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Paraneetroplus synspilus is a Junior Synonym of *Paraneetroplus melanurus* (Teleostei: Cichlidae)

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Abstract

The genus *Paraneetroplus* (Teleostei: Cichlidae) currently consists of 11 species that naturally occur from southern Mexico south to Panama. *Paraneetroplus melanurus* (Günther 1862) is found in the Lago de Petén system of Guatemala, and *P. synspilus* (Hubbs 1935) in the Río Grijalva-Usumacinta system, and other systems in Mexico, Belize, and Guatemala. Reported morphological differences between the two nominal species in the literature are vague but center around characteristics of a dark band that begins at the caudal fin and tapers anteriorly near mid-body. This band is reported as straight (horizontal) in *P. melanurus* but ventrally sloped in *P. synspilus*. Some authors have previously suggested that these two forms are not distinct. The purpose of this study was to conduct a systematic morphological comparison of *P. melanurus* and *P. synspilus* to further investigate their validity. We examined meristic, morphometric, and geometric morphometric characters and failed to recover diagnostic differences between these two forms. The characters proposed to separate them do not allow for their differentiation, and we conclude that *P. synspilus* is a junior synonym of *P. melanurus*. A re-description of *P. melanurus* is provided on the basis of existing type material and additional material recently collected.

Key words: cichlid, taxonomy, morphology, Central America

Introduction

In his checklist of New World cichlids, Kullander (2003) recognized 16 species in the genus *Vieja*, a group that naturally occurs from southern Mexico to Panama. However, like many other genera of the family Cichlidae, *Vieja* is an enigmatic group that is taxonomically difficult to define. Previous molecular phylogenies have recovered the genus as paraphyletic (López-Fernández *et al.* 2010 and references within), and a recent phylogeny (mtDNA and nDNA) of *Vieja* including all 16 species and close allies *Theraps* and *Paraneetroplus* also recovered the genus as paraphyletic (McMahan *et al.* 2010). The molecular analyses of the latter study found strong evidence that most species in *Vieja* should be assigned to the genus *Paraneetroplus*.

One problem plaguing *Vieja* (now *Paraneetroplus*) taxonomy is that the genus was never adequately diagnosed. Moreover, original descriptions of some species are insufficiently detailed to allow positive identification (Günther 1862; Fernández-Yépez 1969). Several recent guides to fishes contain anatomical descriptions useful in identifying many species of *Paraneetroplus* (Greenfield and Thomerson 1997; Bussing 1998; Miller *et al.* 2006), but these publications largely treat only the fish fauna of a particular country. Consequently, certain species of *Paraneetroplus* are not included, making morphological comparisons difficult.

The present study focuses on two nominal species of *Paraneetroplus*: *P. synspilus* (Hubbs 1935) and *P. melanurus* (Günther 1862). Kullander (2003) indicated that *P. synspilus* is found in Mexico, Guatemala, and Belize within the Río Usumacinta drainage, and *P. melanurus* in Guatemala within the Río de la Pasión (tributary of the Río Usumacinta) and Lago de Petén systems (Fig. 1). Miller *et al.* (2006) provide additional occurrence records for *P. synspilus* (Fig. 1). Due to taxonomic confusion in the technical and popular literature, both species have been identified under a variety of generic names, in addition to *Paraneetroplus*, mainly *Vieja*, *Cichlasoma*, *Paratheraps*,

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and *Heros*, with minor variation in the spelling of the specific epithet (e.g., *synspilus* versus *synspilum*) to maintain rules of gender agreement between it and the generic name used. Some of the common English names applied to *P. synspilus* include redhead cichlid, pastel cichlid, quetzal cichlid, and firehead cichlid. *Paraneetroplus melanurus* has been referred to as the black tail vieja.

Paraneetroplus melanurus was originally described as *Heros melanurus* by Günther in 1862, the type locality given as Lake Petén, Guatemala. When Hubbs (1935) later described *P. synspilus*, he initially considered it to be closely related to *P. maculicauda* (Regan, 1905). His publication included a photograph of the holotype, and he detailed four characters distinguishing the two species. However, while the manuscript was in press Hubbs added a short footnote in which he stated that *P. synspilus* was closely related to *P. melanurus*, "differing in the downward slope of the caudal band," a characteristic he found in the holotype of *P. synspilus*, collected in Guatemala by C. L. Lundell (Hubbs 1935). In the original description of *P. melanurus*, Günther (1862) only noted that this species possesses a "deep black band along the middle of the tail." No description is given regarding the angle or slope of the band. Therefore, it cannot be concluded that Hubbs (1935) meant that the caudal band of *P. melanurus* is less sloped than that of *P. synspilus*, or that it is straight compared to downward-sloped in *P. synspilus*. Hubbs' (1935) brief comparison of *P. melanurus* with *P. synspilus* is one of the few known from the primary literature. Schmitter-Soto (1998) mentioned supposed differences in belly coloration of mature males, red in *P. synspilus* and yellow in *P. melanurus*, but provided no data.

There has been limited discussion in the literature regarding the taxonomic validity of *P. melanurus* and *P. synspilus*. Miller (1966) stated that *P. synspilus* might not be distinct from *P. melanurus*, but provided no explanation. These cichlids, particularly *P. synspilus*, are common in the aquarium trade and the notion that the two are probably synonymous is frequently mentioned in the current hobbyist/aquarist literature (Artigas Azas 2008). The purpose of this study was to conduct a morphological investigation of *P. melanurus* and *P. synspilus* to further investigate their taxonomic validity.

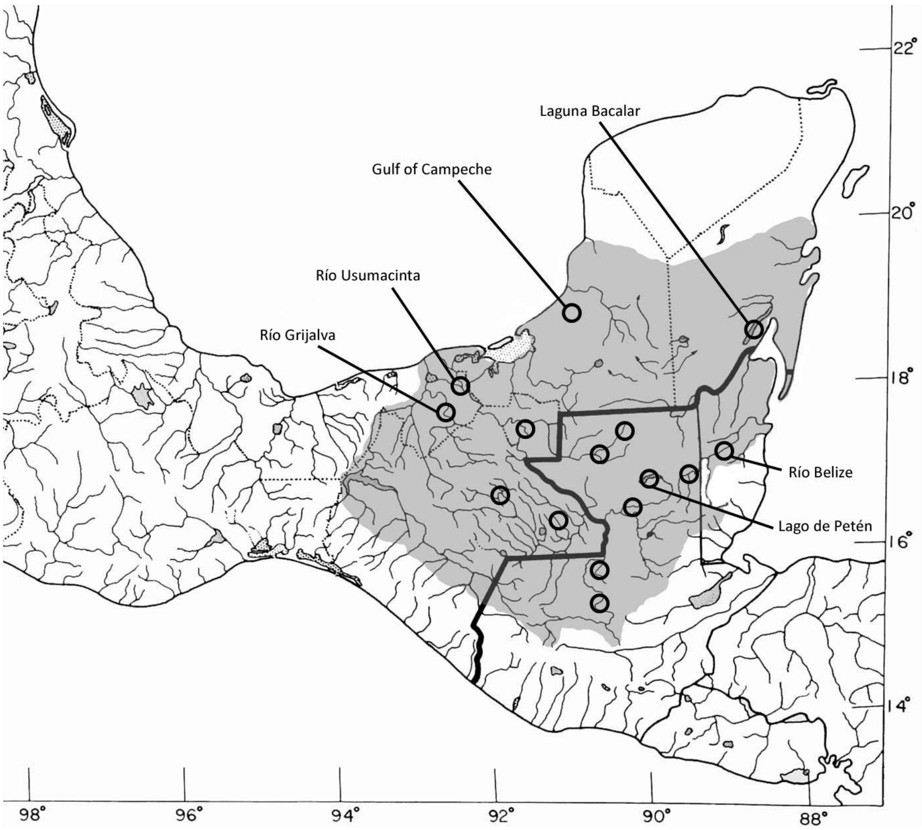

FIGURE 1. Distribution of *Paraneetroplus melanurus* represented by gray shaded area. Circles indicate localities for specimens examined in this study.

