphology (Stauffer *et al.* 1997; Genner & Turner 2005). Coloration has been shown to be a major factor in mate recognition and selection among the mbuna (Fryer 1959; Stauffer & Van Snik 1996; Knight & Turner 2004) and unique color patterns are recognized to be sufficient to diagnose valid species (Barlow 1974; Barel *et al.* 1977; Stauffer *et al.* 1995). It is difficult to determine whether allopatric populations that differ in color are hetero- or conspecific, if similarities in behavioral, ecological, and morphological characteristics are observed. Multivariate statistical analyses of morphometric and meristic characters have generally been accepted in further distinguishing between species similar in morphology (Bowers & Stauffer 1993). The purpose of this paper is to describe five new species in the genus *Metriaclima* identified as several populations of the Aurora group (*M.* sp. "aurora blue", *M.* sp. "aurora lumbaulo", *M.* sp. "aurora north", *M.* sp. "blue reef", *M.* sp. "aurora chinuni", *M.* sp. "aurora yellow", and *M.* sp. "aurora blacktail"; Konings 2007) through an examination of morphometric and meristic data.

## Material and methods

Fishes were collected while SCUBA diving, using monofilament nets for capture. The pigmentation patterns of males and females were recorded in the field prior to preservation. Variations of color patterns for each population collected are reported in the descriptions by placing a slash between two colors to designate the pigmentation is

either one of the two reported colors or intermediate between the two. Fishes were anesthetized with clove oil, preserved in 10% formalin with fins pinned erect, and later transferred into 70% ethanol for permanent storage. External measurements and counts follow Barel *et al.* (1977) and Konings & Stauffer (2006). In the pectoral fin, all rays were counted including the small splinter on the upper edge. Measurements and counts were made on the left side of the fish, with the exception of gill-raker counts. The size of specimens is reported as standard length (SL) in mm. Institutional abbreviations follow Leviton *et al.* (1985), except UMBC, University of Malaŵi, Bunda College.

To examine differences in body shape among neighboring populations or species, sheared principal component analysis of the morphometric data was used in which the covariance matrix was factored (Humphries *et al.* 1981; Bookstein *et al.* 1985). The meristic data were analyzed through a principal component analysis, in which the correlation matrix was factored. The first principal components of the meristic data were plotted against the sheared second principal components of the morphometric data. If the minimum polygon clusters did not differ along one axis ($p<0.05$), independent of the other, a MANOVA in conjunction with a Hotelling-Lawley trace was used to determine if the clusters were significantly different. If however the mean multivariate scores were significantly different ($p<0.05$) along one axis independent of the other, a Duncan's Multiple Range Test was used to determine differences among the clusters (Stauffer *et al.* 1997).

Cichlids are substrate-oriented fishes that will not cross open water or large tracts of unsuitable habitat, limiting their exploratory movements along coastlines. It is thus assumed that when genetic exchange exists between allopatric populations it is between neighboring populations and not significantly between populations that are separated by geographically large distances or separated by populations of congenerics in similar habitats. We have therefore limited our comparisons to populations of the Aurora group in which genetic exchange may have occurred and disregarded those in which such is highly unlikely. Therefore, it was only necessary to compare the new species with *Metriaclima aurora* and *M. chrysomallos* populations.

**Comparative material:** *Metriaclima benetos*. PSU 3058, holotype; PSU 3059, 9, USNM 349125, 3; ANSP 176199, 3; MFU 28, 3; 59.7–81.4 mm SL; Malaŵi: Lake Malaŵi: Manzinzi Reef.

*Metriaclima callainos*. PSU 2542.1, PSU 2542.2, MFU 2, USNM 322426, 60.5–80.1 mm SL; Malaŵi: Lake Malaŵi: Nkhata Bay, May 1988.

### *Metriaclima aurora* (Burgess 1976)

Fig. 2A&B

**Coloration.** Lateral body coloration blue dorsally in males from Likoma Island, Mara Point North, and N'kolongwe, but brown dorsally in males from Mbweca and Tumbi Point, with anterior portion of scales sky-blue and 6 faint blue bars below dorsal fin; caudal peduncle dark blue; yellow belly and breast fading to light blue towards anal fin. Head sky-blue with preorbital, ventral half of cheek, operculum, and preoperculum yellow; dark yellow/green opercular spot; gular yellow. Dorsal fin yellow with submarginal sky-blue band and sky-blue blotches throughout. Caudal-fin rays yellow with light-blue membranes. Anal fin pale blue to pale yellow with one ocellus. Pelvic fin with light-blue leading edge, remaining yellow. Pectoral-fin rays pale yellow and membranes clear.

Female lateral ground coloration pale blue with center of scales orange/brown; belly white. Head brown; cheek and operculum with purple highlights; gray/black opercular spot; white gular. Dorsal fin brown with brown lappets. Caudal-fin rays brown with clear membranes. Anal fin gray proximally and brown distally with single small orange/brown ocellus. Pelvic fin with white leading edge; first two rays and membranes brown, remainder clear. Pectoral fin clear.

**Remarks.** Morphometric and meristic data for populations from Likoma Island, Mara Point, Mbweca, Tumbi Point, and N'kolongwe in Table 1. The lack of a black submarginal band in the dorsal fin, a yellow ventral half of the head, breast, and dorsal fin, and the light-brown colored females that have yellow fin-margins distinguish *Metriaclima aurora* from most members of the genus, except *M. hajomaylandi, M. chrysomallos*, and *M. xanthos*. *Metriaclima aurora* differs from *M. hajomaylandi* and *M. chrysomallos* by fewer (faint) vertical bars below the dorsal fin (6 vs. 7–9) and from *M. xanthos* by a shorter lower jaw (mean 31.2, range 28.4–33.5 % HL vs. mean 35.4, range 34.6–36.7).

**TABLE 1.** Morphometric and meristic values of *Metriaclima aurora* from Likoma Island, Mara Point, Mbweca, Tumbi Point, and N'kolongwe.

| | All | | Likoma Island n=17 | | Mara Point n=20 | |
|---|---|---|---|---|---|---|
| | mean | holotype | mean | range | mean | range |
| Standard length, mm | 70.4 | 80.5 | 76.7 | 69.2–83.8 | 66.5 | 53.4–81.7 |
| Head length, mm | 21.7 | 24.9 | 24 | 21.9–25.8 | 20.4 | 16.3–25.5 |
| Percentage of standard length | | | | | | |
| Head length | 30.8 | 30.9 | 31.3 | 29.9–32.7 | 30.6 | 29.3–32.3 |
| Snout to dorsal | 33.8 | 32.9 | 33.6 | 32.0–35.1 | 33.7 | 31.3–35.9 |
| Snout to pelvic | 38.1 | 40.3 | 39.4 | 37.6–42.2 | 38.3 | 36.6–40.1 |
| Greatest body depth | 32.6 | 30.4 | 31.3 | 29.5–33.2 | 33.2 | 31.2–36.0 |
| Caudal peduncle length | 14.3 | 15.4 | 13.9 | 12.2–15.4 | 14.2 | 13.2–15.6 |
| Least caudal peduncle depth | 11.7 | 11.1 | 11.9 | 10.8–13.0 | 11.8 | 10.9–12.8 |
| Dorsal-fin base length | 60.1 | 61.5 | 60 | 57.3–61.5 | 60 | 57.1–61.9 |
| Anterior dorsal to anterior anal | 52.4 | 53.2 | 52.9 | 50.1–56.5 | 52.7 | 51.1–54.9 |
| Anterior dorsal to posterior anal | 63.6 | 63.8 | 63.5 | 60.6–66.6 | 63.7 | 61.3–65.8 |
| Posterior dorsal to anterior anal | 29.4 | 29.9 | 29 | 27.0–30.7 | 29.5 | 27.5–30.9 |
| Posterior dorsal to posterior anal | 15.0 | 16.3 | 14.4 | 12.5–16.3 | 15.1 | 13.5-16.4 |
| Anterior dorsal to pelvic-fin origin | 36.0 | 34.4 | 34.6 | 32.5–36.7 | 36.5 | 33.4–39.9 |
| Posterior dorsal to pelvic-fin origin | 57.4 | 53.2 | 54.3 | 49.5–56.2 | 58 | 56.1–60.6 |
| Percentage of head length | | | | | | |
| Horizontal eye diameter | 37.0 | 36.6 | 37.6 | 35.5–39.8 | 36.8 | 35.1–38.1 |
| Vertical eye diameter | 36.8 | 36.4 | 37.2 | 34.9–40.3 | 36.5 | 33.3–38.2 |
| Snout length | 26.9 | 29.8 | 26.4 | 23.7–29.8 | 25.5 | 23.4–27.9 |
| Postorbital head length | 39.3 | 39 | 38.5 | 37.2–39.8 | 39.1 | 36.9–41.6 |
| Preorbital depth | 21.8 | 26.4 | 21 | 18.6–26.4 | 20.7 | 18.6–23.7 |
| Lower-jaw length | 31.2 | 30.2 | 30.7 | 29.2–32.5 | 32 | 30.5–33.5 |
| Cheek depth | 23.1 | 23.8 | 24.1 | 20.2–26.2 | 22.1 | 18.8–25.4 |
| Head depth | 86.8 | 85.2 | 82.5 | 75.8–87.2 | 87.9 | 79.9–94.5 |
| Meristics | mode | | mode | range | mode | range |
| Dorsal-fin spines | 18 | 17 | 18 | 17–18 | 18 | 17–19 |
| Dorsal-fin rays | 9 | 9 | 9 | 8–10 | 9 | 8–10 |
| Anal-fin spines | 3 | 3 | 3 | 3–3 | 3 | 3–3 |
| Anal-fin rays | 8 | 8 | 8 | 7–8 | 8 | 7–8 |
| Pelvic-fin rays | 5 | 5 | 5 | 5–5 | 5 | 5–5 |
| Pectoral-fin rays | 14 | 14 | 14 | 14–15 | 14 | 13–14 |
| Lateral line scales | 31 | 31 | 30, 31 | 29–32 | 31 | 30–33 |
| Pored scales posterior to lateral line | 2 | 2 | 0 | 0–2 | 2 | 0–2 |
| Cheek scales | 4 | 4 | 4 | 4–5 | 4 | 4–5 |
| Gill rakers on first ceratobranchial | 12 | 11 | 12 | 10–13 | 11 | 10–13 |
| Gill rakers on first epibranchial | 3 | 3 | 3 | 3–4 | 3 | 2-4 |
| Teeth in outer row of left lower jaw | 20 | 17 | 22 | 17–26 | 18 | 12–25 |
| Teeth rows on upper jaw | 3 | 3 | 3 | 3–4 | 3 | 3–4 |
| Teeth rows on lower jaw | 3 | 4 | 4 | 3–4 | 3 | 3–4 |

continued.

| | Mbweca n=19 | | Tumbi Point n=20 | | N'kolongwe n=20 | |
|---|---|---|---|---|---|---|
| | mean | range | mean | range | mean | range |
| Standard length, mm | 70.7 | 55.3–79.7 | 71.3 | 60.8–79.3 | 67.8 | 59.2–75.2 |
| Head length, mm | 21.8 | 16.8–24.6 | 21.8 | 18.3–24.5 | 21 | 18.3–22.7 |
| Percentage of standard length | | | | | | |
| Head length | 30.8 | 29.5–31.9 | 30.5 | 28.9–32.4 | 31 | 29.7–33.0 |
| Snout to dorsal | 33.5 | 31.3–34.9 | 33.7 | 31.9–36.3 | 34.6 | 33.1–37.4 |
| Snout to pelvic | 37.3 | 34.1–41.4 | 38.1 | 36.2–40.3 | 37.8 | 36.4–39.6 |
| Greatest body depth | 33.2 | 31.2–35.5 | 32.6 | 30.2–34.9 | 32.7 | 30.2–35.6 |
| Caudal peduncle length | 14.8 | 13.7–16.2 | 14.2 | 12.3–16.5 | 14.4 | 12.6–15.8 |
| Least caudal peduncle depth | 11.8 | 11.2–12.5 | 11 | 10.5–11.7 | 11.9 | 11.3–13.0 |
| Dorsal-fin base length | 60.5 | 58.7–62.6 | 60.3 | 57.3–62.0 | 59.8 | 56.8–61.4 |
| Anterior dorsal to anterior anal | 52.1 | 50.7–54.2 | 51.5 | 48.8–54.3 | 53.1 | 51.4–55.4 |
| Anterior dorsal to posterior anal | 63.7 | 61.9–65.6 | 63.5 | 60.5–65.3 | 63.6 | 60.2–65.7 |
| Posterior dorsal to anterior anal | 29.6 | 28.3–30.9 | 29.5 | 27.7–30.7 | 29.4 | 27.5–31.4 |
| Posterior dorsal to posterior anal | 15 | 14.3–16.0 | 14.9 | 13.7–16.0 | 15.7 | 14.6–17.1 |
| Anterior dorsal to pelvic-fin origin | 36.2 | 33.6–39.5 | 36 | 33.0–38.4 | 36.6 | 34.5–39.3 |
| Posterior dorsal to pelvic-origin | 57.7 | 54.0–59.7 | 58.4 | 55.7–59.9 | 58 | 55.3–60.2 |
| Percentage head length | | | | | | |
| Horizontal eye diameter | 38 | 35.6–40.3 | 36.8 | 34.8–38.9 | 36 | 32.3–39.6 |
| Vertical eye diameter | 38.1 | 35.1–39.8 | 36.7 | 34.5–38.7 | 35.9 | 33.0–38.8 |
| Snout length | 27.6 | 25.4–30.1 | 27.7 | 25.1–30.5 | 27.3 | 23.7–29.9 |
| Postorbital head length | 38.3 | 36.4–40.0 | 38.9 | 37.0–40.7 | 41.5 | 39.0–44.2 |
| Preorbital depth | 23.3 | 20.4–26.0 | 23 | 20.7–25.7 | 20.8 | 19.0–23.8 |
| Lower-jaw length | 30.9 | 28.4–32.1 | 31.2 | 28.9–33.1 | 31.2 | 28.6–32.6 |
| Cheek depth | 23.2 | 19.8–25.9 | 22.8 | 21.1–25.1 | 23.4 | 20.2–26.2 |
| Head depth | 85.4 | 81.7–90.6 | 90.4 | 84.3–95.4 | 87.3 | 80.3–94.1 |
| Meristics | mode | range | | range | mode | range |
| Dorsal-fin spines | 18 | 17–18 | 18 | 17–18 | 18 | 17–19 |
| Dorsal-fin rays | 8,9 | 8–10 | 9 | 8–10 | 8 | 8–9 |
| Anal-fin spines | 3 | 3–4 | 3 | 3–4 | 3 | 3–3 |
| Anal-fin rays | 8 | 7–8 | 8 | 7–8 | 8 | 7–8 |
| Pelvic- fin rays | 5 | 5–5 | 5 | 5–5 | 5 | 5–5 |
| Pectoral- fin rays | 14 | 14–15 | 14 | 13–15 | 14 | 13–15 |
| Lateral line scales | 31 | 30–33 | 30 | 30–32 | 31 | 29–32 |
| Pored scales posterior to lateral line | 2 | 0–2 | 2 | 0–2 | 2 | 0–2 |
| Cheek scales | 5 | 3–5 | 4 | 4–6 | 5 | 4–7 |
| Gill rakers on first ceratobranchial | 12 | 10–13 | 12 | 11–13 | 12 | 10–14 |
| Gill rakers on first epibranchial | 3 | 2-5 | 3 | 2–4 | 3 | 2–4 |
| Teeth in outer row of left lower jaw | 20 | 16–25 | 18, 19, 21 | 17–23 | 20 | 16–25 |
| Teeth rows on upper jaw | 3 | 3–4 | 3 | 3–4 | 3 | 3–4 |
| Teeth rows on lower jaw | 3 | 3–4 | 3 | 3–4 | 4 | 3–4 |

