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FEEDING ECOLOGY OF THE GENUS AUSTRALOHEROS (TELEOSTEI: CICHLIDAE: CICHLINAE) BASED ON EXAMINED SPECIMENS AND LITERATURE INFORMATION

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ABSTRACT

The objective of this paper was to study the diet of six species populations of the genus *Australoheros*, comparing the obtained results with information present in the literature. For this, two values related to the diet were calculated for the populations analyzed: frequency of occurrence and the proportion in which food category contributed to the diet of each species. The obtained results demonstrated that the species of *Australoheros* usually have a generalist and opportunist feeding habit, showing a preference for aquatic arthropods. It was not possible to affirm any alimentary preference for *A. scitulus*, since the gut and intestine content data were based only on radiographed specimens, revealing the presence of Gastropoda in their guts and intestines. It is just an evidence of the presence of Gastropoda in its diet, but it is not an evidence of a feed preference for Gastropoda. Comparing the gut and intestine contents of the six populations of *Australoheros* herein analysed with the diet of *A. acaroides*, it was concluded that only Cladocera and Diptera Larvae can be considered similar items of the feeding habit. In addition, in the present study, it was possible to observe the presence of some fishes that are characteristic from moderate salty water, in the gut and intestine content of a population of *A. macaensis* occurring in the Carapebus lagoon system. Thus, it could be an evidence of some degree of tolerance of this species for moderate salty water. However, more studies about the degree of the salt in the water are needed to corroborate this hypothesis of tolerance.
Key-words: ecology, food analysis, gut content, Heroini, South American cichlids.

Resumo

Ecologia alimentar do gênero *Australoheros* (Teleostei: Cichlidae: Cichlinae) baseado em exemplares examinadas e informações de literatura

O presente trabalho teve como objetivo estudar a dieta de seis populações de espécies do gênero *Australoheros*, comparando os resultados obtidos com informações presentes na literatura. Para tal, foram calculados dois valores relacionados à dieta das populações analisadas: frequência de ocorrência e a proporção que a categoria de alimento contribuiu para a dieta de cada espécies. Os resultados aqui obtidos demonstraram que as espécies do gênero geralmente possuem um hábito generalista e oportunista, apresentando uma preferência por artrópodes aquáticos. Não foi possível afirmar nenhuma preferência alimentar para *A. scitulus*, pois os dados relacionados a seu conteúdo estomacal e intestinal foram baseados apenas em exemplares radiografados, revelando a presença de Gastropoda em seus estômagos e intestinos. Isso consiste apenas em uma evidência de presença de Gastropoda na dieta da espécie, porém não é uma evidência de preferência alimentar por Gastropoda. Comparando o conteúdo estomacal e intestinal das seis populações de *Australoheros*, aqui analisadas, com a dieta de *A. acaroides*, podemos concluir que apenas Cladocera e larvas de Diptera podem ser considerados itens similares dos hábitos alimentares. Além disso, o presente estudo pode observar a presença de alguns peixes característicos de água moderadamente salgada no estômago e intestino de exemplares da população de *A. macaensis* que ocorre no Sistema lagunar de Carapebus. Assim, isso poderia ser uma possível evidência de algum grau de tolerância da espécie para água moderadamente salgada. Entretanto, mais estudos sobre o grau de salinidade da água são necessários para corroborar essa hipótese de tolerância.
Palavras chave: análise alimentar, ciclídeos sul-americanos, conteúdo estomacal, ecologia, Heroini.

