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EFFECT OF HUMAN DISTURBANCES ON ANT COMMUNITY AND AMAZONIAN LANDSCAPE

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ABSTRACT

The present work aimed to evaluate the effect of anthropogenic disturbances on the ant community and on the Amazonian landscape in areas of tropical rain forest. The study was conducted in two areas: Cabo Rosa Forest and Tauari Forest with different levels of human disturbances in the municipality of Marabá, Pará, Brazil. A characterization of the descriptors of anthropogenic activities was carried out for each study area in order to generate an index of anthropogenic disturbance. The vegetation structure was classified into: exposed soil, low, medium and high vegetation cover through NDVI. Ant sampling was carried out using pitfall traps. The vegetation structure, diversity and abundance parameters were related to the areas. Similarities between the species composition of the ant communities were verified by a similarity analysis. We found that human disturbances are modifying the vegetation structure by reducing the forest cover of the tree stratum and leaving the landscape with a higher occurrence of open areas. Regarding the ant community, we corroborate the hypothesis that anthropic disturbances are reducing the local biodiversity. Thus, this study shows that anthropogenic disturbances have negative effects on the Amazonian landscape and on the ant community through the reduction of forest cover and decrease in ant biodiversity. These changes can cause

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the conversion of climax communities in early successional stages and reduce the ecological services provided by ants (e.g. seed dispersal).

Keywords: Ant biodiversity, Forest cover, Tropical rainforest, Landscapes modified by humans.

1. INTRODUCTION

The diversity of local communities is result of evolutionary processes (e.g. speciation rate), biogeographic (e.g. migration processes), ecological (e.g. interactions between species and community response to environmental gradients and disturbances), and to be understood it must be analyzed in regional scale [1]. Human disturbances have long been known to be the main factor in reducing biodiversity and ecosystem services [2]. A decline in populations of species sensitive to disturbance [3] and non-random loss of taxonomic, functional and phylogenetic diversity [4]has been reported. Human activities on ecosystems can both selectively remove species from environments and add others as well [5]. As an example, a set of invasive species and diseases were introduced into tropical forests, leading to extinctions of species that affected pollination, seed dispersal, herbivory and predation functions [6].

That is a reality in legal Amazon territory in Brazil, which in the year 2019 recorded a 30% increase in deforestation in relation to the previous year and is the highest percentage since 2007 according to data generated by the *Programa de Monitoramento do Desmatamento da Amazônia por Satélite* (PRODES) managed by *Instituto Nacional de Pesquisas Espaciais do Brasil* (INPE) [7]. Changes in the extent of the forest influence biogeochemical cycles and the biophysical properties of the Earth's surface [8]. For example, simulations of deforestation in tropical areas generate an increase in the global temperature of 0.9 °C, mainly due to changes in the carbon cycle which can lead to local extinctions [9]. In the interval of 150 years (1863 - 2013) the number of endangered species increased from 1 record to 11,749 and over the years 2007 to 2013 alone, this number increased by 28% [10]. This is worrying since Brazil has the greatest biodiversity on the planet, representing 20% of all fauna and flora. If we consider only the Amazon rainforest there are 13,993 species of plants, 1800 of fish, 1300 of birds, 399 of mammals, 284 of reptiles and 250 of amphibians, not to mention the invertebrates that make up 70% of all Amazonian biodiversity not yet cataloged [11].

In the ecological context of human-modified landscapes, only a group of species originally from the ecosystem must withstand the new environmental conditions: the pioneer plant species[12] become increasingly dominant in fragmented landscapes and groups of generalist animals [13]. This leads to a more homogeneous taxonomic, phylogenetic and functional ecosystems [14].In general, the responses of biological communities to human disturbances may include loss of diversity, changes in species composition, in interspecific interactions and changes in the

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ecological services provided, like the animal plant interaction: seed dispersal, pollination and predation [14]. Thus, specific responses from plant and ant communities in relation to human disturbances may reflect responses from other organisms with which they co-occur and has ecological interactions [15].

Given this information, this work aimed to expand knowledge about the responses of biological communities in tropical rainforests in relation to human disturbances. Specifically, we tested the hypothesis that human disturbances in areas of tropical rainforest have negative effects for biota, at two levels: (1) ant community and (2) vegetation structure. We hoped to find in areas of high human activity: (i) less abundance, evenness, richness and diversity of ant species; (ii) greater dominance of ant species, (iii) low similarity in species composition compared to the area with the less human impact. In addition, we expect that areas with the highest human disturbance will present a reduction in the arboreal stratum and with an increase in open areas: a higher proportion of medium and low density vegetation cover. In order to do this, we obtain information about the effects of human disturbances on the Amazonian biota.

2. MATERIALS AND METHODS

2.1 Study area

The present study was carried out in areas of tropical rainforest in the city of Marabá (5°22'26"S 49°08'17"W) located in the southeast of the state of Pará, Brazil. The climate of the region is semi-humid tropical (Aw, according to the classification of Köppen) with average temperature and precipitation of 27°C and 121.91 mm, respectively [16]. The study area is drained by Tauari River, which flows into the Tocantins River. The soil type commonly found is the red yellow latosol with low drainage associated with red yellow podzolic soil. The vegetation has three types: dense rainforest, open rainforest and anthropic areas. The floristic composition shows the predominance of families: Fabaceae, Sapotaceae, Moraceae, Burseraceae, Lecythidaceae and Myrtaceae [16]. Two areas were selected around the Tauari River to carry out the research: (A) Cabo Rosa Forest Base (hereinafter, Cabo Rosa forest - CRF) (5°21'44"S 49°01'08"W), it is a territory for the exclusive use of the Brazilian Army and its access to the local community is partially restricted; and (B) forest area of the Tauari River that is around campus III of the Universidade Federal do Sul e Sudeste do Pará – Unifesspa (hereinafter, Tauari forest – TF) (5°21'26"S 49°00'21"W) (Figure 1), The area is a reserve of Unifesspa. Until 2015 the area was mostly deforested for pasture (and other activities like: hunting, removal of non-timber forest products, and removal of wood). With the implantation of the campus of Unifesspa the forest started to regenerate.

