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Original article

Update on the occurrence and dispersion of the *Achatina* (*Lissachatina*) *fulica* Bowdich, 1822 (Mollusca, Gastropoda) snail within the Distrito Federal, Brazil

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ABSTRACT: *Achatina* (*Lissachatina*) *fulica* is present in most Brazilian States. This paper aims at providing a diagnosis of the occurrence and dispersion of *A. fulica* in the Federal District. Pages and posts for social medias were created to identify areas of *A. fulica* occurrences. In addition, interviews and active searches at commercial plant nurseries were undertaken. Collection took place from March 2019 to February 2020 and January 2021. The sampled areas were categorized into commercial nurseries, Paranoá Lake shore, other urban areas, and agricultural areas. Commercial nurseries were identified as the main sources of *A. fulica* in the Federal District.

Keywords: giant African snail, mollusk, invasive species

RESUMO (Atualização sobre a ocorrência e dispersão do caracol *Achatina* (Lissachatina) *fulica* Bowdich, 1822 (Mollusca, Gastropoda) no Distrito Federal, Brasil): *Achatina (Lissachatina) fulica* está presente na maioria dos estados brasileiros. Este trabalho tem como objetivo fornecer um diagnóstico da ocorrência e dispersão de *A. fulica* no Distrito Federal. Páginas e posts para mídias sociais foram criados para identificar áreas de ocorrências de *A. fulica*. Além disso, foram realizadas entrevistas e buscas ativas em viveiros de plantas comerciais. A coleta ocorreu de março de 2019 a fevereiro de 2020 e janeiro de 2021. As áreas das amostras foram categorizadas em viveiros comerciais, orla do Lago Paranoá, outras áreas urbanas e áreas agrícolas. Viveiros comerciais foram identificados como as principais fontes de *A. fulica* no Distrito Federal.

Palavras-chave: caracol-gigante africano, molusco, espécies invasoras

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INTRODUCTION

Achatina (*Lissachatina*) *fulica* Bowdich, 1822 is a land snail coming from East-Northeast Africa (Franco-Acuña 2009). It´s morphological characteristics are an oblong conic shell in a greyish color with dark and light brown longitudinal stripes (Simião and Fischer 2004). As an adult it presents a body mass above 200 g and is approximately 15 cm long (Eston *et al*. 2006). The *A. fulica* may host worms that cause diseases in man and animal (Thiengo *et al*. 2013; Lima *et al*. 2019; Silva *et al.* 2019), besides disseminating pathogens by means of its feces that cause diseases in plants (Raut and Barker 2002).

Considered a highly invasive snail it prefers altered environments where it deposits many eggs with a high survival rate (Fischer and Colley 2005; Thiengo *et al*. 2007; Lima *et al*. 2019). It´s generalist eating habits favors establishment and dispersion in urbanized environments (Fischer & Colley 2005; Albuquerque *et al*. 2008; Gołdyn *et al*. 2017). This mollusk presents a climbing and gregarious behavior, climbing both trees and construction and showing up in groups after population explosions (Thiengo *et al*. 2007; O'Loughlin and Green 2017).

A. fulica was introduced in several countries as a possible commercial source of snail meat (Cowie 1998; Thiengo *et al*. 2007; Franco-Acuña 2009). In the countries where it was successfully established it has jeopardized small agriculture crops, domestic kitchen gardens and ornamental gardens (Raut and Barker 2002; Thiengo *et al*. 2007; Franco-Acuña 2009). It is considered the most important snail pest in the sub-tropics and tropics (Thiengo *et al*. 2007). The attempt to control *A. fulica* populations with chemical products represents a serious risk to native snails in various parts of the world (Cowie and Robinson 2003; Fischer and Colley 2005; Colley 2010; Zanol *et al*. 2010).