Material and methods

The University of Michigan's Museum of Zoology (UMMZ) contains a substantial amount of material from Mexico and Central America, the result of numerous collection surveys conducted by museum staff and affiliated investigators. Consequently, most of the preserved material used in this study was from the UMMZ (including the holotype of *P. synspilus*) and included specimens collected from sites throughout the native ranges of the two species (Fig. 1). Type material for *P. melanurus* was provided on loan by the Natural History Museum, London. The total number of specimens examined is 253. Specimens were *a priori* identified as *P. melanurus* or *P. synspilus* based on identification by their collectors. While this is not ideal there was no alternative given the ambiguity in characteristics to differentiate the two putative species.

A set of 25 meristic and morphometric characters was developed, all of which are defined in Appendix 1. Included was orientation of the caudal band, a trait that Hubbs (1935) used to distinguish *P. melanurus* from *P. synspilus*. Data were taken on the right side of specimens and gathered by a single individual (CMM) in an attempt to ensure standardization and reduce bias.

Multivariate statistical analyses were performed using PRIMER 6 (Clarke 1993, Clarke and Gorley 2006). Non-parametric statistical methods including multi-dimensional scaling (MDS) and hierarchical cluster analyses were used to test for differences between *P. melanurus* and *P. synspilus.* These analyses were chosen because they are complementary to one another, each working off the same resemblance matrix, and provide a more reliable assessment of morphology than either analysis on its own. Furthermore, non-parametric statistical analyses allowed comparisons to be made despite the unbalanced nature of the data (i.e. unequal number of specimens from each species).

Meristic and morphometric data were analyzed separately in order to avoid confounding units in the data. Morphometric data were standardized by dividing all values for a given variable by the total of that variable, to account for size variation between individuals; however, the meristic data were not transformed due to the comparability of counts despite body size. Euclidean Distance resemblance matrices were created separately for both the meristic and morphometric data based on between-sample distances. Multi-dimensional scaling (MDS) models were run from each resemblance matrix using 50 restarts and 0.01 minimum stress levels, allowing the depiction of relationships between samples in two-dimensional space. Because the data plotted in the MDS are based on all variables used in the study cumulatively, the data are able to freely rotate in the ordination plane, and axes are not defined for any one independent variable. Data were deemed interpretable at a stress level less than 0.15 (high stress levels >0.15 are indicative of poor depiction of data in two-dimensional space). MDS plots were labeled by species and then by locality.

In order to allow a more reasonable interpretation in cluster analyses, all data were averaged by factors created for samples (lots/catalog numbers). From this, Euclidean distance resemblance matrices were created separately for the meristic and morphometric data based on between-sample distances. Group average hierarchical cluster analyses were then run utilizing the previous resemblance matrices. A similarity profile test (SIMPROF) of significance was coupled with each cluster analysis in order to check for internal structure within the dendrogram. Permutation tests (n=999) were employed at each node of the completed dendrogram, and compared with simulated dendrograms representing the null hypothesis (random distribution with no significant structuring). Significant structure was denoted by black, solid branches and insignificant structure was denoted by red, broken branches (significant at $p < 0.05$). Because SIMPROF is *a priori* unstructured, it allows comparisons between samples rather than between predefined groups.

Similarity percentage analyses (SIMPER) were run comparatively between the two species, reporting average dissimilarity percentages between groups, and the average dissimilarity percentages of the contributing variables; in this case meristic and morphometric characters (a 90% cutoff was used for low contributing variables). This analysis was run utilizing Bray Curtis similarity resemblance matrices, which yielded dissimilarity percentages in the SIMPER analyses rather than distance measures.

Geometric morphometric analyses were performed on 33 *P. synspilus* and 52 *P. melanurus* specimens obtained from multiple sampling periods and localities (UMMZ 95518, 143889, 143937, 144035, 144048, 144053, BMNH 1864.1.26.78-82). This included type specimens of both species. A Nikon digital camera was used to photograph the left side of all specimens. Thirteen homologous landmarks were assigned in order to quantify body shape in both *P. synspilus* and *P. melanurus* specimens (Fig. 2). Landmark positions included: anterior and posterior origins of the dorsal fin; dorsal and ventral origins of the caudal fin; anterior and posterior origins of the anal fin; anterior pelvic fin origin; dorsal origin of the pectoral fin; the most posterior edge of the operculum; anterior operculum insertion at the base of the isthmus; posterior of the gape of the mouth; anterior tip of the snout; and the center of the eye. All landmarks were digitized for each individual using the software TPSDig version 2.12 (Rohlf 2008). TPSUtil version 1.44 (Rohlf 2009) was then used to append all files, creating a TPS combined data file including all specimens used in the analyses. Multivariate statistical analyses were performed using MorphoJ version 1.01b (Klingenberg 2008). A Procrustes fit was aligned by principal axes and then run in order to scale all individuals, and remove non-shape variation such as size and position of specimen. Principal components analysis (PCA) was then performed, utilizing the Procrustes coordinates as a covariance matrix, which quantified shape variation across all specimens, within each resulting principal component (PC). PCs that represented greater than 5% of the variance in body shape were interpreted; all lesser values were omitted due to their inability to explain any meaningful amount of variance (Zelditch *et al.* 2004).

To quantify slope of the caudal band, the angle between the lower lateral line and middle of the caudal band was recorded for the same individuals used in geometric morphometric analyses. Sixteen individuals of *P. melanurus* were added, to ensure the variation in caudal band slope observed in specimens was present in the analysis. Individuals of similar size ranges were used for both species. A two sample t-test was used to determine if significant differences in caudal band slope existed between *P. melanurus* and *P. synspilus*. Additionally, a RELATE analysis (PRIMER) was conducted to determine if there was a correlation between size (SL) and slope of caudal band (i.e. the algorithm searches for covariation between the size and caudal band slope variables). Data residuals were not normally distributed; therefore, a linear regression was not used.

