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NOTES ON GEOGRAPHIC DISTRIBUTION

Actinopterygii, Siluriformes, Callichthyidae, *Hoplosternum littorale* (Hancock, 1828): Distribution extension in the upper São Francisco River region, southeast Brazil

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ABSTRACT: The tamoatá *Hoplosternum littorale* (Hancock, 1828) is an alien catfish to the São Francisco River basin. Although it has been registered along all of this hydrological system's extension, including the segment located upstream of the Três Marias dam, up to now the species had not yet been detected in the Pará River sub-basin. Between the 19th and 28th of October 2009, 27 specimens were collected in this drainage system; over half of them captured in a highly polluted artificial reservoir. The results of the present study reinforce that the implementation of reservoirs and the pollution of the continental waters favor not only the expansion, but also the establishment of non-native teleosts with opportunist habits.

The dispersion of organisms into new territories is a natural biogeographic phenomenon limited not only by physical barriers, but also by the intrinsic mobility of each species (Helfman *et al.* 1997). When such range extensions occur as a result of human actions, it is considered an introduction (Helfman *et al.* 1997; Gozlan *et al.* 2010).

Despite its disastrous effects (Zaret and Paine 1973; Achieng 1990; Molina *et al.* 1996; Latini and Petrere-Jr. 2004; Pelicice and Agostinho 2008), the release of non-native fish has become a common practice and can occur not only intentionally (Zaret and Paine 1973; Achieng 1990; Agostinho and Júlio-Jr. 1996; Molina *et al.* 1996; Magalhães *et al.* 2002; Latini and Petrere-Jr. 2004; Vitule 2009; Gozlan *et al.* 2010), but also passively by accidental escapes from tanks or fish farming stations (Zaret and Paine 1973; Agostinho and Júlio-Jr. 1996; Magalhães 2007; Vitule 2009; Gozlan *et al.* 2010).

The tamoatá *Hoplosternum littorale* (Hancock, 1828) is a benthonic air-breathing catfish (Burgess 1989; Reis 2003; Abdallah *et al.* 2006; Jucá-Chagas and Boccardo 2006), usually associated with swampy rivers and floodplains (Burgess 1989; Abdallah *et al.* 2006). Although it is the Callichthyidae with the largest spatial distribution (Reis 2003), this species is allochthonous to the São Francisco River basin (Oliveira and Moraes-Jr. 1997; Alves and Pompeu 2001; 2005; Pompeu and Alves 2003; Sato and Sampaio 2005; Barbosa and Soares 2009; Alves and Leal 2010).

Detected for the first time in this basin in 1990 (Oliveira and Moraes-Jr. 1997), nowadays *H. littorale* is found amply diffused within its limits (Alves and Pompeu 2001; 2005; Pompeu and Alves 2003; Pompeu and Godinho 2003; 2006; Sato and Sampaio 2005; Silva *et al.* 2006; Luz *et al.* 2009; Alves and Leal 2010). Despite being present upstream of the Três Marias dam (Alves and Leal 2010), up until now the presence of this species had not been registered in the sub-basin of the Pará River (Tupinambás *et al.* 2007; Alves and Leal 2010), considered one of the main tributaries of the São Francisco River's right bank (Pereira *et al.* 2007; Tupinambás *et al*. 2007).

Thus, considering the need to relate and emphasize the presence of non-native species as part of conservationist strategies (Vitule 2009; Gozlan *et al*. 2010), the present paper has the objective of accusing the increased distribution of *H. littorale* upstream of the Três Marias dam, pointing out the first records of this Callichthyidae in the Pará River sub-basin. It also aims to co-relate its local presence and establishment with human intervention in this aquatic environment, as well as to evaluate its possible impacts within its new range. Management recommendations are also proposed in order to prevent new introductions and the risk of biological invasions.

Between the 19th and 28th of October 2009, while conducting experimental fisheries (License Nº 134-09 – IEF/MG) using gill and sieving nets in the São João and Pará Rivers, and Coelhos stream (Figure 1), we collected a total of 27 specimens of *H. littorale* (Figure 2) with standard length varying between 9.5 and 19.1 cm and body weight oscillating between 25 and 245 grams. Of this total, seven individuals were submitted for preservation at the Museu de Zoologia da Universidade de São Paulo (MZUSP), and the others were dissected for macroscopic evaluation of the gonadal maturation stages according to Bazolli (2003) (Table 1).

