Diet and foraging behavior of *Ageneiosus inermis* (Teleostei, Auchenipteridae)

Tiago Magalhães da Silva Freitas¹, William Oliveira dos Santos¹, Bruno da Silveira Prudente², Luciano Fogaça de Assis Montag³

¹ Faculdade de Ciências Naturais, Universidade Federal do Pará – UFPA, Campus Universitário do Marajó-Breves, Alameda IV, 3418, Parque Universitário, CEP 68.800-000, Breves, PA, Brazil

² Laboratório de Ecologia e Conservação da Amazônia, Universidade Federal Rural da Amazônia – UFRA, Rua Professora Antônia Cunha de Oliveira, S/N, Vila Nova, CEP 68650-000, Capitão Poço, PA, Brazil

³ Laboratório de Ecologia e Conservação, Instituto de Ciências Biológicas, Universidade Federal do Pará – UFPA, Rua Augusto Corrêa, 01, Guamá, CEP 66.075-110, Belém, PA, Brazil

Corresponding author: Tiago Magalhães da Silva Freitas (freitastms@gmail.com.br)

Abstract

*Ageneiosus inermis* is the largest species of the family Auchenipteridae (Siluriformes) and has a primarily piscivorous diet, although no comprehensive data are available on the habitat use of this species. Given this, the present study describes the diet of *A. inermis*, and provides inferences on its habitat use, based on the known behavior of its prey species. We analyzed the stomach contents of 14 specimens collected in the middle of Xingu River in the Brazilian state of Pará, which we complemented with data on 47 other specimens obtained from two published studies. Most of the ingested items were fish associated with the bottom substrate and riverbanks. Although *A. inermis* is considered a pelagic species, we conclude it forages by exploring the river’s bottom and margins. Furthermore, as *A. inermis* is presumed to be diurnal, we assume that it does not pursue its prey actively, given that most of the prey species are nocturnal, but rather searches actively during the daytime for prey hidden in the bottom substrate. This hypothesis on the feeding strategy of *A. inermis* can only be confirmed by underwater observations, either in the wild or under captive conditions.
Resumo

Ageneiosus inermis é a maior espécie da família Auchenipteridae (Siluriformes), com um hábito principalmente piscívoro. Porém, nenhum estudo focou no uso do hábitat com essa espécie. Em vista dessa lacuna no conhecimento, o presente estudo objetivou descrever a dieta e inferir sobre o uso do hábitat do A. inermis baseado no comportamento de suas presas. Avaliamos 61 estômagos com conteúdo de indivíduos capturados no médio Rio Xingu (Estado do Pará), e outras duas literaturas publicadas. A maioria dos itens consumidos vive associado ao substrato e margens de rios. Considerando que A. inermis é um peixe pelágico, supomos que os indivíduos realizem um movimento lateral e vertical para forragear nas margens e fundo, respectivamente. Além disso, A. inermis é descrito como uma espécie diurna, porém se alimenta preferencialmente de presas de hábitos noturnos. Isso nos leva a presumir que o A. inermis não realiza perseguição das presas, e sim realizaria busca ativa no substrato ou margem dos rios, pois as mesmas estariam abrigadas no período diurno. Para testar essa hipótese de estratégia alimentar, encorajamos estudos complementares com observações subaquáticas no seu hábitat natural ou até mesmo em estudos comportamentais em cativeiro.

Keywords

Amazon, behavior, feeding, fish, habitat use, trophic ecology

Palavras-chave

peixe, ecologia trófica, comportamento, uso do hábitat

Introduction

The mandubé catfish Ageneiosus inermis (Linnaeus, 1766) is one of the most widely distributed fish of the family Auchenipteridae found in South American freshwater systems (Ribeiro et al. 2017). Most auchenipterids are quite small, predominantly omnivorous, nocturnal, and can be seen swimming actively just below the water surface (Ferraris 2003; Freitas et al. 2011). The catfish genus Ageneiosus is a distinct group, however, being the largest auchenipterids, with a primarily piscivorous diet (Mérona et al. 2001; Sá-Oliveira et al. 2014) and diurnal activity cycle (Ferraris 2003). These species are also assumed to inhabit the pelagic zone (Santos et al. 1984; Birindelli 2014).

