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Expansão agrícola em fragmentos da mata atlântica do nordeste do Brasil e seus impactos sobre liquens

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RESUMO

A expansão agrícola e urbana vem comprimindo e erradicando áreas de florestas nativas, levando à perda da biodiversidade e extinção das espécies. Na mata Atlântica do Nordeste Brasileiro o cultivo da cana-de-açúcar domina a paisagem, onde ainda restam fragmentos do bioma. Apesar de muitos estudos com os organismos componentes da mata Atlântica e os efeitos da ação humana serem objeto de muitas pesquisas, pouco se conhece acerca dos efeitos de borda na ocorrência e preferência de habitats por liquens. Neste estudo objetivou-se correlacionar a preferência de liquens pela borda, centro ou ampla distribuição em três fragmentos florestais (São Braz, Café e Xangô) da reserva Biológica de Gurjaú, Cabo de Santo Agostinho, Pernambuco (Brasil). Liquens foram coletados e identificados por caracteres morfológicos e químicos. Espécimes foram georreferenciados e determinada sua preferência. Observou-se que a maioria das espécies e famílias tiveram preferência pela borda do fragmento, seguida pela ampla distribuição, o que se explica pela penetração da luz solar causada pelo desflorestamento. Por outro lado, foi possível determinar serem alguns fragmentos mais conservados do que outros. Dendrogramas de correlação entre as preferências de habitats demonstraram que os fragmentos têm poucas espécies em comum, no entanto ainda assim foi possível apontar a similaridade entre os centros, bem como entre bordas, de Xangô e São Braz, e a similaridade da diversidade liquênica com ampla distribuição dos três fragmentos. A diversidade liquênica dos fragmentos são mais distintas entre si, enquanto que a diversidade em cada setor desses fragmentos somados, são mais similares, evidenciando que média de riqueza liquênica é mais determinada pelo setor que pelo fragmento. Foi possível concluir que o levantamento da preferência de ocorrência dos liquens dentro dos fragmentos possibilitou constatar o estágio avançado de degradação da área. O aumento das áreas plantadas e desinformação da população local incrementam a degradação gerada, o que dificulta sobremaneira a reversão do quadro.

Palavras-chave: bioindicadores; cana-de-açúcar; impacto ambiental; efeito de borda; biodiversidade.

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Agricultural expansion over fragments of atlantic rainforest in northeast Brazil and its impacts on lichens

ABSTRACT

Agricultural and urban expansion has been compressing and eradicating areas of native forests, leading to biodiversity loss and species extinction. In the Atlantic Forest of Northeastern Brazil, sugar cane farming dominates the landscape, where fragments of the biome remain. Although there have been many studies on the organisms component of the Atlantic Forest, and the effects of human action being the subject of much research, little is known about edge effects on the occurrence and habitat preference of lichens. This study aimed to correlate the preference of lichens for the edge, center, or broad distribution in three forest fragments (São Braz, Café, and Xangô) of the Gurjaú Biological Reserve, Cabo de Santo Agostinho, Pernambuco (Brazil). Lichens were collected and then identified by morphological and chemical characters. Specimens were georeferenced, and their preference was determined. It was observed that most species and families preferred the edge of the fragment, followed by a broad distribution, which can be explained by the penetration of sunlight caused by deforestation. On the other hand, it was possible to determine that some fragments were more conserved than others. Correlation dendrograms between habitat preferences showed that the fragments have few species in common. However, it was still possible to point out the similarity between the centers and between the edges of Xangô and São Braz and the similarity of lichen diversity with broad distribution. The fragments' lichen diversity is more distinct. In contrast, the diversity in each sector of these fragments combined is more similar, showing that the average lichen richness is more determined by the sector than by the fragment. It was possible to conclude that the survey of lichen occurrence preferences within the fragments allows us to verify the advanced stage of degradation in the area. The increase in planted areas and the misinformation of the local population have increased the degradation, making it extremely difficult to reverse the situation.

Keywords: bioindicators; sugarcane; environmental impact; edge effect; biodiversity.

Expansión agrícola en fragmentos de bosque atlántico en el noreste de Brasil y sus impactos sobre líquenes

