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Short Communication

Variation in head morphology in the electric knifefish *Apteronotus brasiliensis* (Reinhardt, 1852) (Gymnotiformes: Apteronotidae) in the Paraná and São Francisco River Basins

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Abstract

Specimens of *Apteronotus brasiliensis* from Paraná and São Francisco River basins (Brazil) present snout always moderately elongated, that can be oblique or directed forward or strongly downward. Detailed examination revealed that these head-morphology differences are related to individual variation, not to sex, ontogeny or geographic distribution.

Keywords: freshwater, morphology, Neotropical fish, Ostariophysi, Teleostei, systematics

Intraspecific head-morphology variation is common among fishes, and this variation has been assigned to different causes in different species. Thus, Schwassmann & Carvalho (1985) described individual variation in head morphology found in *Archolaemus blax* Korringa, 1970, a sternopygid species. "Extreme" sexual cephalic dimorphism related to ontogeny was recognized in *Parapteronotus bonapartii* (Castelnau, 1855) by Lundberg et al. (2000), a species containing short snouted forms [described as *A. hasemani* (Ellis, 1913)], males with very long snouts (described as *Apteronotus anas* Eigenmann & Allen, 1942), and animals with intermediate-sized snouts (described as *Sternarchus bonapartii* Castelnau, 1855) (Triques, 2007). Another marked difference in snout morphology was reported by Lundberg et al. (2000) for *Sternarchogiton nattereri* (Steindachner, 1868), considered a senior synonym of *Oedemognathus exodon* Myers, 1936, on the basis of sexually dimorphic tooth morphology. Such variations have taxonomic implications and their understanding is necessary for both the taxonomic knowledge of the involved taxa and for identification purposes.

Apteronotus brasiliensis (Reinhardt, 1852) was described from the das Velhas River (São Francisco river basin), but is also known to occur in the Paraná River basin. For example, specimens from the Paraná River are deposited in the Fish Section of the Museu de Zoologia da Universidade de São Paulo, including large specimens collected in the area of the Ilha Solteira dam (e.g. Travassos, 1960; Albert 2001: 109; Triques 2005: 148). According to Triques (2005: 139), this species can be diagnosed by a combination of apomorphic characters: (1) presence of a clear spot on the caudal-fin base (also present in several other apteronotid species); (2) pectoral-fin chromatophores only present over the rays (also present in *Sternarchella curvioperculata* Godoy, 1968 and *Sternarchorhynchus roseni* Mago-Leccia, 1994); (3) lateral ethmoid not cylindric, with widened bases, better described as wide dorsally, tapering ventrally; (4) lateral processes of anterior portion of vomer (= ventral ethmoid) robust and round [also present in *Orthosternarchus tamandua* (Boulenger, 1898), *Megadontognathus cuyuniense* Mago-Leccia, 1994 and *Apteronotus leptorhynchus* (Ellis, 1912)]; (5) maxillary bone shield-like (also in *A. leptorhynchus* and *O. tamandua*); (6) hypermorphosis of the sphenotic region, resulting in a slender pterosphenotic and a robust orbitosphenotic (this is the single unambiguous autapomorphy of the species). Neither skeletal, nor external morphological differences were found by Triques (2005) between specimens of *Apteronotus brasiliensis* from the São Francisco and the Paraná River basins, thus corroborating the previous assignment of the species to the Paraná River basin (as *Sternarchus brasiliensis,* by Britski, 1972: 91).

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We have found specimens of *A. brasiliensis* from different sites in the Paraná and São Francisco River basins exhibiting different head morphologies relative to the pattern currently known for the species. These could be due to: *a)* differences in conditions during development; *b)* individual variation; *c)* sexual dimorphism or *d)* they may represent a new species to science. Specimens with the snout directed forward and downward can be easily distinguished from each other and from the widely known obliquely-snouted form. The aim of this paper is to determine the source of the observed morphological differentiation in *Apteronotus brasiliensis*.