In Brazil the species was possibly introduced during the 80´s in the state of Parana (Thiengo *et al*. 2007). In 1997, Teles and collaborators registered the presence of *A. fulica* in the state of São Paulo county of Itariri, at the Serra do Mar. The snail has been found in several islands and protected areas of the national territory (Fischer and Colley 2005; Eston *et al*. 2006; Oliveira and Santos 2019). *A. fulica* is currently present in 25 of the 26 states of Brazil and in the Federal District (Thiengo *et al*. 2013). In 2009 the presence of *A. fulica* was found in 82 counties of the state of Goiás (Oliveira *et al*. 2010). In the Federal District, the population reported several reports on finding the snail in several regions (Lago Sul, Lago Norte and Sobradinho) (Montenegro 2006).

According to Teles and collaborators (1997), the Federal District is a region of incidence of the nematode *Angiostrongylus costaricensis* (Morera and Céspedes 1971). *A. fulica* is also an intermediate host for this nematode, which causes abdominal angiostrongiliasis in humans (Thiengo *et al*. 2010). The objective of the current paper is to present an updated diagnosis of the occurrence and dispersion of *A. fulic*a in the Federal District.

METHODS

The study took place in the Federal District (15°30'-16°03'S; 47°25'-48°12'W) located on the Brazilian Central Plateau, within the Cerrado biome, at approximately 1.200 m altitude and with an area close to 5.800 km^2. The climate of the region is classified as *Aw* of Köppen (rainy tropical), with marked seasons of dry and rainy weather (Álvares *et al*. 2013; Cardoso *et al*. 2015).

Collection occurred from March 2019 to February 2020 and in January 2021, during both dry and rainy seasons for a total of eight months in the rainy season and five months of dry season.

Electronic pages and posts for social medias were created to identify possible occurrence sites for the *A. fulica* in the Federal District. Visits were made for interviews with residents and employees (showing *A. fulica* photos and shells), specimen collection and photos of the mollusk on the spot. From the online reports collected, the environments sampled were categorized into Paranoá Lake shores (when located within 400 meters of the lake shore), agricultural areas (located in small agriculture crops), and other urban areas (located in other urban points of the Federal District). Active searches were also carried out in commercial plant nurseries chosen at random at different points in the Federal District.

Some of the live individuals collected in each sampled category were registered in the Mollusks Collection of University of Brasília (CMUnB). The sites with samples identified of *A. fulica* had their geographical coordinates were registered to elaborate an occurrence map in the Federal District.

RESULTADOS

Nineteen sites were identified as places of occurrence of *A. fulica*, in the Federal District. Of this, fifteen sites (79%) were identified from the reports off media and social networks and four sites (21%) were commercial plant nurseries. Of all samples, live snails were found at sixteen spots (84%) and in three spots (16%) only shells were collected (Fig. 1 and Table 1).

Most places of occurrences (70%) were identified during the rainy season, as well as most live samples. During the dry season most collected were dormant snails and empty shells (spots 2, 6, 7, and 8).

Amongst the spots visited due to online reports, two were on the Paranoá Lake shores (11%) and eigth (42%) in other urban areas (condominiums, houses, schools and empty plots), and in the agricultural areas, five places (26%) registered the presence of the snail (Graph 1-A). In half of the places visited (identified by online reports), samples were found of possibly established populations of *A. fulica* (thus inferred when several adult individuals were found, with egg deposition and a recruitment potential). Established populations were found in all sites categories particularly houses and condominiums (other urban areas) (Graph 1-B).