RESUMEN

La expansión agrícola y urbana ha comprimido y erradicado zonas de bosques autóctonos, lo que ha provocado la pérdida de biodiversidad y la extinción de especies. En la Mata Atlántica del Nordeste de Brasil, el cultivo de la caña de azúcar domina el paisaje, donde aún se quedan fragmentos del bioma. Aunque se han realizado muchos estudios sobre los organismos que componen la Mata Atlántica, y los efectos de la acción humana son objeto de muchas investigaciones, poco se sabe sobre los efectos de borde en la ocurrencia y preferencia de hábitat de los líquenes. Este estudio tuvo como objetivo correlacionar la preferencia de los líquenes por el borde, el centro o la distribución amplia en tres fragmentos de bosque (São Braz, Café y Xangô) de la Reserva Biológica de Gurjaú, Cabo de Santo Agostinho, Pernambuco (Brasil). Los líquenes fueron recolectados y identificados por caracteres morfológicos y químicos. Los especímenes fueron georreferenciados y se determinó su preferencia. Se observó que la mayoría de las especies y familias tenían preferencia por el borde del fragmento, seguido de una amplia distribución, lo que puede explicarse por la penetración de la luz solar causada por la deforestación. Por otra parte, se pudo determinar que algunos fragmentos estaban más conservados que otros. Los dendrogramas de correlación entre las preferencias de hábitat mostraron que los fragmentos tienen pocas especies en común, pero aun así fue posible señalar la similitud entre los centros, así como entre los bordes, de Xangô y São Braz, y la similitud de la diversidad liquénica con amplia distribución de los tres fragmentos. La diversidad liquénica de los fragmentos es más distinta entre sí, mientras que la diversidad en cada sector de estos fragmentos combinados es más similar, mostrando que la riqueza liquénica media es más determinada por el sector que por el fragmento. Se pudo concluir que el relevamiento de las preferencias de ocurrencia de líquenes dentro de los fragmentos permitió ver el avanzado estado de degradación del área. El

aumento de las áreas plantadas y la desinformación de la población local aumentan la degradación generada, lo que hace muy difícil revertir la situación.

Palabras-clave: bioindicadores; caña de azúcar; impacto ambiental; efecto de borde; biodiversidad.

INTRODUCTION

Agriculture causes direct losses to the environment, affecting the biodiversity of native species when the plant cover is removed for plantation and indirectly through the use of pesticides, soil compaction, and erosion, among others (Silva, 2021; Feitosa et al., 2023; Cicilinski et al., 2024). In Brazil's case, the history of agriculture shows different steps in the agricultural frontier expansion process. It shows the change of sugarcane in Atlantic Rainforest areas to soybeans in Savannah in the Middle-West and Amazon Rainforest. Thus, the loss of native biome promoted by forest fragmentation is evident in almost all stages of this process, especially concerning the inadequate management of tropical environments. In this case, being affected at landscape and forest fragment levels (Medina, 2021; Hernandez et al., 2022; Cunha et al., 2023; Moreira et al., 2023). In this context, although many studies refer to the effects of human action on tropical landscapes and the organisms that compose them, few are concerned with their relationship with indicator organisms, with emphasis on lichens.

It is known that the presence of live organisms in ecosystems reveals their dependence on environmental and physical factors. Thus, modifying the landscape structure undoubtedly interferes with their presence and distribution. In this sense, these organisms are beneficial in bioindication studies of environmental degradation or indicate the wholesomeness of natural environments. Organisms that comprise those environments must be well studied and interact with those environmental factors. This makes it possible to identify the damages and their extension.

On the coast of the Brazilian Northeast, the Atlantic Rainforest is found in fragments, usually localized in sugarcane plantation areas, characterizing Legal Reserves. However, those forest spots still have a very low known richness. According to Tabarelli et al. (2006), Fernandes (2002), and Almeida et al. (2024), new species of plants and animals are known each year, besides high endemism species being reported. In this sense, in that Region, 40 priority areas for conservation were identified, 24 of them considered to have extreme biological importance (Conservation International, 2000; Conceição et al., 2020; Relatório Annual da Mata Atlântica, 2022; Ministério do Meio Ambiente e Mudança do Clima, 2024).

Forest fragments generate an edge that allows contact between a deforested area and agricultural activity or urban expansion with the forest remnant. At this edge, the effect on species' relative abundance and composition at the marginal part of the fragment, which triggers the process of expansion of activities in high proportions, can lead to species extinction or irreversible problems.

This fact demonstrates the environmental mischaracterization caused by the fragmentation of the "whole," breaking up old continuous vegetation areas into portions that result in fragments whose edges were initially internal to the "whole." This way, the modifications on the more external areas of the forest fragments and their effects are considered the "edge effect." This new configuration alters the air's relative humidity, luminosity, and temperature gradient, as well as the increase in air pollution caused by human actions, among other changes. In this sense, species sensitive to the new situation tend to disappear or tend to occupy the central part of the fragments or even the mildest parts of the habitats (Silva et al., 2021; Fernandes et al., 2022; Oliveira, 2023).

Those findings could be ratified through studies of the PROBIO project promoted by the Environment Ministry. This study inventoried 14 groups of organisms in Atlantic Rainforest remnants located north of the São Francisco River. Those areas were divided into fragments, which allowed a comparison between richness and biodiversity according to the physical-environmental conditions of those localities (Porto et al., 2006). Many of the studied groups showed new species to Science, a high degree of endemism, and potential information for further management plans in Protected Areas.

