Neotropical Ichthyology, 6(4):693-696, 2008

Scientific Note

The introduction of the African catfish *Clarias gariepinus* (Burchell, 1822) into Brazilian inland waters: a growing threat

Gecely Rodrigues Alves Rocha

The biology of the introduced species *Clarias gariepinus* in lagoa Encantada (Ilhéus, Bahia State) was studied. Samples were obtained with gillnets between May 2002 and February 2004. All individuals caught exceeded the average length at first maturity cited in literature. Males and females in maturation stages indicate that the species is already established in the lake.

A biologia de *Clarias gariepinus*, uma espécie introduzida, foi estudada na lagoa Encantada (Ilhéus, Bahia). As amostras foram obtidas com rede de espera, entre maio de 2002 e fevereiro de 2004. Todos os indivíduos capturados estavam acima do tamanho médio de primeira maturação citado na literatura. A ocorrência de machos e fêmeas em estágio de maturação indica que a espécie já está estabelecida na lagoa.

Key words: Freshwater, Fish, Exotic species, Sharptooth catfish.

The introduction of exotic species may have negative impacts on local ecosystems, including the introduction of parasites, and biological competition with native species, which may result ultimately in a loss of biodiversity. Many species listed as threatened or endangered are considered to be at risk primarily because of competition with and predation by non-indigenous species (Wilcove *et al.*, 1998). Despite the increasing number of non-native species introduced, with substantial economic costs (Pimentel *et al*., 2000), little is known about the general patterns of these species introductions for many biological groups. Stohlgren *et al.* (2006) suggest that while human populations are more instrumental in the initial establishment of invasions, environmental factors are more important in the spread and potential distribution of invading species. To document the broad-scale patterns of invasion of different biological groups it is important to set priorities for prevention, early detection, containment, and eradication.

In Brazil, the first occurrences of the African catfish *Clarias gariepinus* (Burchell, 1822) were registered in the São Francisco, Paraná and Doce river basins (Alves *et al*., 1999) and in the estuary of laguna dos Patos, in the State of Rio Grande do Sul (Braun *et al*., 2003). More recently, the introduction of this species into the riacho Sossego, rio Doce basin, in the State of Espírito Santo, the rio Guaragaçu basin, in the State of Paraná, and into the lagoa Encantada, rio Almada basin, in the State of Bahia, were reported by Mili & Teixeira (2006), Vitule *et al.* (2006), and Rocha & Schiavetti (2007), respectively. These last studies have found more than thirty individuals, in contrast to the first occurrences, when just a few individuals were recorded.

Lagoa Encantada (Ilhéus, Bahia) is included in the Lagoa Encantada Environmental Protection Area, created in 1993. Unfortunately, the inclusion did not guarantee protection, and the introduction of non-native species, a common threat to freshwater systems (Saunders *et al*., 2002), was not prevented. Four introduced species occurs in the lake: *Prochilodus argenteus*, endemic to the rio São Francisco basin; *Cichla monoculus*, from the Amazon region; and two African species, *Oreochromis niloticus* and *Clarias gariepinus*. According to fishermen, initial occurrences resulted from escapes around ten years ago; nowadays, *Clarias gariepinus* is the largest species caught in lagoa Encantada, being second in biomass at 15 %

Departamento de Ciências Biológicas, Universidade Estadual de Santa Cruz, Rodovia Ilhéus – Itabuna, km 16. 45650-000 Ilhéus, BA, Brazil. gecely@uesc.br

(Rocha & Schiavetti, 2007). The goal of this study was to improve our understanding of the biology of the introduced species *Clarias gariepinus* in lagoa Encantada.

Local data. The basin of the rio Almada, located in Bahia State, has a drainage area of 1545 km^2 and a perimeter of 252 km. The watershed of the drainage basin is covered by a diverse range of vegetation types, including Atlantic coastal forest remnants, classified as tropical lowland rainforest, and cacao agroforests (Bahia, 2001a). A significant amount of forest cover still persists and has an important role in protecting watersheds from serious erosion. The main watercourse is the rio Almada with an extension of 138 km. Lagoa Encantada (14°36'38''S, 39°08'33''W), formed by a depression in the basin of the rio Almada, has an area of 650.5 ha and a perimeter of 13.3 km. Banks around lagoa Encantada are covered with grass, shrubs, and trees, including introduced oil palm trees (*Elais guineensis*); the dominant floating vegetation is *Eichornia crassipes*. The region has an average annual temperature of 23.3 °C and a highly seasonal pattern of rainfall, occurring mainly from November to April, with an annual average of 1717 mm (Bahia, 2001b).