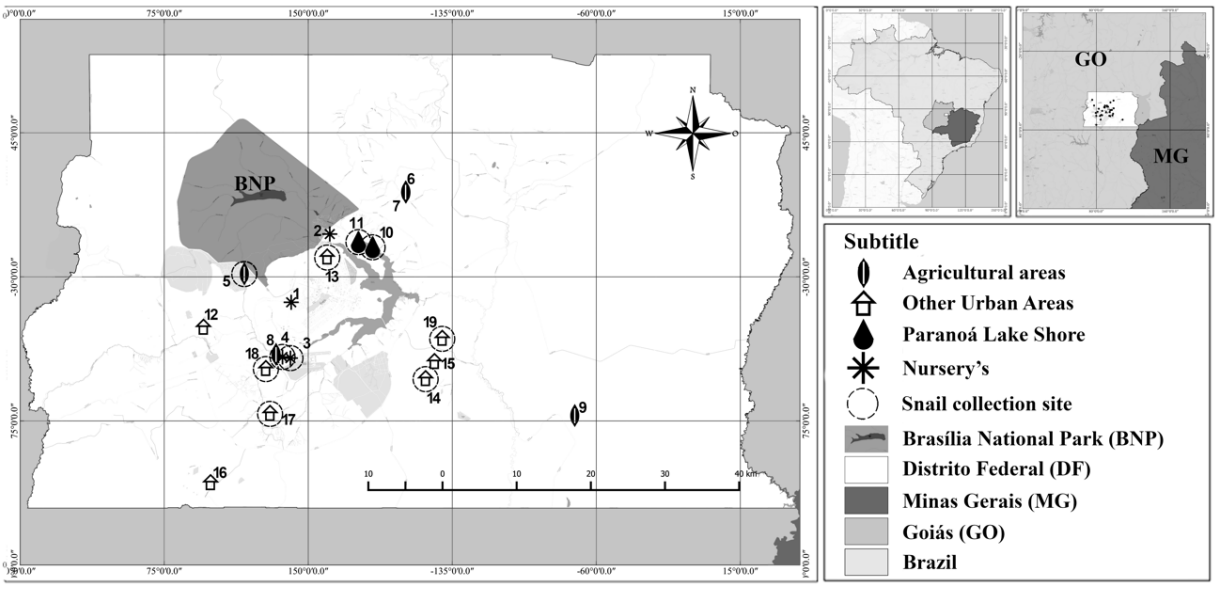
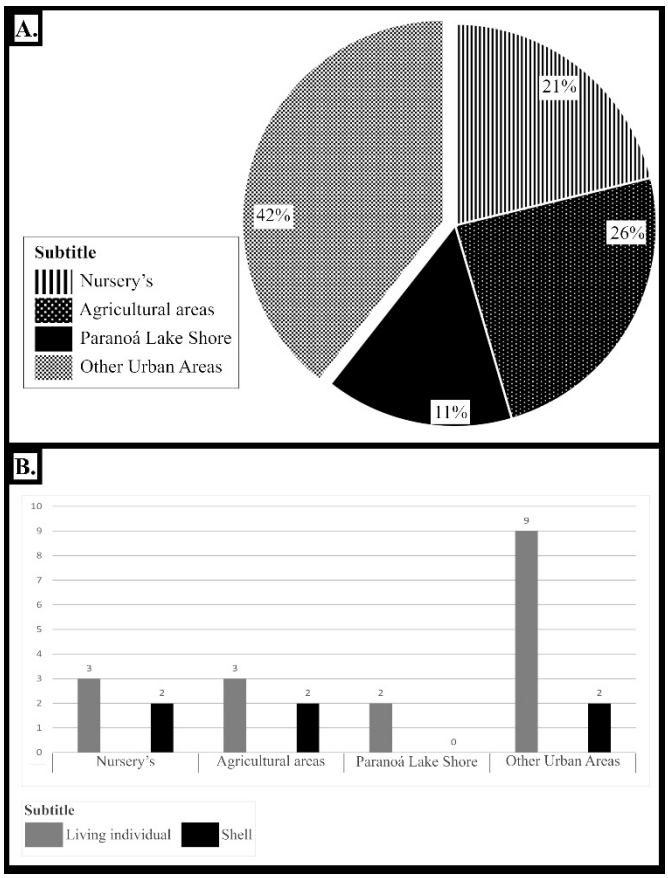


Figure 1. Map with the collection points of *Achatina fulica* in the Federal District, differentiated between agricultural areas, urban areas, the shore of Paranoá Lake and commercial plant nurseries, numbered from 1 to 19.