Given the complexity of the food chains of tropical freshwater systems (Lowe-McConnell 1987), trophic studies can provide valuable insights into the relationships between species and the environment in which they live (Brezjão et al. 2013). Considering the vast diversity of fish in the tropics, especially in the Amazon region (Dagosta and De Pinna 2019), the existing data on species interactions and autecology is far from satisfactory. Accurate data on fish diets and foraging behavior is essential for adequate fishery management and species conservation, as well as the understanding of the ecological services provided by these species, such as the control of the populations of their prey species (Ballesteros et al. 2009; Freitas et al. 2011). The analysis of stomach contents is a reliable method for the collection of detailed data on the feeding ecology (e.g., habitat use, foraging behavior) of fish species (Baker et al. 2014).
While the feeding behavior of some Ageneiosus species has already been studied (Tobías-Arias et al. 2006; Sá-Oliveira et al. 2014), there is no comprehensive investigation of habitat use. Given this knowledge gap on foraging strategies, we describe the diet of Ageneiosus inermis and infer the habitat use of this fish from the known behavior of the prey species identified in its diet. We based our study on data from the middle Xingu River, in the Amazon basin, complemented with information from two published studies, one conducted in the Orinoco basin (Barbarino-Duque and Winemiller 2003) and the other, in the basin of the Madeira River (Cella-Ribeiro et al. 2016). As the construction of hydroelectric dams – the Belo Monte dam on the Xingu and the Santo Antônio dam on the Madeira – has recently impacted two of these rivers, this overview of the feeding ecology of A. inermis, a top predator, provides essential insights, not only into the feeding ecology of this fish but also on the ecology of its prey species.

Methods

We collected the primary data on the middle of the Xingu River (approximately 3°12’52”S, 52°11’23”W; Fig. 1) in the Brazilian state of Pará (eastern Amazonia), at three-month intervals between April 2012 and January 2014. Sampling was conducted by permit #057/2012 and #4681-1 granted by the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) and System Authorization and Biodiversity Information (SISBIO), respectively.

We caught specimens of A. inermis (Fig. 2) using gillnets with meshes of different sizes (see Barbosa et al. 2015 and 2018 for details of the sampling methods). Live specimens were anesthetized using eugenol solution following the recommendations of the American Veterinary Medical Association (AVMA 2013) and the guidelines of the National Council for Control of Animal Experimentation (CONCEA 2013). Voucher specimens are deposited at the Laboratório de Ictiologia de Altamira (LIA; Laboratory of Ichthyology), Altamira, Pará state, Brazil, under the code LIA 728. After capture, specimens were measured for standard length (SL in centimeters) and had their stomachs removed and preserved in a mixed solution of 70% alcohol and 10% formalin to prevent the digestion of the food items. We identified the stomach contents to the lowest possible taxonomic level. We calculated the Alimentary index (Ai%; modified from Kawakami and Vazzoler 1980) for each food item, which determines the relative importance of items in the diet.

For comparison proposes, we used two complementary data: (1) Barbarino-Duque and Winemiller (2003), which presented the diet of A. inermis from the Apure and Arauca Rivers, Venezuela. In this study, the authors provided the information on the abundance of prey; and (2) Cella-Ribeiro et al. (2016), which presented the diet of A. inermis from the Madeira River, and provides the Alimentary index (Ai%).

To infer the habitat use of A. inermis, we compiled published data on the position in the water column and circadian activity of the prey species identified in the stomach contents (see Table 1 for references). We classified the habitat use of each
Figure 1. Examples of microhabitats sampled in the Xingu River (state of Pará, Brazil) between April 2012 and January 2014. **a**) flooded vegetation; **b**) main channel; **c**) small rapids; **d**) marginal lakes.