INTRODUCTION

Australoheros Říčan & Kullander (2006) is a South American cichlid genus currently comprising more than 20 valid species (Ottoni *et al*., 2011; Ottoni, 2012), been one of the most species diverse genus of Cichlinae (Ottoni, 2012; 2013 A, B). Its monophyly has been supported by cytochrome *b* (cyt *b*) sequences (Říčan & Kullander, 2006: 2008), as well as, the colour pattern, characterized by trunk bars 5–7 interrupted above longitudinal stripe, constitutes the most evident morphological diagnostic character state (Ottoni & Costa, 2008; Rícan & Kullander, 2008; Ottoni & Cheffe, 2009; Ottoni, 2010). The genus is distributed along the coastal river basins from Uruguay to south of Bahia, also occurring in the Paraná-Paraguay-Uruguay river systems, Grande and Tietê river drainages of the Paraná river basin, and in the São Francisco river basin (Casciotta *et al*., 1995; Casciotta *et al*., 2006; Rícan & Kullander 2008; Ottoni & Costa 2008; Ottoni, 2010; Schindler *et al*., 2010; Ottoni *et al*., 2011; Ottoni, 2012; Ottoni 2013 A, B).

Recently, several taxonomic works about the genus have been published (e.g. Říčan & Kullander, 2003; 2006: 2008; Casciotta *et al*., 2006; Ottoni & Costa 2008; Ottoni *et al*., 2008: 2011; Ottoni & Cheffe, 2009; Schindler *et al*., 2010; Ottoni, 2010: 2012: 2013A, B). However, information related to the ecology, behaviour and diet of the species of the genus are still scarce. Few published works make some comments about the diet and feeding ecology of some species from the genus. These works are cited below.

Except by Říčan & Kullander (2003), which analysed radiographed specimens of *A. scitulus* Říčan & Kullander, 2003, revealing considerable amounts of snail shells in their guts and intestines, and no other food component; all the other works have demonstrated that the feeding habits of the their analysed species are generalist, usually showing a preference for arthropods (mainly aquatic arthropods), with some other additional general food components composing their diets, such as other invertebrate groups, fish remains, eventually plant and algae parts, and sediments (see Costa, 1987; Hartz *et al*., 2000; Yafe *et al*., 2002; Ottoni *et al*., 2011)

There is another paper about the diet of the genus, however it was based on an introduced species [*Australoheros facetus* (Jenyns, 1842)] in the lower Guadiana basin, Portugal. This work revealed the predominance of insects (Odonata, Diptera, Ephemeroptera, Heteroptera, Plecoptera, Coleoptera, Formicidae and Trichoptera) in the gut contents of the specimens, and also recorded some other item, such as, Crustaceans (Cladocera and Ostracoda), Chelicerata (Acari, Hydracarina and Oribatei), Bivalvia, Teleostei (Cyprinidae, Centrarchidae and Blenniidae) and Rotifera (Ribeiro *et al*., 2007).

The main objective of the current paper is to compare the available published data about to the diet of species of *Australoheros* with six populations of the genus herein examined (*A. macacuensis* Ottoni & Costa, 2008 from the Macacu river basin; *A. macaensis* Ottoni & Costa, 2008 from the Macaé river basin and Carapebus lagoon system; *A.* cf. *minuano* from the middle Uruguay river drainage; *A. saquarema* Ottoni & Costa, 2008 from the Saquarema lagoon system; *A. montanus* Ottoni, 2012 from Paquequer river drainage of the Paraíba do Sul river basin; and *A.* cf.. *paraibae* from the Ribeirão das Lages river drainage of the Paraíba do Sul river basin). Comparing these data, we intend to reveal a general feeding preference for the genus.

MATERIAL AND METHODS

The Materials is deposited in UFRJ, Instituto de Biologia, Universidade Federal do Rio de Janeiro, Brazil.

Fish specimens were fixed in formalin 10 %, just after collection, for a period of about 20 days, and then transferred to ethanol 70 %. A total of 38 specimens from six species populations (Figures 1 and 2) were herein analysed (the number of specimens analysed for each species population are presented in the Table 1). In the analysis of gut and intestine contents, each food items were separated in categories (a total of 24 categories listed in Table 1), and their volume was measured in a 1 mm high square-shaped transparent dish with a scale in millimetres underneath so that the area corresponded to the volume. The food items were identified to the lowest possible taxonomic category. Two values were calculated: percentage of fish specimens that contained a determined food item (frequency of occurrence) and the proportion in which food category contributed to the diet of each fish species, calculated by the average of the volume percentage of that food category is occupied in each gut (contribution in volume) (e.g. ZARET & RAND, 1971).