Although *H. littorale* was detected in only four (26.7%) (Figure 3) of 15 sampled stations, all the dissected specimens were in full reproductive activity. We also point out that in the Britos reservoir this teleost was the only species captured by the experimental fisheries, with a total of 15 individuals collected during 12 hours of exposure of the gill nets. Such representation is most likely related to the fact that this reservoir receives all the domestic sewage of the urban area of the Itaúna municipality, thus accumulating a large quantity of organic

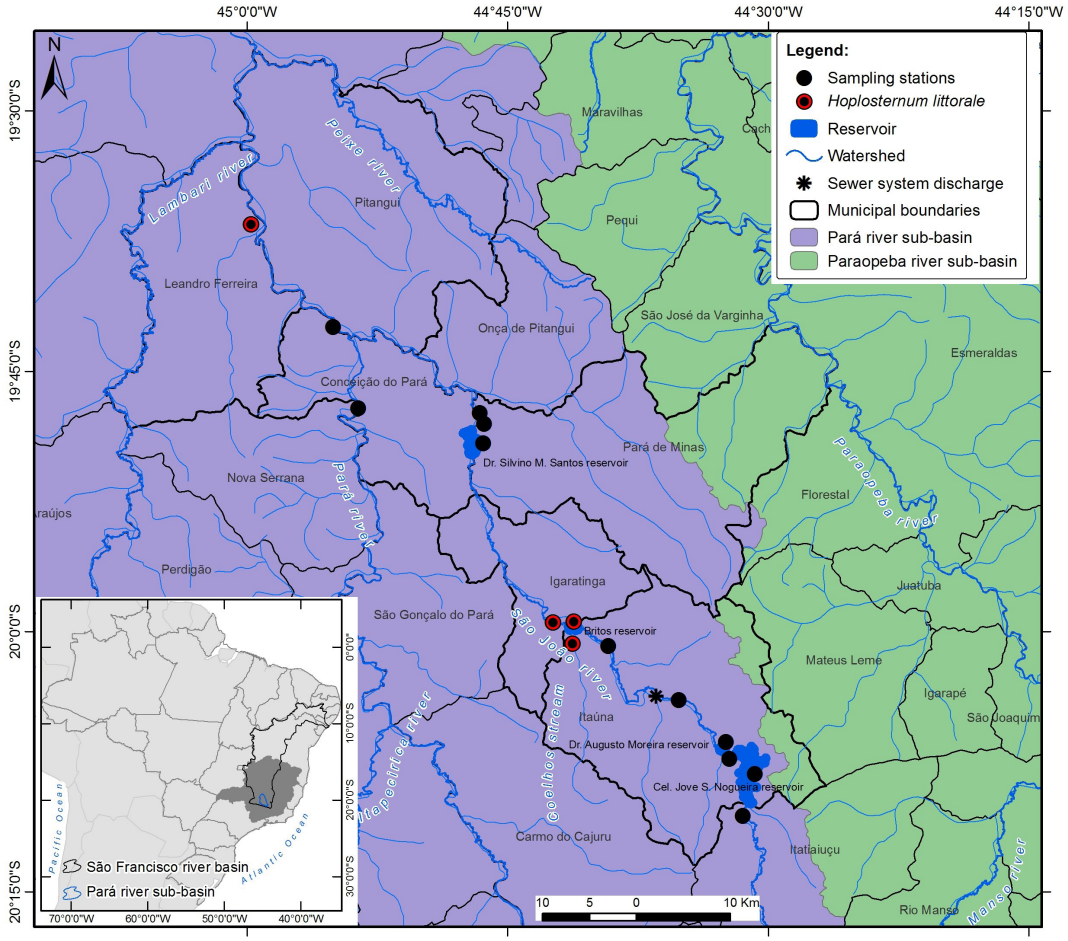

FIGURE 1. Partial view of the Pará River sub-basin, highlighting the sampling stations where captures of *Hoplosternum littorale* were made.

matter responsible for the poor quality of its waters. Since the tamoatá is an obligate air-breather (Reis 2003; Jucá-Chagas and Boccardo 2006), which tolerates low concentrations of oxygen in the water (Burgess 1989; Brauner *et al.* 1995), the apparent adverse conditions for other native teleosts found in this reservoir do not seem to constitute obstacles for this species. Although only one sample was carried-out within its limits, the number of sexually mature individuals captured, associated to the apparent absence of environmental factors capable of causing the decline of *H. littorale* in this sampling station, permits us to assert that this species is locally established in Britos reservoir according to the definitions proposed by Lockwood *et al.* (2007), Shafland *et al.* (2008) and Gozlan *et al.* (2010).