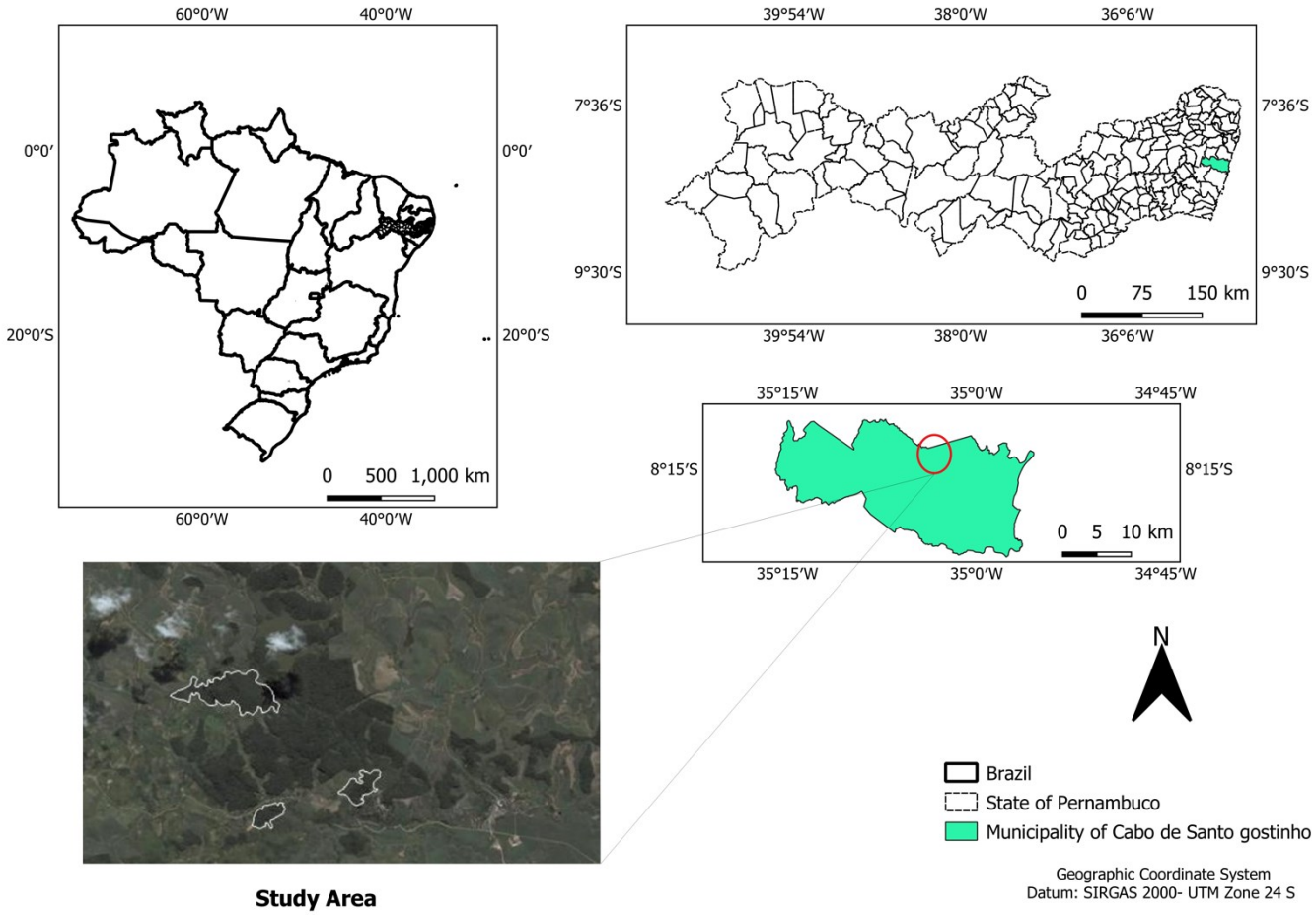
An inventory of lichens was performed among studied taxonomic groups because those organisms are excellent indicators of environmental quality. In those areas, 93 new citations of lichen species to Pernambuco and Alagoas were registered. The significant richness was attributed to species occurring in the Serra Grande Plant forest (Alagoas) and the highest diversity in the Ecological Reserve of Gurjaú (Pernambuco) (Pereira et al., 2006).

This way, based on the excellence of lichens as tools for environmental diagnosis and their relationship with physical-climatic environmental conditionings, we aimed to compare three different forest fragments of Gurjaú Ecological Reserve. We evaluated the species distribution according to their position inside the fragment (edge, center, and intermediary portion in between). The results could fill a gap of information yet to be glimpsed for this biome, mainly in the Pernambuco State. In addition, the correlation of those results will subside new contributions to biogeography and relevant information to agroecology.

METHODOLOGY

For this study, fragments of the Atlantic Rainforest located at Gurjaú Ecological Reserve (coordinates 08º10'00"- 08º15'00" S; 35º02'30"- 35º05'00" W) were selected (Figure 1). Gurjaú exhibits an area of 1,077.10 ha, comprising the municipalities of Cabo de Santo Agostinho (744.47 ha), Moreno (175.19 ha), and Jaboatão dos Guararapes (157.44 ha), in Pernambuco state (Brazil). Among the existent fragments in that area, São Braz, Café, and Xangô were chosen for this study (FIDEM, 1987).