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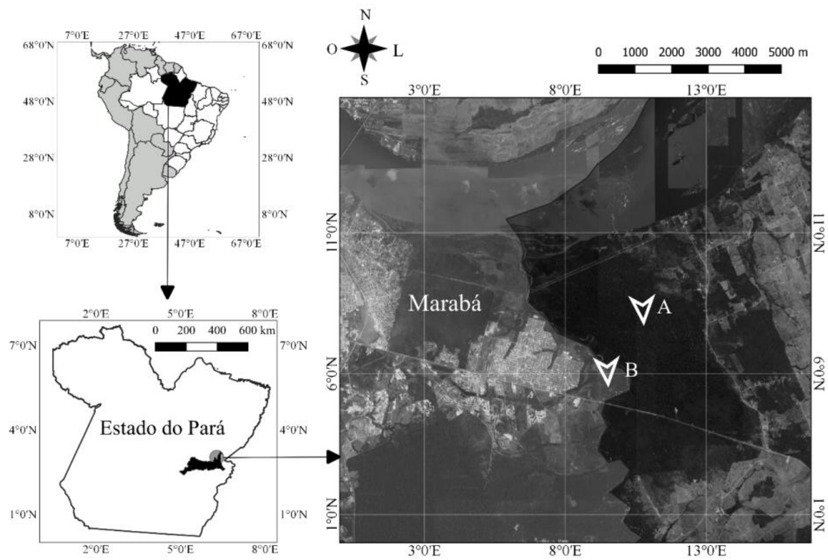

Fig. 1: Georeferencing of the study areas: (A) Cabo Rosa forest, and (B) Tauari forest areas located in in the city of Marabá, PA, Brazil.

2.2. Characterization of human disturbances

Considering that different human activities can have different effects on tropical forests, it is important to measure the disturbance from different descriptors of sources of disturbance [17]. Considering the reality of human occupation in the Marabá region, we selected two disturbance descriptors: 1) descriptors linked to the distance from urban centers; and 2) a descriptor related to the loss of vegetation cover.

The descriptors related to distance for human activities centers consisted of measuring in meters between the central point of each area in relation to: 1) the headquarters of the city of Marabá (5°22'26.8"S 49°08'17.1"W); 2) the nearest human settlement; 3) the shortest distance between the nearest road (paved or unpaved). Theoretically, the greater the distance to the nuclei of human activity, the fewer disturbances the area is subjected to. According to Ahrends et al. (2010) the resources that are located closest to human settlements tend to be exploited first, which produces sequential waves of forest degradation. The distance values of the descriptors will be combined into an arithmetic mean and a disturbance index will be generated for each study area (the lower mean value means the higher human disturbance). The descriptor of loss of vegetation cover was related through the vegetation structure. The vegetation structure was measured using NDVI (Normalized Difference Vegetation Index). NDVI measures the relationship between radiation reflected by the Earth's surface in the wavelengths of visible red and near red (assumes values between zero and one). It has been widely used as an indicator of

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photosynthetic activity, the amount of plant biomass and, frequently, correlates with the level of disturbance to which ecosystems are subject (Wang et al., 2007). The image package of the study areas was used of the United States Geological Survey website (United States Geological Survey - USGS) generated by the LANDSAT8 satellite. After that the bands were treated using the software Qgis (v. 3.4.). Iso Cluster Unsupervised Classification (with variation of -1 to 1) was used to create four categories of vegetation cover in the both study areas based on reflectance of soil vegetation: (1) exposed soil (0-10% of vegetation cover = -0.5 NDVI cluster), (2) low vegetation cover (11-30% = 0 NDVI cluster) or predominantly herbaceous vegetation, (3) medium vegetation cover (31-50% = 0.5 NDVI cluster) or predominant shrub vegetation and (4) high vegetation cover (>51% = 1 NDVI cluster) or arboreous vegetation. The vegetation structure is used as an environmental balance parameter [20]. In secondary forest environments the canopy is more open with predominance of understory trees and woody vines [16] in contrast, climax forests have the most closed canopy [18].

2.3. Ant sampling

Ant samples were taken using 20 pitfall traps placed 10 meters apart in a 200 m long transect in each study area. Each trap consisted of a 300 ml plastic cup filled just under half with water, salt solution and detergent. The traps were buried in such a way that the opening of the cups was level with the surface of the soil and exposed for 48 hours. After this period, all biological material was collected and taken to the *Museu de Biodiversidade Tauari* from Unifesspa, and stored in plastic pots containing 80% alcohol. The collected ants were analyzed and identified according to Baccaro et al (2015) and morphotyped with the help of the sites: AntiWiki (https://www.antwiki.org/) and AntWeb (https://www.antweb.org/), stored and registered in the museum's collection.