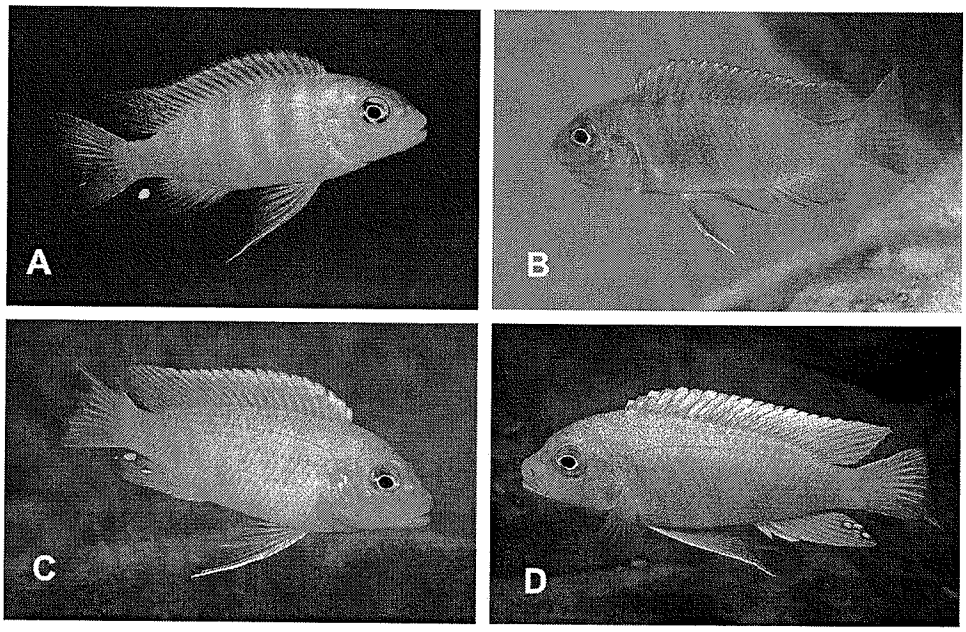


**FIGURE 2.** A. *Metriaclima aurora*, male in habitat at Likoma Island, Malaŵi; approx. 80 mm SL; not preserved; B. *M. aurora*, female in habitat at Likoma Island, Malaŵi; approx. 70 mm SL; not preserved; C. *M. chrysomallos*, male in habitat at Nametumbwe, Malaŵi; approx. 80 mm SL; not preserved; D. *M. chrysomallos*, male in habitat at Gome, Malaŵi; approx. 80 mm SL; not preserved.

**Distribution.** *Metriaclima aurora* is distributed at Likoma Island (type locality) and along the coast of Mozambique at Mara Point, Mbweca, Tumbi Point, and a relatively isolated location to the south near N'kolongwe (Fig. 1). Mbweca and Tumbi Point are the only localities where the brown-barred males are found. Populations have been transplanted to Thumbi West Island, where the species has spread to several locations around Cape Maclear (Stauffer & Hert 1992; Konings 2001).

**Material examined.** USNM 215292, holotype; USNM 215293, 16; 69.2–83.8 mm SL; Malaŵi: Lake Malaŵi: probably Likoma Island; J. Freiberg, 5 May 1976. — PSU 4480, 20; 53.4–81.7 mm SL; Mozambique: Lake Malaŵi: Mara Point North, 12° 11.254' S, 34° 41.968' E; A.F. Konings & J.R. Stauffer, 17 Feb 2002. — PSU 4481, 19; 55.3–79.7 mm SL; Mozambique: Lake Malaŵi: Mbweca, Lake Malaŵi, 12° 17.513' S, 34° 42.392' E; A.F. Konings & J.R. Stauffer, 28 Feb 2006. — PSU 4482, 20; 60.8–79.3 mm SL; Mozambique: Lake Malaŵi: Tumbi Point, 12° 20.297' S, 34° 41.853' E; A.F. Konings & J.R. Stauffer, 17 Feb 2002. — PSU 4483, 20; 59.2–75.2 mm SL; Mozambique: Lake Malaŵi: N'kolongwe, 12° 47.671' S, 34° 47.159' E; A.F. Konings & J.R. Stauffer, 16 Feb 2002.

### *Metriaclima chrysomallos* Stauffer, Bowers, Kellogg & McKaye 1997

Fig. 2C&D

**Coloration.** Lateral body coloration of breeding males from populations at type locality (Mumbo Island) and from Malaŵian east coast between Nsinje River and Makanjila Point light blue with gold highlights and 7–9 faint bars below dorsal fin, fading to white ventrally; breast orange fading to white at pelvic fin. Dorsal half of head, operculum, and cheek light blue; ventral portions orange/yellow; snout orange. Dorsal fin pale blue, posterior membranes orange distally. Caudal-fin rays orange with clear membranes. Anal-fin rays blue/gray with 2 orange ocelli. Distal portion of pelvic fin orange, remaining clear. Pectoral fin clear.

Females brown/gray with light-blue highlights laterally; belly white. Head dark brown with blue/green highlights, gray/black opercular spot, and white gular. Dorsal fin brown. Caudal-fin rays brown and membranes clear. Anal-fin rays brown with clear membranes. Leading edge of pelvic fin white, rays brown; membranes clear. Pelvic fins clear.

**TABLE 2.** Morphometric and meristic values of *Metriaclima chrysomallos* from Nametumbwe and Gome.

| | all | Nametumbwe | | Gome | |
|---|---|---|---|---|---|
| | | n=20 | | n=20 | |
| | mean | mean | range | mean | range |
| Standard length, mm | 67.5 | 65.1 | 53.6–71.9 | 69.9 | 58.4–79.6 |
| Head length, mm | 21.2 | 20.6 | 16.7–22.6 | 21.8 | 18.7–23.9 |
| Percentage of standard length | | | | | |
| Head length | 31.4 | 31.6 | 30.0–32.8 | 31.3 | 29.9–32.8 |
| Snout to dorsal | 33.4 | 33.4 | 30.7–35.7 | 33.3 | 31.1–34.8 |
| Snout to pelvic | 37.9 | 37.9 | 36.5–39.8 | 38.0 | 35.5–40.1 |
| Greatest body depth | 33.1 | 33.5 | 31.8–36.0 | 32.7 | 30.7–35.2 |
| Caudal peduncle length | 13.6 | 13.5 | 12.1–14.6 | 13.7 | 12.5–15.1 |
| Least caudal peduncle depth | 12.3 | 12.1 | 11.2–13.1 | 12.5 | 11.5–13.2 |
| Dorsal-fin base length | 61.4 | 61.4 | 58.9–63.0 | 61.4 | 58.8–64.5 |
| Anterior dorsal to anterior anal | 53.0 | 52.9 | 50.5–54.6 | 53.1 | 51.0–55.0 |
| Anterior dorsal to posterior anal | 64.2 | 64.0 | 62.3–65.9 | 64.3 | 61.5–66.7 |
| Posterior dorsal to anterior anal | 29.6 | 29.5 | 28.4–31.2 | 29.7 | 27.8–31.4 |
| Posterior dorsal to posterior anal | 15.0 | 14.7 | 13.9–16.0 | 15.3 | 14.1–16.1 |
| Anterior dorsal to pelvic-fin origin | 36.5 | 37.2 | 35.1–39.2 | 35.9 | 33.3–38.2 |
| Posterior dorsal to pelvic-fin origin | 57.9 | 58.5 | 56.3–60.1 | 57.2 | 54.7–59.0 |
| Percentage of head length | | | | | |
| Horizontal eye diameter | 35.5 | 36.9 | 35.1–39.1 | 34.2 | 31.7–36.7 |
| Vertical eye diameter | 35.4 | 36.9 | 34.0–39.4 | 33.8 | 31.8–35.9 |
| Snout length | 25.7 | 24.5 | 20.3–27.3 | 26.9 | 23.5–29.9 |
| Postorbital head length | 39.0 | 38.4 | 37.0–39.9 | 39.7 | 37.8–41.5 |
| Preorbital depth | 20.3 | 19.6 | 16.5–22.2 | 20.9 | 18.4–24.2 |
| Lower-jaw length | 32.1 | 32.0 | 29.6–33.8 | 32.1 | 29.6–34.2 |
| Cheek depth | 23.9 | 22.7 | 17.8–25.4 | 25.1 | 20.6–28.4 |
| Head depth | 86.4 | 86.2 | 80.4–91.0 | 86.6 | 79.9–93.3 |
| Meristics | mode | mode | range | mode | range |
| Dorsal-fin spines | 18 | 18 | 17–19 | 18 | 16–19 |
| Dorsal-fin rays | 9 | 9 | 8–10 | 9 | 8–9 |
| Anal-fin spines | 3 | 3 | 3–3 | 3 | 3–3 |
| Anal-fin rays | 8 | 8 | 7–8 | 8 | 7–9 |
| Pelvic-fin rays | 5 | 5 | 5–5 | 5 | 5–5 |
| Pectoral-fin rays | 14 | 14 | 14–15 | 14 | 14–15 |
| Lateral line scales | 31 | 31 | 30–32 | 31 | 30–32 |
| Pored scales posterior to lateral line | 2 | 0, 2 | 0–2 | 2 | 0–2 |
| Cheek scales | 4 | 4 | 3–6 | 4, 5 | 4–5 |
| Gill rakers on first ceratobranchial | 12 | 12 | 10–12 | 12 | 9–13 |
| Gill rakers on first epibranchial | 3 | 3 | 2–3 | 3 | 2–4 |
| Teeth in outer row of left lower jaw | 22 | 21, 22 | 15–24 | 22 | 19–25 |
| Teeth rows on upper jaw | 3 | 3 | 3–4 | 3 | 3–4 |
| Teeth rows on lower jaw | 3 | 3 | 3–4 | 3 | 3–4 |

At Gome, lateral body coloration of breeding males light blue, with 7–9 faint bars below dorsal fin. Head light blue with gray highlights; interorbital area gray with 1 blue bar; gular white with yellow blotches. Dorsal fin gray proximally, fading to white distally. Caudal-fin rays clear with blue membranes. Anal-fin rays gray with light blue/white membrane and 2 orange ocelli. Leading edge of pelvic fin white, rays clear; first 2 membranes gray, remaining clear. Pectoral fin clear. Females same as in other populations.

**Remarks.** Morphometric and meristic data for Nametumbwe and Gome populations in Table 2. The absence of a black submarginal band in the dorsal, a lack of distinct vertical bars, and the light-brown colored females that have yellow fin-margins distinguish this species from most other *Metriaclima*, except *M. benetos, M. glaucos* new species, and *M. mossambicus* new species. Male *M. chrysomallos* from Mumbo Island and Nametumbwe are distinguished from those of the latter three species, except the Lumessi population of *M. mossambicus*, by a sky-blue nape and a yellow/orange ventral half of the head. *Metriaclima chrysomallos* is distinguished from males of the Lumessi population of *M. mossambicus* by a blue dorsal fin, which is yellow in latter species. Males of the Gome population of *M. chrysomallos* (which are all light blue and have a white-blue pectoral-fin base) are distinguished from those of *M. glaucos* and *M. benetos* and those of *M. nkhunguensis* by the absence of orange/yellow pigment in the base of the pectoral fin. In addition, males of *M. benetos* possess some degree of black pigment between the eyes and in the iris. On the basis of coloration, females of a number of species in the Aurora group are indistinguishable from each other, but those of *M. aurora* have fewer and broader bars below the dorsal (6 vs. 7–9) and those of *M. glaucos* generally have fewer teeth in the outer row of the lower left jaw compared to those of *M. chrysomallos* (mode 16, range 14–19, vs. mode 21/22, range 15–24).