Figure 1. Localization map of Gurjaú Ecological Reserve (Pernambuco, Brazil), and Xangô, São Braz, and Café fragments.



Source: Bruno F. da Silva, 2024.

Lichen families and species occurring in Gurjaú were studied based on their preference and distribution in the habitat (edge, center, or broad distribution) as they were geo-referenced when collected. The samples were collected identically in all surveyed fragments. Random walks were performed to cover the entire sampling area. Trees were observed from the base until they reached an average height of 2.5 m.

Samples were collected with a knife and spatula and then geo-referenced. Each sample was registered and kept in a paper bag. In the laboratory, they were cooled for 24 h and kept at room temperature (28 ± 3°C) until identification. Samples were later analyzed in the Environmental Geography Laboratory (LAGEAM) of Universidade Federal de Pernambuco (UFPE) according to the thallus' morphological and chemical characters, using identification keys, color reaction tests, and thin-layer chromatography to ratify the species identified (Asahina, Shibata, 1954; Culberson, 1972).

To verify a possible correlation among the three fragments, as well as the relationship between species and center/edge occurrence, analyses were carried out for richness with the Sörensen Similarity Index, and for abundance, the Bray-Curtis dissimilarity and X^2 with Eigen ordination for correspondence analyses. Dendrograms were generated using the UPGMA grouping method using NTSYS 2.21h software. After determining species with a preference for the edge, center, and broad distribution and correlating their occurrence with fragment zones, these data were superimposed with the cluster analysis of the fragments, generating an MxPlot similarity matrix, also using the NTSYS software.

RESULTS AND DISCUSSION

All vegetation of continuous natural areas, interrupted by anthropic or natural barriers, are considered forest fragments (Cunha et al., 2021; Stevanato, 2023). In those fragments, the genetic flux between the parts can significantly diminish compared to the previous non-fragmented forest. Landscape fragmentation reduces habitat and loss of biodiversity due to its degree of isolation (Cunha et al., 2021; Garcia, 2023. Thus, the number of species in a fragment will be directly proportional to the intensity of human disturbances to the surrounding vegetation (Ferraz, 2023; Mendes, 2023; Dias et al., 2023).

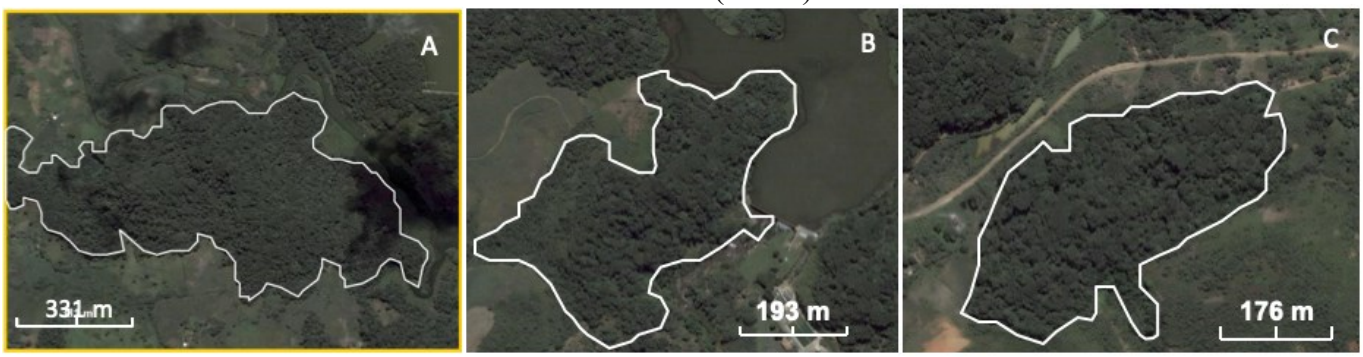
Studies have proved that the isolation of populations of plants, animals, and other organisms in forest fragments restricts the migration, dispersion, and gene exchange between organisms of an ecosystem that initially formed an entire matrix. In this context, the systems became more homogeneous, which characterizes the loss of biodiversity (Lessa et al., 2024; Vieira et al., 2024). In this sense, forest fragmentation is a very well-studied theme concerning natural ecosystem degradation. One may mention this problem for all biomes in Brazil, but the Atlantic Rainforest is emphasized since its depredation reaches 90 %. Thus, the fragmentation of Brazilian ecosystems is at an advanced stage due to agricultural development, which is pointed out as the primary responsibility for this kind of degradation since it is a disordered practice in large portions of land and diversity of biomes (Marques, Grelle, 202). Not only genic flux and loss of biodiversity are mentioned as consequences of landscape fragmentation, but the edge effect

is harmful to organisms since some of them were adapted to more shaded and humid habitats in the interior of the forest that, after fragmentation, turned up with higher temperature and lower humidity than in past conditions. In this context, plants disappear, adapt to new situations, or migrate inside the fragments (Kun et al., 2019).