Figure 2. Specimen of *Ageneiosus inermis* (Linnaeus, 1766) (female; 43 cm SL) collected in the Xingu River (state of Pará, Brazil). Photo by Leandro Souza.
### Table 1. Preys consumed by the catfish *Ageneiosus inermis* from three sources, and their respective information on habitat use and circadian activity.

| Source                          | Order     | Family              | Species                  | Method | Value | Habitat use | Circadian activity | References* |
|---------------------------------|-----------|---------------------|--------------------------|--------|-------|-------------|---------------------|-------------|
| Primary data (Xingu River)      | Characiformes | Characidae          | Brycon sp.               | Ai%    | 6.2   | PL, RB      | D                   | 2**         |
| Characiformes                   | Characidae | Moenkhausia xinguensis | Ai%   | 14.8 | PL, RB | D | 3*         |
| Characiformes                   | Characidae | n.i.                | Ai%   | 6.6  | –     | – | –          |
| Characiformes                   | Erythrinae | Ai%                | Erythrinus erithrinus   | 11.4   | BO    | N | 3**        |
| Gymnotiformes                   | Gymnottiidae | Ai%             | Gymnotus sp.             | 10.0   | RB, BO | N | –          |
| Siluriformes                    | Auchenipteridae | n.i.    | Ai%   | 1.7  | –     | – | –          |
| Siluriformes                    | Callichthyidae | Ai%         | Callichthys callichthys | 22.4   | BO    | N | 3          |
| Siluriformes                    | Trichomycteridae | Ai%     | Ituglanis amazonicus  | 15.1   | BO    | N | 2**        |
| Siluriformes                    | n.i.       | Ai%                | 0.3                      | RB, BO | N | 2**        |
| Synbranchiformes                | Gymnotidae | Ai%                | Synbranchus maronatus    | 5.1    | –     | – | –          |
| Fish remains                    | n.i.       | Ai%                | 6.7                      | –      | –     | – | –          |
| Decapoda                        | n.i.       | Ai%                | 0.2                      | RB, BO | N | 4*         |
| Isopoda                         | n.i.       | Ai%                | <0.1                     | –      | –     | – | –          |
| Barbarino-Duque & Winimiller (2003) | Characiformes | n.i.  | Ai%   | 6.6  | –     | – | –          |
| Characiformes                   | Serrasalmidae | Mylossoma duriventre | Ai%   | 1    | PL, RB | D | 11*        |
| Characiformes                   | Serrasalmidae | Pygocentrus cariba | Ai%   | 2    | PL, RB | D | 11**       |
| Siluriformes                    | Doradidae  | Ai%                | 1                        | BO, DC | N | 8**        |
| Siluriformes                    | Loricariidae | Ai%           | 2                        | BO, DC | N | 11**       |
| Siluriformes                    | Loricariidae | Pterygoplichthys multifilis | Ai%   | 4    | BO, DC | N | 11*        |
| Siluriformes                    | Pimelodidae | Ai%                | 2                        | BO, DC | N | 9**        |
| Fish remains                    | n.i.       | Ai%                | 13                       | –      | –     | – | –          |
| Cella-Ribeiro et al. (2016)     | Characiformes | n.i.  | Ai%   | 6.6  | –     | – | –          |
| Siluriformes                    | Callichthyidae | Hoplesternum littorne | Ai%   | 1.7  | BO    | N | 3          |
| Siluriformes                    | Doradidae  | Ai%                | 6.6                      | BO    | N | 6, 8**     |
| Siluriformes                    | Doradidae  | Ai%                | 1.1                      | BO    | N | 6, 8**     |
| Siluriformes                    | Doradidae  | Ai%                | 1.7                      | BO, DC | N | 7, 8**     |
| Siluriformes                    | Loricariidae | Ai%           | 70.5                     | BO, DC | N | 8**        |
| Siluriformes                    | Loricariidae | Ai%           | 1.7                      | BO, DC | N | 10**       |
| Fish remains                    | n.i.       | Ai%                | 0.6                      | –      | –     | – | –          |
| Fish remains                    | n.i.       | Ai%                | 8.0                      | –      | –     | – | –          |

Ai% – Alimentary index; n.i. – not identified; habitat use: bottom-oriented (BO), deep-channel (DC), pelagic (PL), and riverbanks (RB); circadian activity: diurnal (D) or and nocturnal (N). *1) Sabino and Zuanon (1998); 2) Oyakawa et al. (2006); 3) Brejão et al. (2013); 4) Melo (2003); 5) Brusca et al. (2016); 6) Sabaj et al. (2014); 7) Agostinho et al. (2009); 8) Sabaj and Ferraris Jr. (2003); 9) Lundberg and Littmann (2003); 10) Thomas and Sabaj (2010); 11) Arrington et al. (2002). ** Information based on species of the same genera or higher taxa.
prey species as bottom-oriented (BO), deep-channel (DC), pelagic (PL) or riverbank (RB), with species being assigned to more than one category in some cases. According to the circadian activity, we classified the preys as diurnal (D) and nocturnal (N). When no information was available for a given prey species, we considered the data for the nearest taxonomic level (e.g., genus, family) that we deemed reliable.

