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Densidade de Hedychium coronarium *em mata ciliar de rio de 1ª ordem numa área de proteção ambiental*

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ABSTRACT

The exotic invasive plant species *Hedychium coronarium*, which due to its accelerated growth and dispersion ends up replacing native vegetation, was found on the banks of a prime river in an environmental protection area, in the city of Piratininga, state of São Paulo. Quantitative monitoring to calculate the density, diversity, dominance, and evenness of the species in the areas were carried out between August and October 2022. In the sampled areas, differences in the diversity and quantity of plants present were observed, probably related to the luminosity and the soil favoring greater advantage of exotic plants, which are more adapted than native species, in addition to a greater dominance of *H. coronariumin* areas of lower diversity.

Keywords: exotic species, invasive species, *Lírio do Brejo*, riparian forest.

RESUMO

A espécie de planta exótica invasora *Hedychium coronarium*, que devido ao seu crescimento e dispersão acelerados acaba substituindo a vegetação nativa, foi encontrada às margens de um rio de primeira ordem em área de proteção ambiental, na cidade de Piratininga, estado de São Paulo. Monitorias quantitativas para calcular a densidade, diversidade, dominância e equabilidade das espécies nas áreas foram realizadas entre agosto e outubro de 2022. Observou nas áreas amostradas, diferença na diversidade e na quantidade das plantas presentes, provavelmente relacionada com a luminosidade e o solo favorecendo plantas exóticas, que são mais adaptadas que espécies nativas, além de uma maior dominância de *H. coronarium* nas áreas de menor diversidade.

Palavras-chave: espécie exótica, espécie invasora, Lírio do Brejo, mata de galeria.

INTRODUCTION

Brazil possesses 12% of the world's available fresh water, which is distributed in 12 Hydrographic Regions: Amazonian, Tocantins-Araguaia, Paraguay, Paraná, Uruguay, South Atlantic, San Francisco, Northeast Atlantic, East Atlantic, Parnaíba, East Northeast Atlantic, and Southeast Atlantic. However, the distribution of water resources among these regions is not well balanced. The total water available amounts to 35.732 m³ population/year (TOMAZ, 2001).

Water is an indispensable input for economic development, as all human activities depend on it, such as navigation, tourism, agriculture, supplying industries, among others.Scarcity in many regions is a significant obstacle to development, as water pollution, especially linked to various human activities, further compromises water availability in terms of quality and quantity (ANA, 2005). According to Costa, et al. (2007), an essential tool in the coordination of these resources is knowledge of water conditions in small basins, given the current scenario of water degradation and the increasing need for new sources of supply.

A according to the scientific Fluvial Hierarchy, water courses are defined as: rivers of the first order, which do not receive any affluent and the primordial water flow comes from the sources; second-order rivers, which originates from the junction of two or more first-order rivers, making the water flow greater; and third-order rivers, which determine the main flow of water from the watersheds and may flow directly into the sea or into another watershed. This hierarchy is based on the process of classifying a watercourse in the total set of the hydrographic basin in which it is located (STRAHLER, 1952; CHRISTOFOLETTI, 1980; WETZEL, 2001).

For the protection of water sources and riparian forests, increasing the retention time and connection of flooded and non-flooded areas, the present of these forests is of utmost importance. They play a critical role in various processes such as infiltration, runoff, and nutrient cycling (COSTA et al., 2022). These forests can be inserted in Environmental Protection Areas - EPA, Ecological Stations, among other types of Conservation Units, as well as on private properties. Therefore, it is essential to preserve these areas to avoid damage not only to nature but also to, society as a whole (FELDENS et al., 2019).

According to Paiva (2010):

> "The Environmental Protection Area (EPA) is defined as an extensive natural area, with a certain level of human occupation, which guarantees the protection and conservation of biotic, abiotic, aesthetic, or cultural attributes that are important for the quality of life of the population. That is, the EPA values the conservation of nature with the sustainable use of natural resources, where certain activities are

> allowed as long as they do not represent a threat to renewable environmental resources and ecological processes (art. 15, SNUC Law No. 9.985/00) ".