As lichens interact closely with environmental physical and biological constituents, they are remarkable bioindicators of environmental quality (Abas et al., 2024). For this reason, this study described the distribution of individuals and their preference for different parts of the fragments. In observing the distribution of lichen species and families in each fragment, in the case of São Braz (Figure 2A), species showed a broad distribution in their majority. The others were found at the edge, and only one in the center. In Café (Figure 2B), the distribution was balanced when lichens considered the preferred parts of the habitat. Many preferred the habitat's interior part. In fragment Xangô (Figure 2C), species showed broad distribution; some were exclusive to the edge. No species were found in the center of that fragment (Table 1).

In a previous study, Pereira et al. (2006) compared the number of species and families in those fragments. The authors found that 46.66% of the 45 registered species grouped in 17 families were concentrated in Xangô and Café fragments. These fragments were also considered the most diverse, emphasizing Café due to its small area. It is known that the smallest fragments tend to have the highest and fastest loss of diversity, which led to the advisement of quick intervention focusing on preserving this fragment.

Figure 2. Fragments of São Braz (A), Café (B), and Xangô (C) at Gurjaú Ecological Reserve, Pernambuco (Brazil).



Faria (2020) mentions that due to their sensibility to any intervention in ecosystems, bioindicators demonstrate the tendency of sensible species to migrate to the center of the fragment, in the case of those

that can move. On the other side, those who have no locomotion can disappear. The most resistant remain on the edge or have a broad distribution.

The fragment's center is always more humid and has a lower temperature than the edge. Meanwhile, organisms on the edge are exposed to dryness provoked by air currents and sun radiation. These findings could be ratified by Macedo (2009), who registered a temperature variation between 36.4 ºC and 27.8 ºC, respectively, in the edge and center of an Atlantic Rainforest fragment in Recife (Pernambuco, Brazil). In the same area, the relative humidity varied from 56 % to 96 %, which undoubtedly influences the metabolism and development of organisms that constitute its biota.

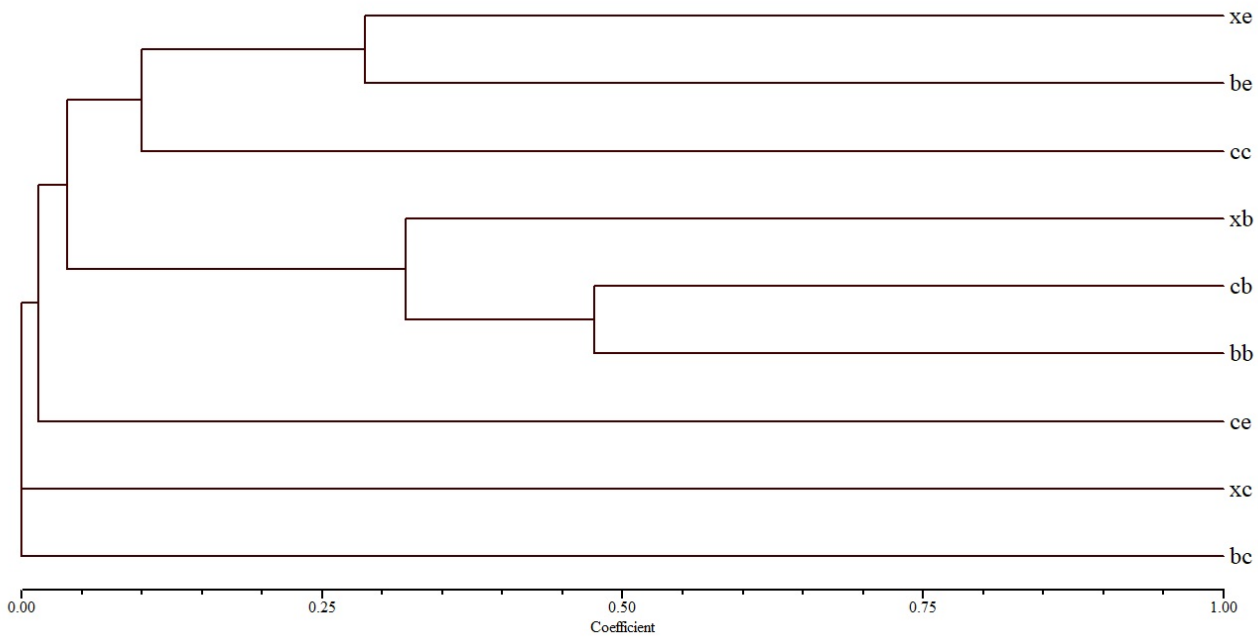
When correlating all areas studied by Sørensen Similarity Index (fig. 3), it is possible to notice that the center area of Xangô and São Braz fragments form outside groups, being more dissimilar in lichen richness compared to all other parts of the fragments, as well as both fragments' edges are more similar between each other, which indicates a preferential tendency for lichens in these habitats, with separation in diversity for edge or center distribution. When analyzing the diversity of lichens with broad distribution, all three fragments formed a cluster, indicating that species with broad distribution also occurred in all fragments, reinforcing the notion of higher adaptability. The richness of the Café's edge and center lichen diverged the most from the same parts of the habitat of other fragments, mainly due to its lichen composition.