Results

We analyzed the contents of 61 stomachs, including 14 from specimens collected on the Xingu River in the present study, 27 from the Apure and Arauca rivers in the Orinoco basin (collected by Barbarino-Duque and Winemiller 2003), and 20 from the Madeira River (Cella-Ribeiro et al. 2016).

The 14 stomachs evaluated for the Xingu River were obtained from specimens that ranged from 21.1 to 48.0 cm (standard length – SL). We identified 13 different food items in the stomach contents of *A. inermis* from the Xingu River. The most important of these items was *Callichthys callichthys* (Callichthyidae) with an Ai of 22.4%, followed by *Ituglanis amazonicus* (Trichomycteridae; Ai = 15.1%), *Moenkhausia xinguensis* (Characidae; Ai = 14.8%), *Erythrinus erythrinus* (Erythrinidae; Ai = 11.4%), and *Gymnotus* sp. (Gymnotidae; Ai = 10%).

Barbarino-Duque and Winemiller (2003) examined the stomachs from 503 specimens that ranged between 25 and 50 cm (SL). However, only 27 stomachs presented some content. The authors identified 27 prey items (all fishes: five characiforms, nine siluriforms, and 13 unidentified fish). Of the siluriforms, the loricariid *Pterygoplichthys multiradiatus* was the most abundant prey, with four records.

Cella-Ribeiro et al. (2016) examined 20 stomachs with content from specimens ranging between 12.7 and 45.0 cm (SL). The diet of these individuals was entirely composed of fishes. Nine food items were recorded: eight siluriforms (Ai = 85.4%), one unidentified characiform (Ai = 6.6%), and unidentified fish (Ai = 8.0%). Of the siluriforms, doradid catfishes were the most important food items (Ai = 70.5%).

We were able to compile reliable information on the ecology of 22 of the prey species consumed by *A. inermis* (see Table 1). Most (77%) of these species were identified as bottom-oriented (n = 17), followed by species that inhabit riverbanks (41%, n = 9), deep channels (32%, n = 7), and the pelagic zone (27%, n = 6). Regarding the circadian activity, the majority of these prey species were identified as being nocturnal (77%, n = 17), with only five (23%) being classified as diurnal. Due to the small sample size, we were unable to evaluate seasonal variation in the composition of the *A. inermis* diet.

Discussion

The primary data from the Xingu River indicated that *A. inermis* is a predator that feeds mostly on fish. Overall, the *A. inermis* diet was composed primarily of nocturnal siluriforms that inhabit riverbanks and the bottom substrate. In addition to the data from Barbarino-Duque and Winemiller (2003) and Cella-Ribeiro et al. (2016),
which we included here, two previous studies (Lasso et al. 1995; Mérona et al. 2001) had also confirmed the piscivorous behavior of *A. inermis*.

*Ageneiosus inermis* is a pelagic species that predominantly inhabits river channels (Santos et al. 1984; Birindelli 2014). This behavior is consistent with the morphological features of the species, such as its subterminal mouth and the absence of mental barbels, which would be located in the ventral portion of the head and help to investigate bottom substrates (Jayaram 1978). However, as most of the food items identified in the present study are associated with this type of substrate, we can assume that *A. inermis* forages by exploring bottom and riverbank habitats. Barbarino-Duque and Winemiller (2003) and Cella-Ribeiro et al. (2016) also found that most of the prey exploited by *A. inermis* were bottom-oriented catfishes of the families Loricariidae and Doradidae (Burgess 1989), respectively.