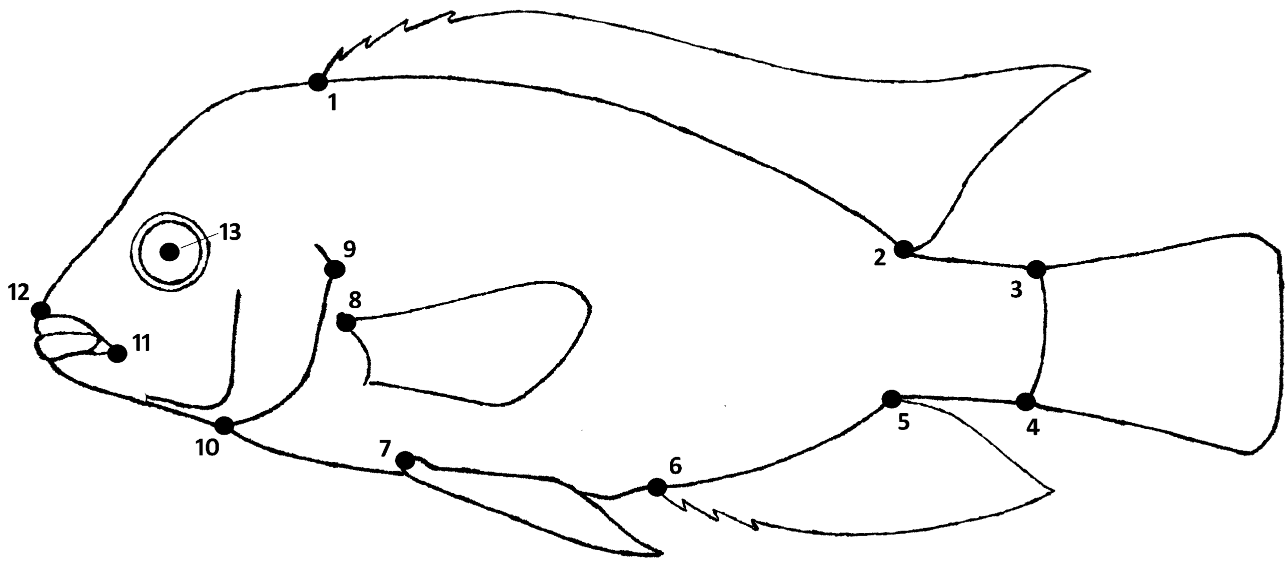

FIGURE 2. Drawing showing landmarks for geometric morphometric analysis as dots: anterior (1) and posterior (2) insertions of dorsal fin; dorsal (3) and ventral (4) insertions of caudal fin; anterior pectoral fin insertion (7); dorsal insertion of pectoral fin (8); most posterior edge of operculum (9); anterior operculum insertion at base of isthmus (10); posterior gape of mouth (11); anterior tip of snout (12); center of eye (13).

Results

Specimens identified as *P. melanurus* and *P. synspilus* were morphologically very similar, showing little variation in meristic traits (Table 1). Counts of dorsal and anal spines and rays are similar for both species. Slight variation is seen in upper and lower lateral-line counts; however, these traits are among the most variable in our dataset and many specimens had some damage to lateral-line scales. No samples display unique features of the meristic characters examined.

TABLE 1. Summary of meristic data for samples of *Paraneetroplus melanurus* and specimens identified as *Paraneetroplus synspilus*. For each character per locality, first number indicates mode, followed by number of individuals with mode for each count in parentheses. Numbers on second line are ranges.

Locality	DS	DR	AS	AR	PecR	UL	LL	AtoLL	ULoLL	PecPv
P. melanurus										
Laguna de Petén	17(75)	12(57)	6(82)	9(55)	15(46)	20(19)	11(19)	7(62)	2(84)	4(44)
(n=85)	16–18	11–12	5–7	7–9	13–16	18–22	7–14	7–8	1–2	4–6
P. synspilus										
Laguna Bacalar	17(4)	12(3)	6(4)	9(3)	15(3)	20(2)	11(4)	7(6)	2(7)	4(4)
(n=7)	17	12–13	6	9–10	12–15	15–22	10–13	7–8	2	4–5
Río Grijalva	17(6)	12(4)	6(9)	9(6)	14(9)	22(2)	14(5)	8(4)	2(9)	4(5)
(n=9)	16–17	10–13	6	8–10	14	18–23	11–14	7–9	2	4–5
Río Usumacinta	17(25)	12(14)	6(32)	9(24)	15(21)	21(13)	14(11)	9(16)	2(33)	4(21)
(n=33)	16–18	11–15	5–6	8–11	14–15	15–22	11–16	8–10	2	4–6
Río de la Pasión	17(15)	12(10)	6(14)	9(12)	14(11)	21(6)	13(8)	8(10)	2(18)	5(9)
(n=18)	15–17	11–12	5–7	7–9	12–15	18–22	9–13	6–8	2	4–5
Gulf of Campeche	17(11)	12(8)	6(10)	9(11)	15(9)	22(5)	13(5)	8(6)	2(11)	5(9)
(n=11)	17	10–12	5–6	9	14–15	21–23	11–13	7–8	2	4–5
Río Chixoy	17(17)	12(17)	6(20)	9(12)	14(19)	21(7)	11(12)	7(13)	2(23)	4(18)
(n=23)	16–18	11–13	6–7	8–11	13–15	16–24	7–13	6–8	2	3–5
Río Belize	17(22)	12(18)	6(19)	9(19)	14(23)	20(18)	12(7)	8(16)	2(25)	4(24)
(n=25)	16–17	10–12	5–7	8–9	14–15	20–21	10–13	7–8	2	4–5
Laguna Perdida	17(14)	12(8)	6(13)	9(6)	14(14)	20(4)	12(7)	7(9)	2(17)	4(9)
(n=17)	16–18	10–13	5–7	7–10	13–15	17–22	9–14	6–9	2	4–5
Laguna Eckibix	17(4)	12(6)	6(6)	9(4)	14(7)	21(3)	13(6)	8(6)	2(7)	4(5)
(n=7)	15–17	12–13	5–6	9–10	14	16–21	12–13	7–8	2	4–5
Laguna de Yalac	17(17)	12(15)	6(18)	9(15)	14(17)	20(8)	13(7)	8(16)	2(18)	4(13)
(n=18)	17–18	11–12	6	8–10	14–15	18–23	10–15	7–9	2	4–5

All meristic data are overlapping between *P. melanurus* and *P. synspilus* samples. The only variation observed was within *P. synspilus*, where four individuals from Lago de Petén and four individuals from Río de la Pasión (Río Usumacinta system) possessed a maxillary cleft which was slightly ventral to the dorsal margin of the pectoral-fin base. In all other specimens examined, the maxillary cleft was equal to the dorsal margin of the pectoral-fin base.

SIMPER analyses show that for *P. melanurus*, average within-group similarity for meristic characters is 97.40%. Average within-group similarity for *P. synspilus* for meristic characters is 96.57%. Average dissimilarity between *P. melanurus* and *P. synspilus* is 3.44% for meristic data. Lateral-line counts contributed the most to this dissimilarity. Results of MDS using data for meristic characters (Fig. 3a) show the relationships between *P. melanurus* and *P. synspilus*. Samples are labeled by species and found to have high overlap in ordination space. It should be noted that with MDS the axes show how the data fall out in multidimensional space (i.e. axes are not associated with any units, factors, etc.). Figure 3b again shows the MDS ordination, but samples are labeled by locality instead of species. Figure 3c depicts results of a cluster analysis using meristic data. *Paraneetroplus melanurus* and *P. synspilus* are distributed throughout the dendrogram. Because the two species appear randomly in the dendrogram (i.e. not as two distinct groups), the differences accounting for the slight variation are not specific to either of the species.