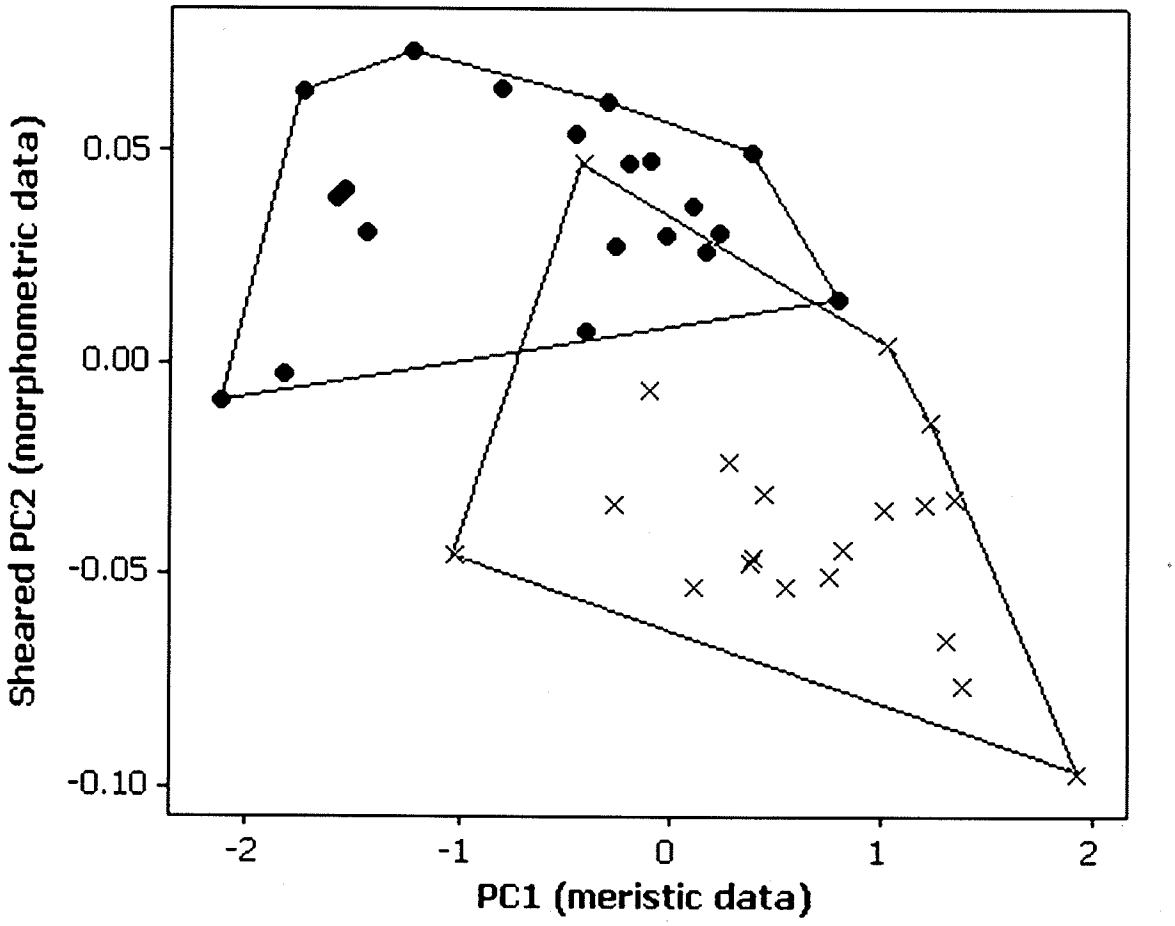


**FIGURE 3.** Plot of the first principal component of the meristic data (PC1) and the sheared second principal component of the morphometric data (PC2) of *Metriaclima chrysomallos* from Nametumbwe (•) and *M. aurora* from N'kolongwe (x).

In the populations at Mumbo Island and Nametumbwe, males possess the orange coloration on the ventral portions of the head and breast to some extent. At Gome, *Metriaclima chrysomallos* males lack the orange coloration on the head, breast, and posterior portion of the dorsal fin and at Ntekete, south of the Nsinje River, all-blue males occur sympatrically with those with orange ventral heads and with those that have varying degrees of yellow coloration.

The population of *Metriaclima chrysomallos* at Nametumbwe is similar in male color pattern to *M. aurora* from Likoma Island with the main difference being the number of vertical bars below the dorsal fin (7–9 vs. 6) and the yellow dorsal fin in *M. aurora*. In Figure 3 the Nametumbwe population of *M. chrysomallos* is compared to the nearest population of *M. aurora* (N'kolongwe) in a principal component analysis. The minimum polygon clusters formed by *M. aurora* and *M. chrysomallos* overlap, but are significantly ($p<0.05$; MANOVA) different.

Size accounts for 81.7% of the observed variance and the second principal component accounts for 5.4%. Variables with the highest loadings on the sheared second principal components are snout length (-0.40), caudal peduncle length (-0.38), and lower jaw length (0.32). Snout length, expressed as percent head length, is generally larger in *M. aurora* from N'kolongwe (mean 27.3, range 23.7–29.9) compared to *M. chrysomallos* from Nametumbwe (mean 24.5, range 20.3–27.3). The first principal component of the meristic data accounts for 20.5% of the total variance. Variables with the highest loadings on the first principal component are pored scales posterior to the lateral line (0.27), dorsal spines (0.24), and teeth rows on the lower jaw (0.24).

**Distribution.** Stauffer *et al.* (1997) originally described this species from Mumbo Island, but it is also found between Makanjila Point (Malaŵi) and Meponda (Mozambique) in the southeastern portion of the lake (Fig. 1).

**Material examined.** PSU 4485, 20; 58.4–79.6 mm SL; Malaŵi: Lake Malaŵi: Gome Rock, 12° 13.30.744' S, 34° 52.021' E; A.F. Konings & J.R. Stauffer, 12 Feb 2001. — PSU 4486, 20; 53.7–72.9 mm SL; Malaŵi: Lake Malaŵi: Nametumbwe, 13° 37.001' S, 34° 55.385' E; A.F. Konings & J.R. Stauffer, 25 Jan 2007.

### *Metriaclima glaucos*, new species

Fig. 4A–C; Table 3

*Metriaclima* sp. "aurora blue": Konings 2001: 155.

**Holotype.** PSU 4487, 69.2 mm SL; Mozambique: Lake Malaŵi: Cobwé, 12° 8.243' S, 34° 45.391' E; A.F. Konings & J.R. Stauffer, 18 Feb 2002.

**Paratypes.** PSU 4488, 16; UMBC 15, 1; AMNH 246003, 2; 53.0–67.4 mm SL; data as for holotype.

**Diagnosis.** A moderately-sloped head and bicuspid teeth in the outer row of the jaws place this species in *Metriaclima*. The absence of a black submarginal band in the dorsal fin in conjunction with a yellow gular region and branchiostegal membranes, and the light-brown colored females that have yellow fin margins distinguish *M. glaucos* from other members of *Metriaclima*, except *M. chrysomallos* and *M. benetos*. There are generally fewer teeth in the outer row of the lower left jaw (mode 16, range 14–19) of *M. glaucos* compared to *M. chrysomallos* (mode 22, range 15–25) and more compared to *M. benetos* (mode 12, range 9–13). On the basis of color pattern, females of *M. glaucos* cannot reliably be distinguished from those of most other members of the Aurora group, but they differ from those of *M. xanthos* new species by a shorter lower jaw (mean 30.8, range 28.8–32.8 % HL vs. mean 35.4, range 34.6–36.7 % HL) and from those of *M. aurora* by 8–11 vertical bars below the dorsal fin vs. 6 in *M. aurora*.

**Description.** Morphometric and meristic data in Table 3. Dorsal snout profile slightly concave to straight; mouth cleft slightly downward to horizontal; jaws isognathous. Teeth on dentary in 2-3 rows, on premaxilla in 2 or 3 rows; outer row teeth typically bicuspid anteriorly and unicuspid posteriorly, middle rows when present tricuspid, innermost row unicuspid; lower pharyngeal jaw with numerous slender teeth with teeth in posterior row slightly larger. Portion of upper dental arcade normally exposed when mouth closed. Tips of teeth in premaxilla and dentary in V-shaped line with anteriormost in upper and lower jaw furthest apart and not touching in closed mouth. Lateral scales ctenoid.

Breeding males light blue/gray laterally with 7 dark gray bars below dorsal fin and white belly. Head light blue/gray with preorbital, cheek, and operculum light blue; darker blue opercular spot; yellow gular region and brachiostegals. Dorsal fin blue with white lappets. Caudal-fin rays gray with white/blue membranes. Anal fin gray with 1–4 yellow ocelli. Pelvic fin with white leading edge, first ray gray and remainder clear. Pectoral fin clear.

**TABLE 3.** Morphometric and meristic values of *Metriaclima glaucos* from Cobwé. Mean and range include holotype.

| | *Metriaclima glaucos* | | |
|---|---|---|---|
| | n=20 | | |
| | holotype | mean | range |
| Standard length, mm | 69.2 | 61.4 | 53.0–69.2 |
| Head length, mm | 21.0 | 18.7 | 16.1–21.0 |
| Percentage of standard length | | | |
| Head length | 30.3 | 30.5 | 29.4–31.9 |
| Snout to dorsal | 32.7 | 33.4 | 31.7–34.6 |
| Snout to pelvic | 37.4 | 38.2 | 35.9–40.4 |
| Greatest body depth | 31.9 | 32.8 | 31.8–34.0 |
| Caudal peduncle length | 14.6 | 14.2 | 12.5–15.5 |
| Least caudal peduncle depth | 10.9 | 11.0 | 9.9–12.3 |
| Dorsal-fin base length | 64.4 | 61.9 | 59.8–64.4 |
| Anterior dorsal to anterior anal | 52.5 | 53.6 | 50.8–55.8 |
| Anterior dorsal to posterior anal | 66.3 | 64.4 | 62.9–66.5 |
| Posterior dorsal to anterior anal | 29.6 | 29.3 | 27.1–30.9 |
| Posterior dorsal to posterior anal | 14.9 | 15.1 | 14.4–16.5 |
| Anterior dorsal to pelvic-fin origin | 36.6 | 37.2 | 35.2–39.5 |
| Posterior dorsal to pelvic-fin origin | 59.1 | 58.7 | 55.6–60.7 |
| Percentage of head length | | | |
| Horizontal eye diameter | 30.8 | 33.7 | 30.7–36.6 |
| Vertical eye diameter | 32.0 | 33.7 | 31.0–36.9 |
| Snout length | 28.1 | 28.9 | 25.4–30.8 |
| Postorbital head length | 42.0 | 41.8 | 38.5–43.3 |
| Preorbital depth | 21.5 | 21.9 | 19.2–23.6 |
| Lower-jaw length | 29.3 | 30.8 | 28.8–32.8 |
| Cheek depth | 25.0 | 23.8 | 21.4–26.7 |
| Head depth | 92.5 | 91.0 | 86.5–95.9 |
| Meristics | | mode | range |
| Dorsal-fin spines | 18 | 18 | 17–19 |
| Dorsal-fin rays | 8 | 9 | 8–10 |
| Anal-fin spines | 3 | 3 | 3–3 |
| Anal-fin rays | 8 | 8 | 7–8 |
| Pelvic-fin rays | 5 | 5 | 4–5 |
| Pectoral-fin rays | 14 | 14 | 14–15 |
| Lateral line scales | 30 | 30 | 29–32 |
| Pored scales posterior to lateral line | 1 | 2 | 0–2 |
| Cheek scales | 6 | 6 | 4–7 |
| Gill rakers on first ceratobranchial | 11 | 11 | 10–11 |
| Gill rakers on first epibranchial | 3 | 3 | 2–4 |
| Teeth in outer row of left lower jaw | 16 | 16 | 14–19 |
| Teeth rows on upper jaw | 3 | 3 | 2–3 |
| Teeth rows on lower jaw | 3 | 3 | 2–3 |

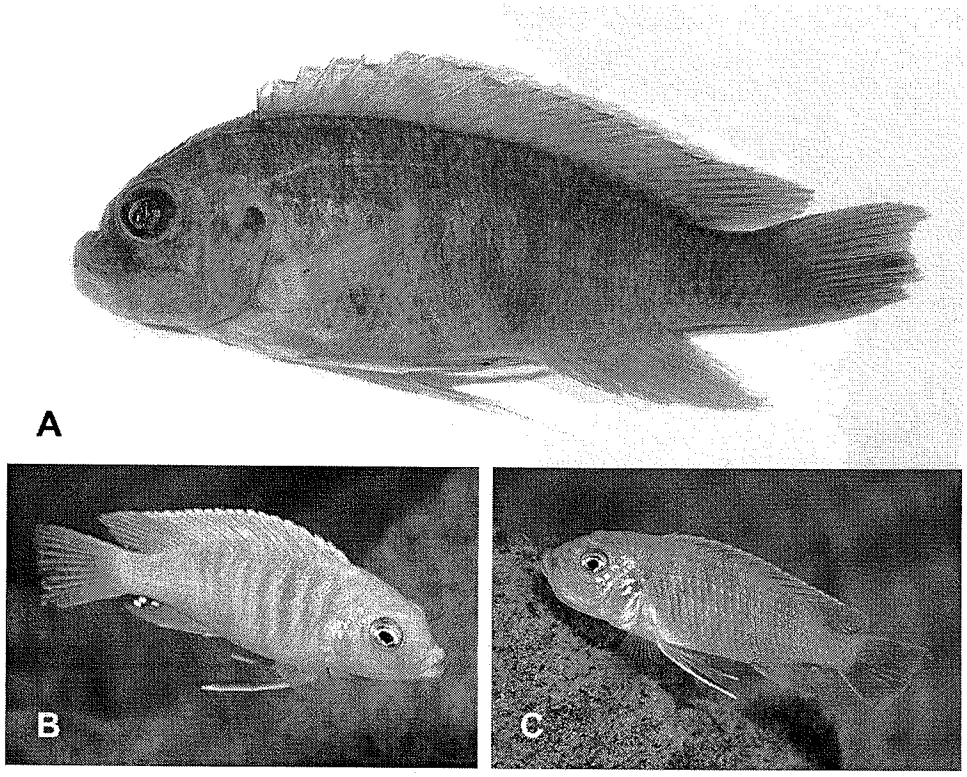


**FIGURE 4. A.** *Metriaclima glaucos*, holotype, PSU 4487, 69.2 mm SL; Mozambique: Lake Malaŵi: Cobwé. **B.** *M. glaucos*, male in habitat at Cobwé, Mozambique; approx. 65 mm SL; not preserved. **C.** *M. glaucos*, female in habitat at Cobwé, Mozambique; approx. 55 mm SL; not preserved.