In order to evaluate the possible relationship between the variation observed in head morphology of *A. brasiliensis* and sex, ontogeny, or specific, populational or individual variation, both qualitative and quantitative features usually presented in the descriptions of recent apteronotid species were examined. Measurements were made as in Triques (1996), and the meristic data studied were the number of scale rows above the lateral line in the deepest body region and numbers of anal and pectoral fin rays. Non-obvious epithets for character nomenclature are: *a)* "prenasal 1" (from the snout tip to the anteriormost edge of the tubular anterior nostril), *b)* "internasal 3" (between the anterior and posterior nostrils) and *c)* "eye depth" (from the head mid-ventral line to the eye inferior margin). The "standard length" of Triques (1996) is herein named "length to the end of anal-fin base" (LEA). Measurements were taken point-to-point with a caliper to the nearest tenth of millimeter, except LEA, that was taken with a ruler to the nearest millimeter. Some body proportions are presented in Tab. 1; others are presented in text. The 59 apomorphic, qualitative or discrete, external-morphology characters used by Triques (2005) were also studied here.

Specimens were cleared and stained as in Taylor & Van Dyke (1985) and dissected as in Weitzman (1974) for skeletal studies, however, there were no specimens representative of all different snout shapes available for anatomical preparation. Studied specimens are: MZUSP 23096 (4 specimens) – Ilha Solteira, coffer dam in Paraná River, São Paulo state, September 1965; MZUSP 24460 (7) – Ilha Solteira, coffer dam in the right margin of the Paraná River, Mato Grosso do Sul state, May 1972; MZUSP 22237 (4, 1 cleared and stained) – Piracicaba, São Paulo state; MZUSP 39605 (2) – Malhada, Abaeté River, tributary of the São Francisco River, Minas Gerais state, March 1988; MZUSP 39954 (1) – Água Vermelha reservoir, Grande River, on the border of the states of São Paulo and Minas Gerais, June 1978; DZUFMG (Departamento de Zoologia da UFMG) 069 (1) – Paraopeba River at Francelinos, municipality of Juatuba, Minas Gerais state, 20º. 0' S 44º. 17' W, November 1999; DZUFMG 068 (04, 1 cleared and stained) – Araguari River, near Uberlândia, Minas Gerais State, Rio Paraná basin.

Sex identification was done through visualization under stereomicroscope of gonad external characteristics, following criteria used by Bazzoli (2003) and Vono et al. (2002).

Different morphologies found in the head of examined specimens were: *a)* snout elongate, forward-directed (Fig. 1B-C); *b)* oblique (Fig. 1A); or *c)* strongly downward-directed (Fig. 1D). These three states were not related to any of the following variables: *i)* sex (Fig. 1); *ii)* body size (for example, the largest and the smallest studied specimens had strongly downward-directed snouts) or *iii)* distribution (strongly-downward directed snout specimens were found in the Paraná River and in the Abaeté River — the latter, tributary of the São Francisco River; forward-directed snouts were found in specimens from the Paraná River

Table 1 - Comparison of body proportions of *Apteronotus brasiliensis* from the Paraná River: Oblique snout (MZUSP 24460), downward snout (MZUSP 23096) and forward snout (MZUSP 23096).

Measurements	Oblique snout (n =7)	Downward snout (n= 2)	Forward snout (n= 2)
LEA (mm)	97 – 176	290 – 400	340,0 – 394
Percentage of head length			
Snout length	42,8 – 48,5	47,5 – 48,5	46,7 – 48,3
Percentage of anal-fin base			
Snout length	8,7 – 10,6	9,2 – 10-3	9,4 – 10,6
Percentages of post-ocular length			
Oculo-nasal distance	30,7 – 43,3	40,5 – 42,0	39,9 – 45,0
Prenasal 1	21,4 – 31,8	18,9 – 20,2	16,7 – 19,1
Ocular diameter	10,4 – 14,8	7,6 – 11,4	7,6 – 9,5
Internasal 3	12,7 – 23,1	6,1 – 8,3	7,2 – 9,0
Greatest head depth	118,7 – 134,7	111,7 – 122,6	123,6 – 125,3
Eye depth	59,1 – 73,4	63,4 – 63,5	71,2 – 73,0