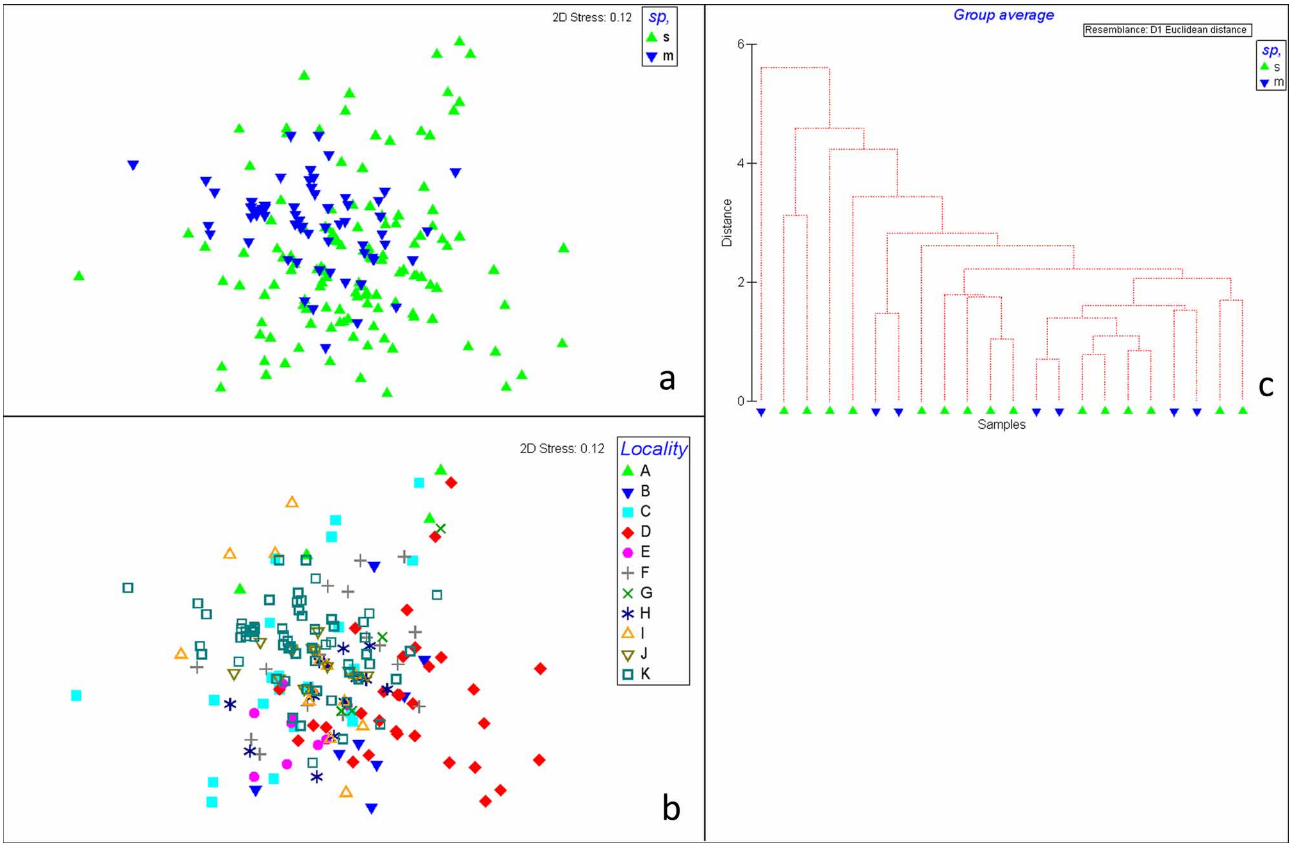

FIGURE 3. Multi-dimensional scaling (MDS) of meristic data distinguished by species (a; stress = 0.12) and by locality (b; stress = 0.12), with each point representing an individual specimen. c) Results of group average cluster analysis of meristic data. For plots a and c, “s” refers to *P. synspilus*, and “m” refers to *P. melanurus*. Localities: A, Laguna Bacalar; B, Río Grijalva; C, Río Chixoy; D, Río Usumacinta; E, Gulf of Campeche; F, Laguna Perdida; G, Laguna de Eckibix; H, Laguna de Yalac; I, Río de la Pasión; J, Río Belize; K, Lago de Petén.

Morphometric data are summarized in Table 2 and show no trends. SIMPER analyses show that for morphometric characters, within-group similarity is 97.40% for *P. melanurus* and 97.51% for *P. synspilus*. Average dissimilarity between *P. melanurus* and *P. synspilus* is 3.08%. Standard length and distance from anterior of dorsal fin to anterior of pelvic fin contributed the most to this dissimilarity. Results of a MDS (Fig. 4a) show that samples of *P. melanurus* and *P. synspilus* overlap in multidimensional space. Figure 4b shows the same MDS as Fig. 4a but with samples labeled by locality. Most individuals of *P. melanurus* appear to be more similar to individuals of *P. synspilus* than other *P. melanurus*. Figure 4c depicts a cluster analysis that shows samples of *P. melanurus* and *P. synspilus* distributed throughout the dendrogram with no taxonomic structure.

TABLE 2. Summary of morphometric data (in mm) for samples of *Paraneetroplus melanurus* and specimens identified as *Paraneetroplus synspilus*. For each character per locality, number on first line indicates mean of raw data; number in parentheses is mean of standardized data to allow for comparisons. Numbers on second line are ranges.

Locality	AntorbMax	PosorbPec	PosDPosA	SL	AntDAntPv	OrbDiam
P. melanurus						
Lago de Petén	8.7(5.1)	14.1(8.7)	14.2(8.9)	80.9(50.3)	35.8(22.2)	7.2(4.8)
(n=85)	1.7–46.6	4.8–55.1	5.3–53.1	30.1–207.0	13.2–90.0	3.8–13.2
P. synspilus						
Laguna Bacalar	7.8(5.1)	12.3(8.5)	13.3(8.9)	73.3(49.6)	33.5(22.9)	6.7(5.0)
(n=7)	2.3–14.6	5.2–21.7	5.5–23.5	32.1–128.1	15.3–59.4	3.9–9.7
Río Grijalva	8.4(5.0)	13.4(8.2)	15.2(9.3)	78.2(48.3)	39.8(24.4)	7.0(4.8)
(n=9)	4.4–17.4	7.6–26.2	7.8–30.6	44.0–153.2	20.5–77.2	4.8–10.9
Río Usumacinta	4.9(4.9)	8.9(8.8)	9.8(9.3)	49.2(48.7)	23.9(23.6)	4.8(4.8)
(n=33)	3.6–8.5	7.0–13.1	7.0–23.0	40.5–73.0	10.0–36.4	2.0–7.1
Río de la Pasión	9.0(5.2)	14.8(8.8)	15.4(9.3)	84.0(48.1)	40.6(23.9)	7.6(4.7)
(n=18)	3.8–17.3	7.6–25.9	7.5–27.8	18.7–161.4	18.3–75.4	4.6–11.7
Gulf of Campeche	5.3(5.0)	8.9(8.5)	9.5(9.0)	52.1(49.4)	24.5(23.2)	5.3(5.1)
(n=11)	3.4–8.0	6.3–12.8	6.4–13.1	37.9–72.2	17.3–35.4	3.9–7.4
Río Chixoy	5.6(4.5)	10.0(8.5)	10.6(8.8)	59.0(49.5)	28.4(23.8)	5.6(4.9)
(n=23)	1.9–11.0	4.9–19.1	5.8–21.3	33.1–115.9	15.1–54.9	3.8–8.9
Río Belize	4.5(4.6)	8.7(9.0)	9.0(9.5)	46.9(48.4)	22.4(23.2)	5.0(5.4)
(n=25)	3.0–16.3	6.1–26.6	7.1–24.0	35.9–140.5	17.3–63.9	4.0–10.2
Laguna Perdida	8.8(5.1)	14.2(8.3)	14.8(8.7)	83.9(49.1)	40.8(23.8)	8.4(5.0)
(n=17)	5.8–14.1	10.4–22.3	11.0–22.2	65.0–128.4	31.5–60.8	6.8–10.9
Laguna Eckibix	6.6(4.7)	11.8(8.3)	12.9(9.3)	71.2(50.7)	31.6(22.3)	6.6(4.8)
(n=7)	5.5–11.8	8.9–20.9	10.9–19.8	58.7–119.1	26.0–56.5	5.4–9.8
Laguna de Yalac	9.3(5.0)	14.9(8.1)	17.1(9.4)	89.9(48.9)	44.2(24.1)	8.1(4.4)
(n=18)	5.5–16.7	9.5–23.7	10.7–23.6	57.6–143.4	27.3–65.0	5.8–10.8