FIGURE 2. Tamoatá *Hoplosternum littorale* (MZUSP 106077) captured in the Britos reservoir located on the São João River, Pará River sub-basin, upper São Francisco region. Photo: Luiz F. Salvador-Jr.

Despite also being detected in the Coelhos stream and in a marginal lagoon of the Pará River, the fact that most records of *H. littorale* occurred in São João River downstream from Itaúna's county sewer system discharge reflects the degree of threat to which this stretch is subject to. Relating to this segment, we point out that as well as the previously mentioned dumping of sewage in the Britos reservoir, it also suffers from siltation and clandestine supply of industrial effluents; besides sheltering another artificial lake, a dam that acts as a barrier to upstream fish migration (Dr. Silvino M. Santos power station), aquiculture stations near its banks and large amounts of *Eichornia* spp. (Pontederiaceae), especially in areas with higher concentration of organic matter.

Regarding the presence of tamoatá in the previously mentioned marginal lagoon, we stress that this kind of environment acts as a nursery habitat for many species of teleosts, and are therefore fundamental in the renovation of fish communities of the tropical rivers (Welcomme 1979; Lowe-McConnell 1999). Since this peculiar habitat shelters individuals of *H. littorale* in full reproductive activity, it is probably acting as an ecological stepping stone for this species, since during the flood period it likely promotes the recruitment of the young to the main channel, therefore helping to disseminate this non-native catfish.

Relating to the deleterious effects resulting from its introduction in the environment, *H. littorale* seems to be a species that causes little or no direct impact on the native fish assemblages (Duxbury *et al.* 2010). However, like

Table 1. Date, standard length (SL in cm), body weight (BW in g), sex (S), gonadal maturation stages (GMS), place of capture and voucher specimens of *Hoplosternum littorale* collected in the Pará River sub-basin between October 19 and 28, 2009. M = Male, F = Female, Cs = Coelhos stream, Br = Britos reservoir, SJr = São João River downstream Britos dam and Ml = Pará River's marginal lagoon.

DATE	SL	BW	S/GMS	SAMPLING STATION	COORDINATES	MUNICIPALITIES	VOUCHER SPECIMENS
19 Oct 2009	9.5	25	M/3	Cs	20°00'01" S, 44°41'37" W	Itaúna	-
19 Oct 2009	17.1	155	M/4A	Cs	21°00'01" S, 44°41'37" W	Itaúna	-
19 Oct 2009	14.5	115	F/4A	Cs	22°00'01" S, 44°41'37" W	Itaúna	-
19 Oct 2009	16.4	160	-	Cs	22°00'01" S, 44°41'37" W	Itaúna	MZUSP 106078
20 Oct 2009	15.5	105	M/4A	Br	19°59'61" S, 44°41'48" W	Itaúna / Igaratinga	-
20 Oct 2009	13.5	65	M/4A	Br	19°59'61" S, 44°41'48" W	Itaúna / Igaratinga	-
20 Oct 2009	15.5	110	F/4A	Br	19°59'61" S, 44°41'48" W	Itaúna / Igaratinga	-
20 Oct 2009	16.5	120	M/4A	Br	19°59'61" S, 44°41'48" W	Itaúna / Igaratinga	-
20 Oct 2009	17.5	155	F/4A	Br	19°59'61" S, 44°41'48" W	Itaúna / Igaratinga	-
20 Oct 2009	14.9	120	F/4A	Br	19°59'61" S, 44°41'48" W	Itaúna / Igaratinga	-
20 Oct 2009	15.7	155	F/4A	Br	19°59'61" S, 44°41'48" W	Itaúna / Igaratinga	-
20 Oct 2009	15.5	140	F/4A	Br	19°59'61" S, 44°41'48" W	Itaúna / Igaratinga	-
20 Oct 2009	16.7	180	F/4A	Br	19°59'61" S, 44°41'48" W	Itaúna / Igaratinga	-
20 Oct 2009	16.3	140	M/4A	Br	19°59'61" S, 44°41'48" W	Itaúna / Igaratinga	-
20 Oct 2009	19.1	160	F/4A	Br	19°59'61" S, 44°41'48" W	Itaúna / Igaratinga	-
20 Oct 2009	17	180	-	Br	19°59'61" S, 44°41'48" W	Itaúna / Igaratinga	MZUSP 106077
20 Oct 2009	18.5	235	-	Br	19°59'61" S, 44°41'48" W	Itaúna / Igaratinga	MZUSP 106077
20 Oct 2009	18	245	-	Br	19°59'61" S, 44°41'48" W	Itaúna / Igaratinga	MZUSP 106077
20 Oct 2009	19	250	-	Br	19°59'61" S, 44°41'48" W	Itaúna / Igaratinga	MZUSP 106077
26 Oct 2009	15.5	105	M/4A	SJr	19°54'55" S, 44°41'50" W	Igaratinga	-
26 Oct 2009	16.5	140	F/4A	SJr	19°54'55" S, 44°41'50" W	Igaratinga	-
26 Oct 2009	16.5	140	F/4A	SJr	19°54'55" S, 44°41'50" W	Igaratinga	-
26 Oct 2009	18	155	M/4A	SJr	19°54'55" S, 44°41'50" W	Igaratinga	-
26 Oct 2009	17.5	170	F/4A	SJr	19°54'55" S, 44°41'50" W	Igaratinga	-
26 Oct 2009	17	170	-	SJr	19°54'55" S, 44°41'50" W	Igaratinga	MZUSP 106079
28 Oct 2009	9.5	25	M/4A	Ml	19°44'08" S, 44°53'52" W	Leandro Ferreira	-
28 Oct 2009	15	135	-	Ml	19°44'08" S, 44°53'52" W	Leandro Ferreira	MZUSP 106080

