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Gross morphology of the brain of *Pseudopimelodus bufonius* (Valenciennes, 1840) (Siluriformes: Pseudopimelodidae)

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The gross morphology of the brain of the pseudopimelodid *Pseudopimelodus bufonius* is described and compared with congeners. Observations were made on removed brains after elimination of bones from the top of the skull and severing of the cranial nerves and the spinal cord. Nine morphometric characters associated with the major subdivisions of the brain were identified, seven of which revealed significant differences among the species examined. The *corpus cerebelli* in all examined species of the genus is the largest structure of the brain. The behavior of the species of *Pseudopimelodus* is still unknown, but in other teleosts that condition is typically correlated with a higher degree of motor coordination. Relative size proportions of the *tectum opticum*, *eminentia granularis*, *lobus facialis* and *lobus vagi*, might be related to carnivory and an enhanced capacity for food selection.

A morfologia externa do encéfalo de *Pseudopimelodus bufonius* é descrita e comparada com seus congêneres. As análises foram feitas no cérebro removido após a eliminação dos ossos do topo da cabeça e secção dos nervos cranianos e cordão espinhal. Nove caracteres morfométricos foram obtidos das principais subdivisões do encéfalo, dos quais em sete ocorreram diferenças significativas entre as espécies. Em todas as espécies examinadas do gênero o *corpus cerebelli* é a maior estrutura do encéfalo. O comportamento das espécies de *Pseudopimelodus* ainda é desconhecido, mas em outros teleósteos esta característica é normalmente correlacionada com uma boa coordenação motora. Além disso, as proporções relativas do *tectum opticum*, *eminentia granularis*, *lobus facialis* e *lobus vagi* podem ser relacionadas a hábitos carnívoros e boa capacidade de selecionar alimentos.

Keywords: Behavior, Catfishes, Comparative Morphology, Neotropical fishes, Neuroanatomy.

Introduction

The neurological system of fishes has been greatly neglected in systematics studies. Within Teleostei, the major lineages are primarily supported by osteological and molecular synapomorphies. It is estimated that almost three-quarters of the total morphological information related to phylogenetic reconstruction is related to skeletal features (Wiley & Johnson, 2010). Datovo & Vari (2014) in a comprehensive review of morphological features used in fish systematics, found a similar predominance of osteological characters (74%) in relation to other sets of data. According to those authors, 6% corresponded to myology, 5% to splanchnology, 14% to other morphological characters (*e.g.* associated structures of external morphology and reproductive system), and only 1% to neurology.

The brain of vertebrates is basically divided into regions that control specific functions related to sense organs, motor coordination, behavior and metabolic regulation (Butler & Hodos, 2005). The size of a particular structure in the brain typically indicates the predominance of its function and/or the accuracy of the sense to which it is related. Evans (1931) examined the brains of cyprinids, to evaluate feeding behavior and diet composition with regard to the size of gustative lobes (*lobus facialis* and *lobus vagi*). In a series of studies, Eastman & Lannoo (1995, 2001, 2003a, 2003b, 2004, 2007, 2008, 2011) found phylogenetic, ecologic and behavior correlations with format and size of brain structures in Antarctic icefishes (Nototheniiformes). Studies on brain evolution in the Teleostei have also been conducted by Ito *et al.* (2007) on the development of main regions of the brain, and Northcutt (2004, 2008) on the development of gustative lobes and of forebrain. More recently, some authors have focused on the association of development and behavioral responses over the brain structures (Gonda *et al.,* 2011; Kotrschal *et al.,* 2012; Lecchini *et al.*, 2014).

Among catfishes, the neuroanatomy is better understood in the North American Ictaluridae (see Atema, 1971; Lundberg, 1982; Tong & Finger, 1983; Meek & Nieuwenhuys, 1998). The brain anatomy of the Callichthyidae and its relation to the phylogeny of the group was discussed by Pupo (2011), and recently, Rosa *et al.* (2014) detailed the gross morphology of the brain of Neotropical catfishes. The systematics and anatomy of the Pseudopimelodidae have been the subject of several studies (*e.g.*, Lundberg *et al.*, 1991; Shibatta, 1998, 2003; Birindelli & Shibatta, 2011), but descriptions of the gross morphology of the brain in the group (and of the Siluriformes as a whole) remain scarce.

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Pseudopimelodus bufonius (Valenciennes, 1840) (Fig. 1) is the type species of the genus, which in turn is the type genus of the family (Shibatta, 2003a). Pseudopimelodidae includes five additional genera and about 32 valid species, among of them are four species of *Pseudopimelodus* (Shibatta, 2003b; Ruiz & Shibatta, 2011). The group is widely distributed throughout the Neotropical region, from the río Atrato in Colombia to the río de la Plata in Argentina (Lundberg *et al*., 1991). Interestingly, species of *Pseudopimelodus* have small eyes and wide mouths, which suggest low dependence on vision, nocturnal activity, and predatory habits (Shibatta, 2013). Herein, we for the first time describe the gross morphology of the brain and the major cranial nerves in *P. bufonius*. We further compare it to the brain anatomy of two congeners, *P. charus* (Valenciennes, 1840) and *P. mangurus* (Valenciennes, 1835), and comment on correlation between the morphology of the brain and behavior.

Fig. 1. *Pseudopimelodus bufonius*, MZUSP 94855, 113.3 mm SL; Brazil, Mato Grosso, Paranatinga, rio Culuene, tributary of the rio Xingu. Photo by José L. O. Birindelli.