The riparian forest, or gallery forest, is characterized by forest systems naturally defined in strips on the banks of rivers and streams. This forest is generally narrow on both sides, rarely exceeding 100 meters in width. It has the function of protecting the margins from silting and degradation of the environment, in addition to being an important security support for the balance of the ecosystem and its intrinsic relationships, making it essential for the conservation of natural resources and transformation of environmental diversity (DURIGAN, SILVEIRA, 1999; COSTA et al., 2022).

The area comprising the riparian forest by the Federal Forestry Code is classified as PPA (Permanent Preservation Area), establishing a minimum distance of forest to be preserved in each case along water bodies (JAKIEVICIUS, 2011). Therefore, environmental monitoring is crucial in these areas to avoid invasive exotic species and conserve native plants (species that occur naturally in the environment) (PASTORE et al., 2012).

With the definitions admitted by the International Convention on Biological Diversity (CBD) of 1992, a species is classified as exotic when it is found in an environment different from its natural distribution due to human actions, voluntarily or not. From the moment the introduced species acquires the ability to reproduce and generate fertile offspring that can survive in the new habitat, it is considered established, and to become an invasive exotic species, it needs to expand its distribution, threatening native biodiversity (LEÃO et al., 2011).

All over the planet, species are introduced into new environments with the aim of providing benefits to society, such as the world's food supply, biological pest control, availability of sports practice and provision of pets, as well as for decoration. In Brazil, a country known for its rich biodiversity, the main cause of the introduction of exotic plants is the market for ornamental species associated with the trade in seedlings and seeds (SAMPAIO, SCHMIDT, 2014; INSTITUTO HÓRUS, 2019).

However, some species end up adapting and invading other areas, causing various negative impacts on the environment, society and the economy. In locations where there are no natural predators or competing organisms, there is an increase in the population growth rate of these individuals, much greater than in their natural distribution area. This is primarily, due to the lack of interactions between organisms that would typically regulate such populations, making the biological invasions one of the biggest factors for the global biodiversity loss (KEANE, CRAWLEY, 2002; SAMPAIO, SCHMIDT, 2014).

As some examples of invasive alien species in the country: *Hovenia dulcis*, *Phyllostachys aurea*,

Centella asiatica, *Deparia peterseniie*, and *Hedychium coronarium* (PASTORE et al., 2012; REIS et al., 2022).

Hedychium coronarium J. Köenig (figure 1), native to Tropical Asia, is an aquatic macrophyte, perennial in humid environments, more frequently found in swampy regions, popularly known as *lírio-do-brejo*, white ginger, *Mariazinha-do-brejo* or false ginger (KISSMANN, GROTH, 1991). It belongs to the Zingiberaceae family, having the greatest diversity of the order, about 50 genera and 1,300 species, mostly from Southeast Asia (COSTA et al., 2011).

It is estimated that the interval between the appearance of the inflorescence and the appearance of the flowers lasts, on average, 20 days. The flowers of *H. coronarium* are zygomorphic, hermaphrodite, nectariferous and with their opening at night, they have a non-showy calyx and corolla, where natural pollination takes place in small amounts and clonal development through rhizomes is the most efficient. At the time of flowering of *H. coronarium* there is a great attraction for the collection of nectar and pollen, mainly by different species of bees, ants, flies, hummingbirds, coleoptera and dermaptera, which act as scavengers of nectar, pollen, or flower tissue predators (BRIGITTE, 2008; SOUZA, 2009).

The species has an aerial part organized in a simple cylindrical stem, reddish at the base, with lanceolate leaves of alternating distribution, spike inflorescence, with imbricate bracts, flowers with white or pale-yellow corollas and petaloid staminodes, its flowering period is from December to March (KISSMANN, GROTH, 1991).

Figure 1 – Engraving of *Hedychium coronarium* (Source: PETERSEN, 1840-1906).