Graph 1. A- Graph illustrating the occurrence of *Achatina fulica* in the sampled areas, differentiated into Nursery's, agricultural areas, Paranoá Lake shores and other urban areas. B- Graph illustrating the types of collections (Live individuals or Shells) of *A. fulica* in each collection area.

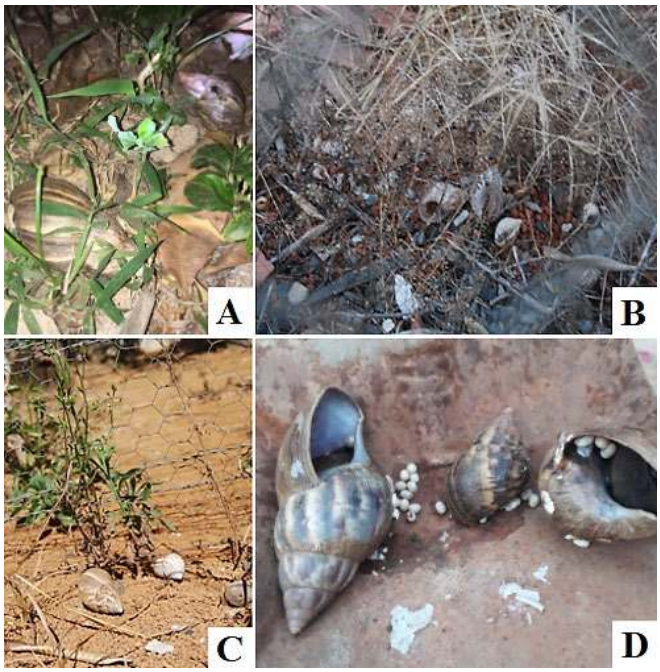


Figure 2. *Achatina fulica* in agricultural areas in the Federal District, Brazil. A, B, C. shells of adult and young individuals: (A) spot 6; (B) spot 8; (C) spot 7. D. adults individuals in established population (spot 9). Note: see Table 1.

In the commercial plant nurseries visited, samples of the *A. fulica* were registered in four of these (21%). In these establishments most of the plants on sale came from the states of Goiás and Minas Gerais.



Figure 3. *Achatina fulica* on other urban areas and commercial plant nurseries in Federal District, Brazil. A. young snail in ornamental garden of school (spot 12). B. shells collected (more than 200) (spot 15). C. adult individuals in residence (spot 16). D, E. young individuals in the nurseries: (D) active in plant pot (spot 1); (E) dormant in plant pot substrate (spot 2). Note: see Table 1.

New records. BRAZIL – **Distrito Federal** • Nursery; 15°48'03"S, 47 56'45"W; Cazarin-Oliveira, L.C. and Fraga, L. obs; active individual; photographic voucher (Fig. 3D) • Nursery; 15°43'05"S, 47°53'50"W; Cazarin-Oliveira, L.C. and Fraga, L. obs; dormant individual; photographic voucher (Fig. 3E) • Nursery; 15 52'06"S, 47 56'49"W; Cazarin-Oliveira, L.C. and Fraga, L. leg.; active and dormant individuals; 6 spec., CMUnB 1365 • Nursery; 15°52'01"S, 47°57'25"W;

