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Re-elevation to species level and redescription of *Serranochromis jallae* and *Serranochromis robustus* (Teleostei: Cichlidae)

JAY R. STAUFFER, JR.[1], ROGER BILLS[2,3], PAUL H. SKELTON[2,4,*] & OLAF L.F. WEYL[2,5]
[1]*Penn State University, 432 Forest Resources Building, University Park, Pennsylvania 16802, USA. Honorary Research Associate, South African Institute for Aquatic Biodiversity, Makhanda, 6140, RSA.*
vc5@psu.edu; https://orcid.org/0000-0001-9653-942X
[2]*South African Institute for Aquatic Biodiversity, Private Bag 1015, Makhanda, 6140, RSA.*
[3] *R.Bills@saiab.ac.za; https://orcid.org/0000-0001-6034-4196*
[4] *p.skelton@saiab.ac.za; https://orcid.org/0000-0001-9587-2802*
[5] *o.weyl@saiab.ac.za; https://orcid.org/0000-0002-8935-3296*
**Wild Bird Trust - National Geographic Okavango Wilderness Project*

Abstract

Serranochromis robustus robustus from Lake Malawi and *Serranochromis robustus jallae* from Zambia were compared using morphological data. We re-elevated *S. robustus jallae* to species based on the following. *Serranochromis robustus* generally has a longer lower jaw (50.7–59.6% HL) than *S. jallae* (49.2–52.7% HL). *Serranochromis robustus* is not as deep-bodied as *S. jallae* as evidenced by the distance between the posterior insertion of the dorsal fin and the posterior insertion of the anal fin (13.4–15.1% SL in *S. robustus* vs. 14.9–18.4% SL in *S. jallae*). Additionally, *S. robustus* has a narrower least caudal peduncle depth (10.9–12.8% SL) than *S. jallae* (11.3–14.2% SL); the least caudal peduncle depth of all *S. robustus* was less than 12.8% SL while, except for the smallest specimen of *S. jallae* (88.1 mm SL), the least caudal peduncle depth was greater than 13.2% SL. Adults in breeding color of *Serranochromis robustus* are blue/green laterally, while adults in breeding color of *S. jallae* are yellow/green laterally. The marginal bands on the dorsal and caudal fins of *S. jallae* are bright orange in specimens from the Okavango River system and creamy yellow in Upper Zambezi specimens. In *S. robustus*, there is a yellow marginal band on the dorsal fin.

Key words: Tsungwa, Nembwe, Yellow-belly Bream, taxonomy, x-ray tomography

Introduction

Regan (1920) described the genus *Serranochromis* in a footnote and designated *Chromis thumbergi* Castelnau as the type species. Trewavas (1964) revised the genus and noted that previous authors had placed *Serranochromis* spp. in *Chromys* (*Chromis*), *Hemichromis*, *Paratilapia*, and *Pelmatochromis*. *Serranochromis* spp., also known as the largemouth breams, are a group of usually riverine predatory cichlids distributed throughout central and southern Africa (Skelton 2001). Günther (1864) described (as *Hemichromis*) *Serranochromis robustus* from Lake Malawi. The holotype (BMNH 1864.1.9.56) is a half-skin from Lake Malawi collected during Livingstone's expedition of 1861 (Trewavas 1964). Subsequently, Boulenger (1896) described *Hemichromis jallae* from the upper Zambezi River system but later Boulenger (1899), synonymized this with *Paratilapia robusta* (Günther 1864) and suggested that a study of the taxonomic status of *S. robustus* was warranted. The holotype is an 80.3 mm SL specimen collected from the upper Zambezi River (Trewavas 1964). Trewavas (1964) retained the synonymy as a set of subspecies of *S. robustus*. Skelton (2001) regarded *S. jallae* as a valid subspecies of *S. robustus*. Although historically *S. robustus* was frequently confused with *S. thumbergi* (Bertram *et al.* 1942, Lowe 1952), *S. robustus* was shown to be delimited from all other species in the genus by several authors including Jackson (1961), Jubb (1961), and Trewavas (1964). Marshall (2011) distinguished *S. robustus robustus* and *S. robustus jallae* and suggested that they should be recognized as distinct species depending on more detailed taxonomic analysis. Joyce *et al.* (2005) showed that *S. robustus* from Lake Malawi was clearly separated from *S. robustus* from the Okavango and the Congo systems. The purpose of this paper is to re-elevate *S. jallae* as a valid species.