Material and Methods

Six specimens of *P. bufonius* (97.8-118.2 mm SL), three specimens of *P. mangurus* (88.5-175.4 mm SL), and one specimen of *P. charus* (123.7 mm SL) were dissected. Dissections were performed in the following sequence (see Abrahão & Pupo, 2014, for more detail and illustrations): the skin covering the skull bones surrounding the supraoccipital process was removed, typically scraping it off with a mini spatula. To avoid damaging brain subdivisions and nerves during dissection, it was necessary to infer their positions in relation to cranial bones (Fig. 2). Incisions were made with a dental drill powered by a suspended electric motor in the sutures between the pterotic, sphenotic, and frontal, forming a circle around the supraoccipital process, which was then removed carefully using forceps. Cross-sections were made with a scalpel on the *medulla spinalis*, *nervus vagus* (nX), *nervus glossopharyngeus* (nIX), *nervus octavus* (nVIII), *nervus facialis* (nVII), *nervus abducens* (nVI), *nervus trigeminus* (nV), *nervus trochlearis* (nIV), *nervus oculomotorius* (nIII), *nervus linea lateralis anterior* (nlla), *nervus linea lateralis posterior* (nllp), *nervus opticus* (nII) and *nervus tractus olfactorius* (ntol) (Figs. 2-5). To remove the brain and the associated olfactory bulb and *nervus olfactorius* (nI), incisions were made in the frontal bone and mesethmoid to reach the olfactory organ, removing it while avoiding incisions that could damage the olfactory tract (Fig. 2). The nomenclature of the brain regions follows Meek & Nieuwenhuys (1998) and Butler & Hodos (2005). The brains were kept in 4% formalin buffered with $CaCO_3$, after removal from the neurocranium. All specimens were preserved in 70% ethanol after fixation in 4% formalin.

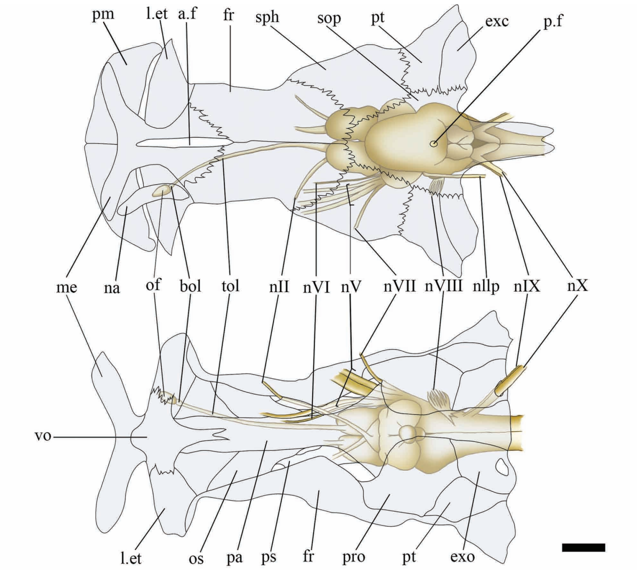

Fig. 2. Diagramatic representation of brain and neurocranium of *Pseudopimelodus bufonius*, MZUEL 5744, 116.4 mm SL, in dorsal and ventral views. a.f: anterior fontanel; bol: *bulbus olfactorius*; exc: extrascapula; exo: exoccipital; fr: frontal; l.et: lateral ethmoid; me: mesethmoid; na: nasal; nII: *nervus opticus*; nV: *nervus trigeminus*; nVI: *nervus abducens*; nVII: *nervus facialis*; nVIII: *nervus octavus*; nIX: *nervus glossopharyngeus*; NX: *nervus vagus*; Nllp: *nervus linea lateralis posterior*; of: olfactory epithelium; os: orbitosphenoid; pa: parasphenoid; pm: premaxillary; pro: prootic; ps: pterosphenoid; pt: pterotic; p.f: posterior fontanel; sop: supraoccipital process; sph: sphenotic; tol: *nervus tractus olfactorius*; vo: vomer. Scale bar = 2 mm.

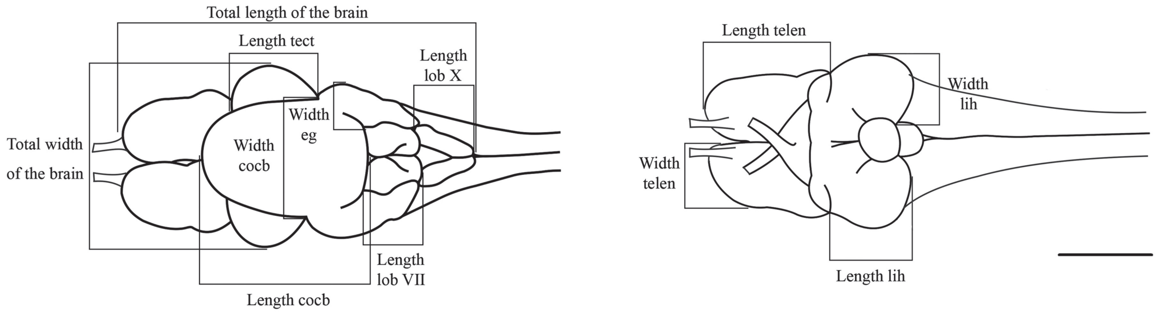

Fig. 3. Diagramatic representation of measurements of major subdivisions of the brain of *Pseudopimelodus bufonius*, MZUEL 5744, 116.4 mm SL, in dorsal and ventral views. Cocb: *corpus cerebelli*; eg: *eminentia granularis*; lih: *lobus inferior hypothalami*; lobVII: *lobus facialis*; lobX: *lobus vagi*; telen: *telencephalon*; tect: *tectum opticum*. Scale bar = 2 mm.