Table 1. Lichen species and their preference for parts of the habitat in the three fragments - Xangô, Café, and São Braz - at Gurjaú Ecological Reserve, Pernambuco (Brazil).

		Xangô			**Café**			**São Braz**		
Família	**Espécie**	**E**	**C**	**B**	**E**	**C**	**B**	**E**	**C**	**B**
Arthoniaceae	*Arthothelium* sp.			X						
Arthoniaceae	*Herpothallon rubrocinctum*						X			X
Arthoniaceae	*Cryptothecia* sp. 2				X					X
Arthoniaceae	*Cryptothecia* sp. 1	X					X			
Brigantiaeaceae	*Brigantiaea leucoxantha*						X			
Caliciaceae	*Dirinaria picta*				X					
Caliciaceae	*Pyxine* sp. 1					X				
Cladonicaceae	*Cladonia* sp.					X		X		
Coenogoniaceae	*Coenogonium leprieurii*			X			X			X
Collemataceae	*Leptogium* sp. 2						X			X
Collemataceae	*Leptogium* sp. 1									X
Graphidaceae	*Graphina* sp.				X					
Graphidaceae	*Phaeographis* sp.				X					
Graphidaceae	*Sarcographa intricans*						X			
Graphidaceae	*Ocellularia piperis*									X
Graphidaceae	*Ocellularia dilatata*			X				X		
Malmideaceae	*Malmidea piperis*					X				
Monoblastiaceae	*Anisomeridium* sp.				X					
Opegraphaceae	*Opegrapha* sp.			X						X
Parmeliaceae	*Bulbothrix laevigatula*									X
Parmeliaceae	*Canoparmelia cryptochlorophaea*						X			
Parmeliaceae	*Parmelinella* sp.							X		
Parmeliaceae	*Parmelinopsis minarum*					X				
Parmeliaceae	*Parmotrema* cf *dilatatum*						X			X
Parmeliaceae	*Parmotrema dilatatum*				X					
Parmeliaceae	*Parmotrema praesorediosum*								X	
Pertusariaceae	*Pertusaria* sp.	X						X		
Porinaceae	*Porina mastoidea*			X			X			X
Ramalinaceae	*Bacidia* sp.									X
Ramalinaceae	*Phyllopsora* sp. 1					X				
Ramalinaceae	*Phyllopsora* sp. 2					X				
Ramboldiaceae	*Ramboldia russula*									X
Trypetheliaceae	*Trypethelium* sp.	X								

Legend: E- Edge of fragment, C- Center of fragment, B- Broad distribution. Source: The authors, 2024

Figure 3. Dendrogram of similarity (Sørensen coefficient) produced by cluster analysis (UPGMA connection method) for parts of the habitat in the three fragments – Xangô, Café, and São Braz – at Gurjaú Ecological Reserve, Pernambuco (Brazil)



Legend: xe – Xangô, edge; be – São Braz, edge; cc – Café, center; xb – Xangô, broad distribution; cb – Café broad distribution; bb - São Braz, broad distribution; Café, edge; xc – Xangô, center; bc – São Braz, center. Source: The authors, 2024

When data from all fragments were analyzed, it was observed that most species showed a broad distribution; some remained at the edge and a minority in the center (Table 2).

Table 2. Total distribution of lichen species, according to habitat preference at Gurjaú Ecological Reserve (Pernambuco, Brazil).