Samples were obtained with gillnets from 20:00 to 06:00 once per month between May 2002 and February 2004. Gillnets with a stretched mesh size of 75 to 90 mm and a length of 34 to 61 m were used in the pelagic zone (up to 10 m deep). In the laboratory, each fish was weighed (to nearest 0.1 g) and its total length was measured (mm). Its gonads were removed and examined. Voucher specimens were deposited in the fish collection at the Laboratory of Biological Oceanography, Universidade Estadual de Santa Cruz (UESC).

The developmental stage was determined following Vazzoler (1996). Macroscopic stages assigned were: I. Immature, II. Developing virgin or recovering-spent, III. Ripe, and IV. Spent. Undeveloped gonads are tiny transparent, thread-like, colourless organs. Following a gradual transition, fully-developed ovaries are large yellow structures almost filling the peritoneal cavity, having a grainy appearance due to the presence of mature oocytes. Maturing testes are white, long and thick; sperm easily flows when the ripe testis is pressed. The gonadosomatic index was calculated for females from the gonad weight (GW, in g) and the somatic weight (W, in g) using the formula:

$$GSI = (GW/ (W – GW)) * 100.$$

A total of thirty-three individuals of *Clarias gariepinus* were caught during the survey period, exclusively in the dry season (June to September). Total length varied from 370 to 880 mm, and total weight from 317 to 3939 g (Table 1). Seventeen males were recorded, all in stage II, with GSI values of 0.10 to 0.74 %. Nine females in stages II and III were recorded, with GSI between 0.13 and 9.35 %. For seven individuals, sex was not determined. Ripe females were observed in August and September; however, these were in the initial stages. Spawning probably occurs in the spring and recruitment in summer. Unfortunately, we could not obtain data to confirm this. As far as we know, the species is no longer commercially cultivated in the region, so the chances of recent escapes from aquaculture ponds are small. The frequency of occurrence and the presence of mature specimens suggest that this population is established in lagoa Encantada, but is not spreading yet.

The species was classified as omnivorous, based on intestine length, and type of teeth and gill rakers; although the diet was not assessed quantitatively, the principal food items recorded were oil palm seeds and molluscs (Lemes, 2006).

Other occurrences. Exotic fish species have been introduced around the world and in many cases with the idea of increasing productivity of the natural systems. However, a loss of biodiversity may be a consequence of this, as reported in Brazilian inland waters (Agostinho *et al*., 2005). To date, more than 20 fish species introduced from other continents have been registered in Brazil (Agostinho & Julio, 1996).

Increasing numbers and size of *Clarias gariepinus* have been reported in Brazilian inland waters. First occurrences probably resulted from escapes, especially during the rainy season when poorly constructed impoundments broke and the exotic specimens fled to the rivers. Recent occurrences, however, reported individuals exceeding the average length at first maturity (L_{50}) and reaching more than 3 kg (Oliveira *et al*., 2005; Mili & Teixeira, 2006; Vitule *et al*., 2006). Till now, the largest individual size registered in Brazilian waters was that for a specimen caught in lagoa Encantada, which was close to the maximum values observed in African lakes. In Lake Tana, Ethiopia, *C. gariepinus* has been caught with lengths varying from 12 to 87 cm, achieving $L\infty$ values of 90 cm for males and 85 cm for females; the average length at first maturity (L_{50}) was 30.5 cm for females and 36.0 cm for males (Wudneh, 1998).

Our findings support that classification of C. *gariepinus* as an omnivore rather than carnivore, as found in its natural habitats, such as in the Upper Zambezi River floodplain (Winemiller & Kelso-Winemiller, 1996), or in Lake Sibaya, South Africa, where it is found to feed on a wide variety of food items, from minute crustaceans to fish, and on whichever cichlid prey is in greatest abundance (Bruton, 1979). In the riacho Sossego, Brazil, where the species was also introduced, stomach content items were categorized into 2 major prey groups, fish (63 % of weight) and crustaceans (31 %), and small amounts of macrophytes and insects, showing evidence of its opportunistic behavior (Mili & Teixeira, 2006).