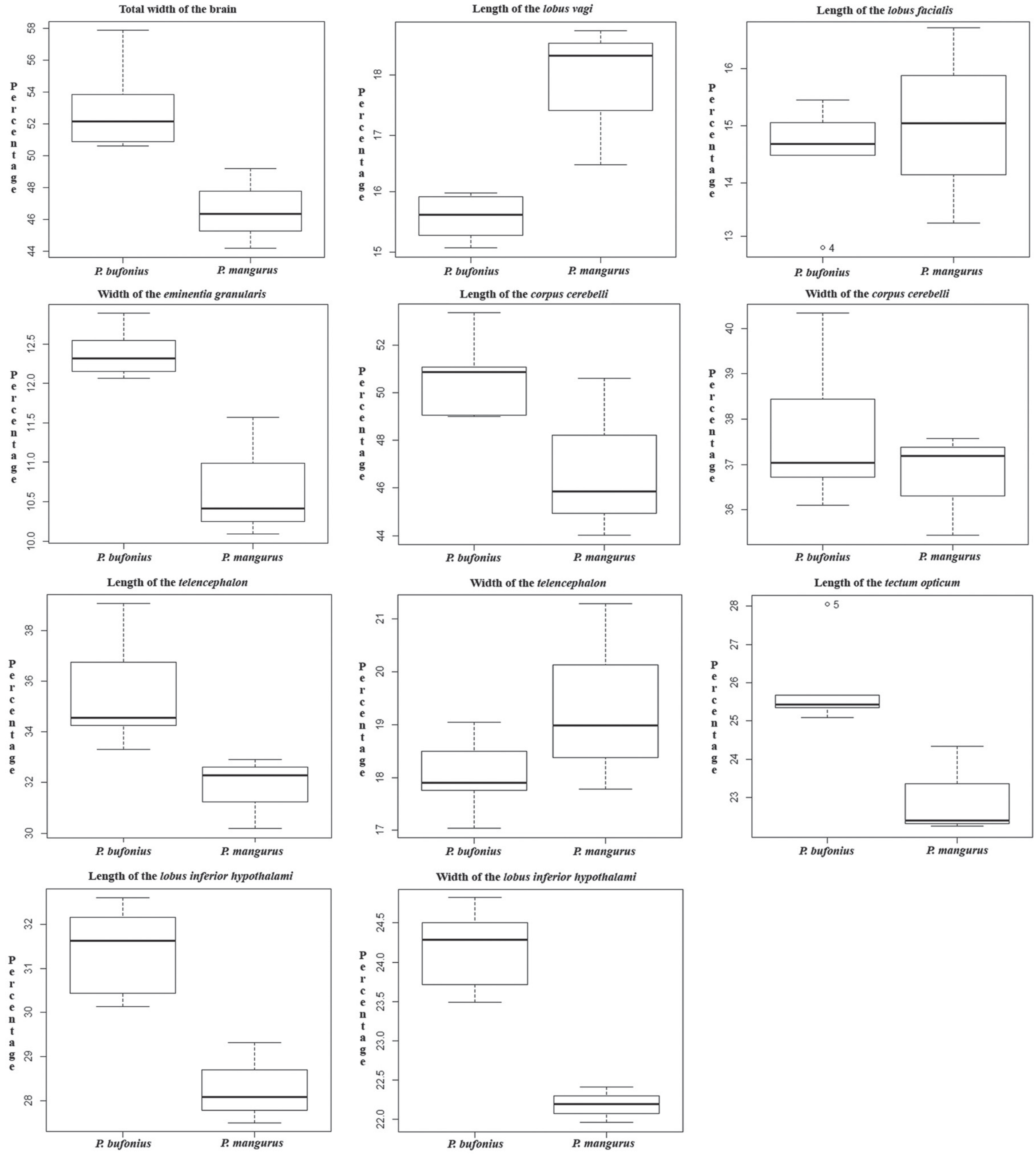

Fig. 4. Boxplot proportions of major subdivisions measurements of *Pseudopimelodus bufonius* and *P*. *mangurus* brains.

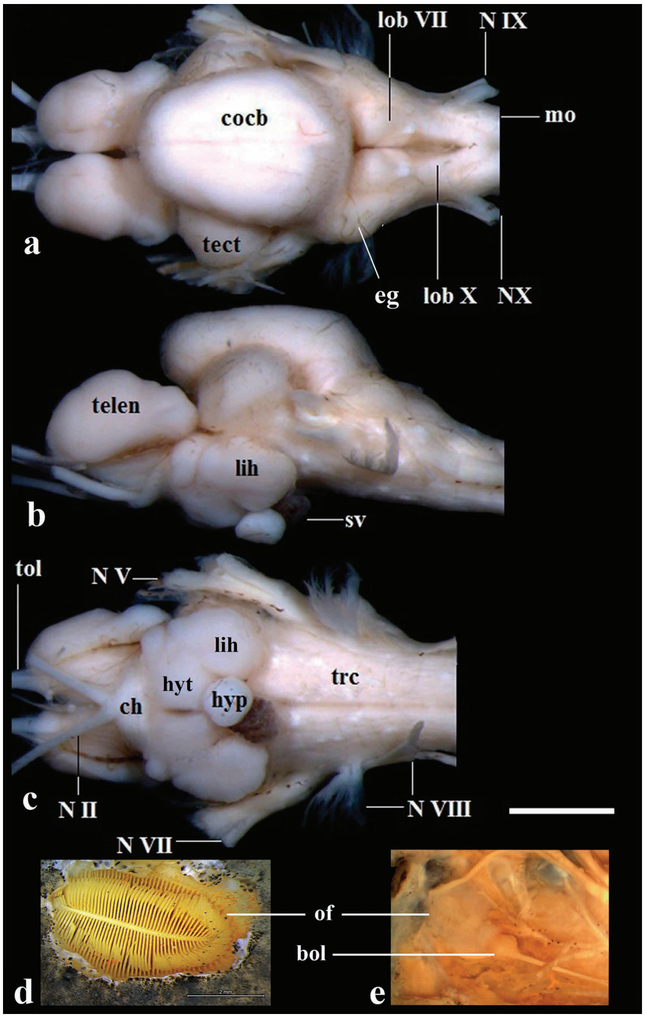

Fig. 5. Brain of *Pseudopimelodus bufonius*, MZUEL 5744, 118.2 mm SL, in (a) dorsal, (b) lateral and (c) ventral views, and (d) dorsal and (e) ventral views of olfactory organ. bol: *bulbus olfactorius*; ch: *chiasma opticum*; cocb: *corpus cerebelli*; eg: *eminentia granularis*; lih: *lobus inferior hypothalami*; hyp: *hypophysis*; hyt: *hypothalamus*; lobVII: *lobus facialis*; lobX: *lobus vagi*; mo: *medulla oblongata*; NII: *nervus opticus*; NV: *nervus trigeminus*; NVII: *nervus facialis*; NVIII: *nervus octavus*; NIX: *nervus glossopharyngeus*; NX: *nervus vagus*; of: olfactory organ; sv: *saccus vasculosus*; trc: *truncus cerebri*; telen: *telencephalon*; tect: *tectum opticum*; tol: *nervus tractus olfactorius*. Scale bar = 2mm.