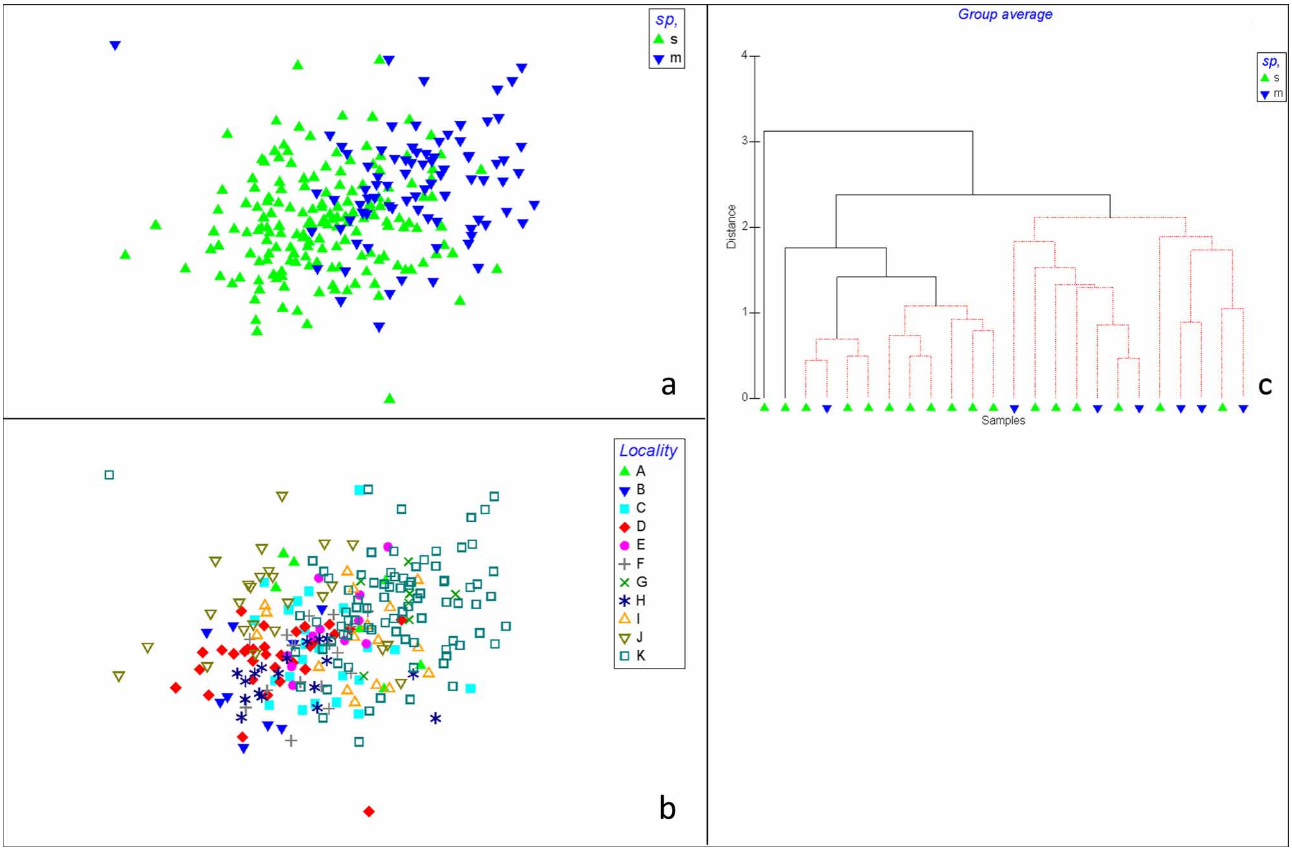

FIGURE 4. Multi-dimensional scaling (MDS) of morphometric data distinguished by species (a; stress = 0.12) and by locality (b; stress = 0.12), with each point representing an individual specimen. c) Results of group average cluster analysis of morphometric data. For plots a and c, "s" refers to *P. synspilus*, and "m" refers to *P. melanurus*. Localities as in Fig. 3.

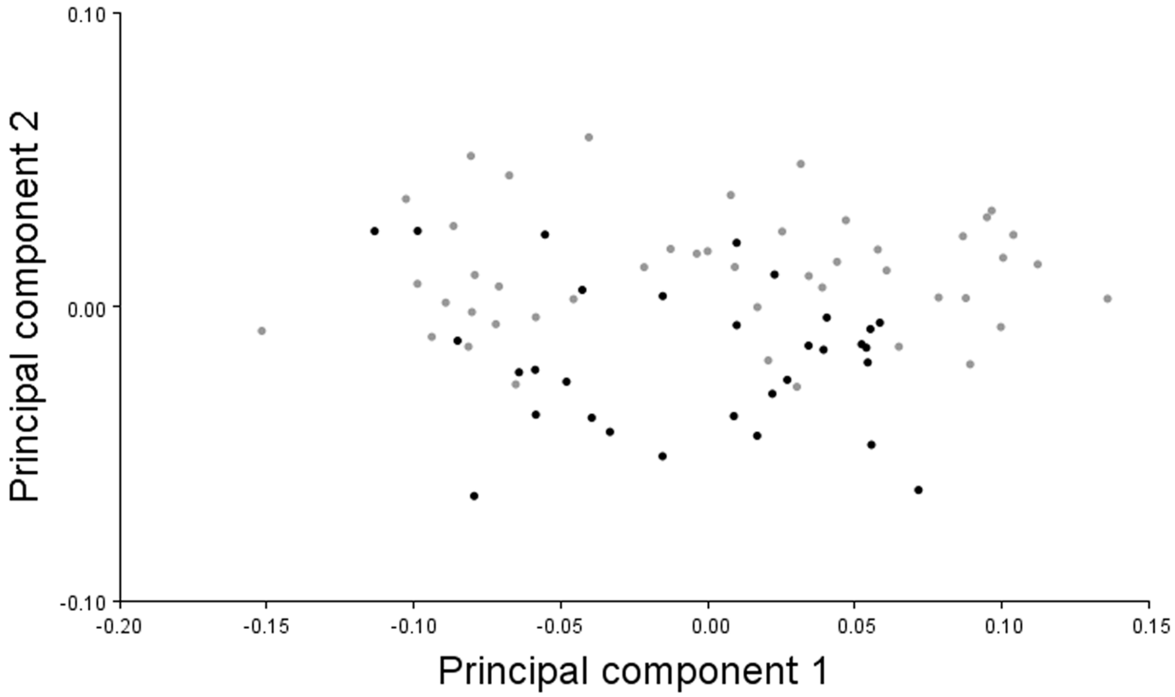

FIGURE 5. Results of Principal Components Analysis (PCA) of geometric morphometric data. PCs 1 and 2 are shown. Black circles represent *P. melanurus*; gray circles represent specimens previously identified as *P. synspilus*.