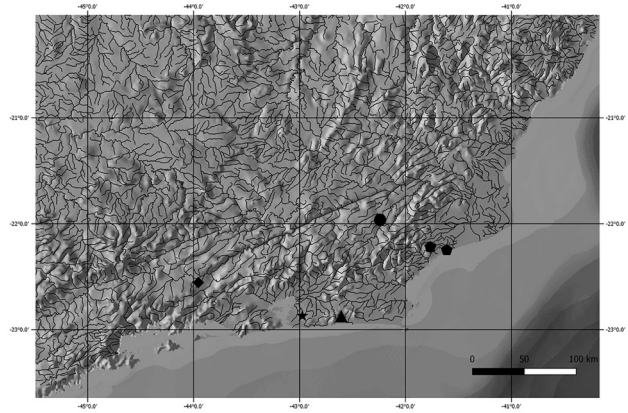

Figure 1. Map with the distribution of the species populations herein analysed from the southeastern Brazil. Circle – *A. montanus*; lozenge – *A*. cf. *paraibae*; star – *A. macacuensis*; pentagon – *A. macaensis*; and triangle – *A. saquarema*.

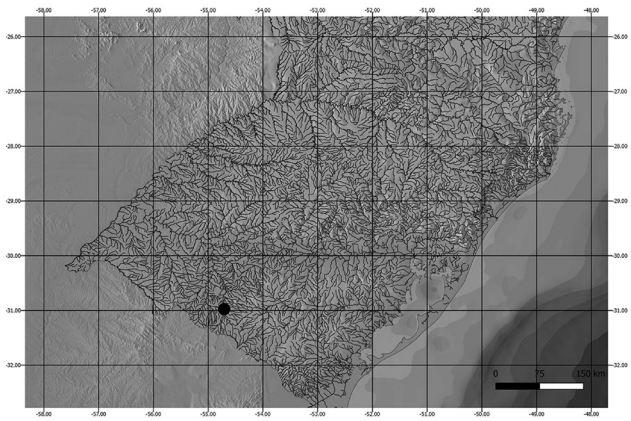

Figure 2. Map with the distribution of the species population herein analysed from the southern Brazil. Circle – *A*. cf. *minuano*.

Material examined

Australoheros macacuensis: Rio de Janeiro state: UFRJ 11197, 6, 46.6–70.3 mm SL; Moshe near rio Aldeia, São Gonçalo Municipality; Rosana Souza-Lima et al., 15 May 2007 (Macacu river basin).

Australoheros macaensis: Rio de Janeiro state: UFRJ 7568, 2 (paratypes), 66.3–73.3 mm SL; dos Quarenta river, BR 101; F. Leal, F.P. Ottoni & J.L Mattos, 24 Aug. 2007. UFRJ 7616, 3, 45.7–64.7 mm SL; Carapebus lagoon, Carapebus Municipality; P. Macedo-Soares, E. Camara, V. Cardoso, D. Antunes & J. Pereira, 18 Feb. 2005. UFRJ 7617, 2, 76.1–80.0 mm SL; Carapebus lagoon, Carapebus Municipality; P. Macedo-Soares, E. Camara, V. Cardoso, D. Antunes & J. Pereira, 18 Feb. 2005 (Macaé river basin and Carapebus lagoon system).

Australoheros cf. *minuano:* Rio Grande do Sul state: UFRJ 7753, 6, 36.4–59.4 mm SL; Santa Maria river, tributary of Ibicuí river, Dom Pedrito municipality; M. Burns, 02 Jan 2009 (middle Uruguay river drainage).

Australoheros saquarema: Rio de Janeiro state: UFRJ 7221, 6 (paratypes), 43.3-59.4 mm SL; córrego Buracão, tributary of Mato Grosso river, Saquarema Municipality; W. Costa, L. Villa-verde, J. Mattos, F. Ottoni & E. Mattos, 09 Oct. 2005 (Saquarema lagoon system).