Considering broad-scale patterns, Stohlgren *et al.* (2006) concluded that the many potential causes for the success of non-indigenous species in species-rich areas include climate and habitat matching, weak competition for resources from native species, and the use of previously under-used resources. According to them, the simplest explanation of the general patterns of non-indigenous species is that they evolved in their original habitats and continents under similar environmental constraints. At the species level, growing evidence suggests that characteristics important at the spread stage differ from

Table 1. Date, total length (LT, mm), weight (W, g), sex (M, male; F, female), maturation stage (I, immature; II, developing virgin or recovering-spent; III, ripe; IV, spent), gonad weight (Wg, g), and gonadosomatic index (GSI %) of *Clarias gariepinus* collected in lagoa Encantada, Ilhéus, Bahia.

Date	Lt	W	sex	stage	Wg	GSI
19/6/2002	450	650.0				
19/6/2002	440	610.0				
19/6/2002	430	480.0				
19/6/2002	438	568.5				
29/6/2002	510	921.6	M	II	1.46	0.16
29/6/2002	485	785.3	M	II	0.90	0.11
29/6/2002	470	809.2	M	II	5.98	0.74
29/6/2002	410	453.2	F	I	0.61	0.13
29/6/2002	491	837.9	F	II	1.25	0.15
29/6/2002	471	728.9	F	II	4.92	0.67
10/7/2002	490	913.1	M	II	1.61	0.18
11/7/2002	470	692.2	M	II	1.95	0.28
11/7/2002	465	615.9	M	II	1.20	0.19
16/7/2002	510	888.4	M	II	1.13	0.13
16/7/2002	425	475.6	M	II	0.93	0.20
8/8/2002	495	797.5	M	II	2.23	0.28
8/8/2002	482	712.1	M	II	1.53	0.21
8/8/2002	470	911.2	M	II	0.89	0.10
8/8/2002	465	677.5	F	II	3.84	0.57
8/8/2002	440	599.4	F	II	2.76	0.46
8/8/2002	435	437.7	M	II	1.28	0.29
8/8/2002	370	317.3	F	II	3.03	0.95
3/9/2002	583	1226.2	M	II	2.21	0.18
3/9/2002	555	1143.0	M	II	3.15	0.28
3/9/2002	542	961.2	M	II	3.45	0.36
3/9/2002	541	1203.3	F	II	6.43	0.53
3/9/2002	530	987.9	M	II	2.22	0.22
3/9/2002	465	836.6	M	II	1.62	0.19
3/9/2002	448	797.6	F	III	23.15	2.99
26/7/2003	720	2538.0				
26/7/2003	880	3524.0				
26/8/2003	650	1780.0	F	III	152.20	9.35
26/8/2003	850	3938.8	F	II	12.93	0.33

those important in other stages of the invasion sequence (Kolar & Lodge, 2002; Marchetti *et al*., 2004). Some of the characteristics that distinguish a successful invading species are physiological tolerance, parental care, and large adult body size (Marchetti *et al*., 2004), characteristics that are shared by *Clarias gariepinus* (Wudneh, 1998), and could have contributed to the establishment of the species in lagoa Encantada.

Cases of reduced numbers of native fish fauna and local extinction of species have been recently reported in Brazilian inland waters related to the introduction of non-native species, among other factors (Pompeu & Alves, 2003; Latini & Petrere, 2004). In most examples of intentional or accidental introductions we have no clear evidence of the effects of the introduction on other species because we have no adequate baselines of the pre-introduction condition. The occurrence of introduced species as dominant species shows a possible alteration of the trophic structure of lagoa Encantada. However, the lack of pre-introduction studies hinders the determination of the magnitude of these impacts.

Stricter controls should aim at preserving native diversity and preventing further damage to natural and managed ecosystems, for once introduced, exotic fishes are generally impossible to eradicate. Preventive strategies are needed, such as public education, sanitation, and effective screening and searches at ports of entry that will help reduce the chances that biological invaders will become established.

Acknowledgements

We are gratefull to CNPq (APQ 478874/2001-4) and UESC for the financial support.

Literature Cited

Agostinho, A. A. & H. F. Julio Jr., 1996. Ameaça ecológica: peixes de outras águas. Ciência Hoje, 21(124): 36-44.

Agostinho, A. A., S. M. Thomaz & L. C. Gomes. 2005. Conservation of the biodiversity of Brazil's inland waters. Conservation Biology, 19(3): 646-652.

Alves, C. B. M., V. Vono & F. Vieira. 1999. Presence of the walking catfish *Clarias gariepinus* (Burchell) (Siluriformes, Clariidae) in Minas Gerais state hydrographic basins, Brazil. Revista Brasileira de Zoologia, 16: 259-263.