The PCA from the geometric morphometric analysis of body shape yielded 22 principal components (PC), which accounted for all body shape variation. PC1 through PC5 however, were the only PCs that individually represented >5% of the variance (PC1=24.556%; PC2=16.705%; PC3=12.506%; PC4=11.225%; and PC5=7.168%), and cumulatively they represented 72.19% of the variance. All other PCs describe <5% of the variance individually.

The greatest amount of shape variance is observed across PC1 and PC2 (Fig. 5). Despite the large total variance across these two axes, there is substantial overlap between *P. melanurus* and *P. synspilus* on both PC1 and PC2. Therefore the variance within each species is almost as large as the total variance within both PC1 and PC2. All other PCs showed a similar relationship, only differing in smaller total variance within the PCs, and greater overlap between species.

Examination of the slope of the caudal band also failed to separate *P. melanurus* and *P. synspilus*. All specimens possessed a caudal band with no distinct caudal spot. Any caudal spot would be considered as part of the caudal band. Figure 6a shows the right side of an individual of *P. melanurus*, which exhibits a fairly straight caudal band. However, the left side of the same individual (Fig. 6b) shows a downward-sloped caudal band. We found this trend to be common in many individuals, indicating that this is a plastic trait. The same trend was observed for the blotched *versus* non-blotched pattern of the caudal band, and can also be seen in Fig. 6a and b.

In nearly all material examined, the caudal band begins at the middle of the posterior end of the caudal peduncle and ends below the level of the lower lateral line, which equals a downward slope. The angle between the lower lateral line and middle of the caudal band was on average 10.2° in *P. melanurus* and 9.9° in *P. synspilus*. A two sample t-test showed no significant differences in angles between the two species ($p = 0.73$). RELATE analysis showed a correlation between angle of the caudal band and size (SL) of individuals, with smaller individuals possessing a less sloped caudal band than larger individuals (sample statistic Rho = 0.18; significance level $p = 0.013$).

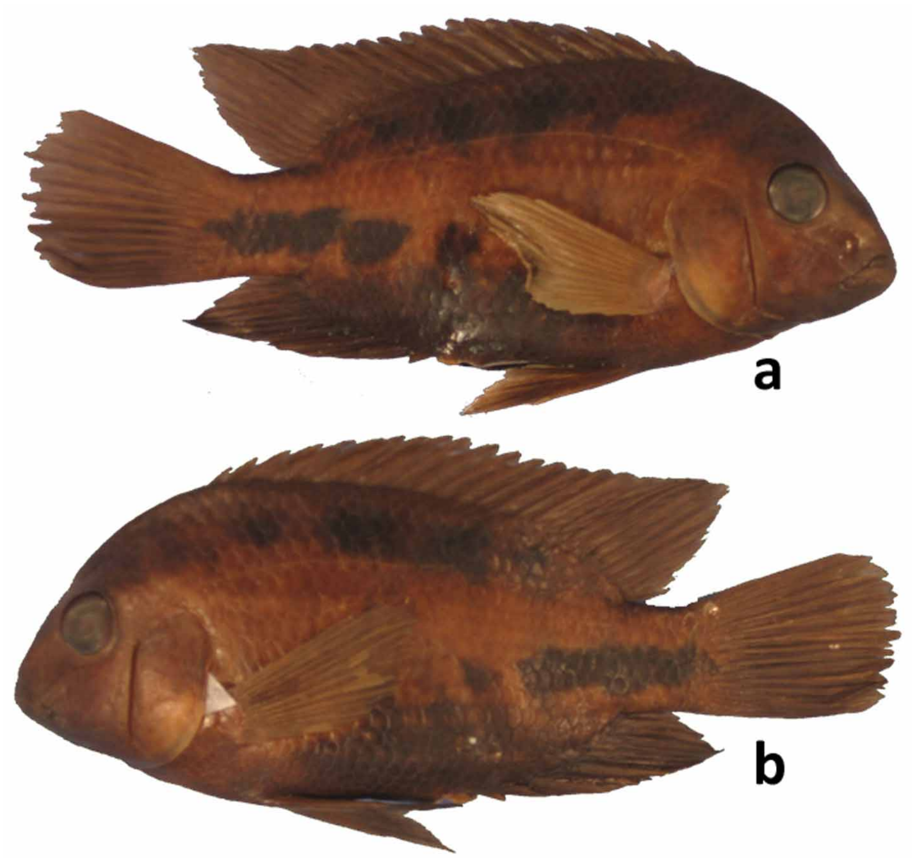

FIGURE 6. Single specimen of *Paraneetroplus melanurus*, UMMZ 143940 [SL 115 mm], showing the a) right side of specimen illustrating blotched and downward sloped appearance of caudal band and b) left side of same specimen illustrating non-blotched and relatively straight appearance of caudal band.

Discussion

The morphological descriptions for these forms (Günther 1862; Hubbs 1935) do not allow for separation based on any meristic or morphometric characters examined. The orientation of the caudal band, the primary character proposed by Hubbs (1935) to differentiate *P. melanurus* and *P. synspilus*, is not consistent or diagnostic. Morphological data from this study show that the two putative species are only slightly more than 3% different for the characters analyzed. No meristic or morphometric differentiation exists for any character. Schmitter-Soto (1998) noted a supposed difference in belly coloration between *P. melanurus* and *P. synspilus*; however, no data are given to support this claim, and we can find no other references indicating such a difference. Furthermore, Conkel (1997) notes high levels of color variation for both species.

In summary, the characters currently used to distinguish these two forms do not allow their separation; therefore, we recognize *P. synspilus* as a junior synonym of *P. melanurus*.

Re-description of *Paraneetroplus melanurus* (Günther 1862)

Lectotype. BMNH 1864.1.26.82 (Fig. 7). Type locality is Lake Petén, Guatemala. We designate the largest syntype as the lectotype and the remaining four specimens as paralectotypes (BMNH.1864.1.26.78-81).

Synonyms. *Heros melanurus* Günther 1862, *Heros melanopogon* Steindachner 1864, *Cichlasoma synspilum* Hubbs 1935, *Cichlaurus hicklingi* Fowler 1956

