

**Analysis of the Spatial Distribution of the African Crab in the City of
Manaus / AM-Brazil**

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Abstract

In 2003, the African snail was found for the first time in the city of Manaus, receiving from the Brazilian Institute of Environment and Renewable Resources the attribution of *Achatina fulica*, a species classified among the hundred worst invaders in the world. The present work presents the results of a study developed on the occurrence and the spatial distribution of this species in the capital of Amazonas. The methodological procedures were conducted through field collections, georeferencing and data projection on cartographic bases. As well as information on the conditions of precipitation, relative humidity and temperature, considering the influence of abiotic factors on the distribution of the species. The survey included 1,855 individuals, collected. The results reveal that temperature values of 25 ° C accompanied by relative humidity rates of around 80% and average precipitation volumes of 17 mm bring together climatic conditions that favor the appearance of the mollusc in the city Manaus.

Keywords: Geotopes, Exotic, Abiotic.

1. INTRODUCTION

The introduction of exotic species, can occur through economic ways, when a native species is replaced by another, in the search for a greater productivity or even accidentally, by goods transport or moving people. (ALMEIDA, 2013).

According to Mead (1961), the first mollusks of the species *Achatina fulica*, was originated in northern Zimbabwe, from humidity areas close to Congo basin in Africa. Currently, the occurrence in the temperature forest margins, far from climatic zones of its origin, indicates the high degree of adaptation of this mollusks to different environments (COLLEY *et al.*, 2012).

The african snail, *Achatina fulica* (Figure 1) it's considered an agricultural pest for promoting big losses to the crops, besides being considered a serious risk to the public health for being an intermediated host of nematodes *Angiostrongylus cantonensis* (CHEN,1935). In urban areas their habitat are wastelands, close to garbage dumps with expressive vegetation and humidity areas. It has a high rate of reproduction in anthropic environments, enabling the spread of diseases (FISCHER, 2006).

Figure 1 – African snails (*Achatina fulica*) found in the Center South Zone of Manaus



Source: Souza, M.G (2018).

The Manaus city, the place where this study was developed, it's located in the range of intertropical biomes of the planet, gathers geographic conditions favorable to the biodiversity expansion, common feature of biogeographic zones, also known as Neotropical Zones.

Among the geographic conditions, considered favorable, can be enunciate: a) a dense drainage network, composed of approximately 1.000 hydrographic channels, distributed on a large scale over the urban basins; b) the relief condition, drawn at low altitude and projected on contour lines whose maximum value is 120 meters.

Beyond these aspects, the vegetation cover must be considered, composed of a relative amount of forest fragments, located nearby small rivers and channels, regionally called igarape, which intersect the urban site surface. These characteristics, are components of a abiotic factors set, that favoring the local humidity, the high precipitation rate with records of 2.500mm/year, the low annual thermal amplitude, the drenched and humid soils, located in the valley bottom ranges, at elevations below 30 meters.