Bahia. 2001a. Diagnóstico das bacias hidrográficas dos Rios Cachoeira e Almada: caracterização ambiental. Governo do Estado da Bahia: SEINFRA. Superintendência de Recursos Hídricos (SRH). Salvador, v. I, Tomo IV, 48p.

Bahia. 2001b. Diagnóstico das bacias hidrográficas dos Rios Cachoeira e Almada: caracterização climatológica. Governo do Estado da Bahia: SEINFRA. Superintendência de Recursos Hídricos (SRH). Salvador, v. I, Tomo III, 80p.

Braun, A. S., P. C. C. Milani & N. F. Fontoura. 2003. Registro da introdução de *Clarias gariepinus* (Siluriformes, Clariidae) na Laguna dos Patos, Rio Grande do Sul, Brasil. Biociências, 11: 101-102.

Bruton, M. N. 1979. The food and feeding behaviour of *Clarias gariepinus* (Pisces: Clariidae) in Lake Sibaya, South Africa, with emphasis on its role as a predator of cichlids. Transactions of the Zoological Society of London, 35(1): 47-114.

Kolar, C. S. & D. M. Lodge. 2002. Ecological predictions and risk assessment for alien fishes in North America. Science, 298: 1233-1236.

Latini, A. O. & M. Petrere, Jr. 2004. Reduction of a native fish fauna by alien species: an example from Brazilian freshwater tropical lakes. Fisheries management and Ecology, 11: 71-79.

Lemes, T. N. 2006. Caracteres morfológicos relacionados à alimentação de peixes da Lagoa Encantada, Ilhéus, Bahia. Unpublished M.Sc. Thesis, Universidade Estadual de Santa Cruz, Ilhéus. 33p.

Marchetti, M. P., P. B. Moyle & R. Levine. 2004. Invasive species profiling? Exploring the characteristics of non-native fishes across invasion stages in California. Freshwater Biology, 49: 646-661.

Mili, P. S. M. & R. L. Teixeira. 2006. Notas ecológicas do bagre-africano *Clarias gariepinus* (Burchell, 1822) (Teleostei, Clariidae), de um córrego do sudeste do Brasil. Boletim do Museu de Biologia Mello Leitão, 19: 45-51.

Oliveira, E. F., C. V. Minte-Vera & E. Goulart. 2005. Structure of fish assemblages along spatial gradients in a deep subtropical reservoir (Itaipu Reservoir, Brazil - Paraguay border). Environmental Biology of Fishes, 72: 283-304.

Pimentel, D., L. Lach, R. Zuniga & D. Morrison. 2000. Environmental and economic costs of non-indigenous species in the United States. BioScience, 50: 53-65.

Pompeu, P. S. & C. B. M. Alves. 2003. Local fish extinction in a small

tropical lake in Brazil. Neotropical Ichthyology, 1(2): 133-135.
Rocha, G. R. A. & A. Schiavetti. 2007. Diversity of fish and fisheries from the Lake Encantada Environmental Protection Area, Ilhéus, Brazil. Aquatic Conservation: Marine and Freshwater Ecosystems, 17: 702-711.
Saunders, D. L., J. J. Meeuwig & A. C. J. Vincent. 2002. Freshwater protected areas: strategies for conservation. Conservation Biology, 16: 30-41.
Stohlgren, T. J., D. Barnett, C. Flather, P. Fuller, B. Peterjohn, J. Kartesz & L. L. Master. 2006. Species richness and patterns of invasion in plants, birds and fishes in the United States. Biological Invasions, 8: 427-447.
Vazzoler, A. E. A. M. 1996. Biologia da reprodução de peixes teleósteos: teoria e prática. Maringá, EDUEM, 169p.
Vitule, J. R. S., S. C. Umbria & J. M. R. Aranha. 2006. Introduction of the African catfish *Clarias gariepinus* (Burchell, 1822) into Southern Brazil. Biological Invasions, 8: 677-681.
Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips & E. Losos. 1998. Quantifying threats to imperilled species in the United States. BioScience, 48: 607-615.
Winemiller, K. O. & L. C. Kelso-Winemiller. 1996. Comparative ecology of catfishes of the Upper Zambezi River floodplain. Journal of Fish Biology, 49(6): 1043-1061.
Wudneh, T. 1998. Biology and management of fish stocks in Bahir dar Gulf, Lake Tana, Ethiopia. Unpublished Ph.D. thesis, Wageningen Agricultural University, Wageningen, 143p.

Accepted July 2008
Published December 22, 2008