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Methods

Counts and measurements follow Stauffer (1994) and Stauffer & Konings (2006). All counts and measurements were taken from the left side of the body except for gill-raker counts, which were taken on the right side.

The untransformed morphometric data were analyzed using a sheared principal component analysis, which factors the covariance matrix and restricts size variation to the first principal components (Humphries *et al.* 1981; Bookstein *et al.* 1985); thus, the second sheared principal components (SPC2) were only based on shape. Meristic data were analyzed using a principal component analysis in which the correlation matrix was factored. Differences between species were illustrated by plotting SPC2 of the morphometric data against the first principal components (PC1) of the meristic data (Stauffer & Hert 1992).

Taxonomy

Serranochromis robustus (Günther 1864)

Hemichromis robustus Günther 1864
Paratilapia robusta (in part) Boulenger 1899
Paratilapia thumbergi (in part) Boulenger 1911
Serranochromis robustus Jackson 1961
Misidentified as *Serranochromis thumbergi* Regan 1922, Trewavas 1935, Bertram *et al.* 1942, Lowe 1952.

Although we have not examined specimens of *Pelmatochromis tanganyicae* Bordin, given the current geographical ranges of what is now recognized as *S. robustus* and *S. jallae* it seems improbable that *P. tanganyicae* is either of these species. We thus consider it an error, and do not include this species in the synonymy, although further examination of this species is warranted.

Tsungwa is the common name in use in the local languages and by anglers.

Material examined. Holotype of *S. robustus* BMNH 1864.1.9.56
Other material: PSU 12920, 2, 188.2–200.5 mm SL, Chembe Beach; PSU 12921, 1, 178.7 mm SL, Nkhata Bay; PSU 12922, 1, 189.6, Mwalamba Rocks, Chirombo Bay.

Diagnosis. The holotype is half of a skin (examined by JRS) collected from Lake Malaŵi by Kirk who accompanied Livingstone's expedition (Trewavas 1964). The presence of four or five scale rows between the posterior margin of the orbit and the ascending arm of the preoperculum, the presence of widely set unicuspid teeth on the jaws, widely separated gill rakers, and anal fins with egg ocelli places this species in *Serranochromis*. Breeding males of *S. robustus* possess ocelli that are restricted to the posterior 4–5 membranes of the anal fin, which delimits them from all other *Serranochromis* spp., which have ocelli throughout the anal fin in breeding males, with the exception of *S. jallae*. As stated above, *S. robustus* was shown to be delimited from all other species in the genus by several authors including Jackson (1961), Jubb (1961), and Trewavas (1964).

Serranochromis robustus generally has a longer lower jaw (50.7–59.6% HL) than *S. jallae* (49.2–52.7% HL); three specimens of *S. jallae* had a lower jaw length greater than 52% of the head length and two specimens of *S. robustus* possessed a lower jaw length of less than 52% of the head length. *Serranochromis robustus* is not as deep-bodied as *S. jallae* as evidenced by the distance between the posterior insertion of the dorsal fin and the posterior insertion of the anal fin (13.4–15.1% SL in *S. robustus* vs. 14.9–18.4% SL in *S. jallae*). Additionally, *S. robustus* has a narrower least caudal peduncle depth (10.9–12.8% SL) than *S. jallae* (11.3–14.2% SL); the least caudal peduncle depth of all *S. robustus* was less than 12.8% SL while, except for the smallest specimen of *S. jallae* (88.1 mm SL), the least caudal peduncle depth was greater than 13.2% SL. *Serranochromis robustus* has a smaller horizontal eye diameter (HED)(17.7–27.4% HL) than *S. jallae* (18.6–25.5% HL). Although the HED is subject to allometric growth, there is no overlap in the minimum polygons when HED is plotted against head length (Fig. 1), and only the two smallest specimens of *S. robustus* have a HED greater than 19% HL. In general, *S. robustus* has more teeth in the outer row of the left lower jaw (14–23) than *S. jallae* (13–14); two specimens of *S. robustus* had 14 teeth with the remainder having 15 or more. Adults in breeding color of *Serranochromis robustus* (Fig. 2) are blue/green laterally with a narrow yellow marginal band on the dorsal fin and usually a small yellowish tip to the upper caudal-fin lobe. Adults in breeding color of *S. jallae* are yellow/green laterally with a bright orange marginal band on the dorsal and

