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First record of the invasion of *Dendrocephalus brasiliensis* Pesta, 1921 (Crustacea: Anostraca: Thamnocephalidae) in São Paulo State, Brazil

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Abstract. This is the first record of invasion of the *Dendrocephalus brasiliensis* in São Paulo State, Brazil. It also is a review of previous studies of this species and discusses the importance of this microcrustacean as feed for aquaculture, as well as the risks of its invasion in new habitats.

Key words: Alien species, branconeta, branchoneta, ornamental fisheries, aquaculture

Resumo. Primeiro relato de invasão de *Dendrocephalus brasiliensis* Pesta, 1921 (Crustacea: Anostraca: Thamnocephalidae) no Estado de São Paulo, Brasil. Este é o primeiro relato da invasão de *Dendrocephalus brasiliensis* no Estado de São Paulo, Brasil. É também uma revisão de estudos anteriores sobre a espécie e discute a importância deste microcrustáceo como alimento na aquicultura, bem como alguns riscos de sua invasão.

Palavras-chave: Espécie exótica, branconeta, branchoneta, piscicultura ornamental, aquicultura.

Abbreviations: UGRHI - Unidade de Gerenciamento de Recursos Hídricos (Water Resources Management Unit); EPPA - Estação de Piscicultura de Paulo Afonso (Paulo Afonso Fish Farming Station); CHESF - Companhia Hidro Elétrica do São Francisco.

The crustacean *Dendrocephalus brasiliensis* (Pesta, 1921 *apud* Lopes 1998) (Crustacea: Anostraca: Thamnocephalidae), popularly known as branconeta, has a cylindrical body and can reach 30 mm in adult length (Figure 1a). It is a filter feeding animal, with a preference for phytoplankton (Lopes *et al*. 1998). This species is dioecious, with females being easily identified by the egg sac near their tail, and males by the vertical appendices, which are essential for species recognition (Lopes *et al*. 1998).

D. brasiliensis occurs naturally from Argentina to northeastern Brazil, typically inhabiting ephemeral rain pools and in fish breeding tanks. These kinds of environments are commonly found in the Brazilian states of Minas Gerais, Bahia, Paraíba, Rio Grande do Norte and Piauí. This species has a short life cycle, from eight to thirty days (Rabet & Thiéry 1998), and after reaching the adult stage, it produces many cysts, which are resistant to dry conditions and hatch when the environment turns favorable.

It is a prolific species (each female releases from 100 to 230 cysts per spawn - Figure 1B), reproducing throughout the year in the region of the Paulo Afonso Fish Farming Station (EPPA) in the state of Bahia, except between June and August, when temperatures are the lowest of the year (Lopes *et al*. 1998). In this same region, those authors recorded a sex ratio of roughly 60% females. According to Rocha *et al*. (2005), the accidental or intentional introduction of exotic and allochtonous species by man is one of the most serious problems