A digital camera attached to a stereomicroscope was used to capture images of the brain topography. The following measurements were taken using the software Axio Vision Rel v.4.8 (Zeiss, 2009): *vagal lobe* length, *facial lobe* length, *eminentia granularis* width, *corpus cerebelli* length, *corpus cerebelli* width, *telencephalon* length, *telencephalon* width, *tectum opticum* length, *lobus inferior hypothalami* length, and *lobus inferior hypothalami* width. Table 1 shows these measurements in proportion to the total brain length (BL), measured from the anterior portion of the *telencephalon* to the most posterior portion of the *lobus vagi* (modified from Lannoo & Eastman, 2000; Fig. 3). Only the *lobus inferior hypothalami* was measured in the *diencephalon* (Figs. 3, 5, 7). R (Ihaka & Gentleman, 1996) was used to assess differences in measurements in a boxplot. This statistical test is appropriated to summarize and compare data sets graphically. It uses median, approximate quartiles and maximum and minimum data point in order to assess the spread and distribution of sample values.

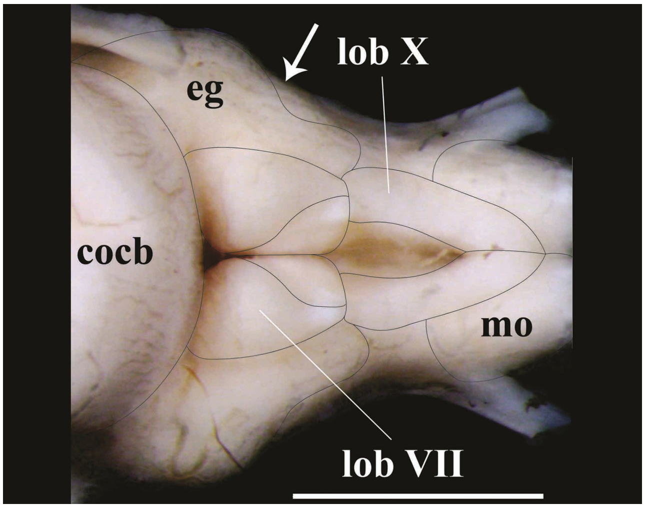

Fig. 6. Posterior portion of *rhombencephalon* of *Pseudopimelodus bufonius*, MZUEL 5744, 118.2 mm SL, dorsal view. cocb: *corpus cerebelli*; eg: *eminentia granularis*; lobVII: *lobus facialis*; lobX: *lobus vagi*; mo: *medulla oblongata*. Arrow indicates the separation point between anterior and posterior bulges of the *eminentia granularis*. Scale bar = 2mm.

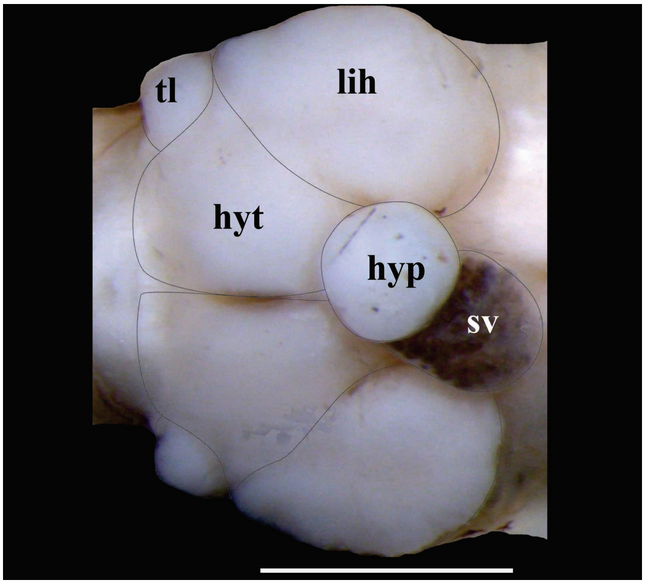

Fig. 7. *Diencephalon* of *Pseudopimelodus bufonius*, MZUEL 5744, 118.2 mm SL, ventral view. hyp: *hypophisis*; hyt: *hypothalamus*; lih: *lobus inferior hypothalami*; tl: *torus lateralis*; sv: *saccus vasculosus*. Scale bar = 2mm.

Results

The brain is completely located beneath the supraoccipital process and above the parasphenoid and prootic in species of *Pseudopimelodus*, with exception of the *bulbus olfactorius* and part of the anterior portion of the *telencephalon* (Fig. 2). Brain width in relation to BL is significantly larger (p=0.01) in *P. bufonius* (mean=53.1%) than in the other examined species, whereas in *P. mangurus* it is the smallest (mean=46.6%; Table 1; Fig. 4). Descriptions below are based on *P. bufonius*, with comments on examined congeners.

Rhombencephalon. In all examined species of *Pseudopimelodus*, the *medulla oblongata* is located above to efferent projections of *nervus vagus* to *medulla spinalis*, and also located dorsally in relation to the *truncus cerebri*, and posterolaterally to the *lobus vagi*. The *medulla oblongata* is composed of two ovoid-shaped structures contacting the *medulla spinalis*. The posterior portion of those structures is slightly smaller than their anterior counterparts, each of which is conspicuously intumescent (Figs. 5-6, 8).