Cazarin-Oliveira, L.C. and Fraga, L. leg; active individual and shell; 1 spec., CMUnB 1366 • Agricultural area; 15°45'60"S, 48°0'18"W; Cazarin-Oliveira, L.C. and Fraga, L. leg; active individual; 1 spec., CMUnB 1360 • Agricultural area; 15°40'03"S, 47°48'04"W; Volkweis, F.S. and Lombardi, M.V. obs; shell; photographic voucher (Fig. 2A) • Agricultural area; 15°40'02"S, 47°48'06"W; Volkweis, F.S. and Lombardi, M.V. obs; shell; photographic voucher (Fig. 2C) • Agricultural area; 15°51'51"S, 47°57'54"W; Volkweis, F.S. and Lombardi, M.V. obs; shell; photographic voucher (Fig. 2B) • Agricultural area; 15°56'18"S, 47°35'18"W; Volkweis, F.S. and Lombardi, M.V. obs; active individual; photographic voucher (Fig. 2D) • Paranoá Lake shore; 15°44'03"S, 47°50'36"W; Martins-Silva, M.J. leg; active individuals; 2 spec; CMUnB 1361 • Paranoá Lake shore; 15°43'40"S, 47°51'40"W; Martins-Silva, M.J. leg; active individuals; 2 spec; CMUnB 1362 • Other urban areas; 15°49'54"S, 48°3'23"W; Cazarin-Oliveira, L.C. and Fraga, L. obs; active individuals; photographic voucher (Fig. 3A) • Other urban areas; 15°44'48"S, 47°54'02"W; Cazarin-Oliveira, L.C. and Fraga, L. leg; active individual; 2 spec; CMUnB 1363 • Other urban areas; 15°53'38" S, 47°46'34" W; Cazarin-Oliveira, L.C. and Fraga, L. leg; active individual and shell; 1 spec; CMUnB 1368 • Other urban areas; 15 52'24"S, 47°45'55"W; Cazarin-Oliveira, L.C. and Fraga, L. obs; active individual and shell; photographic voucher (Fig. 3B) • Other urban areas; 16º01'12"S, 48°02'51"W; Volkweis, F.S. and Lombardi, M.V. obs; active individual and shell; photographic voucher (Fig. 3C) • Other urban areas; 15°56'10''S, 47°58'21''W; Martins-Silva, M.J. leg; active individuals; 2 spec; CMUnB 1364 • Other urban areas; 15°52'43"S, 47°58'24"W; Cazarin-Oliveira, L.C. and Fraga, L. leg; active individuals; 1 spec; CMUnB 1367 • Other urban areas; 15°50'42"S, 47°45'19"W; Cazarin-Oliveira, L.C. and Fraga, L. leg; active individuals; 2 spec; CMUnB 1369.

Identification. *Achatina fulica* (African giant snail) (Mollusca; Gastropoda) has a brown or mottled conical shell with light tones. They have a height that can reach 15 cm and weight of the soft part 200 gr. Native to east-northeast Africa, it was introduced in Brazil in 1983 for the cultivation and commercialization of escargot (Eston *et al*. 2004).

Table 1. Georeferencing of points where there was a record (active/dormant individual or shell) of *Achatina fulica* in the Federal District. The horizontal distance (in meters) from the given decimalLatitude and decimalLongitude describing the smallest circle containing the whole of the Location.

Sites/Spots	Category	Coordinates		Informations	Sampling
		Latitude	Longitude		
1	Nursery's	15°48'03"S	47 56'45"W	Active individual	Picture 3D
2		15°43'05"S	47°53'50"W	Dormant individual	Picture 3E
3		15 52'06"S	47 56'49"W	Active and dormant individuals	CMUnB 1365
4		15°52'01"S	47°57'25"W	Active individual and Shell	CMUnB 1366
5	Agricultural areas	15°45'60"S	48°0'18"W	Active individual	CMUnB 1360
6		15°40'03"S	47°48'04"W	Shell	Picture 2A

7		15°40'02"S	47°48'06"W	Shell	Picture 2C
8		15°51'51"S	47°57'54"W	Shell	Picture 2B
9		15°56'18"S	47°35'18"W	Active individual	Picture 2D
10	Paranoá Lake Shore	15°44'03"S	47°50'36"W	Active individual	CMUnB 1361
11		15°43'40"S	47°51'40"W	Active individual	CMUnB 1362
12	Other Urban Areas	15°49'54"S	48°3'23"W	Active individual	Picture 3A
13		15°44'48"S	47°54'02"W	Active individual	CMUnB 1363
14		15°53'38" S	47°46'34" W	Active individual and shell	CMUnB 1368
15		15 52'24"S	47°45'55"W	Active individual and shell	Picture 3B
16		16º01'12"S	48°02'51"W	Active individual and shell	Picture 3C
17		15°56'10''S	47°58'21''W	Active individual	CMUnB 1364
18		15°52'43"S	47°58'24"W	Active individual	CMUnB 1367
19		15°50'42"S	47°45'19"W	Active individual	CMUnB 1369