Figura 1 – Gravura de Hedychium coronarium *(Fonte: PETERSEN, 1840-1906).*

Hedychium is used for various purposes, from ornamentation, paper production (its stem has almost 50% cellulose), food (used as a NCFP - Non-Conventional Food Plant), in addition, to medicinal purposes, from its extract to help in the treatment of pain, wounds, infections, among

others, in Brazilian folk medicine (PIO-CORRÊA, 1969).

The consequences related to *H. coronarium* are mainly due to the replacement of native vegetation in humid areas and forest understory, which, due to its accelerated growth and dispersion, in addition to the difficult mechanical control, is considered a weed by farmers and researchers (SANTOS, 2005; BRÍGITTE, 2008).

OBJECTIVES

This research is part of a scientific investigation whose objective was to analyze the density of *Hedychium coronarium* on the banks of the first order river in an area of environmental preservation. Taking this objective as a starting point for eventual discussions throughout the research, specific objectives were inserted, such as: determining the diversity and equability of other species; the dominance relationship between native and exotic vegetation in the area where they are found; evaluate the ability of the invasive species to obtain or not the prevalence over other exotic species in the environmental protection area; observe the incidence of native vegetation in order to investigate the possible decrease in local diversity.

MATERIAL AND METHODS

Study area

The collections were carried out at *São João* farm, currently called the Coffee Museum (22°26'59.26''S - 49°06'41.21''W) (figure 2), located in Piratininga municipality, São Paulo, which, from an environmental point of view, is a unique place, as it is in a transition zone between the Atlantic Forest and Cerrado areas, therefore being an EPA (CESARI, CARNEIRO, 2022).

Data collection was performed monthly between the months of August and October, in the afternoon.

Experimental design

With the aid of a square made with string, three areas were delimited on the riverbank, measuring 3m x 3m, totaling 9m², named Points A, B, and C (figure 3). In each quadrant, the total number of plants present was quantified. Using the PlantNet digital platform, the plants were identified and confirmation was carried out using an identification key based on vegetative characters.

The plants were identified using the PlantNet application and confirmation was carried out using the botanical collection of the *Centro Universitário do Sagrado Coração*.