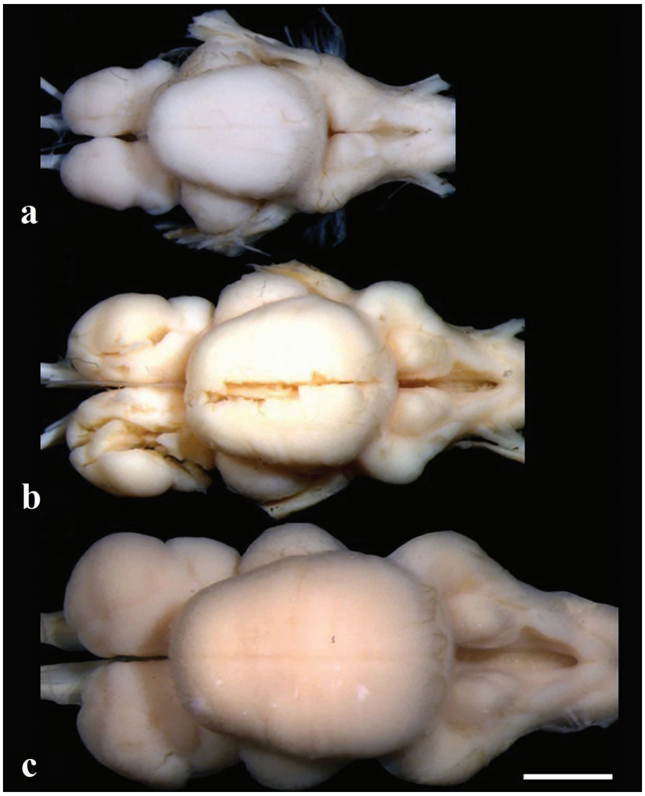

Fig. 8. Brain in dorsal view: (a) *Pseudopimelodus bufonius*, MZUEL 5744, 118.2 mm SL, (b) *P. charus*, MZUEL 6488, 123.7 mm SL, (c) *P. mangurus*, MZUEL 2795, 175.7 mm SL. Scale bar = 2mm.

The *lobus vagi* is located at the dorsal portion of the *rhombencephalon*. In dorsal view, it is immediately posterior to the *lobus facialis*, and anteromedially located in relation to the *medulla oblongata*. The *lobus vagi* is composed of two V-shaped cylindrical paired lobes, whose posterior portion contact each other, forming an acute tip (Figs. 5-6, 8). The length of the *lobus vagi* is shorter than the length of the *tectum opticum*, but is longer than the lengths of the *lobus facialis* and the *eminentia granularis*. The *lobus vagi* length in relation to BL is significantly longer (p=0.005) in *P. mangurus* (Table 1, Fig. 4).

The *lobus facialis* is located at the dorsal portion of the *rhombencephalon*, posterior to the *corpus cerebelli*, anterior to the *lobus vagi*, and medially located in relation to the *eminentia granularis.* A small portion of the anterior area of the *lobus facialis* is under the posterior portion of the *corpus cerebelli.* The lobes of the *lobus facialis* are longitudinally elongated, each approximately rhomboid-shaped, but with rounded edges. A conspicuous bulge is anterolaterally anchored to each lobe. The lobes of the *lobus facialis* are parallel, but do not contact one another, though both contact the *corpus cerebelli* anteriorly (Figs. 5, 6, 8). The length of the *lobus facialis* is shorter lengthwise than the *lobus vagi* and *tectum opticum*, and proportionally longer than the length of the *eminentia granularis.* The length of *lobus facialis* in relation to the BL is longer in *P. mangurus* (Table 1, Fig. 4).

The *eminentia granularis* is prominent in the examined species of *Pseudopimelodus* (Figs. 4-5), and is located at the dorsal portion of the *rhombencephalon*, posterolaterally to the *corpus cerebelli* and lateral to the *lobus facialis*. The structure has two conspicuous rounded bulges, the anterior one more prominent than the posterior. The anterior bulge is positioned at the posterolateral portion of the *corpus cerebelli*, extending up to approximately, but a little less than half the length of the *lobus facialis.* The posterior bulge extends to the anterior area of the *lobus vagi* (Figs. 5, 6, 8). In terms of lengths, the e*minentia granularis* is longer than the *medulla oblongata* and shorter than both the *lobus facialis* and *lobus vagi*. The length of the *eminentia granularis* in relation to BL is significantly longer (p=0.004) in *P. bufonius* (Table 1, Fig. 4).

The *corpus cerebelli* is located at the dorsal portion of the *rhombencephalon*, immediately anterior to the *lobus facialis*, dorsal to the *hypothalamus*, and medial to the *tectum opticum*. The anterior portion of the structure is dorsal to the posterior region of the *telencephalon*. The *corpus cerebelli* is ovoid in shape, with the anterior portion slightly smaller than the posterior one. The anterior margin of the *corpus cerebelli* is rounded, whereas its posterior margin is flap-shaped. The dorsal region of the *corpus cerebelli* in lateral view and the lateral margins on dorsal view are straight, without any conspicuous undulations. The length of the structure is slightly less than half the length of the *telencephalon* (Fig. 5, 8, 9). The mean of *corpus cerebelli* length in relation to BL is longer in *P. bufonius* (Fig. 4). In all examined species of *Pseudopimelodus*, the *corpus cerebelli* is the largest subdivision of brain (Figs. 5-9, Table 1).

Table 1. Morphometry of brain on *Pseudopimelodus* species. Total length of brain (BL) in millimeters, other data on percentages to BL. Min = minimum; max = maximum; sd = standard deviation; CV = coefficient of variation

	P. bufonius (N=6)			*P. mangurus* (N=3)		
	Min-max	mean±sd	CV (%)	min-max	mean±sd	CV (%)
Total length of the brain (BL, mm)	8.4-9.4	8.7±0.4	4.7	7.93-12.4	10.6±2.4	22.4
		Percentages of BL				
Total width of the brain	50.6-57.9	53.1±2.9	5.6	44.2-49.2	46.6±2.5	5.4
Length of *vagal lobe*	15.1-16.0	15.6±0.4	2.5	16.5-18.7	17.8±1.2	6.6
Length of *facial lobe*	12.8-15.4	14.5±1.0	7.0	13.2-16.7	15.0±1.7	11.6
Width of *eminentia granularis*	12.1-12.9	12.4±0.3	2.7	10.1-11.6	10.7±0.8	7.3
Length of *corpus cerebelli*	49.0-53.3	50.7±1.8	3.5	44.0-50.6	46.8±3.4	7.3
Width of *corpus cerebelli*	36.1-40.3	37.7±1.7	4.5	35.4-37.6	36.7±1.1	3.1
Length of *telencephalon*	33.3-39.0	35.6±2.3	6.5	30.2-32.9	31.8±1.4	4.5
Width of *telencephalon*	17.0-19.0	18.0±0.8	4.2	17.8-21.3	19.3±1.8	9.2
Length of *tectum opticum*	25.1-28.0	25.9±1.2	4.7	22.2-24.3	23.0±1.2	5.1
Length of *lobus inferior hypothalami*	30.1-32.6	31.4±1.1	3.4	27.5-29.3	28.3±0.9	3.3
Width of *lobus inferior hypothalami*	23.5-24.8	24.2±0.6	2.3	22.0-22.4	22.2±0.2	1.0