Lateral coloration of females gray dorsally and white ventrally. Head gray with gray cheeks, blue/gray operculum with green highlights, gray/black opercular spot, and white gular region. Dorsal fin gray with yellow/orange lappets. Caudal-fin rays gray with clear membranes and faint yellow/orange spots. Anal fin gray proximally and yellow distally without ocelli. Pelvic fin with white leading edge and black submarginal band, membranes yellow to clear. Pectoral fins clear.

**Distribution.** *Metriaclima glaucos* was collected at Cobwé, Mozambique, and is only known from the type locality (Fig. 1).

**Etymology.** The specific epithet, *glaucos,* is Greek for bluish gray, in reference to the blue-gray body and fin coloration. It is treated as a noun in apposition.

### *Metriaclima xanthos*, new species

Fig. 5A–C; Table 4

*Metriaclima* sp. "aurora lumbaulo": Konings, 2001: 155.

**Holotype.** PSU 4494, 44.3 mm SL; Mozambique: Lake Malaŵi: Lumbaulo, 11° 54.024' S, 34° 54.307' E; A.F. Konings & J.R. Stauffer, 19 Feb 2002.

**Paratypes.** PSU 4495, 4; 44.6–49.3 mm SL; data as for holotype.

**Diagnosis.** A moderately-sloped head and bicuspid teeth in the outer row of the jaws place this species in *Metriaclima*. The brown and blue/gray alternating lateral bars in conjunction with the yellow dorsal and dark anal fin of breeding males distinguish *M. xanthos* from males of all other members of *Metriaclima*. Female *M. xanthos* are yellow/brown, usually more yellow than females of any other member of the Aurora group, but not all female *M. xanthos* can be distinguished according to the color pattern. *Metriaclima xanthos* is further distinguished from

*M. aurora* males from the Mbweca and Tumbi Point populations that are similar but lack dark pigment in the anal fin, and from the neighboring *M. glaucos* by the lower jaw length, which is longer in *M. xanthos* (mean 35.4, range 34.6–36.7 % HL) than in *M. aurora* (mean 31.2, range 28.4–33.5 % HL) and in *M. glaucos* (mean 30.8, range 28.8–32.8 % HL).

**Description.** Morphometric and meristic data in Table 4. Dorsal snout profile slightly concave to straight; mouth cleft at slightly downward angle; jaws isognathous. Teeth on dentary in 2 or 3 rows, on premaxilla in 2 or 3 rows; outer row teeth typically bicuspid anteriorly and unicuspid posteriorly, inner rows tricuspid, innermost row unicuspid; lower pharyngeal jaw with numerous slender teeth with teeth in posterior row slightly larger. Portion of upper dental arcade normally visible in closed mouth. Tips of teeth in premaxilla and dentary in V-shaped line with anteriormost in upper and lower jaw furthest apart and not touching in closed mouth. Lateral scales ctenoid.

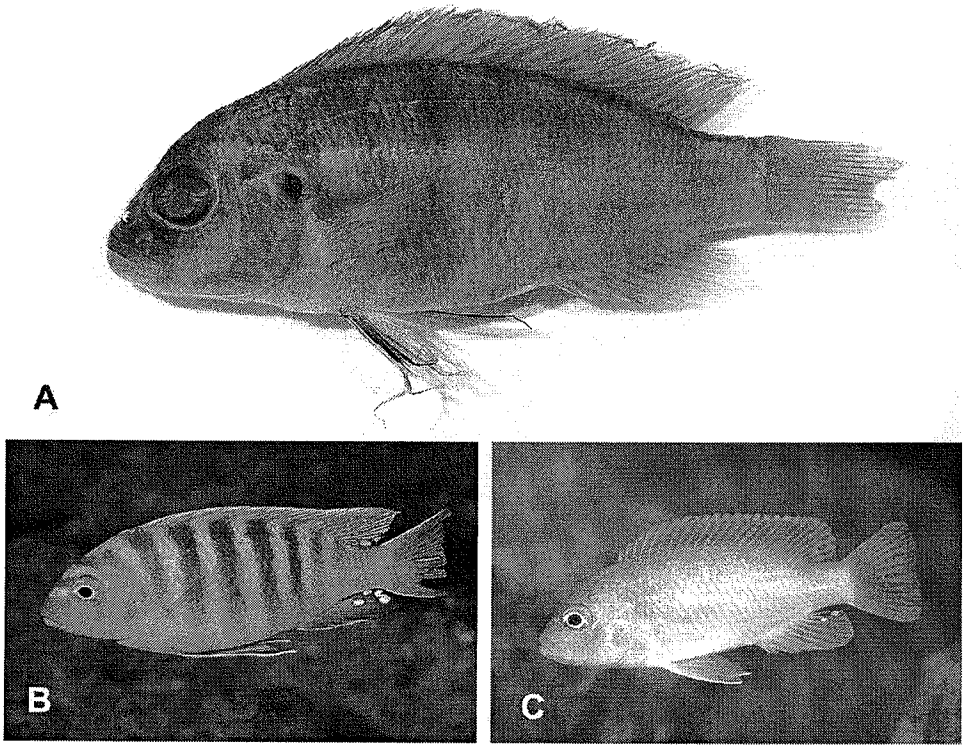


**FIGURE 5. A.** *Metriaclima xanthos*, holotype, PSU 4494, 44.3 mm SL; Mozambique: Lake Malaŵi: Lumbaulo. **B.** *M. xanthos*, male in habitat at Lumbaulo, Mozambique; approx. 70 mm SL; not preserved. **C.** *M. xanthos*, female in habitat at Lumbaulo, Mozambique; approx. 50 mm SL; not preserved.

Lateral body coloration of breeding male blue/gray with 6 or 7 brown bars below dorsal fin, yellow ventrally, yellow caudal peduncle with flecks of blue. Head gray with 2 blue/gray interorbital bars; ventral third of operculum yellow with gray opercular spot; gular region yellow. Dorsal fin yellow with blue lappets. Caudal-fin rays yellow with blue membranes. Anal fin dark gray/brown with light blue distal edge and 4 orange ocelli. Leading edge of pelvic fin white, first ray brown, remainder yellow. Pectoral fin clear.

Female yellow/brown laterally with 5 faint brown bars, yellow breast, and white belly. Head orange/brown; gular region yellow; gray/black opercular spot. Dorsal fin yellow/brown with orange lappets. Caudal-fin rays orange with brown membrane. Anal fin orange with 1–4 small yellow ocelli. Pelvic fin orange. Pectoral fin clear.

**Remarks.** We compared the minimum polygon clusters formed by plotting the second sheared principal component of the morphometric data against the first principal component of the meristic data for *Metriaclima aurora*, *M. glaucos*, and *M. xanthos* (Fig. 6). Size accounted for 90.9% of the observed variance and the second principal component accounted for 2.4%. Variables with the highest loadings on the sheared second principal components were horizontal eye diameter (0.59), vertical eye diameter (0.55), and snout length (-0.28). The first principal component of the meristic data accounted for 14.3% of the total variance. Variables with the highest loadings on the first principal component were tooth rows on lower jaw (0.34), tooth rows on upper jaw (0.32), and dorsal spines

**TABLE 4.** Morphometric and meristic values of *Metriaclima xanthos* from Lumbaulo. Mean and range include holotype.

| | *Metriaclima xanthos* | | |
|---|---|---|---|
| | n=5 | | |
| | holotype | mean | range |
| Standard length, mm | 44.3 | 45.7 | 44.3–49.3 |
| Head length, mm | 13.9 | 14.7 | 13.9–15.6 |
| Percentage of standard length | | | |
| Head length | 31.4 | 32.2 | 31.4–32.8 |
| Snout to dorsal | 35.4 | 34.7 | 32.4–36.5 |
| Snout to pelvic | 36.4 | 36.9 | 36.1–37.4 |
| Greatest body depth | 33.9 | 33.0 | 30.8–35.1 |
| Caudal peduncle length | 13.2 | 14.2 | 12.8–15.3 |
| Least caudal peduncle depth | 11.4 | 11.9 | 11.4–12.4 |
| Dorsal-fin base length | 62.8 | 61.6 | 58.6–63.9 |
| Anterior dorsal to anterior anal | 52.6 | 51.3 | 49.6–53.1 |
| Anterior dorsal to posterior anal | 65.6 | 64.1 | 62.2–65.6 |
| Posterior dorsal to anterior anal | 30.3 | 29.8 | 28.3–31.1 |
| Posterior dorsal to posterior anal | 15.9 | 15.4 | 14.8–16.7 |
| Anterior dorsal to pelvic-fin origin | 37.2 | 35.9 | 33.3–37.4 |
| Posterior dorsal to pelvic-fin origin | 60.7 | 57.8 | 55.3–60.7 |
| Percentage of head length | | | |
| Horizontal eye diameter | 36.8 | 37.1 | 36.7–37.6 |
| Vertical eye diameter | 33.7 | 35.9 | 33.7–37.1 |
| Snout length | 27.5 | 26.2 | 24.1–27.5 |
| Postorbital head length | 43.7 | 40.0 | 38.4–43.7 |
| Preorbital depth | 21.4 | 20.9 | 19.2–21.7 |
| Lower-jaw length | 34.6 | 35.4 | 34.6–36.7 |
| Cheek depth | 20.1 | 20.8 | 18.7–22.6 |
| Head depth | 92.2 | 87.8 | 80.8–92.2 |
| Meristics | | mode | range |
| Dorsal-fin spines | 17 | 17 | 17–18 |
| Dorsal-fin rays | 9 | 8, 9 | 8–10 |
| Anal-fin spines | 3 | 3 | 3–3 |
| Anal-fin rays | 9 | 8 | 8–9 |
| Pelvic-fin rays | 5 | 5 | 5–5 |
| Pectoral-fin rays | 13 | 14 | 13–14 |
| Lateral line scales | 29 | 29, 31 | 29–32 |
| Pored scales posterior to lateral line | 0 | 1, 2 | 0–2 |
| Cheek scales | 4 | 4 | 3–5 |
| Gill rakers on first ceratobranchial | 12 | 11, 12 | 11–13 |
| Gill rakers on first epibranchial | 3 | 3 | 2–3 |
| Teeth in outer row of left lower jaw | 21 | 21 | 15–23 |
| Teeth rows on upper jaw | 3 | 3 | 2–3 |
| Teeth rows on lower jaw | 3 | 2 | 2–3 |

(0.24). The minimum polygon clusters formed by *M. aurora* and *M. glaucos* did not overlap. *Metriaclima aurora* had a larger horizontal eye diameter (mean 37.0) and vertical eye diameter (mean 36.8) than *M. glaucos* (mean 33.7 for horizontal and vertical eye diameters). *Metriaclima xanthos* was intermediate between these two species, however a MANOVA in conjunction with a Hotelling-Lawley trace demonstrated that the three minimum polygon clusters were significantly ($p<0.05$) different.

**Distribution.** *Metriaclima xanthos* was only collected at Lumbaulo, Mozambique, and is not known to occur elsewhere (Fig. 1).

**Etymology.** The specific epithet, *xanthos*, is Greek for yellow, in reference to the yellow belly and dorsal fin of breeding males. It is treated as a noun in apposition.