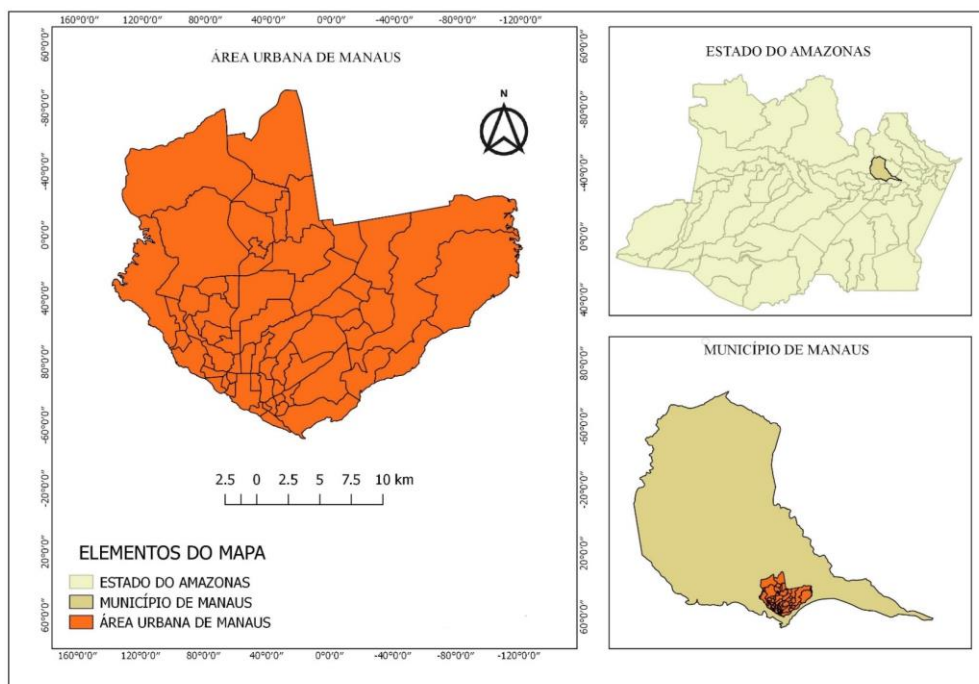
2. OBJECTIVE

Analyze the african snail's spatial distribution in Manaus city.

3. METHODOLOGICAL PROCEDURES

The study was performed in urban area of Manaus county, over a territorial surface of 592,194 Km², delimited between the following geographic coordinates: 02° 56' 12,5 a 3° 09' 45,6" S; 59° 48' 44,4 a 60° 06' 54,7" W. Greenwich (Figure 2).

Figure 2 – Location Map of the study area.



Source IBGE (2018). Organization: Souza, M.G (2019)

According to the Census of the Brazilian Institute of Geography and Statistics (IBGE, 2010) the population of this city is made up of 1.802.014 inhabitants which represents 10,89% of the total number of people in the North region and 49,9% of demographic contingent in the Amazonas State. Estimated data indicated for the year 2019, a population contingent of 2.182.763 people domiciled in this city. The vegetation cover is represented by Dense Ombrophilous Forest, where the relief characterized, by plains, dry lands, low plateaus, presents an altitude preponderantly below 100 meters (IBGE, 2010).

The georeferencing was worked with the purpose of identifying the areas inhabited by the mollusk and to know the environmental characteristics that affects its spatial distribution.

The records *in loco*, allowed the cartographic projection of the occurrence areas, for the subsequent generation of maps.

The field visits were performed in the period from september of 2018 to september of 2019, making a total of 53 visits in six zones of the city, totaling 32 neighborhoods, where it became possible to georeference 126 identification points of the african snail presence in Manaus city, with the purpose of elaborating the Kernel density map.

To obtain the temperature, precipitation and relative air humidity indices, was chose to use the climatic data base of the National Institute of Meteorology (NIMET).

4. RESULTS AND DISCUSSIONS

The vegetation must be considered an important factor in the temperature control and humidity maintenance, these conditions are essential for the survival of the animal. These characteristics influence their behavior and activities, since they provide them with shelter from solar radiation and help maintain the soil humidity.

Considering the case of the high temperatures existing in the city of Manaus, the african snail will only be able to survive if sheltered under the different types of vegetation, that in the north region are largely influenced by precipitation. These aspects are important for its survival. However, this animal nowadays is present in all areas of the city.

In the South Zone neighborhoods, the african snail (*Achatina fulica*) was found in wastelands with excessive vegetation and garbage or in abandoned properties, an analogous feature to the areas corresponding to the neighborhoods Educandos, Nossa Senhora Aparecida and Petropolis. This type of environment, was also described by Fisher *et al* (2010) in the book Natural History of *Achatina fulica* in which the authors describe that the species primarily occupies the anthropic environment.

However, some specialists, such as Mead (1961), believe that the anthropomorphic factor isn't a condition for occupation, since they also occur in peripheral areas that, apparently, haven't been altered by man. Among the basic conditions for successful occupation is its form of adaptation to existing substrates in urban areas.

Regarding the topic, Simião and Fisher (2004), indicate that such environments must provide the efficient displacement, refuge and reproduction of the african snail, therefore, they present selectivity for the available substrates. In Parana, the anthropic substrates most used by this species are piles of tiles, bricks and rubble.

In neighborhoods of North Zone, the snails were regularly found near the banks of channels and rivers, often drained and rectified by engineering works. This geotope unit

corresponds to the range of the greater bed, or floodplain, that in the case of Manaus city, is occupied by housing classified as subnormal, that reflect extreme situations of poorness and social inequality.

In this administrative zone, there are many forest fragments, where the local geomorphology is characterized by the predominance of slopes and the steep slope favors the concentration of superficial runoff water in the relief strip, which fits into the valley floor. The difficulties and lack of maintenance in the drainage system, transform the bottoms of these valleys into swamps, in which the quality of water resources is directly affected by marshy and muddy lands.