and the Paraopeba River — the latter, in the São Francisco River basin). Even in strongly downward-directed snouted specimens, the snout never surpassed a horizontal line passing through the anal-fin base. Comparisons of body proportions between specimens with different snout morphologies are shown in Tab. 1.

Neither qualitative nor quantitative differences could be found in the external morphology of the populations of the São Francisco and Paraná basins. Morphological quantitative intervals overlap between these populations. Unfortunately, since the number of specimens available was not large, statistical analyses could not be implemented; however, the overlap of the quantitative intervals suggests the presence of a single species.

Albert (2001) stated that hypermorphosis is "an ontogenetic extension of the plesiomorphic gymnotiform growth pattern, and produces an elongate head in larger specimens (more than 160 mm TL), in which the orbit lies at about (or in advance of) the midlength of the head". As can be seen in Tab. 1, a small increase in snout length relative to head length is observed when LEA increases between 100 mm and 180 mm; however, the increase of LEA between 180 mm and 400 mm is not accompanied by an increase in relative snout length. Our data, then, does not support the snout hypermorphosis hypothesis of Albert (2001) for *A. brasiliensis* and, thus, snout-length variation does not seem to be related to ontogenetic development, but is congruent with the proposal by Triques (2005) of an autapomorphy defined as: a slender pterosphenoid and robust orbitosphenoid.

However, we observed an allometric growth in the juvenile stage of the oculo-nasal distance (from posterior nostril to eye; Tab. 1). Thus, as LEA increases between 100 mm and 180 mm, the oculo-nasal distance varies from 30,7% to 43,3% of the head length (a negative allometry). As the LEA increases further, this distance remains the same, even in very large animals. As the distance between the anterior and the posterior nostrils diminishes in larger animals (Tab. 1, as "internasal 3"), it seems that this reduction is the responsible for the shift from 30% to 40%-45% of the oculo-nasal distance relative to postocular length.