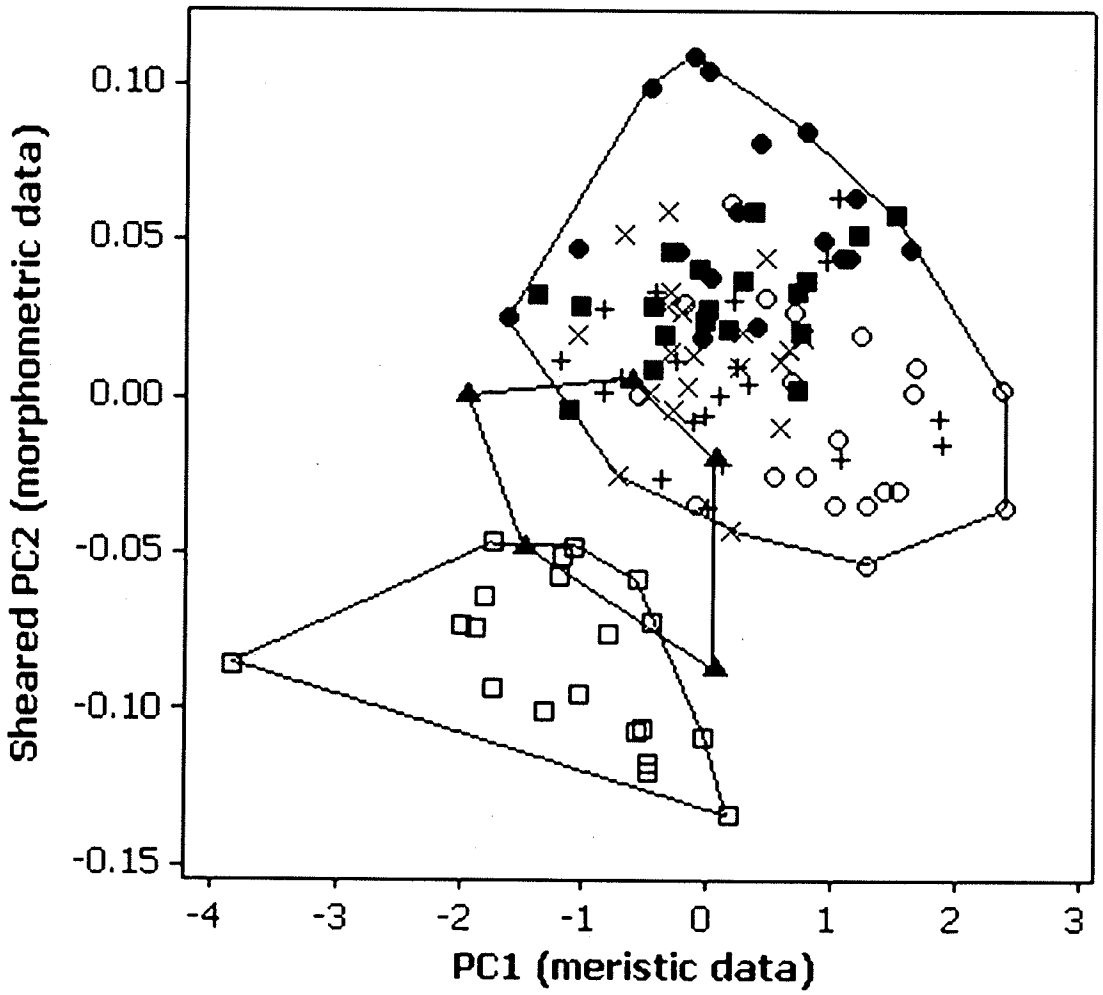


**FIGURE 6.** Plot of the first principal component of the meristic data (PC1) and the sheared second principal component of the morphometric data (PC2) of *Metriaclima aurora* (●, Likoma Island; x, Mara Point; ■, Mbweca; +, Tumbi Point; ○, N'kolongwe), *M. xanthos* (▲), and *M. glaucos* (□).

### *Metriaclima* sciasma, new species

Fig. 7A–C; Table 5

*Pseudotropheus* sp. "kingsizei north": Konings 2001: 159.
*Metriaclima* sp. "aurora north": Konings 2007: 177.

**Holotype.** PSU 4490, 63.8 mm SL; Tanzania: Lake Malaŵi: Magunga, 10° 19.344' S, 34° 34.849' E; T.D. Kocher, A.F. Konings, & J.R. Stauffer, 11 Feb 2005.

**Paratypes.** PSU 4491, 17; UMBC 16, 1; AMNH 246002, 2; 48.4–71.2 mm SL; data as for holotype. — PSU 4492, 20; 46.9–66.9 mm SL; Tanzania: Lake Malaŵi: Ngwazi, 10° 10.490' S, 34° 32.927' E; T.D. Kocher, A.F. Konings, & J.R. Stauffer, 10 Feb 2005. — PSU 4493, 20; 53.6–68.5 mm SL; Tanzania: Lake Malaŵi: Makonde, 9° 56.862' S, 34° 27.296' E; T.D. Kocher, A.F. Konings, & J.R. Stauffer, 8 Feb 2005.

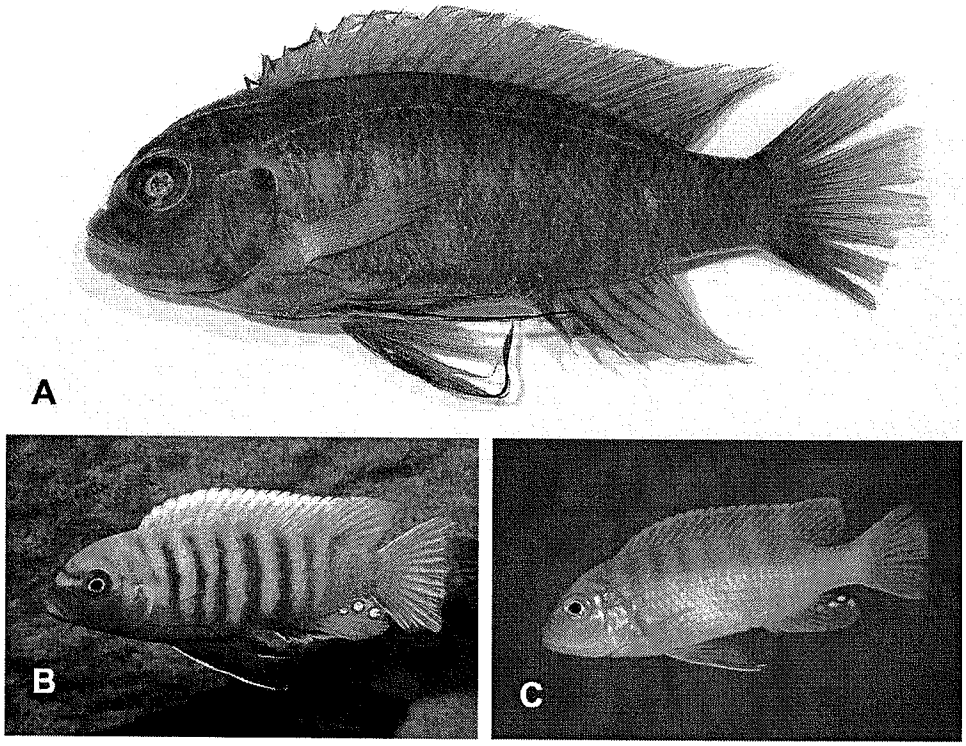


**FIGURE 7. A.** *Metriaclima sciasma*, holotype, PSU 4490, 63.8 mm SL; Tanzania: Lake Malaŵi: Magunga. **B.** *M. sciasma*, male in habitat at Magunga, Tanzania; approx. 60 mm SL; not preserved. **C.** *M. sciasma*, female in habitat at Magunga, Tanzania; approx. 50 mm SL; not preserved.

**Diagnosis.** A moderately-sloped head and bicuspid teeth in the outer row of the jaws place this species in *Metriaclima*. A black pelvic fin, a dark-blue cheek and preorbital area, and a blue dorsal fin without a black submarginal band in breeding males and the light-brown colored females that have yellow fin-margins distinguish *M. sciasma* from all other members of *Metriaclima*. Breeding males of *M. sciasma* are distinguished from those of some populations of *M. zebra* by the presence of a single interorbital bar (2 in *M. zebra*) and by black pigment on the anterior membranes of the anal fin. Female *M. sciasma* cannot reliably be distinguished from those of most other members of the Aurora group, but differ from those of *M. aurora* by more vertical bars below the dorsal fin (7–10 vs. 6).

**Description.** Morphometric and meristic data in Table 5. Dorsal snout profile slightly concave to straight; mouth cleft with slightly downward angle; jaws isognathous. Teeth on dentary in two to three rows, on premaxilla in two to four rows; outer row teeth typically bicuspid anteriorly and unicuspid posteriorly, inner rows tricuspid, innermost row unicuspid; lower pharyngeal jaw with numerous slender teeth with teeth in posterior row slightly larger . Portion of upper dental arcade normally visible in closed mouth. Tips of teeth in premaxilla and dentary in V-shaped line with anteriormost in upper and lower jaw furthest apart and separate in closed mouth. Lateral scales ctenoid.

Lateral body coloration of breeding males blue dorsally with 7–10 gray bars, white ventrally, and blue/gray caudal peduncle. Preorbital, cheek, and operculum dark blue/gray; blue opercular spot; gray/blue gular region; premaxillary and maxillary blue/gray; blue/gray interorbital bar. Dorsal fin blue with light-blue lappets. Caudal fin with gray rays and blue membranes. Anal fin blue/gray with 2–7 yellow ocelli. Pelvic fin black with white leading edge. Pectoral fin clear.

**TABLE 5.** Morphometric and meristic values of *Metriaclima sciasma* from Magunga, Makonde, and Ngwazi. Holotype from Magunga.

| | | all | Magunga | Makonde | Ngwazi |
|---|---|---|---|---|---|
| | | | n=21 | n=20 | n=20 |
| | holotype | mean | range | range | range |
| Standard length, mm | 63.8 | 60.9 | 48.4–71.2 | 53.6–68.5 | 46.9–66.9 |
| Head length, mm | 18.7 | 18.3 | 14.8–21.0 | 16.5–21.1 | 14.4–20.6 |
| Percentage of standard length | | | | | |
| Head length | 29.4 | 30.1 | 28.7–31.8 | 29.0–31.9 | 29.0–31.4 |
| Snout to dorsal | 30.4 | 31.1 | 29.3–33.6 | 29.9–33.1 | 30.0–33.1 |
| Snout to pelvic | 38.6 | 37.8 | 35.6–39.7 | 37.0–43.4 | 34.6–38.4 |
| Greatest body depth | 31.4 | 31.8 | 29.1–34.3 | 30.5–34.1 | 29.6–33.7 |
| Caudal peduncle length | 15.2 | 14.5 | 13.7–15.9 | 12.4–16.2 | 12.9–16.5 |
| Least caudal peduncle depth | 12.4 | 11.8 | 10.7–12.4 | 11.1–12.3 | 11.3–13.1 |
| Dorsal-fin base length | 63.5 | 61.7 | 59.6–63.7 | 59.0–63.6 | 58.9–65.5 |
| Anterior dorsal to anterior anal | 51.6 | 51.1 | 47.7–53.8 | 49.3–54.3 | 48.8–53.6 |
| Anterior dorsal to posterior anal | 65.3 | 64.2 | 62.3–66.7 | 61.8–66.7 | 60.6–66.9 |
| Posterior dorsal to anterior anal | 31.0 | 29.7 | 27.7–32.3 | 26.9–30.7 | 27.0–32.1 |
| Posterior dorsal to posterior anal | 15.6 | 14.8 | 13.7–15.6 | 14.1–15.9 | 13.4–15.7 |
| Anterior dorsal to pelvic-fin origin | 35.6 | 35.3 | 31.0–38.3 | 34.0–38.0 | 32.8–38.0 |
| Posterior dorsal to pelvic-fin origin | 56.8 | 57.3 | 54.6–60.7 | 53.3–58.6 | 56.1–60.5 |
| Percentage of head length | | | | | |
| Horizontal eye diameter | 33.9 | 33.8 | 31.4–37.1 | 30.9–35.1 | 30.4–36.8 |
| Vertical eye diameter | 32.7 | 33.7 | 31.9–36.6 | 30.9–35.1 | 31.5–37.1 |
| Snout length | 26.9 | 26.3 | 22.8–28.1 | 23.0–31.5 | 23.8–28.1 |
| Postorbital head length | 41.5 | 41.0 | 39.2–42.6 | 38.8–43.1 | 38.7–43.3 |
| Preorbital depth | 23.7 | 21.4 | 18.3–24.6 | 16.6–28.9 | 18.0–23.5 |
| Lower-jaw length | 33.2 | 34.3 | 31.6–35.9 | 30.7–36.0 | 32.7–36.9 |
| Cheek depth | 26.4 | 24.5 | 20.2–28.8 | 20.9–27.8 | 18.6–28.7 |
| Head depth | 93.5 | 90.8 | 80.8–101.6 | 86.0–96.8 | 81.9–93.7 |
| Meristics | | mode | range | range | range |
| Dorsal-fin spines | 17 | 17 | 16–18 | 16–18 | 17–19 |
| Dorsal-fin rays | 9 | 9 | 8–10 | 8–9 | 8–10 |
| Anal-fin spines | 3 | 3 | 3–3 | 3–3 | 3–3 |
| Anal-fin rays | 8 | 8 | 7–9 | 7–8 | 7–9 |
| Pelvic-fin rays | 5 | 5 | 5–5 | 5–5 | 5–5 |
| Pectoral-fin rays | 14 | 14 | 14–15 | 14–15 | 13–15 |
| Lateral line scales | 29 | 30 | 29–31 | 28–30 | 29–31 |
| Pored scales posterior to lateral line | 2 | 2 | 0–3 | 0–2 | 0–2 |
| Cheek scales | 5 | 5 | 4–6 | 3–6 | 3–6 |
| Gill rakers on first ceratobranchial | 12 | 12 | 11–13 | 10–13 | 11–14 |
| Gill rakers on first epibranchial | 3 | 3 | 3–4 | 2–4 | 2–4 |
| Teeth in outer row of left lower jaw | 19 | 17 | 13–21 | 14–23 | 12–22 |
| Teeth rows on upper jaw | 3 | 3 | 2–3 | 2–3 | 2–4 |
| Teeth rows on lower jaw | 3 | 3 | 2–3 | 2–3 | 2–3 |

Females brown dorsally and gray/white ventrally. Head brown with blue highlights on operculum and grey/green opercular spot; white gular region. Dorsal and anal fins yellow/brown. Proximal third of caudal fin dark brown, distal third light brown/yellow, membranes with faint blue spots. Pelvic fin with white leading edge, first 2 rays and membranes yellow/brown with remaining clear. Pectoral fin clear.

**Distribution.** *Metriaclima sciasma* has an extensive distribution north of the Ruhuhu River in the northeastern part of Lake Malaŵi (Fig. 1). The river and the sandy shores south of Mbamba Bay form a geographic barrier between *M. sciasma* and the other members of the Aurora group.

**Etymology.** The specific epithet, *sciasma*, is Greek for shadow, in reference to the black pelvic fins of males. It is treated as a noun in apposition.