Figure 3. Sample stations in the Pará River sub-basin where the captures of *Hoplosternum littorale* were made. A) Pará River's marginal lagoon (Ml), B) São João River downstream Britos dam (SJr), C) Britos reservoir (Br) and D) Coelhos stream (Cs). Photos: Luiz F. Salvador-Jr.

other benthophagous fish (Gerking 1994), it can alter the richness and diversity of macroinvertebrates in the waters where it establishes, as detected by Duxbury *et al.* (2010) in an experiment conducted in Florida (USA). Thus, among other possible changes in ecosystem functioning, a re-structuring of the local macroinvertebrates assemblages is expected, as well as competition with native fish species for trophic resources. According to Duxbury *et al.* (2010) it may also cause significant alterations in the results of future water quality monitoring programs which happen to use macroinvertebrates as environmental bioindicators.

Although still unknown to most of the riverine population, the presence of *H. littorale* in the Pará River sub-basin will most likely soon be noticed, since as well as the previously mentioned ability to extract oxygen from atmospheric air, this species possesses other characteristics that are typical of successful invading teleosts. This includes ample tolerance to temperature variations (Brauner *et al.* 1995) and long periods out of the water (Alves and Pompeu 2001), ability to travel (if only for short distances) on land (Burgess 1989), euryphagous diet (Winemiller 1987; Mol 1995; Hahn *et al.* 1997; Pompeu and Godinho 2003), high fecundity rates (Hostache and Mol 1998), parental care (Winemiller 1987; Nakatani *et al.* 2001) and non-migratory reproductive behavior (Nakatani *et al.* 2001).

Despite the previously mentioned attributes that contribute significantly to the colonization of new environments by *H. littorale*, the results of the present investigation reinforce that both the transformation of lotic environments into lentic habitats (Agostinho *et al.* 2005; Jonhson *et al.* 2008) and the pollution of water bodies (Crooks *et al.* 2011) favor not only the expansion, but also the establishment of non-native opportunistic teleosts.

Since it is virtually impossible to eradicate established allochthonous fish (Lévêque 1997; Gozlan *et al.* 2010), we believe that environmental education associated with the conservation and integrated management of the drainage systems are fundamental strategies to avoid new introductions and minimize the effect of biological invasions. However, we point out that although there are numerous established hydrographic basin committees in Brazil, the theme "non-native species and the damaging effects of introductions" is often not treated with due importance by the environmental managers and governmental agencies. Aiming to reverse this scenario, as well as the recommendations proposed by Agostinho and Júlio-Jr. (1996), Vitule (2009) and Gozlan *et al*. (2010), we suggest the inclusion of permanent environmental education programs for students, riverine populations, fishermen, aquaculture farmers, ornamental fish traders and aquarium hobbyists, with the goals of warning the population about the negative effects of this practice, and especially of clarifying that when it comes to introductions, it is much better to prevent them, than trying to eradicate the alien species later on.

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