*Ageneiosus* catfishes are considered to be diurnal (Ferraris 2003). Given this, *A. inermis* might not pursue its prey in the water column since most prey species are nocturnal, and will typically rest during the day. It implies that *A. inermis* searches actively for its prey in bottom substrates or riverbanks, which demands a considerable investment of energy. Additionally, we can also assume that the feeding activity also occurs during the twilight time, when diurnal and nocturnal preys are active and available. However, direct observations would be needed to confirm these assumptions. Torrente-Vilara et al. (2008) reached similar assumptions based on the diet, morphology, and feeding behavior of the piscivorous characiform *Roestes molossus* (Kner, 1858). They concluded that, despite not presenting morphological features for this niche, this fish feeds on prey in the bottom substrate during the night and the crepuscular period. Considering our findings on *A. inermis*, underwater observations in its natural habitat (Brejão et al. 2013), or even behavioral studies in captivity (Volpato 2007), it would be necessary to confirm our hypothesis on the foraging strategy of this species.

Despite the relatively small size of the available dataset (stomachs with contents), we considered the data appropriate for the description of the feeding habit of *A. inermis*, and to provide inferences on its foraging strategies. Previous studies that have described the diet of *A. inermis* have also been based on samples of limited size. Mérona et al. (2001), for example, analyzed the contents of the stomachs of 40 individuals caught on the Tocantins River during five years of fieldwork (1980–1982 and 1984–1987), while Lasso et al. (1995) reported on the contents of only a single stomach.

Overall, then, we believe that our findings provide a more detailed insight into the diet, life history strategies, and habitat requirements of one of the most widely-distributed top predator fish found in the major river basins of South America. The next challenge will be to evaluate the seasonal shifts in the composition of the *A. inermis* diet, related to the natural cycle of the region’s fluvial environments, and their food chains. It will require further, more comprehensive studies that collect a more significant number of specimens over a longer period. In addition, as dams are known to have a considerable impact on the diets of predatory fish and other aspects of their life cycle (Mérona et al. 2001; Winemiller et al. 2016), the results of the present study provide important reference data for the evaluation of the effects
of these projects on the biology of the aquatic fauna, which can help to develop effective conservation strategies and management measures for fishery stocks.

**Conclusions**

The present study results indicate that the mandubé catfish, *Ageneiosus inermis*, have a piscivorous diet and feed primarily on nocturnal, bottom-oriented prey species, despite being described in the literature until now as a diurnal pelagic fish. Based on this, we infer that *A. inermis* forages by exploring the bottom substrate to locate prey sheltering during the daytime or at twilight.

**Acknowledgments**

The authors are grateful to Norte Energia, LEME, Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brazil (CAPES) – Finance Code 001 (LFAM – process 88881.119097/2016-01), and CNPq (LFAM – process 302406/2019-0) for financial support. We also thank all the members of the IctioXingu CNPq Research Group. To Dr. Stephen Ferraris for English review.

**References**

Agostinho CS, Marques EE, Oliveira RJ, Braz OS (2009) Feeding ecology of *Pterodoras granulosus* (Siluriformes, Doradidae) in the Lajeado Reservoir, Tocantins, Brazil. Iheringia 99(3): 301–306. https://doi.org/10.1590/S0073-47212009000300012

American Veterinary Medical Association (2013) AVMA Guidelines for the Euthanasia of Animals: 2013 Edition 38, Schaumburg, Illinois. https://www.avma.org/KB/Policies/Documents/euthanasia.pdf

Arrington DA, Winemiller KO, Loftus WF, Akin S (2002) How often do fishes “run on empty”? Ecology 83: 2145–2151. https://doi.org/10.1890/0012-9658(2002)083[2145:HODFRO]2.0.CO;2

Baker R, Buckland A, Sheaves M (2014) Fish gut content analysis: Robust measures of diet composition. Fish and Fisheries 15(1): 170–177. https://doi.org/10.1111/faf.12026

Ballesteros TM, Torres-Mejia M, Ramírez-Penilla M (2009) How does diet influence the reproductive seasonality of tropical freshwater fish? A case study of a characin in a tropical mountain river. Neotropical Ichthyology 7(4): 693–700. https://doi.org/10.1590/S1679-6225200900400019

Barbarino-Duque A, Winemiller KO (2003) Dietary segregation among large catfishes of the Apure and Arauca Rivers, Venezuela. Journal of Fish Biology 63(2): 410–427. https://doi.org/10.1046/j.1095-8649.2003.00163.x