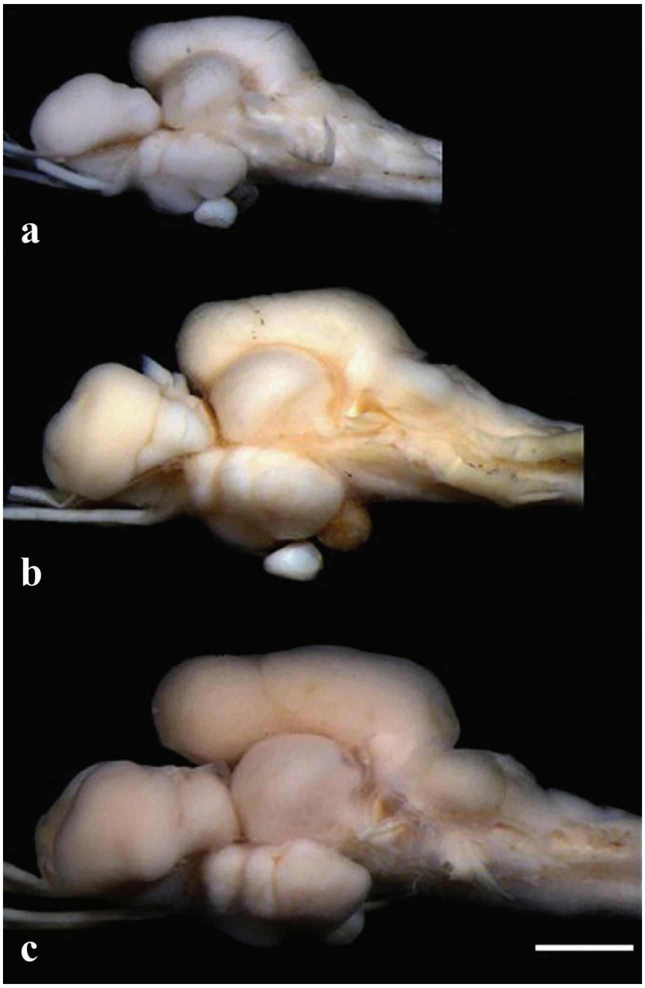

Fig. 9. Brain in lateral view: (a) *Pseudopimelodus bufonius*, MZUEL 5744, 118.2 mm SL, (b) *P. charus*, MZUEL 6488, 123.7 mm SL, (c) *P. mangurus*, MZUEL 2795, 175.7 mm SL. Scale bar = 2mm. (The *hypophysis* of *P. mangurus* is not shown because it was damaged during dissections).

The *nervus glossopharyngeus* and the *nervus vagus* emerge from the lateral wall of the *rhombencephalon*, at approximately the mid-point of the *lobus vagi*, exiting the efferent projections of the braincase through a foramen on the exoccipital. The *nervus octavus*, the *nervus linea lateralis anterior* and the *nervus linea lateralis posterior* emerge from the ventrolateral wall of the *rhombencephalon*, at approximately the midpoint of the *eminentia granularis*. The *nervus facialis* and the *nervus trigeminus* emerge from the ventrolateral portion of the *rhombencephalon*, anterior to the *nervus octavus*, and their efferent projections of the braincase through foramina on the parasphenoid, prootic, sphenotic and pterosphenoid. The anterior ramus of the *nervus trigeminus* and the *nervus linea lateralis anterior* have efferent projections from the braincase through a single foramen between the orbitosphenoid and pterosphenoid (Fig. 2).

Mesencephalon. The *tectum opticum* is located at the dorsal portion of the *tegumentum mesencephali*, anterolateral to the *corpus cerebelli* in dorsal view, and posterior to the *telencephalon* in lateral view. The *tectum opticum* has two bilaterally-rounded structures, which contact both the *corpus cerebelli* and the *telencephalon* (Figs. 5, 8, 9). The length of the *tectum opticum* is longer than that of the *lobus vagi*, *lobus facialis* and *eminentia granularis*. The length of the *tectum opticum* in relation to BL is significantly longer ($p=0.01$) in *P. bufonius* (Table 1, Fig.4).

The *nervus opticus* emerges from the *tectum opticum* on the *mesencephalon*, and efferent projections exit in the region immediately anterior to the *lobus inferior hypothalamic*, where the fibers of this nerve cross the midline of the brain, forming the *chiasma opticum*. These fibers contact each other only in the base of the *chiasma opticum*. The efferent projections of the *nervus opticus* exit the braincase through a foramen located between the frontal, orbitosphenoid and pterosphenoid (Fig. 2).

Truncus cerebri. The *truncus cerebri* is ventrally located in the brain, and is comprised by the *rhombencephalon* and *mesencephalon*. It is more precisely located in the region between the posterior portion of the *mesencephalon* and the anterior portion of *medulla spinalis*. Most cranial nerves exit the efferent projections from the *truncus cerebri*, except for the *nervus olfactorius* and *nervus opticus*. The cranial nerves leaving the *truncus cerebri* include: *nervus oculomotorius*, *nervus trochlearis*, *nervus trigeminus*, *nervus abducens*, *nervus facialis*, *nervus octavus*, *nervus glossopharyngeus*, *nervus vagus*, *nervus linea lateralis anterior*, and *nervus linea lateralis posterior*. Proportional length variations of the *truncus cerebri* among species examined were not found (Figs. 5, 10).