2.4. Data analysis

To test the prediction that human disturbances reduce relative abundance (number of individuals in a population in relation to the total number of individuals in all populations), equability (Pielou) species richness and diversity (Indexes: Shannon-Weaver and richeness estimator Chao1) and increases species dominance (Simpson dominance) a GLMM (General linear models with random effect) test was performed, we consider pitfalls as a random factor (in order to increase sampling independence) with Poisson type error distribution in the following R program packages: *vegan*, *nlme*, *stats*, *mlmRev*, *lme4*, *gplots*, *psych* and *Rcmdr*. A similarity analysis (Morisita-Horn) was carried out between the areas to verify the similarities between the species composition. The Morisita similarity index is the most satisfactory among the available indexes, although it is strongly influenced by the abundance of the most common species. According to the percentages of similarity, measured also through relative abundances [22]. We used chi-

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square tests [23] to assess variation in the frequency of occurrence of vegetation cover categories: exposed soil, low, medium and high density vegetation. We calculate the expected frequencies considering the percentage of areas (5 x 5 m²) cover by the vegetation cover categories multiplied by the proportion of area cover by vegetation cover categories. All analyzes were performed using the R 3.5.3 statistical program.

3. RESULTS AND DISCUSSIONS

Human activities have caused several changes in all ecosystems, accessing the consequences of the disturbance generated by these activities on the structuring of the community is an indispensable and challenging issue in ecology [24]. Here in this study we try to elucidate the effects of human disturbances on the amazonian biota, considering the ant community and the vegetation structure of the landscape in areas of tropical rainforest. We found that the human disturbances are modifying the plant structure of the forests reducing the occurrence of the arboreal layer and reduce the biodiversity of ants.

Considering the descriptors of human activities (disturbance index), the Tauari forest (on average, 2703.5 m ± 4481.2, Standard Deviation) is under higher human pressure than the Cabo Rosa forest (4347.5 ± 3972.8) (Table 1).

Table 1: Summary of anthropogenic disturbance descriptors and disturbance index for the areas: Cabo Rosa forest (CRF), and Tauari Forest (TF) areas located in the city of Marabá, PA, Brazil. The disturbance index corresponds to the arithmetic mean between the disturbance descriptors for each area. SD = Standard Deviation.

Disturbance descriotor	Area	Distance (m)
Distance to Marabá	CRF	10250
	TF	9430
Distance to the nearest human settlement	CRF	2700
	TF	290
Distance to nearest paved road	CRF	2830
	TF	813
Distance to nearest unpaved road	CR	1610
	TF	281
Disturbance index	CR	4347.5 ± 3972.8 (± SD)
	TF	2703.5 ± 4491.2

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Many studies have shown that distance from the nearest road is a strong indicator of local human activity [2,19], and it is a good predictor of loss of woody species in tropical forests in Brazil due to use by people [25]. Ecosystems that are shaped by human activities generally share characteristics such as homogenization of the landscape and high input of nutrients and energy and simplified food chains [26]. Deforestation is one of the main activities (e.g. hunting, extraction of non-wood products, slash-and-burn agriculture, more details see Arnan et al., 2018) which causes a reduction in forest cover and, consequently, changes in the structure of forests, for example, reduction of the tree layer with an increase in exposed soil areas [27]. We found similar results when analyzing the NDVI, where the Tauari forest presented a higher occurrence of areas with medium vegetation cover (36.84%), followed by low vegetation cover (31.58%) and high vegetation cover (26.31%) (Figure 2).

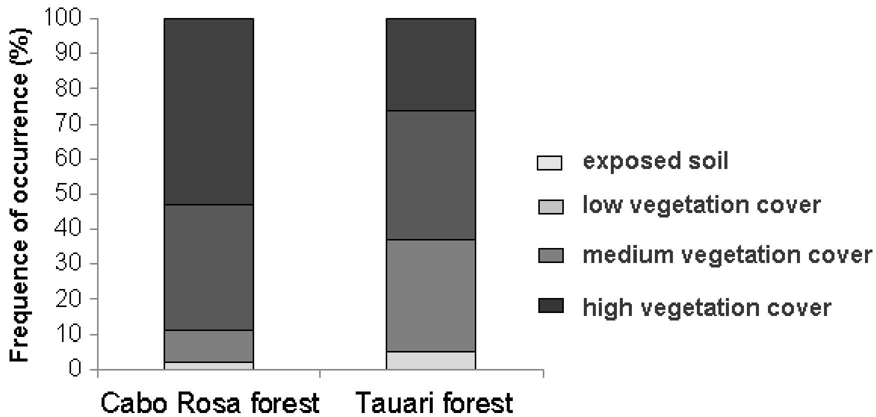

Fig. 2: Frequency of occurrence of vegetation cover categories (exposed soil, low, medium and high vegetation cover) based on normalized difference vegetation index in Cabo Rosa forest and Tauari forest areas located in in the city of Marabá, PA, Brazil.

The different pattern occurred for Cabo Rosa forest where we found a higher occurrence of areas with high vegetation cover (53.27%), medium vegetation cover (35.51%) and low vegetation cover (9.35%) (Figure 2). The frequency of each vegetation cover category had difference between the observed and expected frequency of occurrence (Figure 2, Table 2).

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Table 2: Chi-square analyses of frequency of occurrence categories of vegetation cover (exposed soil, low, medium, high vegetation cover) in Cabo Rosa forest and Tauari forest areas located in the city of Marabá, PA, Brazil.