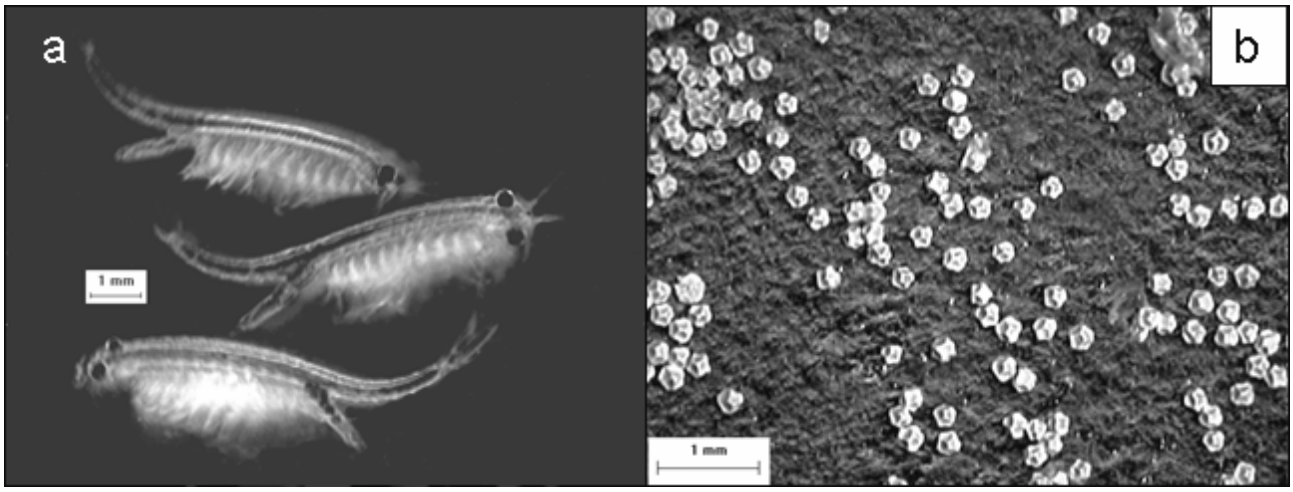

Figure 1. a) *D. brasiliensis* females with egg sac presenting cysts. b) Cysts in detail. Photos by Mônica G. Mai.

to biodiversity and conservation of natural communities and ecosystems, exceeded only by environmental destruction. The same authors emphasize that freshwater environments are particularly vulnerable to biological invasions, because they can carry diasporas for long distances, representing the most important dispersion mechanism, after wind.

Each hydrographic basin has its own endemic species, which once replaced to other basins can lead to similar or even bigger problems than the introduction of exotic species, such as competition, predation, parasitism, hybridization with correlated species and even spread of diseases (Rocha *et al*. 2005). Therefore, the study of exotic and allochtonous species and their interactions with native ones is fundamental to develop control measures.

This study records the invasion of the crustacean *Dendrocephalus brasiliensis* in the Tietê/Jacaré basin.

The specimens were collected directly from earthen ponds at Talarico Fishery, in the municipality of Tabatinga (21º43'00"S; 48º41'15" W, altitude of 490 meters), central-west region of São Paulo State, Brazil), through successive sieving the pond water (with a common kitchen sieve) (Figure 2), then a few individuals were maintained alive for the photos, while the majority collected were conserved in a flask with formalin 4%. Once the presence of these organism in the culture ponds can not pass unnoticed, other regional fisher farmers were questioned but no other register of *D. brasiliensis*' presence were obtained. The municipality of Tabatinga lies within the Tietê/Jacaré Water Resource Management Unit (Figure 3), which covers 34 municipalities and has an area of 11,749 km^2. The region is classified as industrialized. It has approximately 1,304,000 inhabitants, and is considered in a critical situation in terms of surface water availability, because of high demand from alcohol distilleries and for irrigation of sugarcane crops. It also has a moderate to high susceptibility to flooding in the sub-basins of the Jacaré-Guaçú and Jacaré-Pepira rivers, which is worst in the urbanized areas (Gava *et al*. 2007).

According to Belk & Brtek (1995), samples of *D. brasiliensis* are deposited at the Natural History Museum, Vienna, Austria.

A large amount of *D. brasiliensis* was found in the fisheries earthen ponds from Talarico Fishery, and every summer these organisms appear in blooms after drying and fulfilling these ponds, circumstance that reproduces the rain pools (ephemeral) where this organism use to live naturally. There are no studies revealing what are the effects on the local species, but the farmers emphasized that once they hatch, a quick dominance over the pre-existing zooplankton species in the ponds occurs, and the phytoplankton is promptly consumed in mater of few days. When their source of feeding becomes

Figure 2. General view of the Talarico Fishery, showing the pond where *D. brasiliensis* was collected.

scarce, these organisms vanish from the ponds, only remaining their cysts in the bottom of the tanks.

A literature review of the latest knowledge on *D. brasiliensis* is summarized in Table I and reveals a lack of studies on this subject. To date, there have only been experiments carried out using *D. brasiliensis* to feed cultivated fishes, such as the *Cichla ocellaris* (tucunaré) (Carneiro *et al*. 2004), *Lophiosilurus alexandri* (niquim) (Santos *et al*. 1999) and *Oreochromis niloticus* (Nile tilapia) (Santos *et al*. 2000).