Australoheros montanus: Rio de Janeiro state: UFRJ 7795, 5 (paratypes), 63.7-102.8 mm SL; São Francisco river, locality of Barra de São Francisco, between Sumidouro and Carmo municipalities; F. Ottoni, A. Katz, P. Bragança & F. Rangel-Pereira, 04 Jun. 2010 (Paquequer river drainage of the Paraíba do Sul river basin).

Australoheros cf. *paraibae*: Rio de Janeiro

state: UFRJ 7700, 8, 45.9–84.8 mm SL; riberão Maria Preta, Piraí Municipality; F. Ottoni, A. Katz & P. Bragança, 22–23 May 2009 **(**Ribeirão das Lages river drainage of the Paraíba do Sul river basin**).**

RESULTS

The diet components, occurrence frequency (%) of food items and contribution in volume are presented in Table 1.

Table 1. Gut and intestine content of: A. macacuensis, *A. macaensis, A. cf. minuano, A. saquarema, A. montanus* and *A*. cf. *paraibae*. frequency of occurence (%) of food items, followed by contribution in volume (%, in parentheses). *approximately 0.

Species	*A. macacuensis*	*A. macaensis*	*A.* cf. *minuano*	*A. saquarema*	*A. montanus*	*A.* cf. *paraibae*
Number of specimens examined	6	7	6	6	5	8
Standard length (mm)	46.6–72.0	45.7–80.0	36.4–59.4	43.3–59.4	63.7–102.8	45.9–84.8
Crustaceans						
1 - Cladocera	-	16.7 (0*)	33.3 (16.5)	-	-	-
2- Ostracoda	-	50 (0.2)	50 (36.5)	-	-	-
3- Caridea	16.7 (0.4)	33.3 (0.4)	16.7 (0.2)	33.3 (17)	-	25 (2)
Immature aquatic insects						
4 - Coleoptera	33.3 (44)	-	16.7 (0.5)	-	60 (17)	
5 - Chironomidae	66.7 (15)	33.3 (0*)	16.7 (14)	-	60 (0.8)	12 (0.7)
6 - Chironomidae (pupa)	16.7 (0.1)	-	-	-	-	-
7 - Odonata	16.7 (22)	33.3 (0.4)	-	16.7 (19)	-	50 (14)
Adult aquatic insects						
8 - Coleoptera	-	33.3 (0.1)	-	33.3 (13)	-	25 (11)
9 - Hemiptera	33.3 (0.5)	-	33.3 (16.5)	50 (29)	80 (36)	62.5 (44)
Terrestrial Arthropods						
10 - Calliphoridae	-	-	-	-	-	12 (3)
11 - Formicidae	-	-	-	16.7 (20)	-	12 (11)
12 - Araneae	-	-	-	-	-	12 (4.5)
Mollusca						
13 - Gastropoda	-	16.7 (0*)	-	-	-	25 (9.7)
14 - Bivalvia	-	-	-	-	-	12 (0.7)
Fish						
15 – Unidentified fish	-	-	16.7 (0.8)	-	-	-
16 - *Phalloptychus januarius*	-	16.7 (83.2)	-	-	-	-
17 - Atherinidae	-	16.7 (0*)	-	-	-	-
18 - Fish scales	-	33.3 (0.3)	-	16.7 (0.1)	20 (11)	-
Others						
19 - Unidentified Egg	66.7 (0,2)	-	-	-	-	-
20 - Insect Egg	33.3 (0.7)	16.7 (0*)	-	-	-	-
21 - Unidentified adult insect	-	-	-	-	40 (19.6)	-
22 - Unidentified immature insect	-	-	-	-	40 (0.4)	-
23 - Shelled amoeba	16.7 (0.01)	-	-	-	-	-
24 - Unidentified insect pupa	-	-	-	-	20 (0.2)	-

DISCUSSION

Among the 24 item components found in the analyses, only the items corresponding to immature and adult aquatic insects were found in all the six species populations herein examined. In this study, was possible to observe that, all the analysed populations have a generalist and opportunist feeding habit, showing a preference for aquatic arthropods. Their opportunist and generalist feeding ecology is confirmed due to the distinguish types of item components in the diet (e.g. fishes, crustaceans, adult and immature aquatic insects, terrestrial insect, insect eggs and undetermined eggs) and the presence of items that are not common in the habitats which these fishes live (e.g. terrestrial insects), a pattern typical of an opportunist and generalist diet. Our results and hypothesis which support that the species of the genus possess a generalist and opportunist-feeding habit were similar to the results found by the major part of the paper cited in the introduction. In addition, our results about the diet components of *A. saquarema* fits with the results found by Costa (1987), both revealing a highly presence of Arthropoda (mainly adult and immature aquatic insects) on its diet.