Area	Df	χ^2	P
Cabo Rosa forest	3	67.6	0.0001
Tauari forest	3	22.9	0.0001

This is an indication that the Tauari Forest is losing its tree cover in face of anthropic pressures. Reduction in the plant structure of forests causes homogenization of plant and animal communities at the regional level [14] with declining populations of species sensitive to disturbance [25]. If anthropic activities at Tauari forest are not interrupted over the years the vegetation can become increasingly open areas (greater occurrence of areas with exposed soil). Cabo Rosa forest still maintains a high forest cover, which is mainly due to the exclusive use of the Brazilian Army and its use is restricted.

Reduction of vegetation cover in forests causes the conversion of climax communities to initial stages of succession [28]. Thus, the effects of disturbances can result in simplification and homogenization of biological communities. The reduction in species richness is in general the main consequence of human disturbances in ecosystems, which can lead to a reduction in ecosystem services. However, species richness alone does not inform how communities are structuring themselves after human disturbance. Different approaches are needed to understand the functioning of ecosystems: evolutionary history, community structure, species functionality, approaches at different levels of biological diversity [29].

Regarding the ant community in total, 935 ants belonging to 44 morphospecies, distributed in 8 subfamilies were sampled. In general, Myrmicinae was the most representative subfamily with 124 individuals, followed by Ectatomminae with 45 and Ponerinae with 16. *Ectatomma permagnum* was the species with the highest abundance representing 200 individuals followed by *Solenopsis* sp.1 and *Pheidole* sp.2. The pattern of greater representativeness of Myrmecinae and Ectatomminae was expected due to the ecology of these families with several generalist species adapted to different environmental conditions and often associated with anthropization of the environment such as some species of the genera *Ectatomma* and *Pheidole* [30,31].

Analyzing the relative abundance of ants, Cabo Rosa forest (5 ± 4.09) and Tauari forest (5 ± 3.59) presented similar results (Table 3; Figure 3a).

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Table 3: Effects of area and responses to relative abundance, Pielou equability index, Simpson's dominance index, richness, Shannon diversity index and Chao1 estimator in Cabo Rosa forest and Tauari forest areas located in the city of Marabá, PA, Brazil. Significant effects are in bold (P < 0.05) of the full factorial generalized linear mixed models.

Response variable	Effect	Df	*F*	*P*
Relative abundance	Area	19	0.01	0.920
Pielou equability index	Area	19	4.44	**0.041**
Simpson's dominance index	Area	19	10.27	**0.005**
Richness	Area	19	8.60	**0.008**
Shannon diversity index	Area	19	12.64	**0.002**
Chao1 estimator	Area	19	4.43	**0.043**

This is related to the higher occurrence of some species in the Tauari forest, where *Ectatomma permagnum* (Ectatomminae) was the one with the highest occurrence (52.7%) followed by *Pheidole* sp.2 (21.3%) (table 4). We can see that about half of the sampled ants belong to the species *E. permagnun*, generally species of the Ectatomminae family are generalist predators that build their nests on soil, litter, on decomposing trunks or even on the arboreal and shrub strata of forests, including the canopy. Generalist ant species benefit from human disturbances [32]. The same is true for the genus *Pheidole*, they are omnivorous and very opportunistic ants, with some species with proven importance in the dispersion of seeds. These species may be increasing the size of their populations in the Tauri forest and thus balancing the values of abundance between the areas. On the other hand, in Cabo Rosa forest, we observed that *Solenopsis* sp.1 (28%) was the most common species followed by *Cardiocondyla* sp.1 (16.1%) (Table 4).

Table 4: Ant subfamilies and species recorded in: Cabo Rosa forest (CRF) and Tauari forest (TF) areas located in the city of Marabá, PA, Brazil. The overall of relative abundance (%) by the ant species are presented.

	Relative abundance (%)	
Subfamily/Species	**CRF**	**TF**
Dolichoderinae		
Dolichoderus sp.1	0.4	-
Tapinoma sp.1	0.2	-
Dorylinae		
Labidusspininodis (Emery, 1890)	1.4	-

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Neivamyrmexwilsoni (Snelling & Snelling, 2007)	0.4	-
Acanthostichusbentoni (Mackay, 1996)	0.2	-
Ectatomminae		
Gnamptogenyshorni (Santschi, 1929)	0.4	-
Gnamptogenys sp.2	0.5	-
Neoponeraapicalis (Latreille, 1802)	1.9	8.2
Ectatomma edentatum (Roger, 1863)	3.5	-
Ectatomma permagnum (Forel, 1908)	0.5	52.7
Ectatomma tuberculatum (Olivier, 1792)	-	0.5
Gnamptogenysbrunnea (Lattke, 1995)	0.2	0.3
Formicinae		
Camponotusbrettesi (Forel, 1899)	0.4	0.3
Camponotus sp.2	-	0.5
Camponotus sp.3	-	0.3
Nylanderia sp.1	0.7	-
Myrmicenae		
Acromyrmex coronatus (Fabricius, 1804)	1.1	-
Acromyrmex octospinosus (Reich, 1793)	4.7	3
Acromyrmex rugosus (Smith, 1858)	1.4	1.6
Atta sexdens (Linnaeus, 1758)	-	0.5
Cephalotesoculatus (Spinola, 1851)	-	0.5
Crematogaster sp.2	0.2	-
Crematogaster aculeata (Donisthorpe, 1941)	4.2	-
Crematogaster flavosensitiva (Longino, 2003)	0.2	-
Crematogaster sp.2	3.7	-
Cyphomyrmexminutos (Mayr, 1862)	0.5	-
Cardiocondyla sp.1	16.1	-
Dacetonarmigerum (Latreille, 1802)	0.2	-
Pheidole astur (Wilson, 2003)	4	-
Pheidole cataractae (Wheeler, 1916)	3.9	0.5
Pheidole sculptior (Forel, 1893)	10.2	0.8
Pheidole sp.2	7.4	21.3
Pheidole sp.5	0.2	-
Megalomyrmex sp.1	0.2	-
Megalomyrmex sp.2	0.2	-
Solenopsis sp.1	28.5	3