This crustacean has also been experimentally used in the production of the shrimp *Litopenaeus vannamei* (Yflaar & Oliveira 2003) and ornamental fishes such as *Astronotus ocellatus* (oscar) (Lopes & Santos-Neto 2006, Lopes *et al*. 2006) and *Pterophyllum scalare* (acará bandeira) (Lopes *et al*. 2006). *D. brasiliensis* has been considered very attractive in the initial culture phases of carnivorous fish species (Lopes 1998, Lopes *et al*. 1998, Lopes *et al*. 2006), being used as live feed, frozen biomass or in inert diets.

Generally, the current protocols used in larviculture of these fishes include the offering of a marine microcrustacean, belonging to the genus *Artemia*. However, this microcrustacean has a short lifespan when used in fresh water, which motivates fish farmers' to search for freshwater species with similar properties. In this context, *D. brasiliensis* appears as an easily obtained species, with high attractiveness and that possibly meets the nutritional needs of carnivorous species such as the *Pseudoplatystoma coruscans* (pintado), *P. fasciatum* (cachara), *Brycon amazonicum* (*matrinxã)*, *Salminus brasiliensis* (dourado), among others.

The mass production and utilization of *D. brasiliensis* in aquaculture has been considered promising due its apparently easy production, attractiveness as live food and high protein content.

This protein content is comparable to or higher than many organisms conventionally used for such purpose (Table II) (Lopes *et al*. 1998). Experiments carried out with fish feed comparing *D. brasiliensis* to commercial feed or the brine shrimp *Artemia* in most cases showed better results in both survival and growth (weight and length) in those treatments in which *D. brasiliensis* was offered (Lopes 1998, Lopes & Santos-Neto 2006, Lopes *et al*. 2006).

Successful experiments have been carried out in Brazil's Northeast to assess the cyst production capacity (Lopes *et al*. 2007, Molina 2005) and biomass production (Lopes *et al*. 2006) of *D. brasiliensis* in natural environments.

As occurs with many alien species, *D. brasiliensis* was accidentally introduced in the Tietê/Jacaré basin in 1997, when a fish farmer from São Paulo State acquired a lot of fish from Brazil's northeast, containing some individuals of this crustacean. Although the geographical distribution of *D. brasiliensis* is described stretching from Argentina to Piauí, its occurrence is not continuous