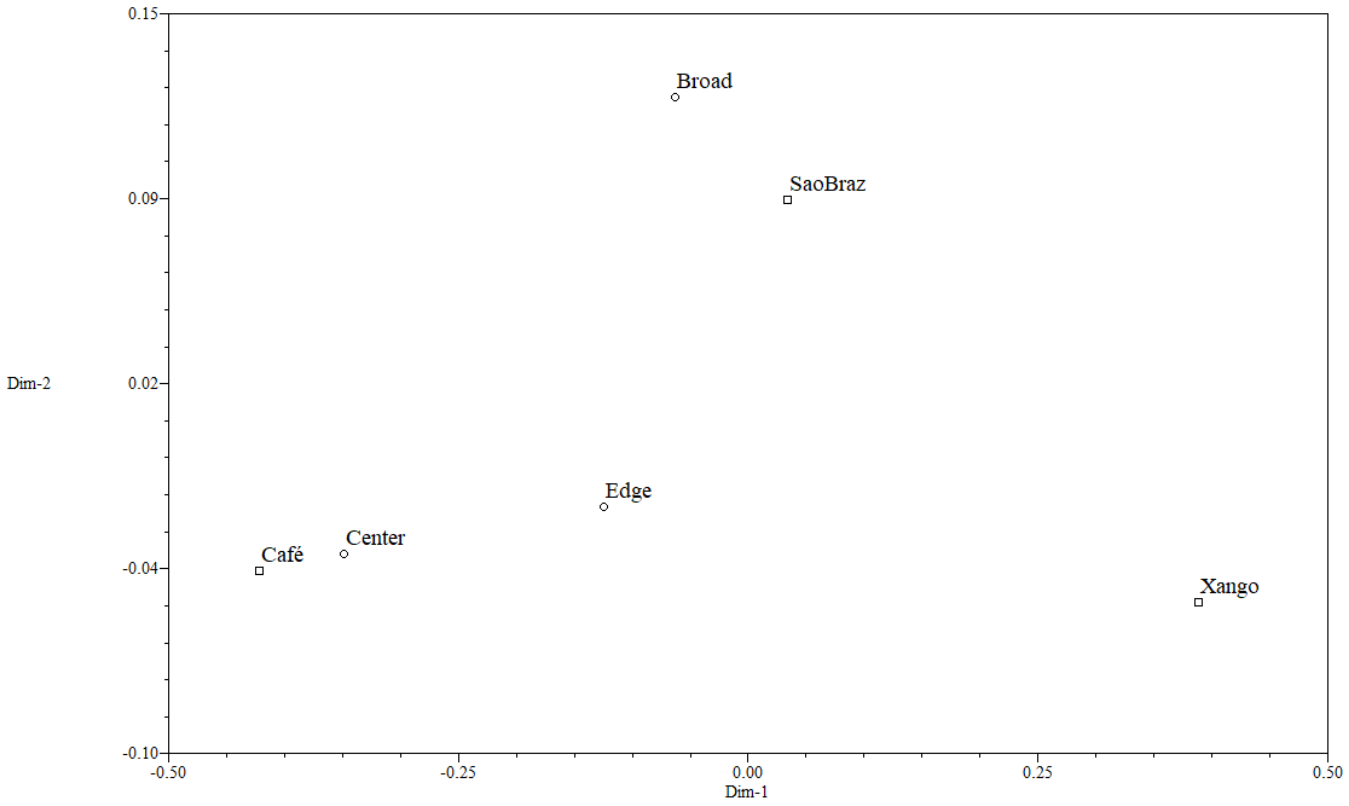
FRAGMENT	HABITAT PREFERENCE			
	EDGE	CENTER	BROAD	TOTAL
SÃO BRAZ	04	01	12	17
CAFÉ	07	06	08	21
XANGÔ	03	00	05	8
TOTAL	14	07	25	46

Source: The authors, 2024

The similarity correlation matrix (Figure 4) shows that the fragments are more dissimilar among themselves than the sector of the habitat of all fragments summed. This way, the area's lichen diversity similarity is less related to the fragments and more correlated to the habitat sector where they occur, with a higher index of species with broad distribution, followed by those occurring exclusively on the edge. In the

central area, the higher humidity and lower light penetration favor the occurrence of small lichen species and foliicolous species, which weren't discussed in this study.

Figure 4. MatrixPlot (MxPlot) of groups similarity using X^2 test, correlating lichen species' fragments diversity and type of habitat preference at Gurjaú Ecological Reserve (Pernambuco, Brazil).



Human interventions could be registered in situ observation of the area, which ratified the responses obtained from the bioindicators. In this sense, it could be observed the stretch from the Gurjaú reservoir, following the river, to the São Braz fragment, where some banana (*Musa paradisiaca*), cassava (*Manihot esculenta*), and papaya (*Carica* spp) cultivations could be seen. It is obvious that in those places, riparian forests must remain (Figure 5 A, B) without suffering competition with those exotic plants, impeding forest regeneration. In addition, how those cultivations are managed can cause instability in the soil, making it vulnerable to erosion and leaching.

Generally, the reservoir margins are well-protected, except at some points where cultivation is seen. Around the reservoir, some herbaceous plants could be registered. Aquatic vegetation is present on the water's surface, as are *Eichhornia* sp. and *Nymphaea* sp. individuals. In those localities, there are no residents, but points for docking of small boats can be seen.

Figure 5. Aspects of the Gurjaú Ecological Reserve, Pernambuco (Brazil). A: Presence of subsistence agriculture with cultivation along with riparian forest; B: Banana tree (*Musa paradisiaca*) cultivation at the slopes of the Atlantic Rainforest (in the background).

Source: Eugênia C.G. Pereira, 2011

Another concerning finding in that area was the register of domestic residues discarded inside the forest or reservoir. The residents mentioned the lack of garbage collection and basic sanitation. This way, the waste is thrown up inside the forest or the water reservoir, which makes it prone to leaching. The breeding of goats, pigs, horses, ducks, etc., and trap points for capybaras could be seen at the margins. The deforested slopes contrast with riparian forests.