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Solenopsis sp.2	1.6	-
Strumigenysdenticulata (Mayr, 1887)	0.4	-
Trachymyrmex sp.1	0.2	-
Paraponerinae		
Paraponeraclavata (Fabricius, 1775)	-	0.5
Ponerinae		
Mayaponeraconstricta (Mayr, 1884)	0.2	0.3
Odontomachusbauri (Emery, 1892)	-	0.8
Pachycondylacrassinoda (Latreille, 1802)	-	3.3
Pseudomyrmecinae		
Pseudomyrmex tenuis (Fabricius, 1804)	30.5	0.8

Species of the genus *Solenopsis* are found in the most diverse habitats, such as forest environments, fields and savannas and some species are well adapted to disturbed environments [33]. The same occurs for species of the genus *Cardiocondyla* [21]. We note that both areas present as the most abundant species of ants that benefit from human disturbances. Indicating that both areas are under the effect of these disturbances but with different intensities (Table 2; Figure 2). When comparing the two areas in relation to equability, the data becomes even clearer. Cabo Rosa forest showed greater uniformity between the abundance of ant species (0.73 ± 0.19) compared to Tauari forest (0.59 ± 0.26) (Table 3; Figure 3b). Values above 0.70 suggest uniformity in the proportions of the number of individuals in relation to number of species within the community, an expected finding, as equitability is directly proportional to diversity and antagonistic to dominance [34]. These contrasting values between areas can be explained precisely due the predominance of *E. permagnum* and *Pheidole* sp.2 in Tauari forest, that is, both species represent 73.9% of ants sampled in that area. Thus, the Tauari forest showed a greater dominance of species (0.58 ± 0.21) when compared to Cabo Rosa forest (0.40 ± 0.20) (Table 3; Figure 3c). This result was expected due to less equability in the most disturbed area, which shows that few species are proliferating in the Tauari forest (e.g. *E. permagnum* and *Pheidole* sp.2). It is expected that in landscapes modified by humans, only a few species of ants support the new environmental conditions and make them dominant in the area, culminating in biotas with less richness and more homogeneous in taxonomic, phylogenetic and functional terms[14].

The dominance of some species in the community and changes in the physical environment, such as changes in temperature and humidity, plant structure of forests and through changes in the pattern of ecological interactions [25] puts the biodiversity reduction in areas with high human activity as the main result of human disturbance. Our results corroborate this premise, where Tauari forest presented a lower ant species richness (3.45 ± 1.64) and diversity (0.77 ± 0.43) when compared to Cabo Rosa forest (5.3 ± 2.30, 1.22 ± 0.49, respectively) (Table 3; Figure 3d

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and 3e). The same pattern was found when we calculated the richness expected by the Chao1 estimator (Table 3; Figure 3f).