In these circumstances, the humidity is maintained even in dry periods — under insalubrity conditions — a fact that exposes the social groups that reside there to the vulnerability of acquiring various diseases, that can be transmitted by the African snail. It's evidenced examples of the neighborhoods Etelvina, Monte das Oliveiras and Cidade nova.

In the West Zone, the occurrences of these snails were recorded on the river banks that were channeled by basic sanitation programs, close to the riverbank of the city, such as Sao Raimundo and Gloria; on the other hand, on the edges of urban forest fragments, the species were collected in Lirio do Vale and in Rendeção, these two neighborhoods in particular, are located at 93 meter contour intervals, that is unfavorable to floods and overflowing rivers. In this case, in a different way of the wet and muddy valleys range the humidity soil is guaranteed by the vegetation cover and is indicated as the factor that adjusts to its survival and its appearance in this area of Manaus city.

In the East Zone, the mollusks were found mainly on lands with large amounts of rubble, residues and dumps located in inappropriate locations. This type of waste disposal occurs through people and companies, which negligently discard any type of waste, even hospital waste. The neighborhoods where the greatest concentration of african snail was detected were: Sao Jose Operario, Zumbi dos Palmares and Jorge Teixeira.

In the neighborhoods of the Center West Zone, landfills and the canalization of water courses, built to facilitate urban settlements, directed to abandoned lands in strips of forest fragment with springs, the ideal shelters for the species. These places are located close to Manaus International Airport and constitute a very suitable habitat

Regarding the neighborhood in the Center South, the oldest area of the city, were not found a significant amount of snails, restricting itself to places such as abandoned gardens and wastelands in the neighborhoods of Flores, Aleixo and in the Parque Municipal do Mindú — along the Corredor Ecológico do Mindú and Parque dos Bilhares — areas drained by urban rivers. According to IBGE surveys (2010), this region is considered the noblest area of the city, in addition with the largest number of buildings.

4.1 The areas with the highest density of the African snail

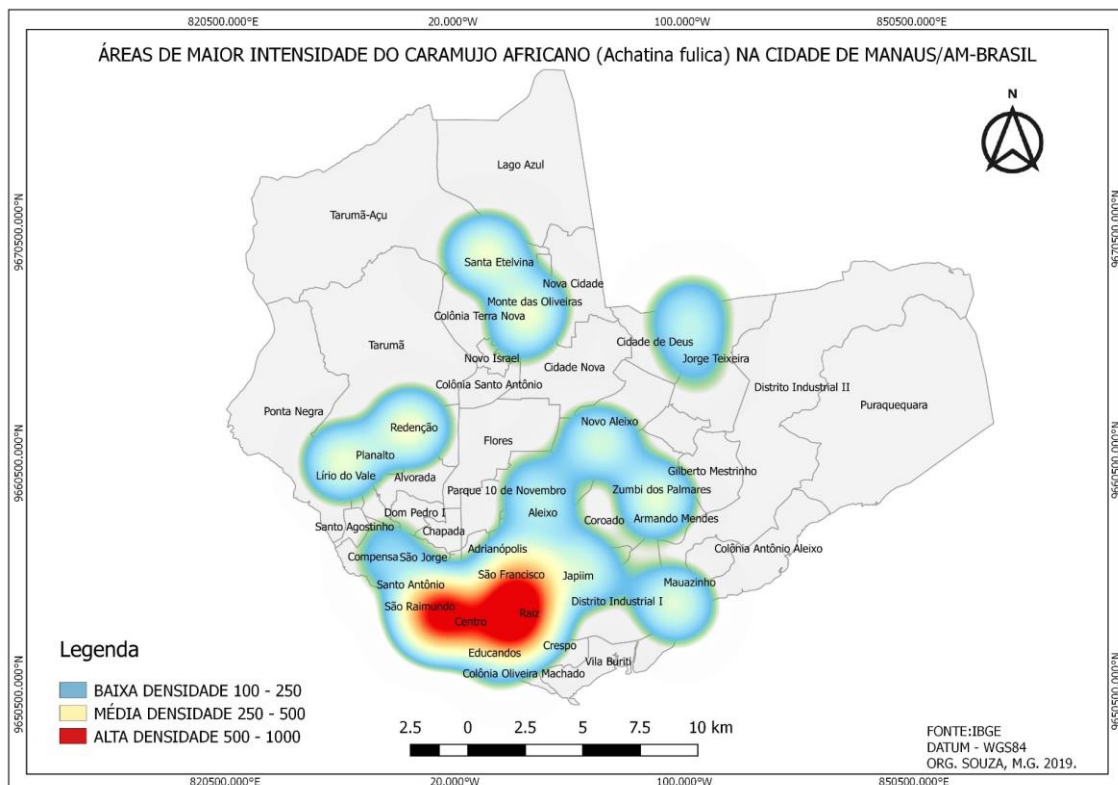
During the study period it was possible to identify a total of 126 points of african snail occurrence in 32 visited neighborhoods, with a large part concentrated in the West and South zones.