caudal fins in fish from the Okavango River system, but creamy yellow bands in fish from the Upper Zambezi River system (Fig. 3). The throat and belly of *S. jallae* becomes more intensely yellow-orange in breeding dress hence the local name 'yellow-belly'. Rarely, specimens from the Okavango River in Namibia also have yellow rather than orange marginal bands (D. Tweddle, pers. comm.). Trewavas (1964) noted that breeding males of *S. robustus robustus* had no yellow on throat and belly while those of *S. robustus jallae* possessed yellow on throat and belly.

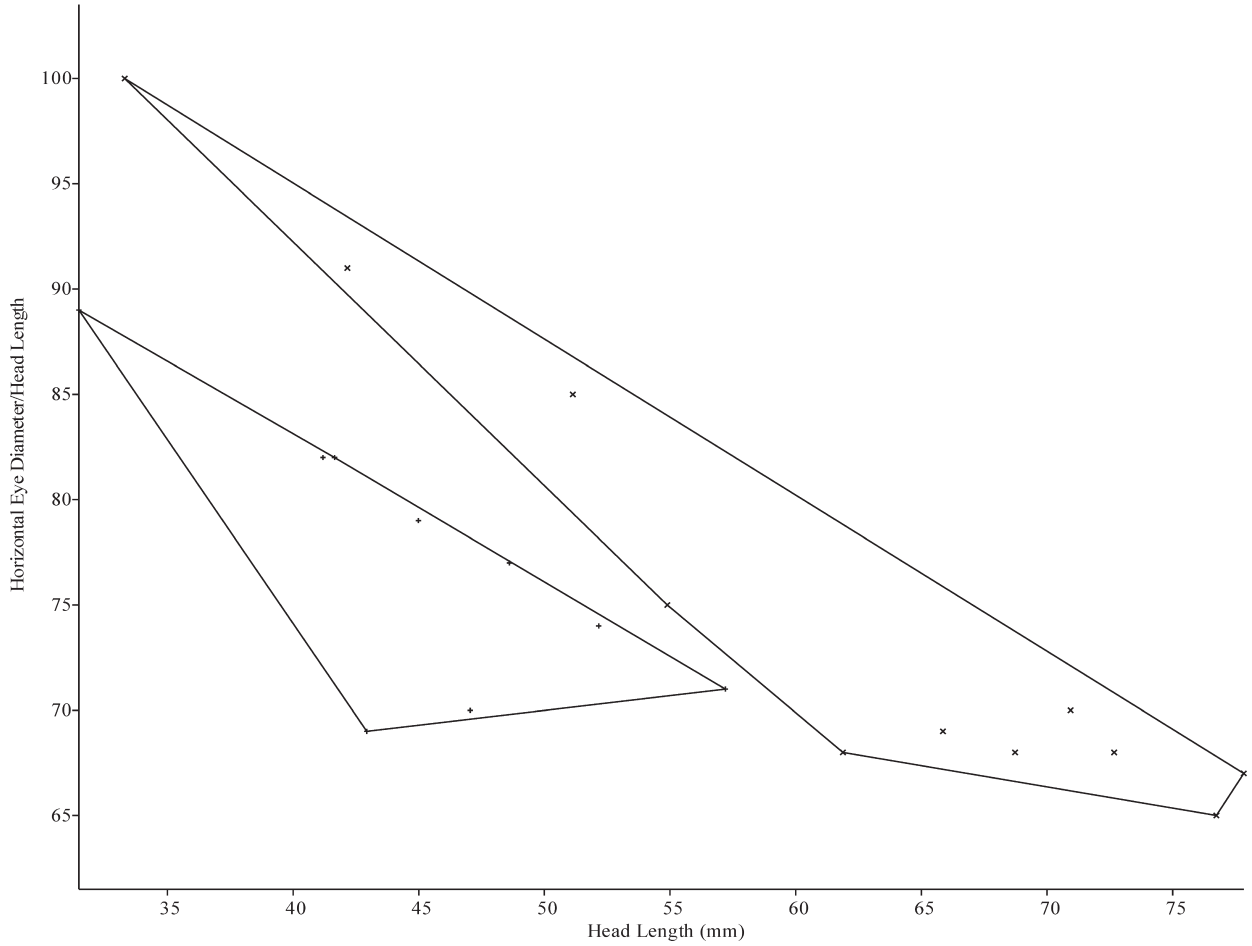

FIGURE 1. Horizontal eye diameter as percent head length plotted against head length of *Serranochromis robustus* (+) and *Serranochromis jallae* (x).

Description. Large robust *Serranochromis* with general body shape as in Fig. 2. Principal morphometric and meristic data in Table 1 and documented above in diagnosis. Head elongate (36.2–38.0% SL). Cheek depth 26.1–33.5% HL. Snout elongate (35.2–39.8% HL) and posterior end of lower jaw anterior to anterior margin of orbit. Two pored scales posterior to hypural plate, and 9–11 rows of scales on cheek. Outer arch of epibranchial with 4–5 gill rakers; outer arch of ceratobranchial with 10–12. Teeth in 2 series on upper and lower jaws. One or two scales between pectoral fin and posterior margin of opercle. Caudal fin emarginate and lacking marginal band in breeding adult males. Pectoral fin directly under origin of dorsal fin. Pelvic fin posterior to origin of dorsal fin.

Distribution and habitat. The native range of *S. robustus* is Lake Malaŵi and the outflowing Shire River and Lake Malombe — where it occupies mostly complex habitats in water shallower than 10 m. In southern Lake Malawi, *S. robustus* are generally associated with the rock/sand interface or, associated with submerged aquatic vegetation and among reed beds in shallow water and inlets. The *Serranochromis* species in the Luangwa River may be *S. robustus* based on photographs taken by anglers but specimens are needed to confirm this (Denis Tweddle, pers. comm.). Fish larger than 2 kg are rare. *Serranochromis robustus* was introduced from Lake Malawi into the Sand River Dam in Swaziland where it established and spread into the Komati River system in South Africa (De Moor & Bruton 1988; Bills *et al.*, 2004). Verbal reports (2019 pers. com., Erica Tovela, Maputo Museum) from Mozambique indicate the species has recently spread onto the Mozambique coastal plain.

TABLE 1. Morphometric and meristic values of *Serranochromis robustus* (n = 8) and *Serranochromis jallae* (n = 9).