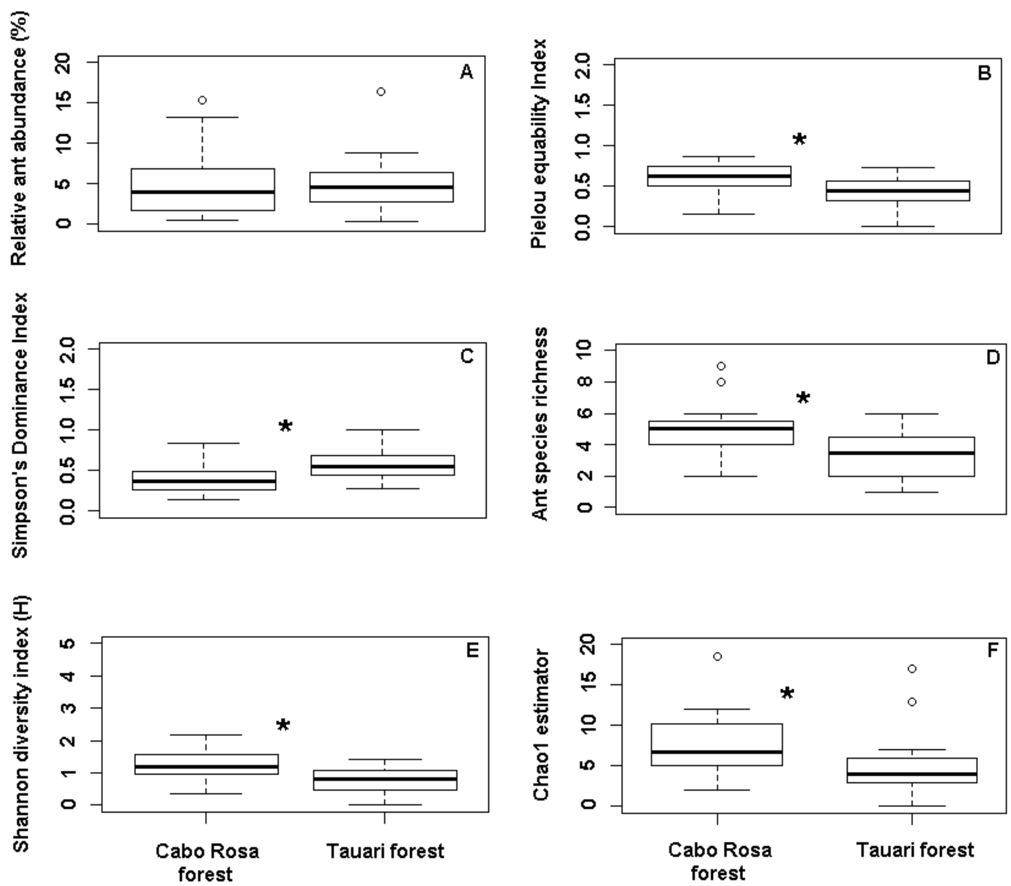

Fig. 3: Boxplot of the results of relative ant abundance (A), Pielou equability index (B), Simpson's dominance index (c), ant species richness (D), Shannon diversity index (E), and Chao1 estimator (F) plotted in relation to Cabo Rosa forest and Tauari forest areas located in in the city of Marabá, PA, Brazil. * Means significant effects (P < 0.05) of the full factorial generalized linear mixed models.

It is known that areas with different levels of anthropogenic disturbance shows a reduction in the patterns of species richness [35]. The diversity of ants in conserved areas can be up to two times greater in relation to anthropic areas [36] which demonstrates the effects of human pressure on the ant community. Although the area with less human disturbance has higher diversity values, the Shannon-Weaver index found of 0.77 demonstrates that there is a low concentration of species in general. Where in conserved environments or low anthropogenic impacts are expected to be above 3 for the Shannon-Weaver index [34]. Another worrying value is the data from the

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Chao1 richness estimator, where 1.58 times more species were expected for Cabo Rosa forest than was collected and 1.42 times more species for Tauari forest. Thus, we demonstrate that the patterns of biodiversity (richness and diversity) are reduced in an area with higher human disturbance. The Tauari forest has a smaller proportion of the number of species available at the local level. This shows that human disturbances are acting as environmental filters and are altering the competitive balance between species, changing the most abundant groups, however, not necessarily causing the local extinction of the groups of ants most susceptible to human disturbances [37]. These changes may have an important impact on the provision of environmental services such as seed dispersal, since distinct functional groups of ants (with different efficiencies as seed dispersers) have different responses to human disturbances [38].

As reported here in this study, human disturbances had negative effects on the ant community (reduction: biodiversity and equability; and increased dominance); such changes in the community cause distinct biotas in relation to different intensities of anthropic impact on the ecosystem [14]. Where we found a low similarity (14%) between Tauri forest and Cabo Rosa forest (Figure 4), this result is because some species and subfamilies are exclusive to a single area or occur with low abundance.

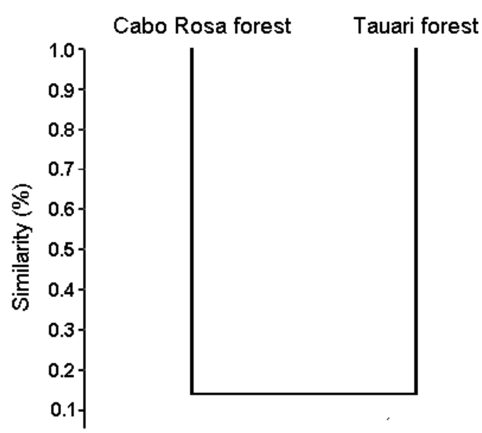

Figure 4: Morisita–Horn similarity dendrogram between Cabo Rosa forest and Tauari forest areas located in in the city of Marabá, PA, Brazil.

Cabo Rosa forest presented 21 exclusive species while Tauari forest presented 8 species (Table 4).The subfamilies Dolichoderinae (species: *Dolichonderus* sp.1 and *Tapinoma* sp.1) and Dorylinae (species: *Labidusspininodis* and *Neivamyrmexwilsoni*) were exclusively in Cabo Rosa forest. The subfamily Dorylinae has a low occurrence in soils altered by anthropic activities (Bulova et al., 2016), while the occurrence of Dolichoderinae in fragmented forest areas has been reported to be low in abundance and richness [15]. The leaf-cutting ant *Atta sexdens* was present only in the area with the highest anthropic impact. Leaf-cutting ants of the genus *Atta* are known

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to proliferate after human disturbance in Neotropical forests due to their preference for open habitats and the lack of population control in those disturbed areas [39]. Therefore, the low similarity found is explained to the diverse pressures exerted on communities throughout different historical situations, in which many are particular to each species or community, which can be influenced by environmental issues, in addition to anthropic ones. As a result, each community presents different responses to natural or man-made evolutionary pressures [40]. Since groups of species whose life history characteristics give them less tolerance for human disturbances must be, at least locally extinct [41]. Thereby, there are ecosystems with impoverished fauna in terms of species, as well as in ecological strategies and evolutionary histories distinct.

4. CONCLUSIONS

The present study shows that human disturbances have negative effects on the ant community and on the Amazonian landscape in areas of tropical rainforest. Specifically, more preserved areas have greater coverage of the tree strata and a more diverse ant community than in areas with a high level of human disturbance where there was a greater occurrence of opens areas, low diversity and high dominance of some species of ants. Areas with higher human impact show low similarity with more preserved areas. The low similarity between the areas may indicate that there is no gene flow between the ant communities of Cabo Rosa forest and Tauari forest. The low similarity is worrying due to differences in species richness between areas, mainly due to changes in the structure of vegetation. What can cause morpho-functional changes in ant communities over the years and these modifications can harm the provision of environmental services such as seed dispersal, herbivory, predation and maintenance of ecological interactions.