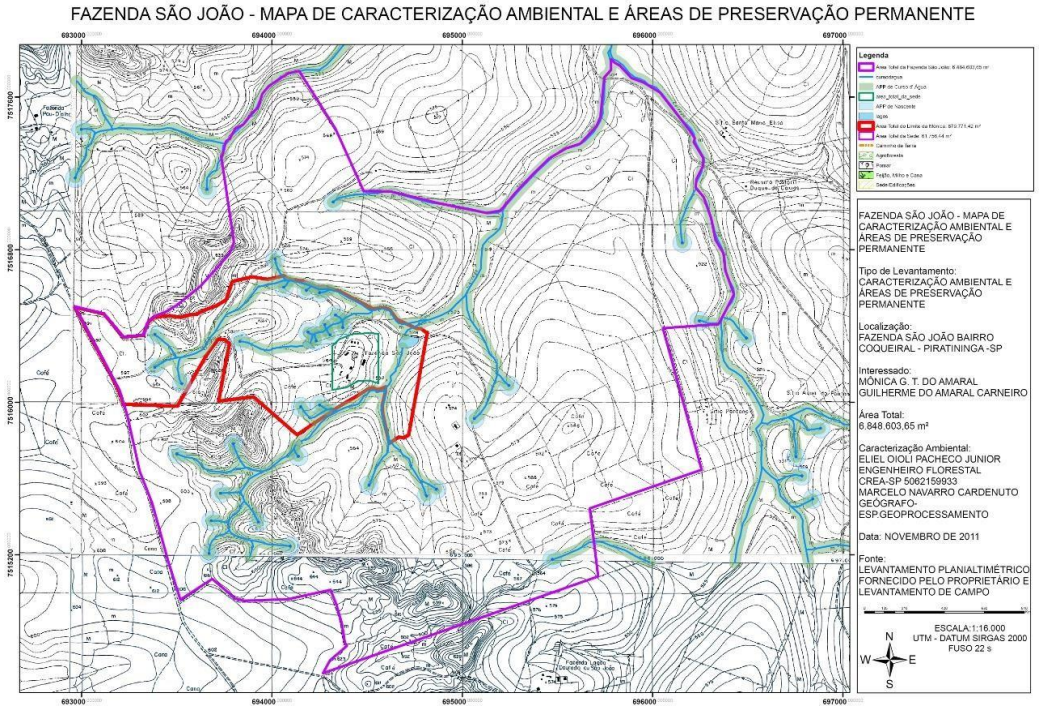

Figure 2 -Map of the *São João* farm (Source: AMARAL, CARNEIRO, 2011).

Figura 2 - Mapa da Fazenda São João (Fonte: AMARAL, CARNEIRO, 2011).

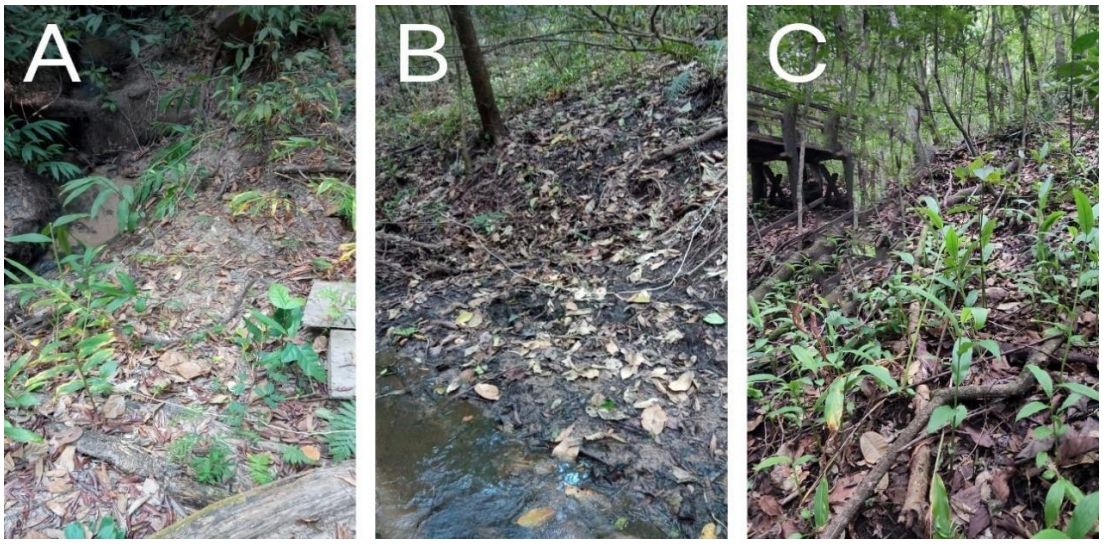

Figure 3- Monitoring point A, B and C on the banks of the river.

Figura 3 - Ponto A, B e C de monitoramento às margens do Rio.

Ecological Variables

For the study of *H. coronarium*, density, diversity (Shannon-Weaver), and dominance (Simpson) indices were used, in addition to evenness (Pielou) were measured from the data obtained.

Density–is represented by the size of the population relative to some unit of space (BEGON, 2009).

$$D = \frac{N}{A}$$

Where:

D= population density (number of individuals per area unit);

N= number of individuals;

A= area unit (m2)

Diversity Index – estimates the total diversity (MAGURRAN,2004).

$$H' = -\sum pi * \ln pi,\ pi = ni/N$$

Where:

H'= Shannon Weaver's index;

ni= number of individuals in each species (abundance);

S= number of species (richness);

N= total number of all individuals;

pi= relative abundance of each species, calculated by the proportion of individuals of a species by the total number of individuals in the community: ni/N.

Dominance Index–is the probability of selecting two individuals of the same species in the sample at random (PEET, 1975).

$$D = \sum_{i-1}^{s} pi^2$$

Where:

D= Simpson dominance index;

S= number of species;

pi= relative abundance of each species, calculated by the proportion of individuals of a species by the total number of individuals in the community: ni/N.