Another disturbance that could be attributed to Gurjaú's area was the irregularity register on the synusia line in a fragment behind the reservoir (Figure 6). The lack of uniformity showed a discontinuous line at their top. This finding supports the idea of the existence of forest clearing. According to Wanderley et al. (2019), clearing is another problem in ecosystem dynamics since it breaks up the ecological succession inside the forest. Despite natural clearings, those that resulted from the selective and predatory cuts of vegetation open space to the luminosity, an increase of temperature, and loss of air relative humidity, which affect the organisms, as the edge effect.

Figure 6. Gurjaú Reservoir (Pernambuco, Brazil) – effects of deforestation in the Café fragment.

Legend: The red line indicates irregularities in the forest's canopy, and red arrows indicate the deforested slopes. Source: Eugênia C.G. Pereira, 2011

The squatters aim for short-term profitable results. For this reason, they destroy forests to plant sugar cane, as it is an easy-to-maintain crop, has a guaranteed market (the Bom Jesus Sugar Mill buys the production), and uses the mill's vehicles to transport the product.

Some characteristics give a certain degree of homogeneity to the studied area: poverty, lack of information, and few resources. These aspects reproduce the general situation of the environmental problem, with all the difficulties in finding solutions. Figure 7 portrays this issue in the form of a practical example. During one of the field studies, teenagers were caught with a pale-throated sloth (*Bradypus tridactylus*), an animal typical of the Atlantic Forest. They usually use it as food and prefer it because it is a docile animal that is easy to capture. More effective public policies that encourage environmental education could alleviate this problem. Young people are more accessible to information and can easily pass it on to their elders, some of whom are also open to change.

Figure 7. Teenagers from Gurjaú Ecological Reserve neighborhoods communities after a hunt for a pale-throated sloth, aiming to use it as food.

Source: Eugênia C.G. Pereira, 2011

The disregard for planning institutions with the local community was found at different levels. Surveys, diagnoses, reports, recommendations, plans, and projects exist considerably, but concrete actions to solve fundamental problems are lacking. The regulation of the use of soil would imply its ordering, discipline, and recovery of deforested areas and riparian forests, as well as the prediction of the maintenance of water reservoirs and forests. Thus, the lack of that maintenance leads to expanding agricultural and farm allotments, endangering the balance of ecosystems.

The influence area of the Ecological Reserve of Gurjaú fragments can be defined as exerting any direct interference on the Unit. In this context, there are considered the municipalities where the reserve is inserted - Jaboatão dos Guararapes, Cabo de Santo Agostinho e Moreno. It was defined by its geographical insertion and the relationship between the reserve and its neighborhood through inspection actions or potential vectors of anthropic transformation originating from surrounding areas. These vectors are potential pressure forces for anthropic use in the Gurjaú Reserve region.

This discussion attempted to place the Reserve in a context subject to anthropogenic changes resulting from development processes triggered by the presence of public policies implemented in that region, mainly those to encourage agriculture and livestock farming. Thus, the Reserve is exposed to the forms of pressure that are exerted, directly and indirectly.

The activities and public policies implemented in the surrounding area may conflict, to a greater or lesser extent, with the conservationist objectives that motivated the creation of the Reserve. Regarding administrative interference, municipal and state agencies could intervene as essential active agents in raising environmental awareness among the surrounding communities.

On the other hand, several approaches exist to understanding and contextualizing the area of influence of the Gurjaú Reserve since the Reserve cannot be isolated and reduced to the physical space it occupies. Its impact must be understood from the inside out and vice versa, which offers different perspectives for evaluating the various anthropogenic factors identified.

In recent decades, human pressure on the Reserve has reduced the vegetation cover to a very worrying extent. Aerial photos from the FAB/SUDENE project (GERAN-1970) and the FIDEM project (1983), obtained from the aerial survey of the 1º/6º GAV of the Recife Air Base, prove that the area surrounding the reserve in the 1970s had almost contiguous vegetation cover. Photos from the 1980s showed that the reserve, located in an insular area and with practically no occurrence of native vegetation in the surrounding area, managed to maintain its integrity partially. However, there is concern about the advance of crops over the forests and how much more farmers will cut down.

FINAL CONSIDERATIONS

In general, degradation is caused by the expansion of rural properties, increased sugarcane production, and misinformation among communities surrounding the reserve. On the other hand, the arrangement and distribution of organisms in an ecosystem and how they develop and interact between populations, among other aspects, are valuable information for diagnosing environmental quality.

In this way, the degradation of ecosystems reduces the area of natural vegetation, especially in the case of monoculture, whose progressive fragmentation of these remnants leads to higher isolation of the parts (Testa et al., 2020; Balassa et al., 2023).

It was possible to conclude that based on knowledge of the local history, environmental problems, and the actors involved in the issue, the data generated by the survey and distribution of lichens inside and on the edge of the fragments corroborate the advanced stage of disturbance of the area, qualifying these living beings as efficient bioindicators.

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