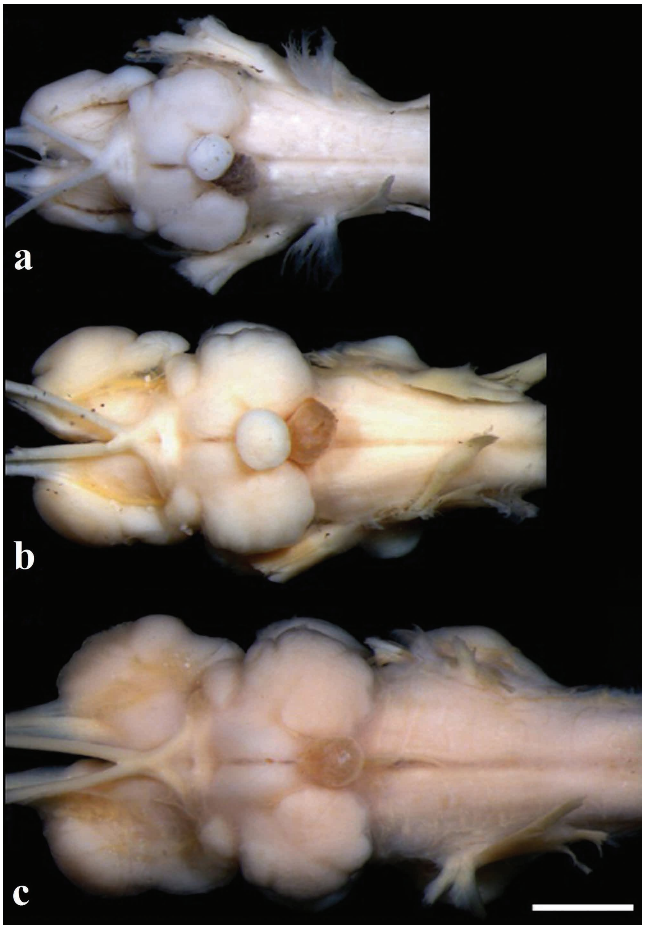

Fig. 10. Brain in ventral view: (a) *Pseudopimelodus bufonius*, MZUEL 5744, 118.2 mm SL, (b) *P. charus*, MZUEL 6488, 123.7 mm SL, (c) *P. mangurus*, MZUEL 2795, 175.7 mm SL. Scale bar = 2mm. (The *hypophysis* of *P. mangurus* is not shown because it was damaged during dissections).

Diencephalon. The *lobus inferior hypothalami* is located at the ventral portion of the *diencephalon*, in a region posterior to the *chiasma opticum*, ventral to the *truncus cerebri* and the *tectum opticum*, posterior to the *telencephalon*, and lateral to the *hypothalamus*. The *lobus inferior hypothalami* is semi-circular, with the anterior portion slightly smaller than the posterior portion. The *hypophysis* is circular, and anchored medially on the *hypothalamus*. The *hypothalamus* is located at the ventral portion of the *diencephalon*, posterior and above the *lobus inferior hypothalami*. The *hypothalamus* is also semi-circular, with the medial portions straight (Figs. 5, 7, 10).

In all examined species of *Pseudopimelodus*, the length of the *lobus inferior hypothalami* is longer than that of the *tectum opticum*, but significantly longer (p=0.006) in *P. bufonius* in relation to the BL (Table 1, Fig. 4).

Telencephalon. In all examined species of *Pseudopimelodus*, the *telencephalon* is anterior to the *tectum opticum* and posterior to the *bulbus olfactorius* in lateral view. Less than half the length of the posterior portion of the *telencephalon* is positioned ventrally to the *corpus cerebelli* in dorsal and lateral views. The *telencephalon* is longitudinally elongated and somewhat cylindrical, with both the anterior and posterior margins rounded. The anterior margin of the *telencephalon* is slightly smaller than the posterior one in *P. bufonius* (Figs. 5, 8, 9, 10). The length of the *telencephalon* is longer than the *lobus inferior hypothalami* and the *tectum opticum*. The length of the *telencephalon* in relation to BL is significantly (p=0.04) longer in *P. bufonius* (Table 1, Fig. 4).

The *bulbus olfactorius* is stalked and is positioned at the anterior portion of the brain. The structure is ventral to the nasal bone, located near the articulation between the lateral ethmoid and the vomer (Fig. 2). The *bulbus olfactorius* is rounded. It is connected to the olfactory epithelium via the *nervus olfactorius*, and to the *telencephalon* via the *nervus tractus olfactorius*. The olfactory epithelium is rounded, with the anterior edge slight smaller than the posterior one. It is laterally curved with a large amount of lamellae on each side, with the appearance of a feather (Fig. 5).

Discussion

Gross morphological and morphometric differences were detected among the brains of *Pseudopimelodus bufonius*, *P. charus* and *P. mangurus*. No intraspecific variation was observed, though this may be related to the specimens examined. These findings highlight the validity and importance of characters derived from the anatomy of the brain as diagnostic even among closely related species. As would be expected, some features are shared by all examined species of *Pseudopimelodus*: the longer relative length of the *corpus cerebelli* and the *tectum opticum*, the small relative length of the *lobus facialis* and the *lobus vagi*, and the small relative width of the *eminentia granularis*. Given that shared patterns of morphological encephalic structures might be interpreted in an ecological context (Kotrschal *et al*., 1998), some considerations on the possible adaptive significance of those features in *Pseudopimelodus* are presented below.

The *corpus cerebelli* is relatively large in all examined species of *Pseudopimelodus*. This condition might be related to a higher degree of motor coordination during swimming. Species of *Pseudopimelodus* live among trunks, rocks and roots on the bottom and river banks (Shibatta, 1998). Even though they live in a structurally complex environment, these fishes are obviously able to quickly capture prey and hide from predators. A similar enlargement of the *corpus cerebelli* was reported by Bauchot *et al.* (1989) in *Rhyacichthys aspro* (Valenciennes, 1837) (Perciformes: Rhyacichthyidae), which also lives in rapids of mountain rivers with rocky bottoms. In both cases, it is presumed that great accuracy in terms of movement is required, and the relatively large *corpus cerebelli* may be related to this. Despite the lack of information on the role of the *corpus cerebelli* in fish, it is generally accepted that this part of the brain is essential in sensorimotor integration (Meek & Nieuwenhuys, 1998; Nieuwenhuys *et al.*, 1998; Butler & Hodos, 2005). Sharks and teleosts with strong-swimming and wide range of hunting maneuvers have increasing in the relative size, volume and foliation of the *corpus cerebelli* (Lisney & Collin, 2006).