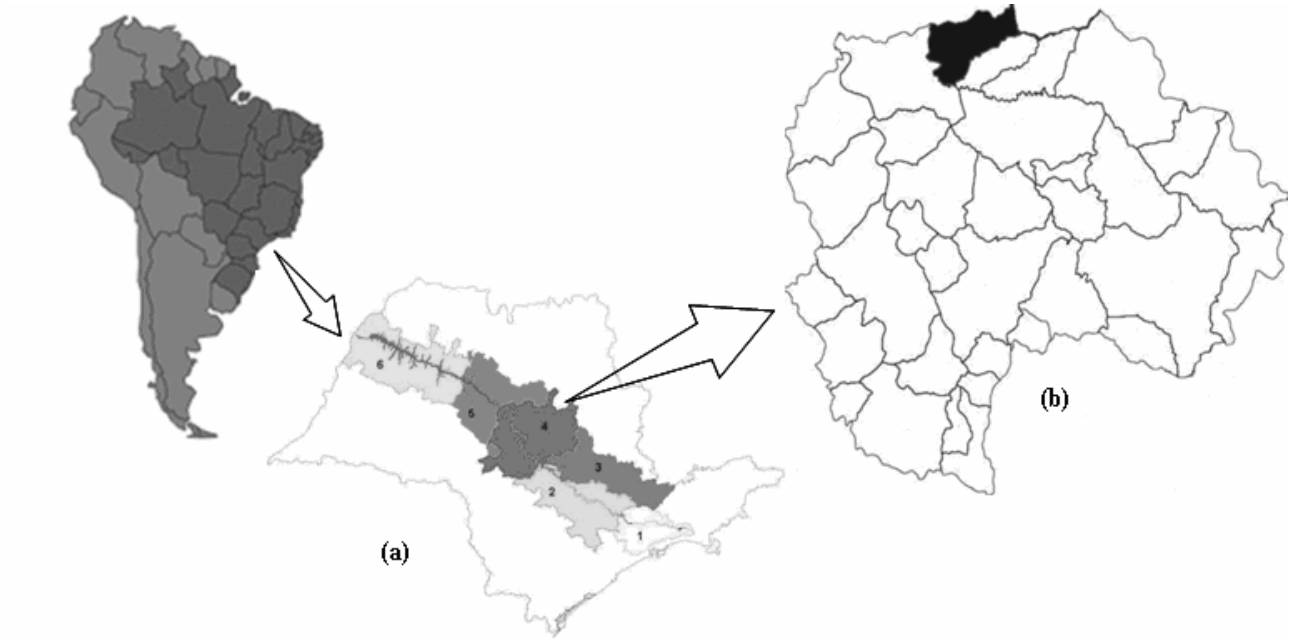

Figure 3 – Geographical location of the region where branconeta *Dendrocephalus brasiliensis* was introduced. (a) São Paulo State, showing the Tietê Basin with its sub-basins: 1. Upper Tietê; 2. Middle Tietê; 3. Piracicaba / Jundiaí; 4. Tietê/Jacaré; 5. Tietê / Batalha and 6. Baixo Tietê. (b) Detail of the Tietê/Jacaré sub-basin, with Tabatinga municipality indicated in black. Maps modified from http://www.netzsch.com.br/website/pt_br/representantes.php; http://www.rededasaguas.org.br/nucleo/na_hidrografia.htm; http://www.maenatureza.org.br/projetoeducando/folders/poster32_bh_tj/index.htm

Table I. Summary of studies about *Dendrocephalus brasiliensis*.

Authors	Year	Title	Focus
Belk & Brtek	1995	Checklist of the Anostraca.	Taxonomy
Cuchie *et al*.	1997	Intra and interspecific variation in the chitin content of some anostracans.	Physiology
Lopes	1998	A branchoneta (*Dendrocephalus brasiliensis*, Pesta 1921) na alimentação de espécies carnívoras.	Feeding
Lopes *et al*.	1998	Branchoneta - Uma notável contribuição à larvicultura e alevinagem de peixes carnívoros de água doce.	Feeding
Rabet & Thiéry	1998	Branchiopoda. Anostraca and Spinicaudata.	Taxonomy
Santos *et al*.	1999	Utilização da branchoneta *Dendrocephalus brasiliensis* na alimentação do niquim *Lophiosilurus alexandri* durante o período pós-larval.	Feeding
Santos *et al*.	2000	Efeitos do microcrustáceo branchoneta, *Dendrocephalus brasiliensis*, no crescimento da tilápia nilótica, *Oreochromis niloticus*, durante a fase juvenil.	Feeding
Gonçalves	2001	Remoção de algas via alimentação pelo microcrustáceo *Dendrocephalus brasiliensis* (Crustacea: Anostraca).	Biotechnology
Yflaar & Olivera	2003	Utilização de náuplios de "branchoneta" *Dendrocephalus brasiliensis* (Pesta 1921) na alimentação de larvas do "camarão cinza" *Litopenaeus vannamei* (Boone 1931).	Feeding
Carneiro *et al*.	2004	Uso do microcrustáceo branchoneta (*Dendrocephalus brasiliensis*) na ração do Tucunaré.	Feeding
Molina	2005	Procedimento de cría de branchoneta *Dendrocephalus brasiliensis* (Crustacea, Anostraca, Thamnocephalidae).	Production
Lopes *et al*.	2006	A branchoneta na piscicultura ornamental.	Feeding
Lopes & Santos-Neto	2006	Piscicultura ornamental: estudo compara o uso da branchoneta e da artêmia na dieta do acará-bandeira.	Feeding
Lopes *et al*.	2007	Produção de cistos de "branchoneta" *Dendrocephalus brasiliensis* (Crustacea: Anostraca).	Production

in the watersheds in this range due to the lack of ephemeral rain pools, where it typically occurs, in most of the northeast region of Brazil and north of Argentina.

Its presence was not reported in the Tietê/Jacaré basin before 1997. Since its accidental introduction in this region, apparently the species has been restricted to the Talarico Fishery, where fish tanks are dried every year, promoting the dry conditions that *D. brasiliensis* cysts need to hatch. However, it is important to monitor the natural environments near this fish farm to avoid the spread of this biological invasion.