### *Metriaclima nkhunguensis*, new species

Fig. 8A–C; Table 6

*Metriaclima* sp. "blue reef": Konings 2001: 58.

**Holotype.** PSU 4603, 72.8 mm SL; Mozambique: Lake Malaŵi: Nkhungu Reef, 12° 58.801' S, 34° 45.837' E; A.F. Konings & J.R. Stauffer, 1 Mar 2006.

**Paratypes.** PSU 4604, 5; 65.3–73.3 mm SL; data as for holotype.

**Diagnosis.** A moderately-sloped head and bicuspid teeth in the outer row of the jaws place this species in *Metriaclima*. Both males and females are light blue, fading to white ventrally, distinguishing them from all other members of *Metriaclima*, except *M. callainos*. Male *M. nkhunguensis* are distinguished from those of the similarly colored *M. chrysomallos* from the Gome population, *M. estherae*, and *M. callainos*, the latter two species of the sediment-free rocky habitat, by the yellow base of the pectoral fin (vs. no yellow pigment in males of the other three species). Female *M. nkhunguensis* are light blue, lighter than those of the only other known species with all-blue females, *M. callainos*, which are a darker cobalt-blue (female *M. estherae* are either brown or orange/red). *Metriaclima nkhunguensis* is further distinguished from *M. callainos* by a shorter lower jaw (mean 31.2, range 29.4–34.1 % HL vs. mean 37.5, range 34.9–43.3 % HL).

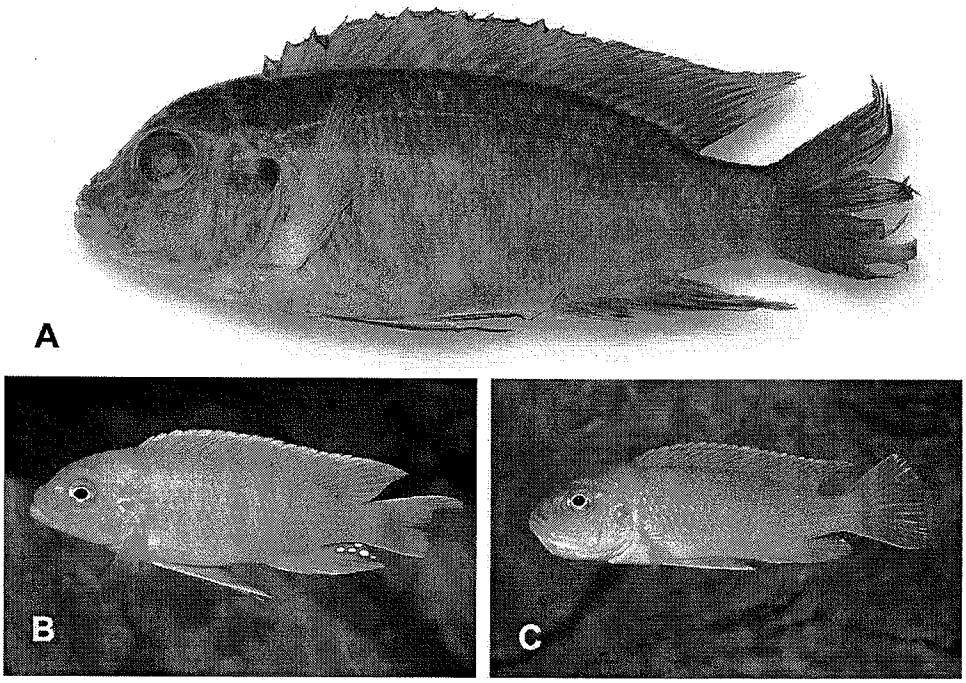


**FIGURE 8. A.** *Metriaclima nkhunguensis*, holotype, PSU 4603, 72.8 mm SL; Mozambique: Lake Malaŵi: Nkhungu Reef. **B.** *M. nkhunguensis*, male in habitat at Nkhungu Reef, Mozambique; approx. 60 mm SL; not preserved. **C.** *M. nkhunguensis*, female in habitat at Nkhungu Reef, Mozambique; not preserved.

**TABLE 6.** Morphometric and meristic values of *Metriaclima nkhunguensis* from Nkhungu Reef. Mean and range include holotype.

| | *Metriaclima nkhunguensis* n=6 | | |
|---|---|---|---|
| | holotype | mean | range |
| Standard length, mm | 72.8 | 69.6 | 65.3–73.3 |
| Head length, mm | 22.3 | 20.9 | 19.8–22.3 |
| Percentage of standard length | | | |
| Head length | 30.6 | 30.1 | 29.1–31.0 |
| Snout to dorsal | 29.8 | 31.1 | 29.8–33.1 |
| Snout to pelvic | 38.1 | 37.5 | 36.5–38.1 |
| Greatest body depth | 31.9 | 32.9 | 31.6–34.1 |
| Caudal peduncle length | 14.3 | 14.0 | 12.9–15.3 |
| Least caudal peduncle depth | 12.3 | 12.2 | 11.7–12.7 |
| Dorsal-fin base length | 62.5 | 61.4 | 58.5–62.6 |
| Anterior dorsal to anterior anal | 53.7 | 52.6 | 51.5–53.7 |
| Anterior dorsal to posterior anal | 64.9 | 63.7 | 62.1–64.9 |
| Posterior dorsal to anterior anal | 29.5 | 29.6 | 28.0–32.0 |
| Posterior dorsal to posterior anal | 15.9 | 15.2 | 14.1–16.4 |
| Anterior dorsal to pelvic-fin origin | 36.2 | 36.1 | 34.6–37.5 |
| Posterior dorsal to pelvic-fin origin | 59.8 | 59.5 | 58.3–60.2 |
| Percentage of head length | | | |
| Horizontal eye diameter | 32.6 | 34.0 | 32.6–35.8 |
| Vertical eye diameter | 33.1 | 34.3 | 33.1–35.3 |
| Snout length | 29.4 | 27.1 | 24.6–29.4 |
| Postorbital head length | 39.4 | 38.3 | 35.6–40.6 |
| Preorbital depth | 23.5 | 21.1 | 19.0–23.5 |
| Lower-jaw length | 29.7 | 31.2 | 29.4–34.1 |
| Cheek depth | 24.5 | 24.8 | 23.0–26.3 |
| Head depth | 91.6 | 92.5 | 89.4–96.3 |
| Meristics | | mode | range |
| Dorsal-fin spines | 17 | 17, 18 | 17–18 |
| Dorsal-fin rays | 10 | 9 | 9–10 |
| Anal-fin spines | 3 | 3 | 3–3 |
| Anal-fin rays | 7 | 8 | 7–8 |
| Pelvic-fin rays | 5 | 5 | 5–5 |
| Pectoral-fin rays | 15 | 14 | 14–15 |
| Lateral line scales | 31 | 30, 31 | 30–31 |
| Pored scales posterior to lateral line | 1 | 1 | 0–2 |
| Cheek scales | 4 | 5 | 4–5 |
| Gill rakers on first ceratobranchial | 13 | 13 | 11–13 |
| Gill rakers on first epibranchial | 2 | 3 | 2–3 |
| Teeth in outer row of left lower jaw | 22 | 22 | 19–23 |
| Teeth rows on upper jaw | 3 | 3 | 3–4 |
| Teeth rows on lower jaw | 3 | 3 | 3–3 |

**Description.** Morphometric and meristic data in Table 6. Dorsal snout profile slightly concave to straight; mouth cleft with slightly downward angle; jaws isognathous. Teeth on dentary in three rows, on premaxilla in three to four rows; outer row teeth typically bicuspid anteriorly and unicuspid posteriorly, inner rows tricuspid, innermost row unicuspid; lower pharyngeal jaw with numerous slender teeth with teeth in posterior row slightly larger. Portion of upper dental arcade normally visible in closed mouth. Tips of teeth in premaxilla and dentary in V-shaped line with anteriormost in upper and lower jaw furthest apart and separate in closed mouth. Lateral scales ctenoid.

Breeding males pale blue laterally fading to white-blue ventrally. Head entirely pale blue with white gular region. Dorsal fin light blue with white-blue lappets. Caudal-fin rays clear with blue membranes. Anal fin light blue and 1–5 orange ocelli. Pelvic fin light blue with white leading edge. Pectoral fin clear with orange base.

Females light blue fading to white ventrally. Head light blue/gray, white gular region. Dorsal fin light blue with orange lappets. Caudal fin light blue. Anal fin light blue with 1-4 orange ocelli. Pelvic fin light blue/gray with white leading edge. Pectoral fin clear with white base.

**Distribution.** *Metriaclima nkhunguensis* is endemic to Nkhungu and Minos reefs in Mozambique (Fig. 1).

**Etymology.** The specific name refers to one of the reefs at which the species is endemic.

### *Metriaclima mossambicus*, new species

Fig. 9A–E; Table 7

*Metriaclima* sp. "aurora chinuni": Konings 2001: 158.
*Metriaclima* sp. "aurora black tail": Konings 2001: 158.
*Metriaclima* sp. "aurora yellow": Konings 2001: 158.

**Holotype.** PSU 4497, 79.7 mm SL; Mozambique: Lake Malaŵi: Chiloelo, 13° 12.541' S, 34° 48.523' E; A.F. Konings & J.R. Stauffer, 13 Feb 2002.

**Paratypes.** PSU 4498, 16; UMBC 17, 1; AMNH 246001, 2; 54.9–77.0 mm SL; data as for holotype. — PSU 4601, 19; 47.8–76.5 mm SL; Mozambique: Lake Malaŵi: Chinuni, 13°03.753'S 34°47.909'E; A.F. Konings & J.R. Stauffer, 14 Feb 2002. — PSU 4602, 18; 54.5–79.1 mm SL; Mozambique: Lake Malaŵi: Lumessi, 13° 8.196' S, 34° 47.844' E; A.F. Konings & J.R. Stauffer, 14 Feb 2002.

**Diagnosis.** A moderately-sloped head and bicuspid teeth in the outer row of the jaws place this species in *Metriaclima*. Male *M. mossambicus* from Chiloelo are distinguished from those of all other members of *Metriaclima* by the absence of a black submarginal band in the dorsal and by black streaks in the caudal and in the posterior portion of the dorsal fin. Male *M. mossambicus* from Chinuni are distinguished from those of all other *Metriaclima* by the absence of a black submarginal band in the dorsal and by a narrow black submarginal band in the anal fin. Male *M. mossambicus* from Lumessi are distinguished from all other *Metriaclima*, except *M. aurora, M. chrysomallos*, and *M. xanthos* by the absence of a black submarginal band in the dorsal, a yellow ventral half of the head, breast, and dorsal fin, and a light-blue nape. Male *M. mossambicus* from Lumessi population differ from those of *M. chrysomallos* by a yellow dorsal fin which is light-blue in the latter. *Metriaclima mossambicus* differs from *M. aurora* by more vertical bars below the dorsal, 7–9 vs. 6, and from *M. xanthos* by a shorter lower jaw (mean 31.4, range 27.9–33.8 % HL vs. mean 35.4, range 34.6–36.7 % HL). Based on the color pattern, female *M. mossambicus* cannot reliably be distinguished from those of most other members of the Aurora group but have 7 or 8 bars below the dorsal fin vs. 6 bars in *M. aurora*.

**Description.** Morphometric and meristic data in Table 7. Dorsal snout profile slightly concave to straight; mouth cleft with slightly downward angle; jaws isognathous. Teeth on dentary in two to four rows, on premaxilla in two to four rows; outer row teeth typically bicuspid anteriorly and unicuspid posteriorly, inner rows tricuspid, innermost row unicuspid; lower pharyngeal jaw with numerous slender teeth with teeth in posterior row slightly larger. Portion of upper dental arcade normally exposed when mouth closed. Tips of teeth in premaxilla and dentary in V-shaped line with anteriormost in upper and lower jaw furthest apart and not touching in closed mouth. Lateral scales ctenoid.