The african snail control and combat brigades, have been orienting the population about disease prevention since 2005. However, the types of environments where the snails are found and which favor the animal's reappearance, as well as the population density of this

mollusk by administrative zones, as well as the environmental conditions that favor its survival. Due to this context, this work consisted, in a previous way, a proposal to build a map of african snail spatial distribution in Manaus city in order to contribute the visualization of the focuses of its occurrence.

The highest density of snail was found in the neighborhoods of Sao Francisco and Gloria, however it's noteworthy that the kernel map doesn't consider administrative limits, exceeding its estimation zone beyond the zones or pre-established divisions. (Figure 3).

Figure 3 –Density Areas Map of African Snail (*Achatina fulica*) in Manaus.



Source: IBGE, (2010). Elaborate: Souza, M.G. 2019.

The area with the highest density of the species is found in the surrounding of hydrographic basins, where we can highlight the Educandos River Basin which has a total area of 46,14 km². The drainage area involves 10 neighborhoods fully inserted within its limits formed by the igarape do Quanto, Mestre Chico, Bittencourt, Manaus and Cachoeirinha (IBGE, 2010).

This area is an advanced state of environmental degradation, where it's found throughout its entirety, sewage outfalls, besides the accumulation of garbage. In addition, in these places, housing classified as subnormal agglomerations with low income, lack of basic sanitation and garbage collection (CALVO, 2018).

4.2 Climatic conditions of Manaus and the occurrence of African Snail.

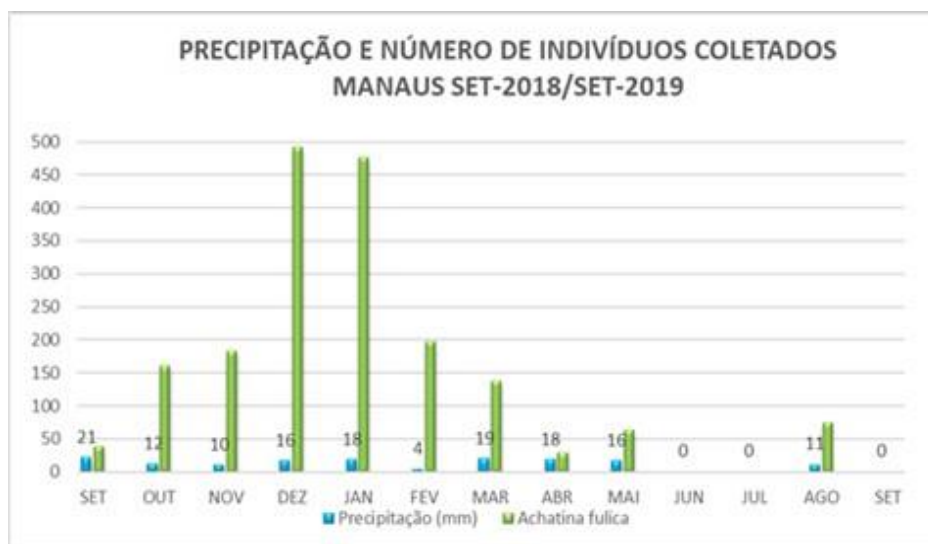
According to Raut and Barker (2002) the species *A. fulica* is active in active in rainy periods, establishing as a parameter the relative humidity above 50%. The sudden changes in

temperature and in the humidity, they condition the hibernation process, being an evolutionary survival strategy for the maintenance of its colonization and recolonization in environments with stressful conditions and altered by man (FISCHER, 2010).

Based on the above, were added to this study, informations about the temperature, the relative air humidity and precipitation rate, extracted from the National Institute of Meteorology database, due to detecting variations in the quantity of snails sighted during the field supervision, for mapping purpose. Then, the interpretations of data on Weather conditions in the period from september of 2018 to september of 2019, made evident the average temperature values and relative air humidity, besides establishing the relationship of these rates with the african snail appearance in Manaus.