Material examined. ***Paraneetroplus melanurus***—GUATEMALA: UMMZ 143888 (n=11), 143889 (n=2), 143937 (n=30), 143940 (n=30), 143949 (n=3), 187210 (n=4); BMNH 1864.1.26.78-82 (n=5) [Lago de Petén]; UMMZ 95518 (n=1) [Río San Pedro de Mártir; Río Usumacinta Drainage]; UMMZ 189985 (n=23) [Río Chixoy]; UMMZ 144044 (n=17) [Laguna Perdida]; UMMZ 144035 (n=7) [Laguna de Eckibix]; UMMZ 144048 (n=18) [Laguna de Yalac]; UMMZ 144053 (n=18) [Río de la Pasión; Río Usumacinta Drainage]. MEXICO: UMMZ 196488 (n=2), 210868 (n=5) [Laguna Bacalar]; UMMZ 184628 (n=7), 184637 (n=2) [Río Chilapa; Río Grijalva Drainage]; UMMZ 196435 (n=30) [Río Usumacinta]; UMMZ 196605 (n=11) [Gulf of Campeche]; UMMZ 210943 (n=2) [Río El Huil; Río Usumacinta Drainage]. BELIZE: UMMZ 167692 (n=1), 190144 (n=1), 190149 (n=1), 202885 (n=22) [Río Belize]. COMPARATIVE MATERIAL—*P. maculicauda* (UMMZ 180667, n=3, Costa Rica: Tortugero; UMMZ 195944; n=1; Belize: Golden Stream); *P. guttulatus* (UMMZ 194116, n=5, Guatemala: Río Sis); *P. zonatus* (UMMZ 178573, n=4, Mexico: Río Tehuantepec); *P. fenestratus* (SLU 5022; n=1; Río Chiquito); *P. argentea* (UMMZ 189984; n=4; Guatemala: Río Chixoy); *P. regani* (UMMZ 184757; n=2; Mexico: Río Coatzacoalcos); *P. bulleri* (BMNH 90.10.10.94, n=1, Mexico: Río de Sarabia; FMNH 63937, n=1, Mexico: Río Papaloapan); *P. hartwegi* (UMMZ 186407, n=3, Mexico: Río Grijalva); *P. breidohri* (UMMZ 193906, n=3, Guatemala: Río Usumacinta); *P. bifasciatus* (UMMZ 143879, n=2, Guatemala: Río Usumacinta).

Diagnosis. *Paraneetroplus melanurus* possesses a single dark horizontal to slightly angled band or stripe that typically extends from the caudal-fin base to near the mid-point of the body; ranging from about one-third to nearly half the length of the body. The band appears as a series of connected dark blotches that, in many specimens, are then broken into separated blotches near the band's anterior extent (Figs. 6, 7, and 8b). The characteristic "caudal band" is present in both adults and large juveniles, and distinguishes the species from its congeners as well as all other syntopic cichlid fishes.

This species is most closely related to *Paraneetroplus maculicauda* (Hubbs 1935; McMahan *et al.* 2010) which occurs from the Río Usumacinta drainage south to the Río Chagres in Panama (Kullander 2003). *Paraneetroplus melanurus* is clearly distinguished from *P. maculicauda* by the presence in *P. melanurus* of a long black caudal band, often extending to mid-body. In *P. maculicauda*, the "band" is absent, replaced by a single large dark blotch at the caudal-fin base (Fig. 8a). In addition, adult *P. maculicauda* typically possess a dark vertical bar (belt) at mid-body (Fig. 8a). This character is absent in *P. melanurus*. The caudal band of *P. melanurus* also allows this species to be differentiated from all other members of the genus *Paraneetroplus* (*sensu* McMahan *et al.* 2010). In contrast to *P. melanurus*, the three congeners *P. guttulatus*, *P. zonatus*, and *P. fenestratus* each have a longitudinal band that extends the entire length of the body. *Paraneetroplus argentea* and *P. regani* are distinguished from *P. melanurus* by the absence of a caudal band. *Paraneetroplus bulleri* is distinguished from *P. melanurus* based on the presence in *P. bulleri* of an irregular longitudinal stripe down the body that ends at or just before the caudal-fin base and includes a series of large dark blotches. *Paraneetroplus bulleri* also possesses a prominent rounded snout (versus angular in *P. melanurus*) and a more elongate body. *Paraneetroplus hartwegi* can be distinguished from *P. melanurus* by the presence of lateral blotches/bars that form a nearly complete longitudinal stripe down the body, which begins with a blotch dorsal to the pectoral fin. *Paraneetroplus bifasciatus* differs from *P. melanurus* based on the presence of two stripes along each side of the body. The upper stripe may be a blotch if not developed; however, the lower stripe runs from the pectoral fin base to the caudal fin. *Paraneetroplus breidohri* differs from *P. melanurus* by possession of a relatively complete longitudinal dark band extending from near the head to the caudal-fin base.

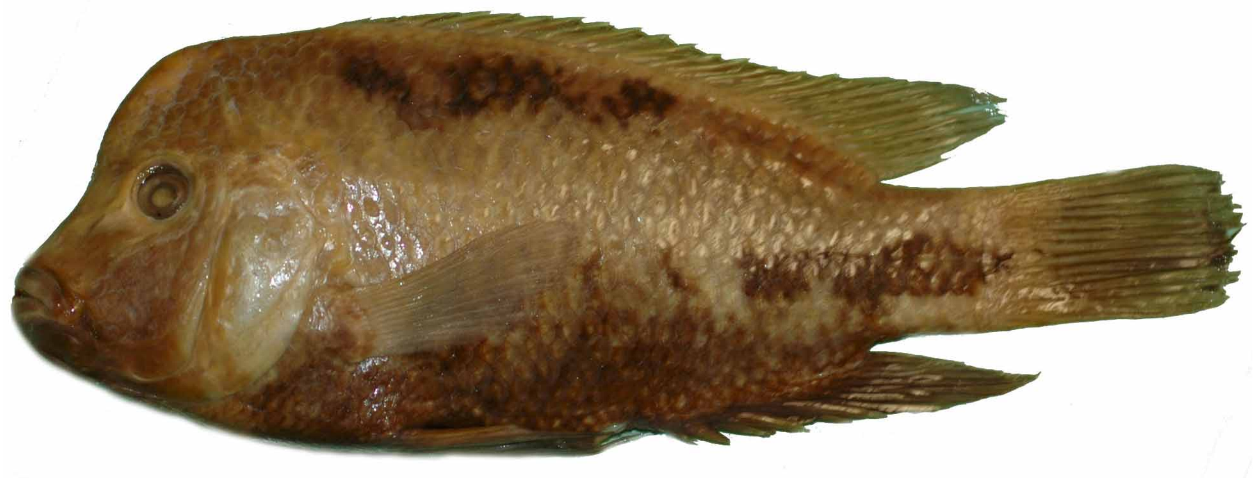

FIGURE 7. Lectotype of *Paraneetroplus melanurus* (BMNH 1864.1.26.82), 207 mm SL.

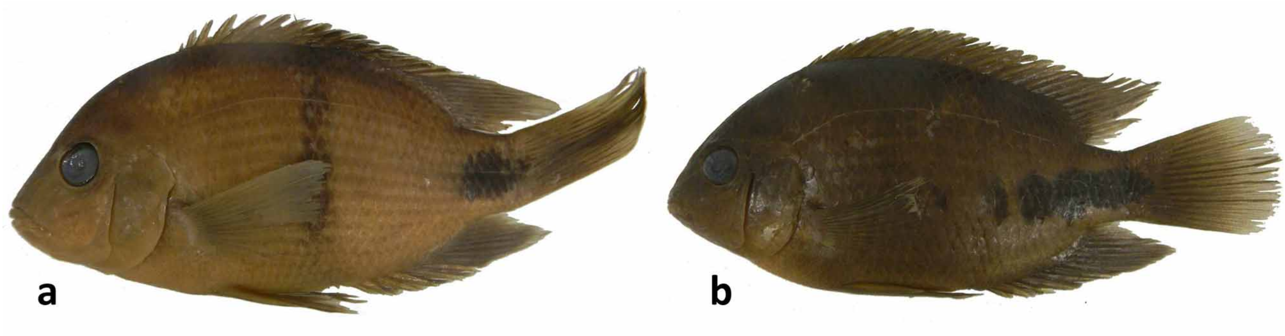

FIGURE 8. Comparison of caudal markings in a) *P. maculicauda* (UMMZ 195944) and b) *P. melanurus* (UMMZ 189985). The caudal marking of *P. melanurus* extends up to mid-body anteriorly, while the caudal marking of *P. maculicauda* resembles a large spot or blotch.