**TABLE 7.** Morphometric and meristic values of *Metriaclima mossambicus* from Chiloelo, Chinuni, and Lumessi. Holotype from Chiloelo.

| | | all | Chiloelo | Chinuni | Lumessi |
|---|---|---|---|---|---|
| | | | n=20 | n=19 | n=18 |
| | holotype | mean | range | range | range |
| Standard length, mm | 79.7 | 67.4 | 54.9–79.7 | 47.8–76.5 | 54.5-79.1 |
| Head length, mm | 23.7 | 20.8 | 16.6–23.9 | 14.5–23.4 | 16.7–24.2 |
| Percentage of standard length | | | | | |
| Head length | 29.8 | 30.9 | 29.8–32.7 | 29.3–31.9 | 29.7–32.0 |
| Snout to dorsal | 31.3 | 33.8 | 31.3–37.0 | 32.6–35.2 | 32.7–36.3 |
| Snout to pelvic | 39.4 | 39.3 | 37.8–41.0 | 37.3–41.3 | 37.4–40.4 |
| Greatest body depth | 33.8 | 34.1 | 32.6–37.4 | 31.2–37.0 | 32.1–35.1 |
| Caudal peduncle length | 13.2 | 13.9 | 13.1–15.6 | 12.3–15.2 | 13.0–15.3 |
| Least caudal peduncle depth | 12.4 | 11.9 | 11.3–13.0 | 11.0–13.3 | 10.7–12.6 |
| Dorsal-fin base length | 62.4 | 61.0 | 59.5–63.4 | 59.0–63.8 | 59.0–62.5 |
| Anterior dorsal to anterior anal | 56.6 | 54.3 | 51.7–58.4 | 51.6–57.8 | 52.2–56.3 |
| Anterior dorsal to posterior anal | 66.7 | 64.8 | 63.7–67.2 | 61.8–67.3 | 63.6–67.1 |
| Posterior dorsal to anterior anal | 30.8 | 29.6 | 28.8–32.1 | 27.6–31.2 | 27.4–31.5 |
| Posterior dorsal to posterior anal | 16.5 | 15.7 | 15.2–17.4 | 13.5–16.9 | 14.6–16.9 |
| Anterior dorsal to pelvic-fin origin | 38.8 | 37.8 | 35.5–41.8 | 33.1–40.7 | 35.8–39.2 |
| Posterior dorsal to pelvic-fin origin | 58.9 | 58.1 | 55.6–61.7 | 55.7–61.2 | 55.6–59.8 |
| Percentage of head length | | | | | |
| Horizontal eye diameter | 31.4 | 33.8 | 31.4–37.5 | 31.1–35.8 | 32.1–36.6 |
| Vertical eye diameter | 31.0 | 33.6 | 31.0–35.9 | 31.6–35.6 | 31.9–36.5 |
| Snout length | 28.9 | 28.2 | 26.6–31.3 | 26.0–29.7 | 26.3–30.2 |
| Postorbital head length | 42.1 | 41.7 | 40.4–44.8 | 39.3–42.4 | 40.2–43.0 |
| Preorbital depth | 23.4 | 23.6 | 19.1–29.0 | 18.9–26.2 | 21.3–27.9 |
| Lower-jaw length | 31.0 | 31.4 | 27.9–33.8 | 29.0–32.6 | 29.8–33.1 |
| Cheek depth | 31.8 | 24.9 | 22.7–31.8 | 19.0–26.2 | 21.7–28.2 |
| Head depth | 96.9 | 96.0 | 89.0–103.0 | 83.3–100.0 | 95.1–111.8 |
| Meristics | | mode | range | range | range |
| Dorsal-fin spines | 18 | 18 | 17–18 | 17–18 | 16–18 |
| Dorsal-fin rays | 9 | 9 | 8–10 | 8–10 | 8–10 |
| Anal-fin spines | 3 | 3 | 3–3 | 3–3 | 3–3 |
| Anal-fin rays | 8 | 8 | 7–9 | 7–9 | 7–8 |
| Pelvic-fin rays | 5 | 5 | 5–5 | 5–5 | 5–5 |
| Pectoral-fin rays | 14 | 14 | 14–15 | 14–15 | 14–15 |
| Lateral line scales | 31 | 30 | 29–32 | 30–32 | 29–31 |
| Pored scales posterior to lateral line | 2 | 2 | 0–2 | 0–2 | 0–3 |
| Cheek scales | 4 | 5 | 3–5 | 3–6 | 3–6 |
| Gill rakers on first ceratobranchial | 12 | 12 | 11–13 | 11–12 | 10–13 |
| Gill rakers on first epibranchial | 3 | 3 | 2–4 | 2–4 | 2–3 |
| Teeth in outer row of left lower jaw | 15 | 21 | 15–23 | 15–24 | 16–26 |
| Teeth rows on upper jaw | 3 | 3 | 3–4 | 3–4 | 2–4 |
| Teeth rows on lower jaw | 3 | 3 | 2–4 | 3–4 | 3–4 |

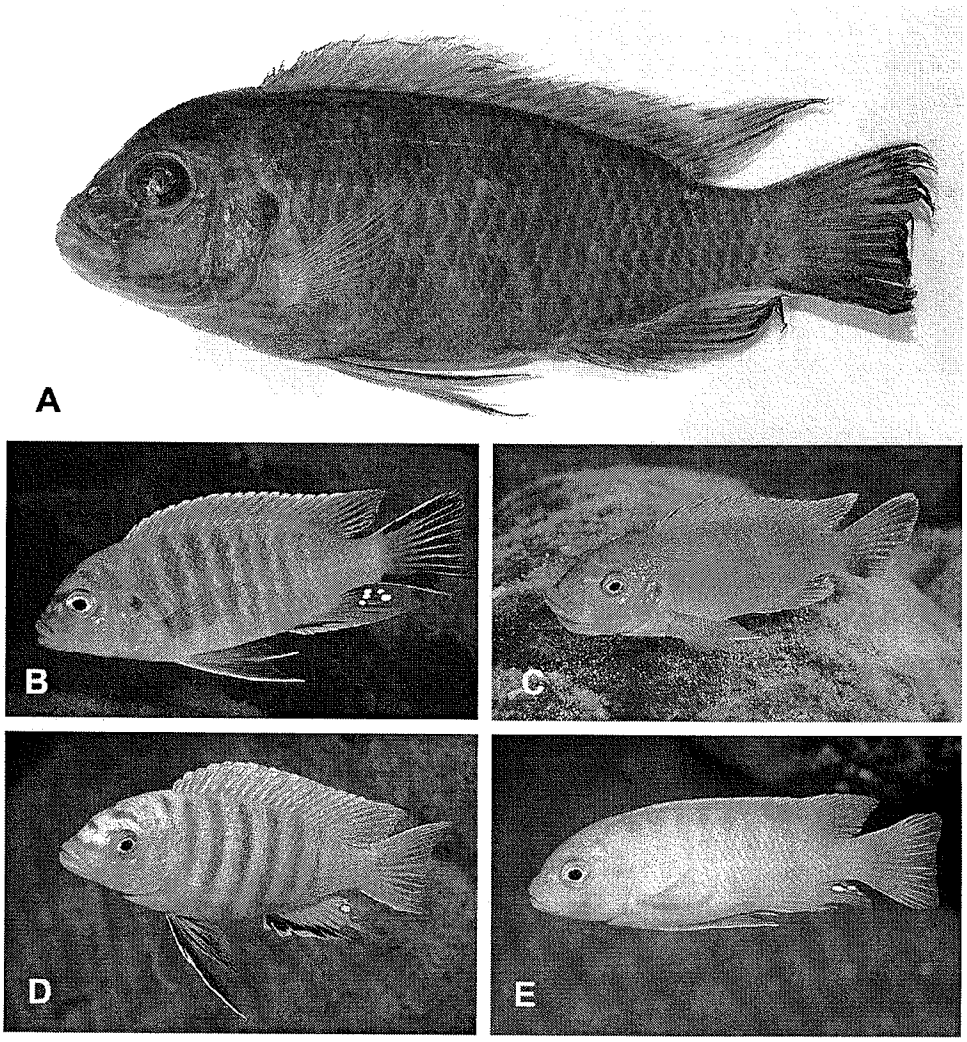


**FIGURE 9. A.** *Metriaclima mossambicus*, holotype, PSU 4497, 79.7 mm SL; Mozambique: Lake Malawi: Chiloelo. **B.** *M. mossambicus*, male in habitat at Chiloelo, Mozambique; approx. 75 mm SL; not preserved. **C.** *M. mossambicus*, female in habitat at Chiloelo, Mozambique; approx. 50 mm SL; not preserved. **D.** *M. mossambicus*, male in habitat at Chinuni, Mozambique; approx. 75 mm SL; not preserved. **E.** *M. mossambicus*, male in habitat at Lumessi, Mozambique; approx. 80 mm SL; not preserved.

Breeding males at Lumessi typically with gray/blue ground color with posterior edge of scales gold in dorsal 2/3 and faint lateral barring; ventral third gold. Ventral third of head gold; cheeks yellow, gular region orange, interorbital light blue/gray with gray/green interorbital bar, and gray/black opercular spot. Proximal 2/3 of dorsal fin gold, remainder blue/gray. Caudal fin gold with yellow/gray membranes. Proximal 1/3 of anal fin orange, distal 2/3 blue/gray. Pelvic fin orange. Pectoral-fin rays orange with clear membranes.

Breeding males from Chinuni typically with light-blue ground color and 7 gray bars below dorsal fin, caudal peduncle blue/gray. Head light blue dorsally with 1 dark interorbital bar, purple cheek and operculum, pale yellow gular region, and gray opercular spot. Dorsal fin blue with orange tips. Caudal-fin rays pale blue with light-orange membranes. Anal fin gray with a black submarginal band, white lappets, and 2-3 yellow ocelli. Pelvic fin dark gray with white leading edge and broad black submarginal band. Pectoral fins clear.

Breeding males from Chiloelo with light-blue ground color and 7 or 8 dark blue bars below dorsal fin; belly white with area between pelvic fins orange. Head light-blue with 1 gray interorbital bar, gular region orange. Dorsal fin light-blue with white lappets, posterior third of rayed portion with black membranes. Caudal fin black with light-blue rays. Anal fin light blue/gray with 2–6 orange ocelli and black submarginal band and white lappets. Pel-

vic fin clear, except for white leading edge and gray/black band. Pectoral fins clear with gray rays and yellow/orange base.

Females of all three populations of *Metriaclima mossambicus* indistinguishable. Body gray/brown laterally; belly white. Head brown, cheek with green highlights, gular region white. Dorsal fin gray with green spots and orange lappets; orange tips on rays. Caudal fin clear with orange/yellow margin and small blue spots throughout. Anal fin clear in proximal half, orange/brown in distal half. Pelvic fin clear except for first two orange/brown membranes. Pectoral fin clear.

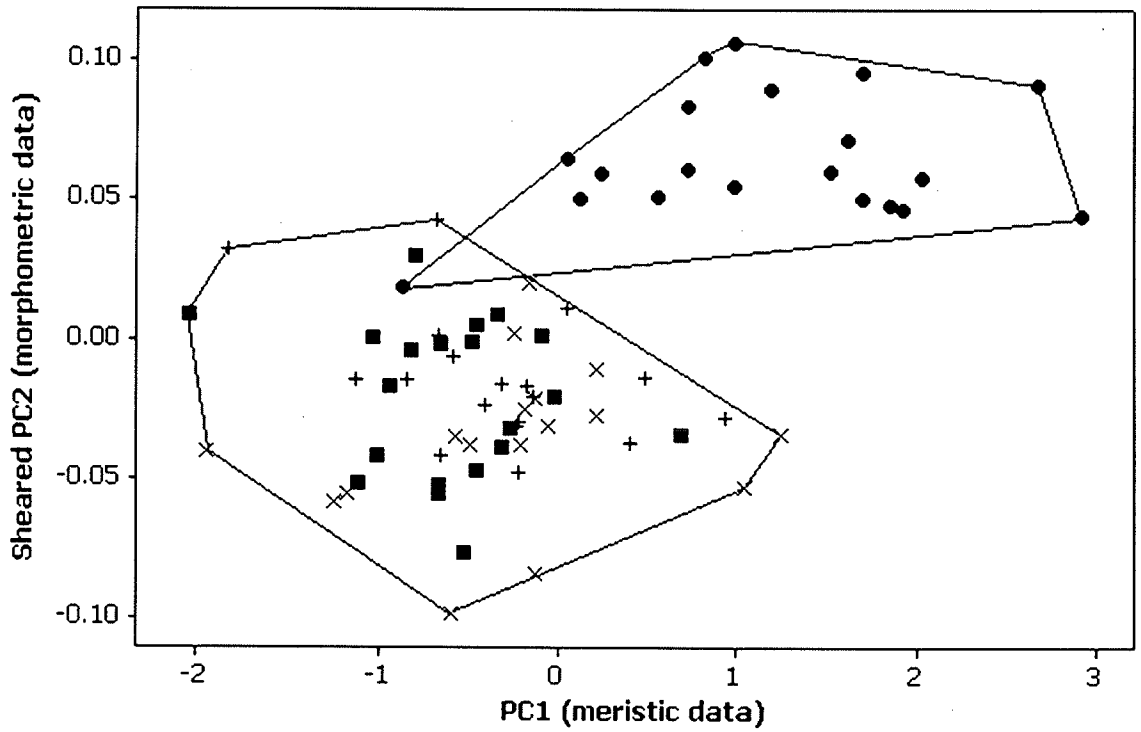


**FIGURE 10.** Plot of the first principal component of the meristic data (PC1) and the sheared second principal component of the morphometric data (PC2) of *Metriaclima* aurora from N'kolongwe (•) and *M. mossambicus* (x, Lumessi; ■, Chiloelo; +, Chinuni).

**Remarks.** Initially, we believed the three populations of *M. mossambicus* were separate species based on differences in male breeding color. The minimum polygon clusters formed by plotting the first principal components of the meristic data against the sheared second principal components of the morphometric data for the populations from Chiloelo, Chinuni, and Lumessi completely overlap, however (Fig. 10). These morphologically similar populations of *M. mossambicus* are considered conspecific. Variation in male coloration within populations has been observed, such as the amount of black pigment in the caudal fin in males from Chiloelo or the extent of yellow on the lateral portions of males from Lumessi. Between Meponda and the Chiloelo River (28 km) no other Aurora group species have been observed.

In the principal component analysis of *M. mossambicus* and *M. aurora* from N'kolongwe, size accounts for 88.1% of the observed variance and the second principal component accounts for 3.4%. Variables with the highest loadings on the sheared second principal components are preorbital depth (-0.64), vertical eye diameter (0.31), and head depth (-0.31). The first principal component of the meristic data accounts for 17.9% of the total variance. Variables with the highest loadings on the first principal component are tooth rows on lower jaw (0.57), dorsal spines (0.48), and tooth rows on upper jaw (0.38). The minimum polygons for *M. aurora* and *M. mossambicus* overlap, but are significantly ($p<0.05$; MANOVA) different (Fig. 10).

**Distribution.** *Metriaclima mossambicus* is found along the Mozambique shore of the lake, between the Chiloelo River and Chinuni (Fig. 1).