The quantity of individuals colleted and the precipitations rates, When compared, attest according to data expressed, that there was na increase in the number of individuals collected in rainy days, that is, the snails were presente in the mapped geotopes, concomitantly with the increase in rainfall rates (Figure 4) faciliating the georeferencing of locations.

Figure 4 – Number of individuals and precipitation in (mm)



Source: NIMET (2018-2019). Elaboration: Authors (2019).

For Perez (2008), the *Achatina fulica*, tends to be more abundant in rainy periods, When the air and soil humidity indicate a tendency to increase. In January of 2019, 285 snails were collected within 20 minutos of grooming on a 10 x 25 meter plot in the after rain period. The same didn't happen When there was the increase in temperature or in periods of more than three days without precipitation that corresponds to the months of de June and July. Therefore, it was observed that the african snail can be seen in its habitat through the relative humidity rates with values of 80% followed by precipitation. Eduvirgem, (2018) estimate that the average temperatures of 23,69°C associated with relative humidity rates of 60,02% adjust to favorable conditions for the survival of arican snail.

In the rainy season, the notifications about the appearance of the african snail become evidente and, the reports from Municipal Environment Departament inform that the

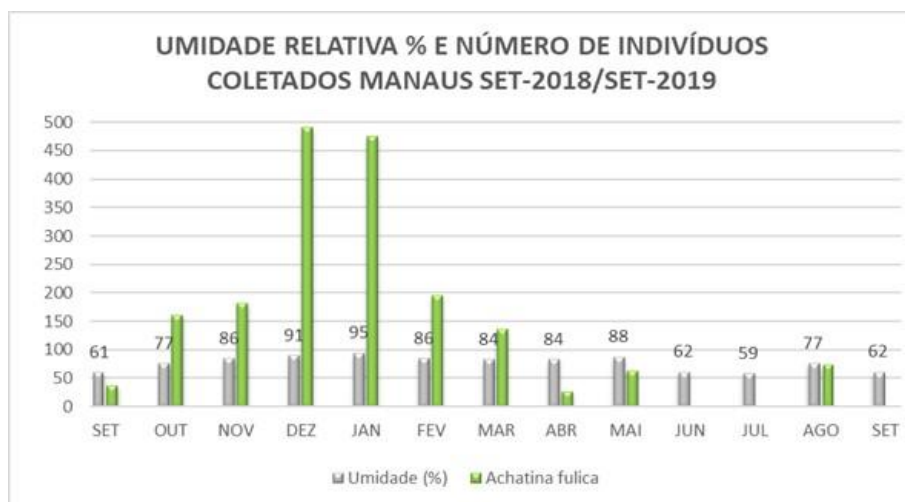
animal's shell, being very resistente because it contains calcium carbonate, remains in the environment for a long time, favoring the accumulation of water and insect niches, vectors of diseases. In addition, the content of the report likewise elucidates and clarifies the facts, about the diseases caused by the contact with the snail:

The african snail is highly harmful to human life, as it transmit two types of worms, that is, the *angiostrongylus costaricensis*, na agent of *angilostrogiliase* abdominal, a disease that leads the individual to the death for bowel perfuration, peritonitis and abdominal bleeding. In this condition, the syptoms are prolonged fever, anorexia and vomiting. The other worm is the *angiostrongyliase catonesis*, that tramits the *angiliostrongyliase meningoencefalica*, whose symptoms are Strong and constant headache, neck stiffness and nervous system disorders (SEDEMA, 2005).

On the days when there was no record of the precipitation occurrence, but the relative humidity rates remained high with regard to the climact conditions of Manaus city, difficulties were faced to detect the presence of african snail, during supervision and field surveys.

This climatic condition, became na impediment and contrary to the appearance of the animal, signaling that the high rate of relative humidity, when isolated from precipitatio, they don't consttue favorable environmental circsumstances for the appearance of the species in urba environment (Figure 5). That said, it appears that a set of environmtnal factors, intrinsically related between th conditions of temperature, relative humidity and precipitations, become suitable for the species.

Figure 5 – Number of individuals collected and relative humidity (%).