Equability - verifies the distribution of the number of individuals among the species (CORREIA, 2000).

$$J = \frac{H}{logS}$$

Where:

J= Pielou evenness index;

H= Shannon Weaver's diversity index;

S= number of species;

H(max)= ln(S)= maximum diversity.

RESULTS

Figure 4 presents the climatic data of the months during the collection in Piratininga/SP, carried out on August 28th, September 30th and October 31st. The yellow indicates the days with clear skies, the gray represents the sky cover with clouds, and the darker the gray background is the denser the cloud cover. The blue shows the amount of precipitation in millimeters, with October being

the month with the most rainfall over the recorded high test days.

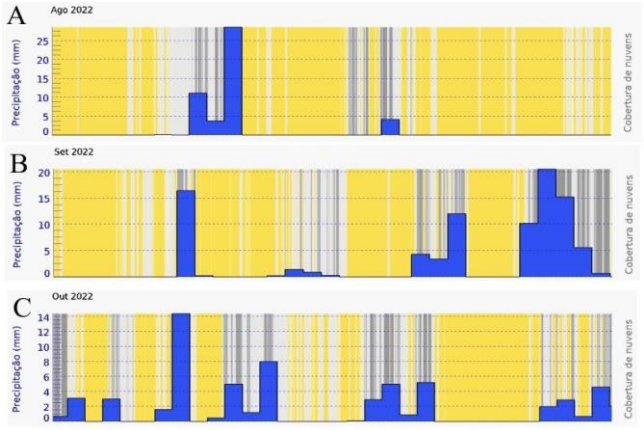

Figure 4 – August precipitation, with few days of rain (A); September precipitation, more days with rain and heavy rain at the end of the month (B); October precipitation, with regular rainfall throughout the month (C) (Source: METEOBLUE, 2022).

Figura 4 – Precipitação de agosto, com poucos dias de chuva (A); precipitação de setembro, mais dias com chuva e chuva intensa no final do mês (B); precipitação de outubro, ocorrendo chuvas regulares durante o mês inteiro (C) (Fonte: METEOBLUE, 2022).

Figure 5 presents the total density of organisms found in the three studied sites. It is noted that there was an increase over the months at all collection points, but at point 2 there was no significant difference from September to October. And the density of *H. coronarium* had a high incidence at point 3.

Table 1 shows the total number of plants per area and the total of the *H. coronarium* species that were identified; there was an accelerated increase in point 3 of the studied species.

The results indicated in Table 2 show, respectively, the index of diversity, dominance and evenness, where only point 1 has high species diversity (0.7) and low dominance (0.28) in relation to the other points (0.4 and 0.4; 0.2 and 0.7) respectively. At point 3 there is a significant difference in the evenness index in the different months compared to the others.

Table 3 indicates the presence of different types of species between collection points. As observed, the first point has a greater number of individuals than the other points.

DISCUSSION

In total, 24 species were found, distributed among 23 genera and 15 families, in which 16 of them located in the first point, 6 in the second point and 9 in the last point. Among the identified species, only 8 are native to Brazil, they are: *Calliandra tweendii, Piperhispidum, Ingaac cuminata, Ctenitis submarginalis, Desmanthus virgatus, Eugenia brasiliensis, Psychotria carthagenensi* and *Duguetia cadaverica*, which indicates that there is a high rate of exotic species in the studied area, but without the same degree of invasiveness of *H. coronarium*. Point 1 has 6 native species, while point 2 has only 1, and point 3 has 3 native (PINHEIRO, 2018).