We suggest that in future research they aim to identify the functional attributes of ants, as well as the phylogenetic structuring of communities subjected to different environmental filters (e.g. soil type, seasonality and different levels and / or sources of disturbance) to elucidate whether these losses they are, in fact, random, or whether there are successful and unsuccessful ecological strategies in relation to these environmental filters. Regarding the Amazonian landscape, it is important to know which plant species are most susceptible and tolerant to different types of human disturbances in order to plan forest management, in regions that are in a better state of conservation or that have already been altered. This is an important issue to be addressed by ecologists in view of the management of “new ecosystems” altered by humans.

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REFERENCES

[1] Ricklefs RE. 2008. Disintegration of the Ecological Community. The American Naturalist, 172 (6): 741-750.Perfect, T. J., & Schwartz, B. L. (Eds.) (2002). Applied metacognition Retrieved from http://www.questia.com/read/107598848.

[2] Martorell C, Peters EM. 2005. The measurement of chronic disturbance and its effects on the threatened cactus Mammillaria pectinifera. Biological Conservation, 124 (2): 199-207.

[3] Laurance WF, Camargo JLC, Luizão RCC, Laurance SG, Pimm SL, Bruna EM,Stouffer PC, Williamson GB, Benítez-Malvido J, Vasconcelos H. 2011. The fate of Amazonian forest fragments: A 32-year investigation. Biological Conservation, 144 (1): 56-67.

[4] Santos JC, Leal IR, Almeida-Cortez JS, Fernandes GW, Tabarelli M. 2011. Caatinga: The Scientific Negligence Experienced by a Dry Tropical Forest. Tropical Conservation Science, 4 (3): 276-286.

[5] Clavero M, García-Berthou E. 2005. Invasive species are a leading cause of animal extinctions. Trends in Ecology and Evolution, 20 (3):110.

[6] Van Kleunen M, Weber E, Fischer M. 2010. A meta-analysis of trait differences between invasive and non-invasive plant species. Ecology Letters,13 (2): 235-245.

[7] Brasil. 2019. Impe (Instituto Nacional De Pesquisas Espaciais Do Brasil). Monitoramento do Desmatamento da Floresta Amazônica Brasileira por Satélite. Disponível em: <http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes>. (Acessoem: 11 fev. 2020).

[8] Gatti LV et al. 2014. Drought sensitivity of Amazonian carbon balance revealed by atmospheric measurements. Nature, 506 (7486): 76-80.

[9] Anderson RG et al. 2011. Biophysical considerations in forestry for climate protection. Frontiers in Ecology and the Environment, 9 (3): 174-182.

[10] Brasil. 2017. Instituto Chico Mendes De Conservação Da Biodiversidade (ICMBIO). Espécies ameaçadas. Disponível em: <https://portaldabiodiversidade.icmbio.gov.br/portal/search/list?ssId=0d3268d7810c649bb2f1e7035308a0a3>. (Acessoem: 11 fev. 2020).

[11] Brasil. 2016. Ministério Do Meio Ambiente (MMA). Biodiversidade. Disponível em: <https://www.mma.gov.br/biodiversidade.html>. (Acessoem: 11 fev. 2020).

 Copyright © IJAER 2022, All rights reserved

ISSN: 2455-6939

Volume: 08, Issue: 01 "January-February 2022"

[12] Tabarelli MI et al. 2012. Secondary forests as biodiversity repositories in human-modified landscapes: insights from the Neotropics Florests. Boletim do Museu Paranaense Emílio Goeldi. Ciências Naturais, 7 (3):319-328.

[13] Lees AC, Peres CA. 2006. Rapid avifaunal collapse along the Amazonian deforestation frontier. Biological Conservation, 133 (2): 198-211.

[14] Ribeiro-Neto JD et al. 2016. Chronic anthropogenic disturbance causes homogenization of plant and ant communities in the Brazilian Caatinga. Biodiversity Conservation, 25: 943-956.

[15] Gomes JP, Iannuzzi L, Leal IR. 2010. Resposta da comunidade de formigas aos atributos dos fragmentos e da vegetação em uma paisagem da Floresta Atlântica nordestina. Neotropical Entomology, 39 (6): 898-905.

[16] Silva WAS. et al. 2014. Composição e Diversidade Florística em Um Trecho de Floresta de Terra Firme no Sudoeste do Estado do Amapá, Amazônia Oriental, Brasil. Biota Amazônia, 4 (3): 31-36.

[17] Arnan X, Leal IR, Tabarelli M, Andrade JF, Barros MF, Câmara T, Jamelli D, Knoechelmann CM, Menezes TGC, Menezes AGS. 2018 A framework for deriving measures of chronic anthropogenic disturbance: Surrogate, direct, single and multi-metric indices in Brazilian Caatinga. Ecological Indicators, 94: 274-282.

[18] Suganuma MS, Torezan JMD, Cavalheiro AL, Vanzela ALL, Benato T. 2008. Comparando metodologias para avaliar a cobertura do dossel e a luminosidade no sub-bosque de um reflorestamento e uma floresta madura. Revista Árvore, 32 (2): 377-385.