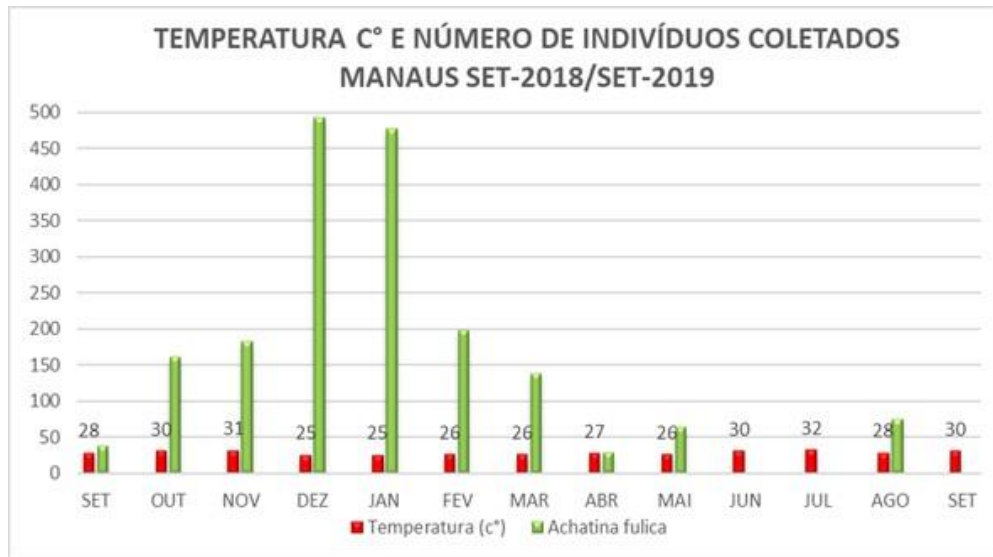


Source: INMET (2018-2019). Org. Authors 2019.

According to Kimura and Chiba (2010), the abiotic factors are responsible for influencing and adapting the behavior of entire communities, mainly the humidity that corresponds to the primordial fator in the maintenance of the species' vital functions. The effetcs are felt in physiology and behavior in the incessante search for water balance.

Regarding the temperature factor, in this study developed under environmental conditions of urban area, the temperature of 25° C recorded during data collection demarcated the presence of mollusk in the field, facilitating the georeferencing of locations used as shelter foci for this animal. The results are presente below (Figure 6).

Figure 6 – Number of individuals and Temperature (C°)



Source: INMET (2018-2019). Org Authors 2019.

From the data analysis, it was observed that values for temperatures of 25°C, relative humidity 80% and precipitation of 17 mm, gathered adequate environmental conditions to find the species in the urban environment. In studies developed by Pilate *et al.* (2013), it was found that under laboratory conditions, the species *Achatina fulica* established as a favorable condition for its survival and reproduction, average temperatures of 24,4C° and relative humidity of 86,2%, and, that the temperature increase negatively influenced the snail activities.

Based on the reports of these authors and applying the analogy of these aspects to environmental conditions, it can be seen that the temperature increase may have conditioned the ways of locomotion and appearance of the African snail and, as a result of temperature rise, it was not possible to find the species in any of the geotopes already described. About the topic, Pilate *et al.* (2013), describes that at temperatures above 28 C° the mollusk develops as a survival strategy the process of burying itself in the ground, to reduce its body temperature, protecting itself from solar radiation. This author, studying molluscs of native and exotic species, concluded that the African snail is susceptible to desiccation, decreasing its activities at high temperatures by a natural defense mechanism, in which the mollusk prefers to go out at low temperature or at dusk when the humidity conditions favor its locomotion.

According to Raut and Barker (2002) the African snail is active in rainy periods, establishing as a parameter the relative humidity above 50%. The sudden changes in temperature and in the humidity, they condition the hibernation process, being an evolutionary survival strategy for the maintenance of its colonization and recolonization in environments with stressful conditions and altered by man (FISCHER, 2010).

5. FINAL CONSIDERATIONS

The seasonality of the african snail's biogeographic cycle in Manaus city, indicates that the climatic factors in the region, favor its dissemination in the urban environment.

During the study period, it was observed that days with no precipitation, only the conditions of high humidity and temperature variation, were not enough for the mollusc to be sighted.

These aspects, show that only a set of interacting factors (temperature, relative humidity and precipitation conditions), becomes favorable to the occurrence of the species in Manaus city. The localization of Manaus city, in the central sector of Equatorial Blome, contributes to the climatic variables maintenance, helping th survival of the african snail. Therefore, it's urgente that public policies are implemented to implement effective methods of eradication or management of the species, that can directly or indirectly affect the human health.

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