	Serranochromis robustus			*Serranochromis jallae*		
Variable	**Mean**	**SD**	**Range**	**Mean**	**SD**	**Range**
Standard length, mm	167.1	41	91.3–204.5	122.4	19.7	88.1–154.7
Head length, mm	61.65	16	33.3–77.8	45.2	7.3	31.5–57.2
Percent of standard length						
Head length	36.9	0.6	36.2–38.0	37.0	0.80	35.8–39.7
Body depth	31.9	1.5	29.3–33.1	32.8	1.3	29.9–34.1
Snout to dorsal-fin origin	37.8	1.7	35.2–41.0	38.0	1.03	36.7–39.3
Snout to pelvic-fin origin	43.0	1.6	41.7–46.5	40.9	0.73	39.9–42.2
Dorsal fin base length	53.3	1.6	51.8–56	54.4	1.37	52.6–56.3
Anterior dorsal to anterior anal	44.4	1.2	42.8–46.5	47.1	1.78	43.0–49.2
Anterior dorsal to posterior anal	56.8	1.4	54.9–58.9	58.4	1.73	54.5–59.9
Posterior dorsal to anterior anal	28.1	0.7	27.2–29.3	28.4	3.5	19.8–30.8
Posterior dorsal to posterior anal	14.4	0.6	13.4–15.1	15.8	1.04	14.9–18.4
Posterior dorsal ventral caudal	19.7	0.7	18.7–20.6	19.2	0.70	18.4–20.3
Posterior anal to dorsal caudal	21.4	0.7	20.5–22.7	21.8	0.96	20.3–23.3
Anterior dorsal to pelvic-fin origin	32.4	1.2	30.0–33.6	34.1	1.5	30.4–35.3
Posterior dorsal to pelvic-fin origin	50.3	1.6	47.5–52.5	52.8	1.47	49.6–54.7
Caudal peduncle length	16.6	1.1	15.0–18.0	14.4	1.33	13.0–17.0
Least caudal peduncle depth	11.9	0.6	10.9–12.8	13.4	0.87	11.3–14.2
Percent of head length						
Snout length	36.8	1.5	35.2–39.8	35.7	1.47	33.9–38.6
Postorbital head length	45.7	1.5	43.2–47.7	47.2	2.11	44.8–51.6
Horizontal eye diameter	20.4	3.5	17.7–27.4	20.8	2.0	18.6–25.0
Vertical eye diameter	18.5	3.6	15.7–25.8	18.6	1.4	16.7–20.9
Interorbital width	20.2	1.6	17.2–22.1	21.3	1.0	19.1–22.6
Head Depth	75.9	4.5	69.6–81.4	76.6	4.5	68.1–83.9
Pre-orbital depth	20.8	2.1	17.6–22.9	19.3	0.7	18.2–20.2
Cheek depth	30.8	2.8	26.1–33.5	29.7	2.9	23.1–33.2
Lower jaw length	54.7	3.0	50.7–59.6	51.4	1.2	49.2–52.7
Counts	**Mode**	**Freq (%)**	**Range**	**Mode**	**Freq (%)**	**Range**
Dorsal-fin spines	15	63	15–16	16	78	15–17
Dorsal-fin rays	14	63	13–16	16	56	14–16
Anal-fin spines	3	100		3	100	
Anal-fin rays	11	63	10–11	11	44	10–12
Pelvic-fin rays	5	100		5	100	
Pectoral-fin rays	15	50	13–16	16	56	15–16
Lateral line scales	38/39	38	37–39	38	56	37–39
Pored scales posterior to LL	2	100		2	89	2–3
Cheek Scales	9	50	9–11	9	67	7–9
Gill rakers on first epibranchial	4	75	4–5	4	100	
Gill rakers on first ceratobranchial	11	50	10–12	11	56	11–12
Teeth outer row of left lower jaw	14/16	25	14–23	14	78	13–14
Teeth rows on upper jaw	2	100		2	100	
Teeth rows on lower jaw	2	100		2	100	

FIGURE 2. Adult male of *Serranochromis robustus*. Photo by Denis Tweddle.

Serranochromis jallae **(Boulenger 1896)**

Hemichromis jallae Boulenger (1896)
Paratilapia zambesensis: Gilchrist &Thompson (1917)
Pelmatochromis ngamensis Gilchrist & Thompson (1917)
Serranochromis robustus: Jubb (1961), Jackson (1961), Jubb (1967),
Serranochromis robustus jallae: Trewavas (1964)
Misidentified as *Paratilapia thumbergi:* Boulenger (1911)

The holotype is an 80.3 mm SL specimen collected from the upper Zambezi River (Trewavas 1964).

Nembwe is the widely used common name.

Material examined. *Serranochromis jallae*: SAIAB 72820, 6, 111.3–144.4 mm SL, 16° 05' 16" S, 23° 16' 12" E, Zambia; SAIAB 71287, 15° 34' 1.9194" S; 23° 16' 59.88" E, Kataba River, Kataba; SAIAB 7343, 12° 14' 34.998" S; 25° 34' 26.0004" E, Mwombezhi River;

Diagnosis. The presence of four or five scale rows between the posterior margin of the orbit and the ascending arm of the preoperculum, the presence of widely set unicuspid teeth on the jaws, widely separated gill rakers, and anal fins with egg ocelli places this species in *Serranochromis*. Breeding males of *S. jallae* possess ocelli that are restricted to the posterior 4–5 membranes of the anal fin, which delimits them from all other *Serranochromis* spp., which have ocelli throughout the anal fin in breeding males, with the exception of *S. robustus*. See above for the distinctions between *S. jallae* and *S. robustus*.