Rícan & Kullander (2003) discovered amounts of snail shells in the gut and intestine of *A. scitulus*. Comparing the presence of Gastropoda on the diet of *A. scitulus* with the six species populations herein examined, only *A.* cf. *paraibae* and *A. macaensis*, exhibit it as one of the components of their gut and intestine contents. However, Rícan & Kullander (2003) did not present an analysis of the diet of *A. scitulus*. Just some specimens were radiographed, and revealed the considerable presence of snail shells in their guts and intestines. Thus, it is not possible to affirm any alimentary preference or diet of *A. scitulus* with those radiographies. It is just an evidence of the presence of Gastropoda in its diet. Bistoni & Hued (2002) affirmed that *A. facetus* from rivers of central region of Argentina have an omnivore habits, but did not presented any list or table with the alimentary components, and Latini & Petrere (2004) examined *A.* cf. *perdi* from lakes of the Doce river system, affirming that the diet of this species is composed by vegetable parts, invertebrates and sediments, but not specified the items. As both papers did not specify the diet components of their examined species, this makes it impossible to compare the results found by them with the statistical results herein obtained.

Yafe et al. (2002) presented a list of the gut contents for A. facetus from lago Rodó, Montevideo, Uruguay. In this list the following items were presented: Crustaceans (adults of Amphipoda, Cladocera, Copepoda and Decapoda), Insects (Hemiptera, Coleoptera and adults, larvae and pupae of Diptera), Arachnida (Araneae), Gastropoda (Heleobia sp.), Oligochaeta (earth worms), Bryozoa, fish [*Cnesterodon decemmaculatus* (Jenyns, 1842) and unidentified fishes], Unidentified eggs, seeds, vegetal material and sediment; although neither occurrence frequency nor contribution in volume were presented. This result found by these authors just confirm the generalist and opportunist feeding ecology for the species as the expectation for the genus, however does not allow discussing preference for any particular diet component, and Ottoni et al. (2011) examined the food preference of some specimens of A. perdi Ottoni, Lezama, Triques, Fragoso-Moura, Lucas & Barbosa 2011, occurring at the type locality. They verified that the main ingested items was: shrimp [Macrobrachium jelskii (Miers, 1877)], fish scales and remains; sediment; immature aquatic insects (Chironomidae larvae and Odonata nymph); some terrestrial insects (Coleoptera and Hemiptera); and plant material and other invertebrates, in order of greater abundance; what also confirm an opportunist and generalist feeding ecology.

Comparing the diet of the six species populations herein analysed with the diet of *A. acaroides* (Hensel 1870), provided by Hartz *et al*. (2000), it was concluded that only Cladocera and Diptera Larvae, can be considered similar items of the feeding habit (*A.* cf. *minuano* was the only exhibiting Cladocera; and *A. macacuensis*, *A. macaensis* and *A.* cf. *paraibae* were the only exhibiting major preference for Diptera Larvae). None of the species herein analysed exhibit Macrophytes, Hirudinea and aquatic Acaris as components of their food items.

In this current paper, it was possible to observe the presence of some fishes characteristic from moderate salty water in the diet of *A. macaensis*: *Phalloptychus januarius* (Hensel, 1868) and Atherinidae. However, these fishes were found only in the gut and intestine of specimens occurring in the Carapebus lagoon. Thus, it could be an evidence of some degree of tolerance of this species for moderate salty water. However, more studies about the degree of the salt in the water are need to corroborate this hypothesis of the moderate salty water tolerance.

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