Barbosa T, Benone N, Begot T, Gonçalves A, Sousa L, Giarrizzo T, Juen L, Montag LFA (2015) Effect of waterfalls and the flood pulse on the structure of fish assemblages of the middle Xingu River in the eastern Amazon basin. Brazilian Journal of Biology 75(3, suppl 1): 78–94. https://doi.org/10.1590/1519-6984.00214BM
Diet and habitat use of Ageneiosus inermis

Barbosa TAP, Rosa DCO, Soares BE, Costa CHA, Esposito MC, Montag LFA (2018) Effect of flood pulses on the trophic ecology of four piscivorous fishes from the eastern Amazon. Journal of Fish Biology 93(1): 30–39. https://doi.org/10.1111/jfb.13669

Birindelli JLO (2014) Phylogenetic relationships of the South American Doradoidea (Ostariophysi: Siluriformes). Neotropical Ichthyology 12(3): 451–564. https://doi.org/10.1590/1982-0224-20120027

Brejão GL, Gerhard P, Zuanon J (2013) Functional trophic composition of the ichthyofauna of forest streams in eastern Brazilian Amazon. Neotropical Ichthyology 11(2): 361–373. https://doi.org/10.1590/S1679-62252013005000006

Brusca RC, Moore W, Shuster SM (2016) Invertebrates. Sinauer Associates, Sunderland, 1104 pp.

Burgess WE (1989) An atlas of freshwater and marine catfishes. A preliminary survey of the Siluriformes. TFH Publications, Neptune City, 784 pp.

Cella-Ribeiro A, Torrente-Vilara G, Lima-Filho JA, Doria CRC (2016) Ecologia e biologia de peixes do rio Madeira. Edufro, Porto Velho, 305 pp.

CONCEA (2013) Diretrizes da Prática de Eutanásia do Conselho Nacional de Controle de Experimentação Animal – CONCEA. Ministério da Ciência, Tecnologia e Inovação, Brasília, 54 pp.

Dagosta FCP, De Pinna MCC (2019) The fishes of the Amazon: Distribution and biogeographical patterns, with a comprehensive list of species. Bulletin of the American Museum of Natural History 431(431): 1–163. https://doi.org/10.1206/0003-0090.431.1.1

Ferraris CJ (2003) Family Auchenipteridae. In: Reis RE, Kullander SO, Ferraris CJ (Eds) Check List of the Freshwater Fishes of South and Central America. EDIPUCRS, Porto Alegre, 473–485.

Freitas TMS, Almeida VHC, Valente RM, Montag LFA (2011) Feeding ecology of Auchenipterichthys longimanus (Siluriformes: Auchenipteridae) in a riparian flooded forest of Eastern Amazonia, Brazil. Neotropical Ichthyology 9(3): 629–636. https://doi.org/10.1590/S1679-62252011003000032

Jayaram KC (1978) Functional responses of catfish barbels. Bulletin of the Zoological Survey of India 1: 77–80.

Kawakami E, Vazzoler G (1980) Método gráfico e estimaativa de índice alimentar aplicado no estudo de alimentação de peixes. Boletim do Instituto Oceanográfico 29(2): 205–207. https://doi.org/10.1590/S0373-55241980000200043

Lasso CA, Señaris JC, Lasso O, Castroviejo J (1995) Aspectos ecológicos de una comunidad de bagres (Pisces: Siluroidei) en los llanos inundables de Venezuela. Acta Biologica Venezolana 16: 1–31.

Lowe-McConnell RH (1987) Ecological studies in tropical fish communities. Cambridge University Press, Cambridge, 382 pp. https://doi.org/10.1017/CBO9780511721892

Lundberg JG, Littmann MW (2003) Family Pimelodidae (Long-whiskered catfishes). In: Reis RE, Kullander SO, Ferraris CJ (Eds) Check List of the Freshwater Fishes of South and Central America. EDIPUCRS, Porto Alegre, 432–446.

Melo GAS (2003) Manual de Identificação dos Crustacea Decapoda de água doce do Brasil. Edições Loyola, São Paulo, 432 pp.
Mérona B, Santos GM, Almeida RG (2001) Short term effects of Tucurui Dam (Amazonia, Brazil) on the trophic organization of fish communities. Environmental Biology of Fishes 60(4): 375–392. https://doi.org/10.1023/A:1011033025706

Oyakawa OT, Akama A, Mautari KC, Nolasco JC (2006) Peixes de riachos da Mata Atlântica. Editora Neotrópica, São Paulo, 201 pp.