FIGURE 9. Live specimen of *Paraneetroplus melanurus*. SLU 6612; 180 mm SL; Mexico: Quintana Roo, Cenote Azul, collected 11 January 2009. Photo by K. R. Piller.

Description. Morphometric data on the lectotype and paralectotypes are reported in Table 3. *Paraneetroplus melanurus* possesses the following set of meristic traits: average dorsal fin formula XVII 12 [range XV–XVIII 10–15], anal fin formula VI 9 [range V–VII 7–11], upper lateral-line scales usually 20-22 (range 16–24); lower lateral-line scales usually 11–14 (range 7–16); 2 (rarely 1) scale rows between upper and lower lateral line. Individuals possess deep oval shaped bodies (42.8% SL in type material) and consistently have a prominent black caudal band. The band is variable, either blotched (discontinuous) or mostly solid (i.e. non-blotched), typically becoming more broken anteriorly. Slope of the caudal band is somewhat variable, ranging from nearly straight and horizontal in orientation to slightly angled, ventrally sloping anteriorly. The slope and blotched pattern of the caudal band may differ between left versus right side of the body of the same individual (Fig. 6). Small juveniles may possess a relatively straight caudal band; however, large juveniles and adults typically possess downward sloped bands. Most specimens possess a series of dark blotches along the dorso-lateral scales ventral to the dorsal fin. Breeding males of this species possess a large nuchal hump (Fig. 7).

TABLE 3. Measurements in percent of standard length of the lectotype and 4 paralectotypes of *Paraneetroplus melanurus*. SD=standard deviation.

	Lectotype	Range	Mean	SD
Standard length (mm)	207.0	63.2–207.0		
Head length	65.6	20.4–65.6	40.9	16.5
Snout length	33.1	7.6–33.1	18.8	9.3
Head depth	77.6	19.4–77.6	43.6	21.5
Body depth	88.7	28.3–88.7	55.4	22.2
Orbital diameter	11.1	5.3–11.1	8.3	2.0
Interorbital width	25.2	7.7–25.2	15.8	6.3
Caudal-peduncle width	29.6	9.2–29.6	17.9	7.6
Caudal-peduncle length	25.6	6.2–25.6	14.3	7.2

Coloration in alcohol. Body with an overall brown color; smaller individuals may be a darker brown. Caudal band and dorso-lateral blotches remain black or dark. Dorsal, anal, pelvic, and caudal fins tan, with juveniles often possessing dark spots on fins. Pectoral fins are translucent and relatively colorless in adults, but occasionally having dark spots.

Coloration in life. Live specimens have an overall dusky tone, with a gray to yellowish body (Fig. 9). The caudal band and dorso-lateral blotches are black or dark. Fins are a dusky color, often having small dark spots. Individuals may have areas of blue, green, or yellow scales on the body. Adults in breeding condition typically have extensive red or pink on the breast area and sometimes extending over much of the anterior part of the body, with such variation possibly related to localized differences across the native range (Conkel 1997, Schmitter-Soto 1998). Breeding individuals also display blue and yellow coloration on fins.

Etymology. While not stated in Günther's original description, the specific epithet appears to be derived from the Greek *melanos* (black) and *oura* (tail), likely in reference to the characteristic caudal band of this species.

Description of Lectotype. The lectotype is the largest of the five original syntypes (Fig. 7). The specimen appears well preserved and still possesses distinguishable markings. It is an adult male of 207 mm SL, 55.08 mm from posterior of orbit to pectoral fin, 53.07 mm from posterior of dorsal to anal fin, 88.75 mm from anterior of dorsal to pelvic fin, and 11.13 mm orbit diameter. Dorsal fin XVII 12, anal fin VI 8, 14 pectoral rays, 22 upper lateral-line scales, 13 lower lateral-line scales, 7 scale rows from anal fin to lower lateral line, 2 scale rows between upper and lower lateral line, 6 scales from pectoral to pelvic fin. The gill rakers are relatively short and conical. The maxillary cleft is ventral to the dorsal margin of the pectoral-fin base, and the upper and lower jaws do not extend one over the other.

The left side of the specimen possesses a ventral-sloped caudal band, ending anteriorly ventral to the lower lateral line. The caudal band on the right side of the specimen is incomplete, consisting of moderately defined blotches; however, this band also continues to ventral the lower lateral line. The lower lateral line runs through the center of the posterior portion of the caudal band. On both sides of the specimen a series of 3–4 joined dorso-lateral blotches is present. Teeth are conical. The lectotype possesses a nuchal hump on the head, characteristic of breeding males of this species.

Intraspecific variation. Variation in meristic characters is minimal throughout the range of this species. Most variation is associated with the pattern and slope of the caudal band, and this variation does not appear to be geographically differentiated. There is also variation in color pattern (see section on coloration, above).

Distribution. *Paraneetroplus melanurus* naturally occurs along the Atlantic slope in the Río Grijalva-Usumacinta system, and east and southward throughout Quintana Roo, Mexico, and Belize to the Lago de Petén system of Guatemala. An introduced population is presumably established in Singapore (Ng and Tan 2010), and the specimens, likely released pet fish, have been reported for open waters of the USA (Fuller *et al.* 1999) and the Philippines (Froese and Pauly 2009).

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APPENDIX 1. Definition of Morphological Characters— Each character and its definition appear below. All characters reported for right side, all measurements taken in millimeters.

MORPHOMETRIC CHARACTERS:
Orbit-maxillary cleft distance—Distance from anterior of orbit to maxillary cleft at posterior of mouth.
Orbit-pectoral fin distance—Distance from posterior of orbit to dorsal insertion of pectoral fin.
Posterior body height—Distance from posterior insertion of dorsal fin to posterior insertion anal fin.
Standard length—Standard length from snout to center of origin of caudal fin.
Anterior body height—Distance from anterior insertion of dorsal fin to anterior insertion of pelvic fin.
Eye diameter—Diameter of orbit

MERISTIC CHARACTERS:
Dorsal spines—Number of dorsal-fin spines
Dorsal rays—Number of dorsal-fin rays
Anal spines—Number of anal-fin spines
Anal rays—Number of anal-fin rays
Pectoral rays—Number of pectoral-fin rays
Upper lateral count—Number of scales in upper lateral line
Lower lateral count—Number of scales in lower lateral line
Anal fin to lateral line—Number of scale rows between anterior origin of anal fin and origin of lower lateral line
Lateral scale row overlap—Number of scale rows between upper and lower lateral line
Pectoral-pelvic scale rows—Number of scale rows between ventral origin of pectoral fin and anterior origin of anal fin
Gill raker length—Comparative length of gill rakers (short, elongated)
Gill raker shape—Comparative shape of gill rakers (rounded, conical)
Maxillary cleft position—Tip of maxillary cleft in relation to dorsal margin of pectoral-fin base (cleft at level of, ventral to, or dorsal to)
Jaw configuration—Upper jaw in front of or behind lower jaw
Caudal band—Caudal band absent, incomplete, complete and sloped, or complete and straight
Caudal spot—Presence/absence of distinct caudal spot
Interorbital bars—Presence/absence of interorbital bars
Operculum marking—Presence/absence of crescent shape on posterior margin of operculum
Tooth shape—Shape of teeth (conical, bicuspid, intermediate)