**Etymology.** The specific epithet, *mossambicus*, refers to the area where the species is native. An adjective.

## Artificial key to *Metriaclima* species

An artificial key was constructed for *Metriaclima* based primarily on color patterns in addition to characters reported in Stauffer *et al.* (1997), Konings & Stauffer (2006), and examinations of type material. We follow Konings (2007) in regarding *M. sandaracinos* as a synonym to *M. pyrsonotos* and *M. melabranchion* a synonym of *M. zebra*. Several undescribed species will likely be placed in this genus. *Pseudotropheus livingstonii*, *P. elegans*, *P. pursus*, and *M. lanisticola* are the subject of another study in preparation and it appears that the skull of several of these species does not conform to the typical characters of *Metriaclima*. We have included in the key *M. lanisticola* as this species is without doubt a valid member of the genus.

1. Females beige to yellow with yellow pigment in anal fin. . . . 2
- Females brown, dark gray or blue without yellow anal fin. . . . 14
2. Males with black stripe in dorsal fin . . . 3
- Males without black stripe in dorsal fin . . . 4
3. Snout length 27.7–36.6% HL . . . *M. flavifemina*
- Snout length 37.9–44.7% HL . . . *M. phaeos*
4. Six or fewer bars (distinct or faint) below dorsal fin . . . 5
- Seven or more bars (distinct or faint) below dorsal fin . . . 6
5. Lower jaw length 28.4–33.5 %HL (mean 31.2) . . . *M. aurora*
- Lower jaw length 34.6–36.7 %HL (mean 35.4) . . . *M. xanthos* (part)
6. Males with distinct vertical bars . . . 7
- Males without distinct vertical bars . . . 10
7. Males with entirely black pelvic fin . . . *M. sciasma*
- Males with clear pelvic fin or dark band in pelvic fin . . . 8
8. Males with black submarginal band in anal fin. . . . 9
- Males without black pigment in anal fin. . . . *M. hajomaylandi*
9. Males with yellow dorsal fin. . . . *M. xanthos* (part)
- Males with white/blue dorsal fin. . . . *M. mossambicus* (part)
10. Males with yellow nape. . . . *M. barlowi*
- Males with blue nape. . . . 11
11. Males with distinct interorbital bar . . . *M. benetos*
- Males without distinct interorbital bar . . . 12
12. Males with yellow dorsal fin. . . . *M. mossambicus* (part)
- Males with white/blue dorsal fin. . . . 13
13. Fourteen-ninenteen, mode 16 of teeth in outer row of lower left jaw. . . . *M. glaucos*
- Fifteen-twenty five, mode 22 of teeth in outer row of lower left jaw. . . . *M. chrysomallos*
14. Females blue . . . 15
- Females brown to blue-gray . . . 17
15. Females with distinct vertical bars . . . *M. lombardoi*
- Females without distinct vertical bars. . . . 16
16. Lower jaw length 29–34% HL . . . *M. nkhunguensis*
- Lower jaw length 35–43% HL . . . *M. callainos*
17. Males without distinct vertical bars . . . 18
- Males with distinct vertical bars . . . 22
18. Males with orange to red pigment in dorsal fin . . . 19
- Males with blue dorsal fin. . . . 20
19. Males with yellow pectoral fin . . . *M. mbenjii*
- Males with clear pectoral fin. . . . *M. greshakei*
20. Males with yellow gular region . . . *M. xanstomachus*
- Males with white gular region. . . . 21
21. Females light brown . . . *M. zebra* (part)
- Females dark gray-blue. . . . *M. estherae*
22. Five or fewer bars below dorsal fin. . . . *M. lanisticola*
- Six or more bars below dorsal fin . . . 23
23. Males with orange to red pigment in dorsal fin . . . 24
- Males with blue dorsal fin. . . . 27
24. Anal fin same orange color as dorsal fin. . . . *M. cyneusmarginatus* (part)
- Anal fin blue . . . 25
25. Males with black submarginal band in anal fin. . . . *M. emmiltos*
- Males without black band in anal fin . . . 26
26. Base of pectoral fin in males yellow. . . . *M. fainzilberi* (part)
- Base of pectoral fin in males white to blue. . . . *M. pyrsonotos*

27. Anal fin black and black streaks in caudal fin ..... *M. pulpican*
- Anal fin blue and no black streaks in caudal fin ..... 28
28. Base of pectoral fin in males yellow ..... *M. fainzilberi* (part)
- Base of pectoral fin males white to blue ..... 29
29. Males with black stripe in dorsal fin ..... 30
- Males without black stripe in dorsal fin ..... *M. zebra* (part)
30. Males with black pigment in anal fin ..... *M. zebra* (part)
- Males without black pigment in anal fin ..... *M. cyneusmarginatus* (part)

## Discussion

We have used the principal component analysis plots to distinguish between neighboring populations and species. Three of the previously described Aurora group species not examined in these analyses included *Metriaclima benetos*, *M. hajomaylandi* and *M. barlowi*. We disregarded these species because they are geographically separated from the new species described and none have a neighboring population to any of the newly described species. *Metriaclima sciasma* was not included in our PCA analysis because of the geographic distance between their ranges and that of the other Aurora group species discussed herein as well; moreover its male coloration is rather distinct and easily distinguished from all other species in the genus. Similarly, *M. nkhunguensis* was omitted from the PCA plots because of the blue female coloration, which is rare among mbuna in general, and its isolation on Nkhungu and Minos reefs.

Although differing in male coloration, the three sampled populations of *Metriaclima mossambicus* are not considered separate species because of major overlaps in morphology of neighboring populations, the similarity of female coloration, and the observed variability in male coloration within each population. Intra-population variance in color among males, as observed in *M. mossambicus* and in other mbuna species, e.g., *Labeotropheus fuelleborni* (Arnegard *et al.* 1999), suggests that specific mate recognition systems are flexible and have not isolated a precise male color pattern. These neighboring populations may have begun to diverge into separate species. The three populations of *M. mossambicus* are considered semispecies *sensu* Mayr (1963) that have acquired some, but not all characteristics of species status. While it appears that these three populations have acquired the coloration differences necessary for reproductive isolation, different evolution trajectories cannot be diagnosed at this time. The polychromatism in *M. mossambicus* may also be a function of environmental variability.

Polychromatism in Lake Victoria cichlids (Seehausen *et al.* 1997; Seehausen & van Alphen 1998) as well as the Central American cichlid *Cichlasoma citrinellum* (Barlow 1976) both appear to be correlated with water turbidity. Environmental differences at the localities of the three color-morphs of *Metriaclima mossambicus* may have favored the development of one color pattern over the other. Moreover, rocky habitats in between the three collected populations have not been sampled and they may be inhabited by *M. mossambicus* males of which exhibit color patterns intermediate to the ones described here. Such a gradual change in male color pattern is observed in the various populations of *M. chrysomallos* as commented above. *Metriaclima mossambicus* is not regarded as conspecific with *M. chrysomallos* because the intermediate habitat in between the southernmost population of the former and the northernmost population of the latter is occupied by a member of the Black Dorsal group, the not yet scientifically described *M.* sp. 'black dorsal chiloelo'. This area is bordered at either end by a river delta, the Chiloelo River to the north and the Meponda River to the south. These deltas serve as additional barriers to a possible genetic exchange between the two species.

Members of either the Aurora or the Black Dorsal group completely populate, in alternating fashion, the available intermediate habitats along the Mozambique shoreline. The only area with ample intermediate rocky habitat that at first seems to lack a representative of either group is found at Minos and Nkhungu reefs (Fig. 1). Females of all known species of the Aurora group are characterized by a light, yellow to beige body coloration and yellow margins of unpaired fins, yet females of the only member of *Metriaclima* found in the intermediate habitat at these reefs, *M. nkhunguensis*, are light blue and lack any yellow fin margin. The reefs are shallow, less than seven meters deep, and another common member of *Metriaclima*, *M. estherae*, occurs in the more rocky sections, but always in close proximity to *M. nkhunguensis*. Male coloration of both these species is identical, with the exception of the orange pectoral fin base of *M. nkhunguensis*. In addition to the pectoral fin base pigment, these species can only be identified by their respective positions in their habitat or by a close-up examination of their mouths, which are wider in *M. estherae*. The latter characters support our assumption that *M. nkhunguensis* is a member of the Aurora group in which the female coloration is different at these reefs compared to other populations in the group.

## Acknowledgments

We thank the government of Malawi for providing the permits that allowed this research to be possible. Fishes were collected and processed under the research permit issued to the Molecular Biology and Ecology Research Unit (MBERU) University of Malawi and the approval of the Animal Use and Care Committee at Pennsylvania State University (IACUC #16945; 00R084). This work was funded in part by the NSF/NIH joint program in ecology of infectious diseases (DEB 0224958).

## Literature cited

Arnegard, M.E., Markert, J.A., Danely, P.D., Stauffer, J.R., Ambali, A.J. & Kocher, T.D. (1999) Population structure and colour variation of the cichlid fish *Labeotropheus fuelleborni* Ahl along a recently formed archipelago of rocky habitat patches in southern Lake Malawi. *Proceedings of the Royal Society of London, Series B: Biological Sciences*, 266, 119–130.

Barel, C., van Oijen, M., Witte, F. & Witte-Maas, E. (1977) An introduction to the taxonomy and morphology of the haplochromine Cichlidae from Lake Victoria. *Netherlands Journal of Zoology*, 27, 333–389.

Barlow, G.W. (1974) Contrasts in social behavior between Central American cichlid fishes and coral reef surgeon fishes. *American Zoologist*, 14, 9–34.

Barlow, G.W. (1976) The Midas cichlid in Nicaragua. *In*: Thorsen, T.B. (Ed), *Investigations of the ichthyofauna of Nicaraguan lakes*. University of Nebraska, Lincoln, pp. 333–358.

Bookstein, F., Chernoff, B., Elder, R., Humphries, J., Smith, G. & Strauff, R. (1985) *Morphometrics in evolutionary biology.* The Academy of Natural Sciences of Philadelphia. Philadelphia, Pennsylvania, Special Publication 15, 277 pp.

Bowers, N.J. & Stauffer, J.R., Jr. (1993) New species of rock-dwelling cichlid (Pisces: Cichlidae) from Lake Malawi Africa, with comments on *Melanochromis vermivorous* Trewavas. *Copeia*, 1993, 715–722.

Fryer, G. (1959) The trophic interrelationships and ecology of some littoral communities of Lake Nyasa with special reference to the fishes, and a discussion of the evolution of a group of rock-frequenting Cichlidae. *Proceedings of the Zoological Society of London*, 132, 153–282.

Genner, M.J. & Turner, G.F. (2005) The mbuna cichlids of Lake Malawi: a model of rapid speciation and adaptive radiation. *Fish and Fisheries*, 6, 1–34.

Humphries, J.M., Bookstein, F.L., Chernoff, B., Smith, G.R, Elder, R.L. & Poss, S.G. (1981) Multivariate discrimination by shape in relation to size. *Systematic Zoology*, 30, 291–308.

Knight, M.E. & Turner, G.F. (2004) Laboratory mating trials indicate incipient speciation by sexual selection among populations of the cichlid fish *Pseudotropheus zebra* from Lake Malawi. *Proceedings of the Royal Society of London, Series B: Biological Sciences*, 271, 675–680.

Konings, A. (2001) *Malawi cichlids in their natural habitat*, Third edition. Cichlid Press, El Paso, Texas, 352 pp.

Konings, A. (2007) *Malawi cichlids in their natural habitat*, Fourth edition. Cichlid Press, El Paso, Texas, 424 pp.

Konings, A.F. & Stauffer, J.R., Jr. (2006) Revised diagnosis of *Metriaclima* (Teleostei: Cichlidae) with description of a new species from Lake Malawi National Park, Africa. *Ichthyological Explorations of Freshwaters*, 17, 233–246.

Leviton, A.E., Gibbs, R.H., Heal, E. & Dawson, C.E. (1985) Standards in herpetology and ichthyology: part I. Standard symbolic codes for institutional resource collections in herpetology and ichthyology. *Copeia* 1985, 802–832.

Mayr, E. (1963) *Animal species and evolution.* The Belknap Press of Harvard University Press, Cambridge, Massachusetts, 797 pp.

Ribbink, A.J., Marsh, B.A., Marsh, A.C., Ribbink, A.C. & Sharp, B.J. (1983) A preliminary survey of the cichlid fishes of rocky habitats in Lake Malawi. *South African Journal of Zoology*, 18, 149–310.

Seehausen, O., Van Alphen, J.J.M. & Witte, F. (1997) Cichlid fish diversity threatened by eutrophication that curbs sexual selection. *Science*, 277, 1808–1811.

Seehausen, O. & Van Alphen, J.J.M. (1998) The effect of male coloration on female mate choice in closely related Lake Victoria cichlids (*Haplochromis nyererei* complex). Behavioral *Ecology and Sociobiology*, 42, 1–8.

Stauffer, J.R., Jr., Bowers, N.J., Kellogg, K.A. & McKaye, K.R. (1997) A revision of the blue-black *Pseudotropheus zebra* (Teleostei: Cichlidae) complex from Lake Malawi Africa, with a description of a new genus and ten new species. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 148, 189–230.

Stauffer, J.R., Jr., Bowers, N.J., McKaye, K.R. & Kocher, T.D. (1995) Evolutionarily significant units among cichlid fishes: The role of behavioral studies. *In* J. L. Nielson (Ed), *Evolution in the Aquatic Ecosystem: Defining Unique Units in Population Conservation*. American Fisheries Society Special Publication 17, Bethesda, Maryland, pp. 227–244.

Stauffer, J.R., Jr. & Hert, E. (1992) *Pseudotropheus callainos*, a new species of mbuna (Cichlidae), with analyses of changes associated with two intra-lacustrine transplantations in Lake Malawi, Africa. *Ichthyological Explorations of Freshwaters*, 3, 253–264.

Stauffer, J.R., Jr. & Van Snik, E.S. (1996) New species of *Petrotilapia* (Teleostei: Cichlidae) from Lake Malawi, Africa. *Copeia*, 1996, 695–702.