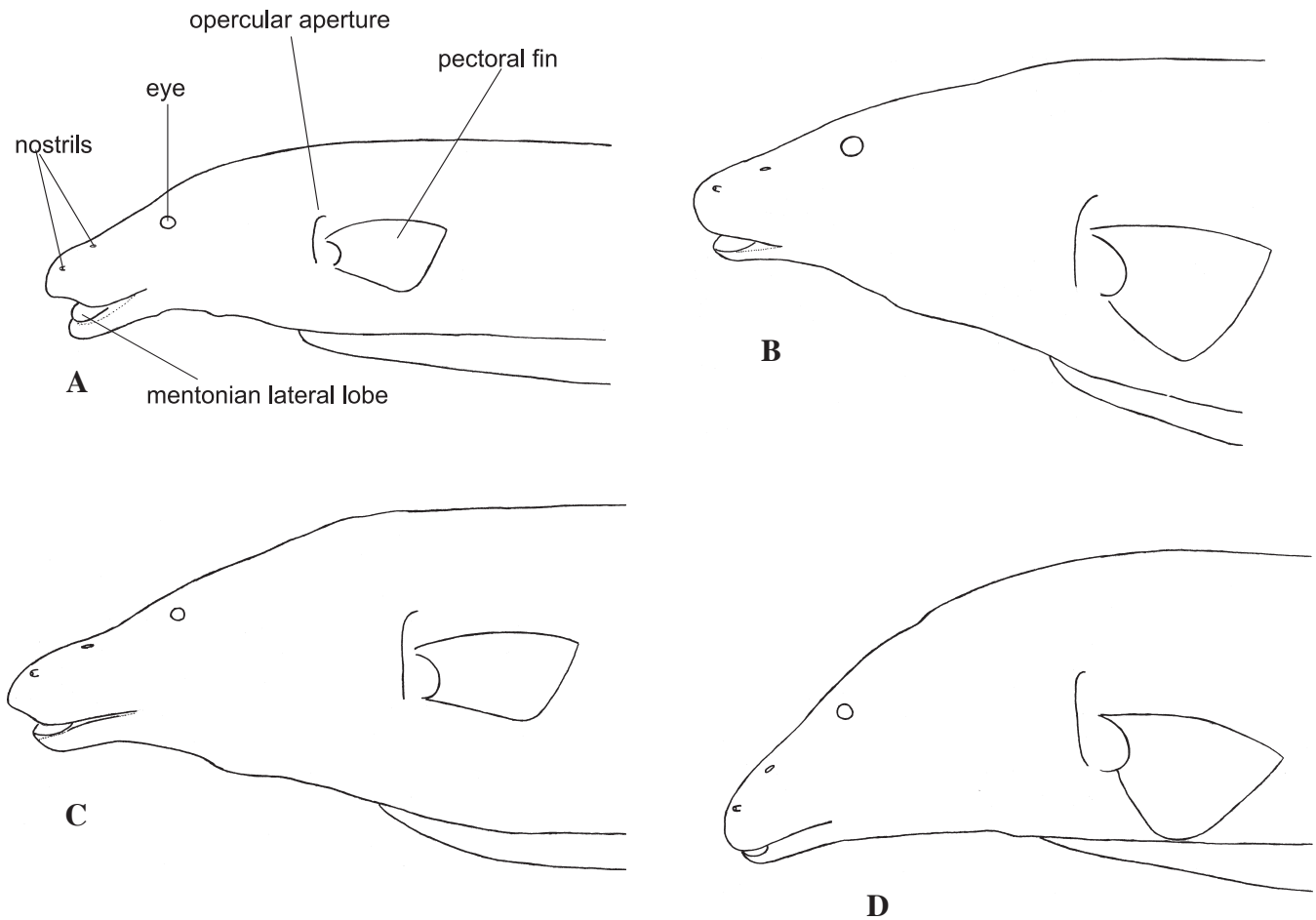

Figure 1 - Lateral views of anterior region of *Apteronotus brasiliensis*. A. Female, 169 mm LEA; 30.3 mm head length (MZUSP 24460). B. Female, 340 mm LEA; 58.0 mm head length. C. Male, 394 mm LEA; 72.3 mm head length. D. Male, 400 mm LEA; 71.3 mm head length (B-D. MZUSP 23096; the illustrations represent the reversed right sides of these specimens).

These allometries suggest that, in fact, the posterior nostril is ontogenetically displaced forward.

Progressive ontogenetic elongation of snout in males was described for *Parapteronotus hasemani* (= *P. bonapartii*, according to Triques, 2007), *A. caudimaculosus*, among others. For this reason, the morphological variation in the snout of *A. brasiliensis* was thought to be also related to sexual dimorphism. However, we found it to be neither sex- nor ontogeny-related. No differences were found in snout length between specimens with forward-directed and downward-directed snouts (Tab. 1). Except for internasal 3 (discussed above), all other proportions presented in Tab. 1 overlap widely. No characters, meristic, morphometric, or discrete, external morphology characters were found that might justify the proposition of new species. Additionally, both male and female specimens were found to possess forward-directed snouts. Very small (e.g. MZUSP 22237; specimen, with 58 mm LEA and snout format as in Figure 1D) and very large specimens (e.g. Figure 1D) were found, with downward directed snouts, suggesting that this snout form is not related to hypermorphic (terminal) males .

We conclude that only individual variation can describe the head morphology variation we found. Our results also did not show any external morphology or osteological differences between specimens from the São Francisco and Paraná river basins, in accordance to Triques (2005).

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