Ribeiro FRV, Rapp Py-Daniel LH, Walsh SJ (2017) Taxonomic revision of the South American catfish genus Ageneiosus (Siluriformes: Auchenipteridae) with the description of four new species. Journal of Fish Biology 90(4): 1388–1478. https://doi.org/10.1111/jfb.13246

Sá-Oliveira JC, Maciel AGP, Araújo AS, Isaac-Nahum J (2014) Dieta do Mandubé, Ageneiosus ucayalensis (Castelnau, 1855), (Osteichthyes: Auchenipteridae) do Reservatório da Usina Hidrelétrica Coaracy Nunes, Ferreira Gomes-Amapa, Brasil. Biota Amazonica 4(3): 73–82. https://doi.org/10.18561/2179-5746/biotaamazonia.v4n3p73-82

Sabaj MH, Ferraris CJ (2003) Family Doradidae ( Thorny catfishes). In: Reis RE, Kullander SO, Ferraris CJ (Eds) Check List of the Freshwater Fishes of South and Central America. EDIPUCRS, Porto Alegre, 456–469.

Sabaj MH, Arce MH, Sousa LM, Birindelli JLO (2014) Nemadoras cristinae, new species of thorny catfish (Siluriformes: Doradidae) with redescriptions of its congeners. Proceedings. Academy of Natural Sciences of Philadelphia 163(1): 133–178. https://doi.org/10.1635/053.163.0102

Sabino J, Zuanon J (1998) A stream fish assemblage in Central Amazonia: Distribution, activity patterns and feeding behavior. Ichthyological Exploration of Freshwaters 8: 201–210.

Santos GM, Jégu M, Mérona B (1984) Catálogo de peixes comerciais do baixo rio Tocantins. Eletronorte/CNPq/INPA, Manaus, 83 pp.

Thomas MR, Sabaj MH (2010) A new species of whiptail catfish, genus Loricaria (Siluriformes: Loricariidae), from the Rio Curuá (Xingu Basin), Brazil. Copeia 2010(2): 274–283. https://doi.org/10.1643/CI-09-097

Tobías-Arias A, Olaya-Nieto CW, Segura-Guevara FF, Tordecilla-Petro G, Brú-Cordero SB (2006) Ecología trófica de la Doncella (Ageneiosus pardalis Lütken, 1874) en la cuenca del río Sinú, Colombia. Revista de Medicina Veterinaria y Zootecnia de la Universidad de Córdoba 11: 37–46. https://doi.org/10.21897/rmvz.1043

Torrente-Vilara G, Zuanon JAS, Amadio SA, Dória CRC (2008) Biological and ecological characteristics of Roestes molossus (Teleostei: Cynodontidae), a night hunting characiform fish from upper Madeira River, Brazil. Ichthyological Exploration of Freshwaters 19: 103–110.

Volpato GL (2007) Considerações metodológicas sobre os testes de preferência na avaliação do bem-estar em peixes. Revista Brasileira de Zootecnia 36(suppl): 53–61. https://doi.org/10.1590/S1516-3598200700100006

Winemiller KO, McIntyre PB, Castello L, Fluet-Chouinard E, Giarrizzo T, Nam S, Baird IG, Darwall W, Lujan NK, Harrison I, Stiassny ML, Silvano RAM, Fitzgerald DB, Pelicice FM, Agostinho AA, Gomes LC, Albert JS, Baran E, Petrere M, Zarfl C, Mulligan M, Sullivan JP, Arantes CC, Sousa LM, Koning AA, Hoeinghaus DJ, Sabaj M, Lundberg JG, Armbruster J, Thieme ML, Petry P, Zuanon J, Vilara GT, Snoeks J, Ou C, Rainboth W, Pavanelli CS, Akama A, Soesbergen A, Saenz L (2016) Balancing hydropower and biodiversity in the Amazon, Congo, and Mekong. Science 351(6269): 128–129. https://doi.org/10.1126/science.aac7082