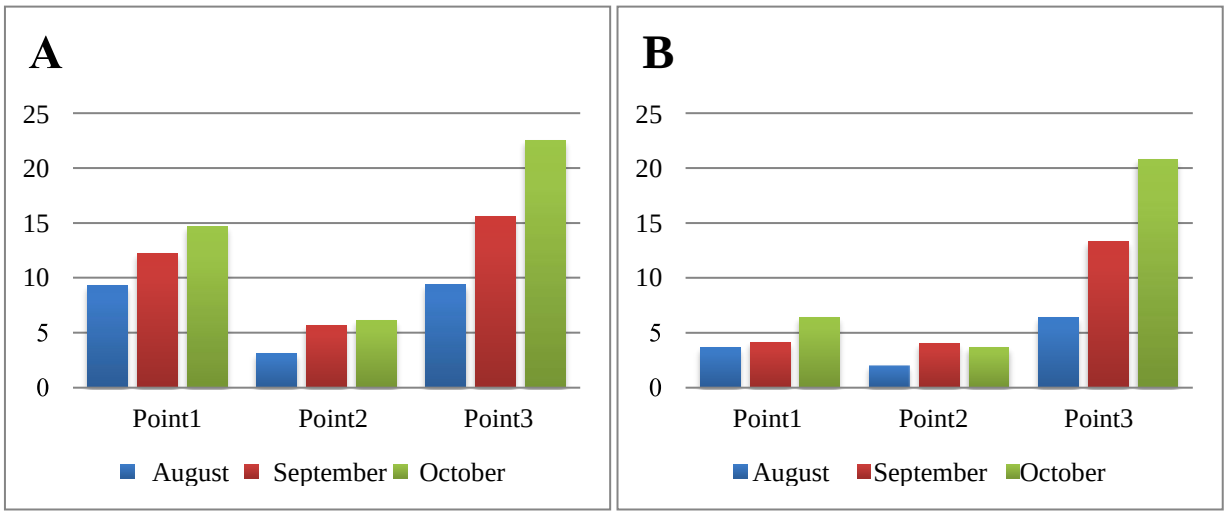

Figure 5 - Total population density (A) and *H. coronarium* population density (B).

Figura 5 - Densidade populacional total (A) e Densidade populacional de H. coronarium *(B).*

Table 1 -Total plants and total *H. coronarium.*

Tabela 1 - Total de plantas e total de H. coronarium*.*

	POINT 1			POINT 2			POINT 3		
	Aug	Sep	Oct	Aug	Sep	Oct	Aug	Sep	Oct
Total plants	84	110	133	28	52	55	85	141	203
H. coronarium	34	36	58	18	36	34	58	120	188

Table 2-Results of calculated indices.

Tabela 2 - Resultados dos índices calculados.

	POINT 1			POINT 2			POINT 3		
	Aug	Sep	Oct	Aug	Sep	Oct	Aug	Sep	Oct
H'	0.7	0.75	0.65	0.46	0.44	0.43	0.45	0.28	0.16
D	0.28	0.24	0.35	0.45	0.51	0.48	0.51	0.73	0.85
J	0.7	0.79	0.63	0.66	0.56	0.65	0.58	0.33	0.2

Table 3 – Presence of species in each sampled area (São João farm), in Piratininga, SP.

Tabela 3 – Presença de espécies em cada área amostrada (Fazenda São João), em Piratininga, SP.

SPECIES	POINT1			POINT2			POINT3		
	Aug	Sep	Oct	Aug	Sep	Oct	Aug	Sep	Oct
Hedychium coronarium	X	X	X	X	X	X	X	X	X
Coffea arabica	X	X	X	-	-	-	-	-	-
Calliandra tweendii	X	X	X	-	-	-	X	X	X
Piper hispidum	X	-	-	-	-	-	-	-	-
Trientalis borealis	X	X	-	-	-	-	-	-	-
Inga accuminata	X	X	X	-	-	-	-	-	-
Bauhinia variegata	X	-	-	-	-	-	-	-	-
Gaultheria shallon	X	X	X	-	-	-	-	-	-
Quercus faginea	X	-	-	-	-	-	-	-	-
Cteniti ssubmarginalis	X	-	-	-	-	-	-	-	-
Morus rubra	-	X	-	-	-	-	-	-	-
Bauhinia tomentosa	-	X	X	-	-	-	-	-	-
Calycanthus floridus	-	X	X	-	-	-	-	-	-
Lauru snobilis	-	-	X	-	-	-	-	-	-
Desmanthus virgatus	-	-	X	-	-	-	-	X	-
Eugenia brasiliensis	-	-	X	-	-	-	-	-	-
Blechnum attenuatum	-	-	-	X	X	X	-	-	-
Magnolia acuminata	-	-	-	X	X	X	-	X	-
Pesea americana	-	-	-	X	X	X	X	X	X
Syzygium jambos	-	-	-	X	X	X	X	X	X
Psychotria carthagenensis	-	-	-	-	-	-	X	X	X
Nyssa sylvatica	-	-	-	-	-	-	X	-	-
Duguetia cadaverica	-	-	-	-	X	-	-	-	-
Annona reticulata	-	-	-	-	-	-	-	-	X