DISCUSSION

By looking at fig. 1, it can be seen that the places with the highest number of pointssites with the occurrence of snails were in the more urbanized regions of the Federal District. Even the agricultural areas surveyed (spots 5 to 10) are located in green urban areas. Our study identified young individuals in commercial nurseries (dormant in plant substratum), in residences (active in ornamental plants), and in schools (active in the ornamental gardens). Young snails are transported, passively, by means of construction materials, herbs and plants (Zanol *et al*. 2010). Young *A. fulica* are not territorial and are efficient dispersers (Tomiyama 1992; Tomiyama & Nakane 1993).

Our study pointed at the commercial 'nurseries as possibly the main source of the *A. fulica*, in the Federal District. The nurseries sell gardening needs such as plants, fertilized land, manure and others, thus spreading the snails to other urban areas (particularly residence and condominiums). According to Colley and Fischer (2009) the distribution of the *A. fulica* is benefitted by many dispersion strategies, amongst which is passive transportation.

In the case of schools, substratum and plants for ornamental gardens, from nurseries, are possible sources for the *A. fulica*. Once at the schools, the care for the gardens (resulting in humidity, nutrients and places for resting) and the crumbs present in patios and corridors (providing food) provide maple foraging grounds for the snails. According to Raut and Barker (2002), the availability of differing food resources benefits the *A. fulica* populations (by also maturing them into adults in shorter periods of time).

Individual adults were found mainly at houses, condominiums and agricultural areas. In common these environments provided a large diversity of hiding places and food. Such results corroborate the Fischer and Colley (2005) studies that observed the efficient establishment and

proliferation of the *A. fulica* in environments with such plentiful resources.

In the agricultural areas that were visited, snail populations were observed in crops (especially small cultures and green gardens). Fischer and collaborators (2008), while researching the use of food resources by the *A. fulica*, found a prevalence for lettuce and other greens. However, Raut and Barker (2002) emphasized the wide adaptation capacity of the snail, listing 46 types of plants with an economic interest that the *A. fulica* consumes.

In an empty plot in the shore of Paranoa Lake, two groups of adult snails were found. The area had quite a diversity of exotic vegetation as well as construction leftovers. Oliveira and collaborators (2010) pointed out that these empty plots are favorable environments for *A. fulica* collection as they found during research in Goiás municipalities. Silva and collaborators (2013) reported the presence of many *A. fulica* individuals, spread out amongst the vegetation in empty plots at the municipality of Tangará da Serra, Mato Grosso state. Julio and Machado (2017) emphasized that the routine cleaning and maintenance of empty plots is an efficient technique to minimize *A. fulica* populations.

The shores of Paranoá Lake are a highly favorable environment for the populations of *A. fulica*. This environment, besides having a higher humidity than other urban areas in the Federal District, it also provides an urban area with natural vegetation. According to Smith and Fowler (2003) the humidity of an area is the best indicator of snail presence.

In the urban areas, most residences and condominiums have large areas for landscaping. Although it is during the rainy season that the snail finds ideal conditions, the species enjoys the shades and the soil humidity (at any season) for reproduction (Eduvirgem & Ferreira 2017). The shores of the Paranoá Lake thus offer several resources for the establishment and dispersion of the *A. fulica* populations.

In view of the dispersion of *A. fulica* in the Federal District and the large number of established populations, we recommend the adoption of public actions focused on the control of exotic species. Special attention should be paid to commercial nurseries, with guidelines for the collection and extermination of the mollusk in these locations. Clarification actions on *A. fulica* are also recommended in condominiums and other urban areas especially on the shores of Lake Paranoá.

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