[19] Ahrends A, Burgess ND, Milledge SAH, Bulling MT, Fisher B, Smart JCR, Clarke GP, Mhoro BE, Lewis SL. 2010. Predictable waves of sequential forest degradation and biodiversity loss spreading from an African city. Proceedings Of The National Academy Of Sciences, 107 (33): 14556-14561.

[20] Calegari L, Martins SV, Gleriani JM, Silva E, Busato LC. 2010. Análise da dinâmica de fragmentos florestais no município de Carandaí, MG, para fins de restauração florestal. Revista Árvore, 34 (5): 871-880.

[21] Baccaro FB. et al. 2015. Guia para os gêneros de formigas do Brasil. Manaus: Inpa.

[22] Krebs CJ. 1998. Ecological Methodology. Addison Wesley, Longman, 2 ed., p.620.

[23] Zar JH. Biostatistical analysis. 2010. Prentice Hall, Upper Saddle River. p. 663.

[24] Chazdon RL. 2008. Chance and determinism in Tropical forest succession. Tropical forest community ecology, p. 384 - 408.

[25] Laurance WF, Camargo JLC, Luizão RCC, Laurance SG, Pimm SL, Bruna EM,Stouffer PC, Williamson GB, Benítez-Malvido J, Vasconcelos H. 2011. The fate of Amazonian forest fragments: A 32-year investigation. Biological Conservation, 144 (1): 56-67.

 Copyright © IJAER 2022, All rights reserved

ISSN: 2455-6939

Volume: 08, Issue: 01 "January-February 2022"

[26] Lôbo D, Leão T, Melo FPL, Santos AMM,Tabarelli M. 2011. Forest fragmentation drives Atlantic forest of northeastern Brazil to biotic homogenization. Diversity And Distributions, 17 (2): 287-296.

[27] Fahrig L. 2013. Rethinking patch size and isolation effects: the habitat amount hypothesis. Journal Of Biogeography, 40 (9): 1649-1663.

[28] Souza AF, Cortez LSR, Longhi SJ. 2012. Native forest management in subtropical South America: Long-term effects of logging and multiple-use on forest structure and diversity. Biodiversity and Conservation, 21 (8): 1953-1969.

[29] Pavoine S, Vela E, Gachet S, Bélair G, Bonsall MB. 2010. Linking patterns in phylogeny, traits, abiotic variables and space: a novel approach to linking environmental filtering and plant community assembly. Journal Of Ecology, 99 (1): 165-175.

[30] Mcglynn TP. 1999. The worldwide transfer of ants: geographical distribution and ecological invasions: geographical distribution and ecological invasions. Journal Of Biogeography, 26 (3): 535-548.

[31] Delabie JHC et al. 2007. Biogeografia das formigas predadoras do gênero Ectatomma (Hymenoptera: Formicidae: Ectatomminae) no leste da Bahia e regiões vizinhas. Agrotrópica, 19: 13-20.

[32] Leal IR, Filgueiras BKC, Gomes JP, Iannuzzi L, Andersen AN. 2012. Effects of habitat fragmentation on ant richness and functional composition in Brazilian Atlantic forest. Biodiversity And Conservation, 21 (7): 1687-1701.

[33] Fonseca RC, Diehl E. 2004. Riqueza de formigas (Hymenoptera, Formicidae) epigéicas em povoamentos de Eucalyptus spp. (Myrtaceae) de deferentes idades no Rio Grande do Sul, Brasil. Revista Brasileira de Entomologia, 48 (1): 95-100.

[34] Magurran AE. 2013. Medindo a diversidade biológica. Curitiba: (Ed) UFPR (universidade Federal do Paraná).

[35] Demétrio MF, Silvestre R, Souza PR, Aoki C. 2017. Inventário da fauna de formigas (Hymenoptera, Formicidae) no Mato Grosso do Sul, Brasil. Iheringia. Série Zoologia, 107: 1-12.

[36] Rocha WO, Dorval A, Peres Filho O, Vaez CA, Ribeiro ES. 2015. Formigas (Hymenoptera: formicidae) bioindicadoras de degradação ambiental em Poxoréu, Mato Grosso, Brasil. Floresta e Ambiente, 22 (1): 88-98.

[37] Hoffmann BD, Andersen AN. 2003. Responses of ants to disturbance in Australia, with particular reference to functional groups. Austral Ecology, 28 (4): 444-464.

[38] Ness JH, Bronstein JL, Andersen AN, Holland JN. 2004. Ant body size predicts dispersal distance of ant-adapted seeds: implications of small-ant invasions. Ecology, 85 (5): 1244-1250.

Copyright © IJAER 2022, All rights reserved

ISSN: 2455-6939

Volume: 08, Issue: 01 "January-February 2022"

[39] Siqueira FFS, Ribeiro-Neto JD, Tabarelli M, Andersen AN, Wirth R, Leal IR. 2018. Human disturbance promotes herbivory by leaf-cutting ants in the Caatinga dry forest. Biotropica, 50 (5): 779-788.

[40] Meador MR, Goldstein RM. 2003. Assessing Water Quality at Large Geographic Scales: relations among land use, water physicochemistry, riparian condition, and fish community structure: Relations Among Land Use, Water Physicochemistry, Riparian Condition, and Fish Community Structure. Environmental Management, 31 (4): 504-517.

[41] Leal IR, Filgueiras BKC, Gomes JP, Iannuzzi L, Andersen AN. 2012. Effects of habitat fragmentation on ant richness and functional composition in Brazilian Atlantic forest. BiodiversityAndConservation, 21 (7): 1687-1701.

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