Description. Large robust *Serranochromis* with general body shape as in Fig. 3. Principal morphometric and meristic data in Table 1 and documented above. Head elongate (35.8–39.7 % SL). Cheek depth 23.1–33.2 % HL. Snout elongate (33.9–38.6% HL) and posterior end of lower jaw anterior to anterior margin of orbit. Two to three pored scales posterior to hypural plate, and 7–9 rows of scales on cheek. Outer arch of epibranchial with 4 gill rakers; outer arch of ceratobranchial with 11–12. Teeth in 2 series on upper and lower jaws. Pectoral fin immediately posterior to posterior margin of opercle and directly under origin of dorsal fin. Pelvic fin posterior to origin of dorsal fin. Caudal fin rounded. Colour described above in diagnoses of *S. robustus*.

Distribution and habitat. *Serranochromis jallae* is native to the Okavango, upper Zambezi, Kafue, Kasai, and Zambian Congo systems; has been introduced to Lake Kariba, and elsewhere in Zimbabwe (Poll 1967, Bell-Cross & Minshull 1988, Skelton 2001, Marshall 2011). Juveniles occur mostly on the floodplain and in lagoons, but larger adults appear to prefer mainstream habitats and are associated with in-stream structures such as woody debris, macrophyte beds, reeds, and eroded clay cliffs on outside bends of the rivers (Winemiller 1991, Tweddle pers.com.).

A movement study of 15 adult (32–49 cm TL) *S. jallae* on the upper Zambezi River demonstrated that the fish occupied relatively small home ranges, with individual fish utilizing a mean river stretch of 1330 m (Thorstad *et al.*, 2005). During low water levels, specimens of *S. jallae* were recorded in a variety of habitats in the mainstream of the river, but many moved onto adjacent temporary flooded areas during rising and high water; but did not undertake long-distance migrations onto the floodplains (Thorstad *et al.* 2005).

FIGURE 3. Adult males of *Serranochromis jallae* in breeding color (Okavango top; Upper Zambezi bottom). The anal fin in the top photo somewhat obscured by a shadow. Photos by Denis Tweddle.

Life history. *Serranochromis jallae* attains weights more than 4 kg (D. Tweddle, pers. comm.) but such large individuals are rare. Reproduction and diet of *S. jallae* in the upper Zambezi floodplain were described by Winemiller (1991). This mouthbrooder breeds in summer based on examination of gonads; *S. jallae* males attained sexual maturity at 275□300 mm SL and females at 250–275 mm SL. Based on age estimates from scale annuli, maturity of *S. jallae* was at approximately 3 years in the Barotse floodplain and the average numbers of mature oocytes per female was 1165. Bowers are simple saucer-shaped depressions of ca. 30 cm diameter that are constructed on sandy substrates among vegetation (van der Waal 1985). Analysis of stomach contents showed that interspecific diet overlap with other serranochromines was low among both immature and mature size classes of *Serranochromis*. Adult

size classes of *S. jallae* are primarily piscivorous with small catfishes (e.g., *Synodontis* spp.) dominating the diet on the Barotse floodplain (Winemiller 1991).

Further notes on distinction between *S. robustus* and *S. jallae*. When overall shape differences in the two species were quantified, there was no overlap in the minimum polygon clusters, when the SPC2 (morphometric data) were plotted against the PC1 of the meristic data (Fig. 4). Size accounted for 96% of the observed variance with second principal component 2.4%. Variables with the highest loadings on the SPC2 were caudal peduncle length (0.59), vertical eye diameter (0.37) and least caudal peduncle length (-0.38). The first principal component of the meristic data accounted for 43.7% of the total variance. Variables with the highest loadings on the first principal components were number of gill-rakers on the ceratobranchial (0.51), dorsal-fin rays (0.52), and lateral-line scales (0.45). Thus, morphological, color, and shape characteristics all support the recognition of two distinct species.