The diversity and evenness indices highlight the differences between the communities in the three monitoring areas. The diversity at point 1 in August showed higher values, almost 2 times greater than points 2 and 3 in the same period, believing that the presence of *H. coronarium* did not interfere with the diversity of the plant community, possibly because it has a greater distribution of species in this area (SILVA, 2010).

The difference in dominance is due to point 1 having more species, totaling 16 in total, which compete and interact interspecifically, resulting in lower dominance. This means that the probability of randomly collected individuals belonging to the same species is low compared to the others points where there is an intraspecific competition of *H. coronarium* (RICKLEFS, RELYEA, 2016; COSTA, 2018). In points 2 and 3 there are only 6 and 9 species, respectively, most of which are also exotic species, which contributes to the absence of their natural predators, as it is not their habitat of origin, thus increasing the density and dominance of the species (PRIMACK, RODRIGUES, 2001; RICKLEFS; RELYEA, 2016).

At all points, there was a considerable number of the invasive species *H. coronarium*. However, the results show that in the area where its density is not predominance, such as point 1, there is a smaller total number of species but greater diversity. This could be attributed to greater exposure to sunlight, which creates a more favorable environment for the growth of other species that require sunlight for germination. These species are positive photoblastic and are able to establish themselves and reproduce. In the contrast other points with lesser sunlight exposure which contributes to the growth of *H. coronarium*, which is highly shade tolerant. *H. coronarium* is classified as neutral photoblastic, meaning it does not depend on light to germination (MAYER, POLJAKOFF-MAYBER, 1989; BLUM, 2005; BRIGITTE, 2008).

In addition, possibly because the composition of the soil is more waterlogged at points 2 and 3, it favors the growth of *H. coronarium* when it rains due to its success in germinating also in swamp areas, where there is less oxygen available, its rhizomes can disperse fragments through the water, occupying new areas, being a competitive advantage in the occupation of areas that, due to their aggressiveness, prevent the regeneration of native species and end up dominating the area (TUNISON, 1991; BRIGITTE, 2008; PINHEIRO, 2018). However, this is not a rule, as in other studies (SILVA, 2010; MOITAS, 2014) it is possible to see other factors influencing the distribution of the species, such as decomposition of debris, pH, and atmospheric temperature, among others.

Only at point 3 was there a very significant change in the diversity and evenness index, possibly due to abiotic factors such as high soil moisture and low sun exposure, which favors

a greater advantage over native species (PINHEIRO, 2018).

CONCLUSION

The results suggest that as the density of *H. coronarium* increases, the diversity and evenness of other species decrease, and the dominance of the area where they are found increases. This pattern is probably influenced by factors such as light available and soil conditions. Point 1, which has the lowest density of *H. coronarium* compared to total density, shows greater species diversity and lower dominance. In contrast point 3 exhibits lower diversity and higher dominance. These findings contrast with the initial hypothesis that the invasive species has the capacity to invade different types of environments, as point 1 was relatively less affected.

Therefore, due to the high prevalence of other types of exotic species in the environmental protection area, which should be dominated by native species of Brazil, it is important to conduct a long term monitoring period for the proper management of invasive exotic plants as soon as possible. This is necessary in order to avoid a decrease in local diversity.

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