In all species of *Pseudopimelodus* examined the *tectum opticum* is also large, whereas the *eminentia granularis*, *lobus facialis*, and *lobus vagi* are relatively small. Together, those conditions may indicate a rather elaborate feeding behavior. The *corpus cerebelli* receives sensory input from various regions of the central nervous system, including the lateral line, auditory, visual, vestibular, somatosensory, and mainly sensorimotor systems, which provide spatial orientation, proprioception, and coordination of eye movements. In the *corpus cerebelli* the sensory input from those regions of the central nervous system are processed in order to provide balance and motor coordination of the body (Kotrschal *et al*., 1998; Butler & Hodos, 2005). The *tectum opticum*, in turn, receives sensory information from the retina through the optic nerve, and is also responsible for generating signals that provides coordination of the motor response (Meek & Nieuwenhuys, 1998). Moreover, it also receives information from the auditory, and somatosensory systems, enabling the structure to create retinotopic maps of the environment (Butler & Hodos, 2005). The combination of the motor coordination of the body and also the coordination of the eyes promote responses from the *corpus cerebelli* and the *tectum opticum* that provide stimulus directing the fish to capture prey (Butler & Hodos, 2005).

The *lobus facialis* and the *lobus vagi* are associated to gustative perception, receiving sensory information from taste buds in the barbels and mouth, and from taste buds present in the pharynx and gill arches, respectively (Meek & Nieuwenhuys, 1998). The *eminentia granularis* is associated with mechanosensory perception that receives sensory input perceived by the lateral line mechanoreceptors (Finger, 1983; Meek & Nieuwenhuys, 1998). Evans (1931, 1940) recognized functional groups of species of British cyprinoids based on morphological variations of the brain, in relation to their feeding habits. Those groups were based mainly on differences in feeding habits, reflected in the proportional lengths of the *lobus facialis* and the *lobus vagi* in relation to the *corpus cerebelli* and the *eminentia granularis*. In fishes that feed mainly on invertebrates, plant remnants and organic debris, the *lobus facialis* and the *lobus vagi* are larger, whereas the *eminentia granularis* and the *tectum opticum* are smaller. In fishes that feed primarily on other fishes, the opposite pattern was observed. Similar results were found on species of the Gadidae (Kotrschal *et al.,* 1998). Studies on the feeding habits of pseudopimelodids (Shibatta 1998) indicate that *P. mangurus* is carnivorous. This observation is supported by the brain morphology, given that species of *Pseudopimelodus* have relatively large *corpus cerebelli* and *tectum opticum*, and small *lobus facialis* and *lobus vagi*.

Studies on brain architecture allows an increase in the number of informative characters for systematics, and also help in understanding the behavior and habits of fishes. In addition, it is noteworthy that there is a great horizon for studies on brain anatomy considering the huge diversity of teleosts.

Material Examined. *Batrochoglanis melanurus*: **Brazil:** MZUEL 3670, 1, 51.2 mm SL, Mato Grosso, Nobres, córrego Cancela, tributary of rio Cuiabá. *Batrochoglanis raninus*: **Brazil:** MZUEL 6035, 1, 76.7 mm SL, aquarium specimen. MZUSP 23407 2 of 24, 51.4-76.6 mm SL, Amazonas, Fonte Boa, igarapé Tucuxi, rio Solimões basin. *Batrochoglanis villosus*: **Brazil:** MZUEL 6037, 1, 143.2 mm SL, Maranhão, Turiaçu, rio Turiaçu. *Cephalosilurus apurensis*: **Venezuela:** MZUEL 6493, 1, 195.6 mm SL, Apure, Cano Bacaral. *Cephalosilurus fowleri:* **Brazil:** MZUEL 6040, 1, 275.0 mm SL, Minas Gerais, Três Marias, rio São Francisco. *Lophiosilurus alexandri*: **Brazil:** MZUEL 5377, 1, 58.7 mm SL, Minas Gerais, Três Marias, rio São Francisco. MZUSP 96276, 1 of 7, 73.1 mm SL, Três Marias, rio São Francisco. *Microglanis cottoides*: **Brazil:** MZUEL 6033, 3, 40.1-48.8 mm SL, Rio Grande do Sul, Canudos do Vale, rio Forquetinha. 29°22'4''S 52°03'19''W. *Microglanis parahybae*: **Brazil:** MZUEL 6393, 2, 39.1-42.0 mm SL, Rio de Janeiro, São Fidelis, rio Dois Rios, tributary of rio Paraíba do Sul. *Microglanis* aff. *poecilus*: **Brazil:** INPA 6828, 1, 20.9 mm SL, Pará, Trairão, rio Jamanxim. *Pseudopimelodus bufonius*: **Brazil:** MZUEL 5744, 6, 97.8-118.2 mm SL, Mato Grosso, Paranatinga, rio Culuene, tributary of rio Xingu. *Pseudopimelodus charus*: **Brazil**: MZUEL 6488, 1, 123.7 mm SL, Minas Gerais, São Roque de Minas, rio São Francisco. *Pseudopimelodus mangurus*: **Brazil**: MZUEL 2795, 2, 138.9-175.4 mm SL, Paraná, Diamante do Norte, rio Paranapanema. MZUSP 24449, 1, 88.5 mm SL, Mato Grosso do Sul, Ilha Solteira, rio Paraná.

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ERRATA

Page 256, caption of Fig. 1:

Where read: MZUSP 94855 ... Paranatinga, rio Culuene, tributary of the rio Xingu. Photo by José L. O. Birindelli.
Should read: MZUSP 97220 ... rio Curuá, Iriri-Xingu drainage, near town of Castelo dos Sonhos. Photo by Mark Sabaj-Pérez.

Page 263, Acknowledgements:

Include in the last line: To Mark Sabaj-Pérez for the photograph of *Pseudopimelodus bufonius*.

All changes are already incorporated in the online HTML version of this article available at http://www.scielo.br/ni