According to Rocha *et al*. (2005), a species' spread must be checked around the spots where it is found, because the species might occur in those geographical interstices. It is known that the increasing trade in cultivated species between different basins facilitates unintentional invasions (Rocha *et al*. 2005).

If in the beginning the introduction of *D. brasiliensis* was accidental, this may become intentional due to its advantages for feeding aquatic organisms, and this may increase the spread of this species to other basins. Specimens could be easily acquired in the transport water of fishes from places where this species occurs, or even by online purchases. In this way, the world wide market of live fish could lead to the spreading of this species to any part of the globe that presents favorable conditions to its survival.

These plankton feeders' organisms are highly adaptable in fisheries, causing high transparency of environments where they establish themselves. While swimming they filter the suspended material, such as algae, bacteria, protozoa, metazoa and organic matter particles, although it has been observed both in aquariums and fishery ponds that they tend to graze on phytoplankton (Lopes *et al*. 2006). Many times their presence is considered harmful to fish farming, since they quickly filter the natural food, leading to great losses in the hatchery processes. In other hand, when the fingerlings reach sizes of 2-5cm in length, *D. brasiliensis* became their preys instead of being competitors by resources. To prevent the competition when the fish are too small, Dipterex (Trichlorfon) is used in a proportion of 1 ppt as a routine treatment against *D. brasiliensis*, before stocking of fish larvae in ponds (Lopes *et al*. 1998).

Table II. Comparison between *D. brasiliensis* nutritional values (%) and other species commonly used in aquaculture.

SOURCES	*Dry matter*	*Crude Protein*	*P* [1]	*Ca* [2]	*Ash*
A) Usual					
1.Anostraca *Artemia*	11.00	61.60			10.10
2.Cladocera *Daphnia* *Moina*		70.10 59.12	1.46 1.32	0.21 0.16	
3.Rotifer *Brachionus plicatilis*		56.92	1.42		
B) Alternative					
Dendrocephalus brasiliensis		67.05	0.54	1.71	14.82

*Drawn from Lopes *et al*. 1998. [1]phosphorus; [2]calcium.

The invasion of natural environments by *D. brasiliensis* causes concern, once its high filtration capacity can cause impacts on the native phytoplankton and it can also compete with other zooplankton species for the feeding resources. Hopefully, *D. brasiliensis* is not considered a lotic water body inhabitant, being restricted to lentic and temporary environments, reason why they can establish in aquaculture ponds (once it is constantly dried and refilled according to the fish production). Furthermore, its capacity to produce cysts makes it hard to eliminate after its introduction. These cysts stay in rest in the dry soil or in the bottom of water bodies, remaining viable for long periods of time and being able to restart the life cycle when more favorable conditions are reestablished. Dry environmental conditions are essential for the maturation of the cysts. On the other hand, this can be an advantage in the case of invasion, since the species only can establish itself in ephemeral environments.

Still in relation to the cysts produced, the main function of them is to allow the survival, maintenance of gene pool, protection against adverse environmental factors and dispersion of species through streams (Dale 1983, cited in Persich & Garcia 2003). These cysts can also play a role as an environmental reservoir of the species, from where new blooms can arise (Steidinger & Baden 1984, Anderson 1984, Anderson 1997, cited in Persich & Garcia 2003). According to Brendonck *et al*. (1990), who studied the brachiopods of Galapagos Island**,** bird migration, wind transport or anthropogenic action are potential agents for the dispersal of cysts from mainland populations.

The introduction of exotic and allochtonous species in communities and ecosystems has been leading to the extinction of many native species, relevant modifications food webs, steady-state populations of communities, and changes in ecosystems' functional processes (Rocha *et al*. 2005).

Thus, in order to know the real impact that *D. brasiliensis* can cause after its introduction in new environments, biological and ecological studies are necessary. Moreover, it is important for such studies to be performed before the practical application of this species as a live feed in aquaculture.

Finally, the lack of studies about this organism can be explained, at least in part, by the fear that tests can increase the dispersion of this species. Nonetheless, more studies should be carried out to elucidate more characteristics of these organisms, in places where they are already established, or elsewhere taking rigorous measures to avoid the escape to the surrounding environment.

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