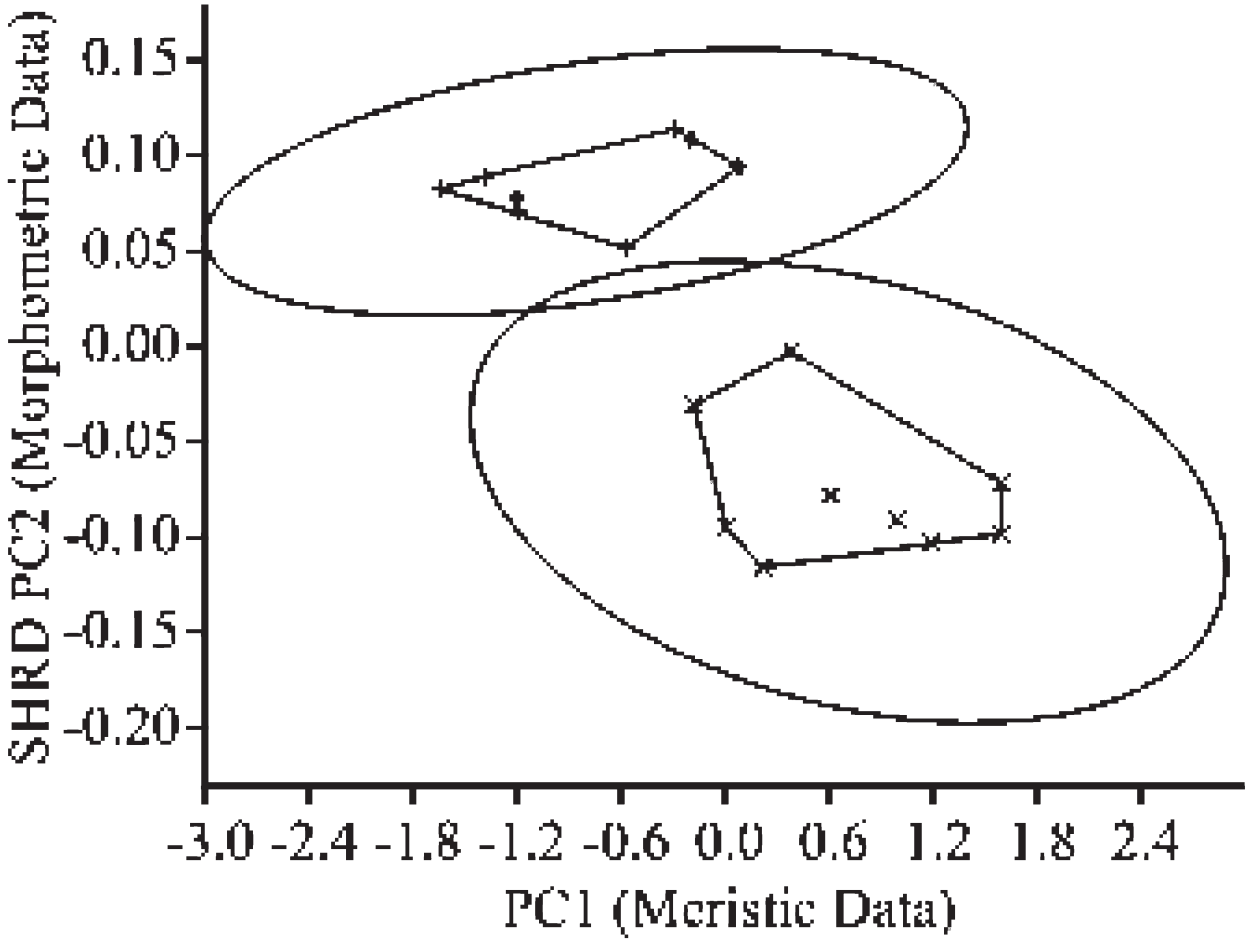

FIGURE 4. Sheared second principal components (morphometric data) plotted against the first principal components of the meristic data for *Serranochromis robustus* (+) and *Serranochromis jallae* (x). The minimum polygon clusters are bounded by 95% confidence levels.

Discussion

There are records of introduction of both species outside of their native range for the purpose of stock enhancement for angling. The distribution of the two species (including Zambian Congo and the populations in Luangwa), introduced range, and the potential for hybridization require further investigation. This is the first paper in a series that will describe additional species of *Serranochromis*, and a key to the genus will be provided after these species are diagnosed.

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