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Leaf litter and terrestrial invertebrates in native forest and *Eucalyptus* field in the Atlantic Forest biome in Bahia (Brazil)

Cristina Vasconcelos Santos

Alagoinhas, Bahia (Brazil)
2024

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LEAF LITTER AND TERRESTRIAL INVERTEBRATES IN NATIVE FOREST AND *Eucalyptus* FIELD IN THE ATLANTIC FOREST BIOME IN BAHIA (BRAZIL)

CRISTINA VASCONCELOS SANTOS

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and my family for
all the support as ever.

ABSTRACT

Litter production and terrestrial invertebrate diversity were analyzed in the native forest fragment of the Atlantic Forest at Patioba Farm and *Eucalyptus* field at 3 km on the road to Catuzinho for 12 months (September 2022 to August 2023). Possible impacts of the green desertification of Eucalyptus spp. on the biodiversity of terrestrial invertebrates expected in the area covered by the biome were investigated. The litter samples were manually sorted for invertebrate capture and separated into the respective weighted and dry stem, leaf and reproductive part (flower, fruit, and seed) fractions for fresh and dry biomass records. The amount of litter accumulated at the edge (P0) can be attributed to a lower decomposition activity in relation to the interior (P2) of the Atlantic Forest fragment. The amount of plant material in the eucalyptus litter is lower than in the forest and the exotic species follows a phase of senescence different from the native ones. Among the component fractions of the litter, leaf litter predominated, as expected. A total of 524 terrestrial invertebrates was captured in the litter of the two study areas. In the native fragment of the Atlantic Forest, there were 435 specimens of 19 orders and 33 families in the litter between the three environments of the edge (P0) and the interior (P1 and P2). On the other hand, the *Eucalyptus* field had 89 specimens from 18 orders and 22 families in the litter of the degraded eucalyptus environment. In the native forest fragment, the edge (P0) of the forest fragment presented the highest number of invertebrates, with 184 specimens, where the highest abundance was represented by the armadillos *Philoscia muscorum*. In the orders with the highest abundance, Isopoda, Blattodea, and Hymenoptera stood out, corresponding to more than 50% of terrestrial invertebrates. The highest indices of diversity and richness were recorded for the eucalyptus and the intermediate point (P1) within the forest fragment. Degraded areas are usually home to their own species and visitors from adjacent area. The terrestrial invertebrates captured were classified into seven functional groups: predator, phytophagous, detritivore, saprophagous, coprophagous, parasite, and bioturbator. Detritivores (armadillos) and predators (ants and spiders) dominated in relation to the other functional groups at the edge (P0) of the native fragment of the Atlantic Forest. In eucalyptus, seven distinct functional groups were found, with organisms represented in only three orders: Isopoda, Blattaria, and Hymenoptera. The presence of these organisms in this area is due to the ability of these groups to tolerate different environments. The detritivores, important for the decomposition of litter and the cycling of nutrients to the trophic network, although present did not stand out for their abundance as in the Atlantic Forest. The balance between prey (detritivores) and predators (carnivores) in the forest and eucalyptus was mainly due to the groups of ants (Hymenoptera) and spiders (Araneae). In this functional group approach, the predatory organisms of the orders Hymenoptera and Araneae were highlighted in the biological control, especially of the detritivorous prey, predominant in both areas of study. The simple Lotka-Volterra simulation for the predator-prey relationship shows prey recovery within 50 days. In the natural environment, this situation can represent chaos given the complexity of ecological interactions possible even in the universe of terrestrial invertebrates associated with leaf litter. In a degraded eucalyptus environment, the discrete predator-prey interaction due to the very low abundance requires only 5-15 days for the recovery of its community.

Keywords: biodiversity, green desertification, ecosystem processes.

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SUMMARY

1. INTRODUCTION

The Atlantic Forest is one of the richest forests in species diversity, but one of the most threatened on the planet, being considered a world hotspot (Hirota, 2022). It covers an area of about 15% of the total Brazilian territory and is home to a considerable number of endemic species (Tabarelli *et al*., 2012; Fundação SOS Mata Atlântica; INPE, 2021). Anthropic action is one of the factors that most contribute to the degradation of this biome, among these activities are plant extractivism, agricultural activities and deforestation that negatively affect the fauna and flora of this ecosystem (Wolf, 2013; Silva *et al.*, 2022).

The loss of biodiversity has direct and indirect consequences on the quality of forest ecosystems. The interactions between organisms and abiotic factors of the ecosystem are fundamental to ensure this biodiversity (Pádua; Chiaravalloti, 2012). Litter is an essential component, composed of the layer of organic matter that is deposited on the forest floor (Andrade *et al.*, 2020). The invertebrate-litter relationship is fundamental in the nutrient cycling process (Portela; Santos, 2007; Henriques, 2012).

Invertebrates are an abundant group in forest ecosystems that perform essential ecosystem processes such as organic matter decomposition, seed dispersal, and nutrient cycling (Correia, 2002; Fujii; Berg; Cornelissen, 2020). These organisms use litter as a nutritional source and shelter, evidencing a mutualistic relationship that contributes to the maintenance of ecosystem processes (Pereira *et al.*, 2013).

There is a direct impact of destructive environmental management monocultures, especially *Eucalyptus* spp., related to the loss of biodiversity in forest ecosystems. The assessment of damage generated by monocultures of exotic species has been imposed in the last two decades (Ferreira *et al.*, 2017). According to the Brazilian Tree Industry, there was a growth of more than 6% in monocultures between 2018 and 2020, totaling 9.55 million hectares, mainly by planting eucalyptus species (IBÁ, 2021). The expansion of this monoculture causes the current phenomenon of green desertification, this occurs due to the false impression that there may be plant and animal wealth in this latifundium, especially due to soil degradation, contamination of water bodies by pesticides and loss of biodiversity (Lima *et al*., 2020).

The present work arose from the need to know possible impacts of the exotic species *Eucalyptus* on tropical biodiversity, given the expansion of this monoculture throughout the Brazilian territory with severe environmental disturbances due to forest fragmentation. The development of *Eucalyptus* field has been increasing in response to the demand of the global commercial timber industry (Forrester *et al.*, 2006). Because of its fast growth, short rotation at planting and high consumption of water and soil nutrients, nutrient cycling is one of the limitations for the establishment of agroforestry systems in areas with eucalyptus monocultures (Gama-Rodrigues; Barros, 2002; Lema *et al.*, 2007).

Due to the importance of organic matter decomposition for the maintenance of nutrient cycling in the litter-soil system and the trophic network, there is a need to investigate the impact of Eucalyptus spp. on the biodiversity of terrestrial invertebrates of the Atlantic Forest at Patioba Farm, municipality of Alagoinhas, Bahia (Brazil).

1.1 Problem

Are litter production and the diversity of terrestrial invertebrates in native fragments of the Atlantic Forest superior to those found in huge áreas of *Eucalyptus* spp., which expand degradation by predatory management similar to a green desert?

1.2 Justification

Biodiversity loss is a global issue of concern and is associated with environmental problems, such as *Eucalyptus* monoculture (Bensunsan, 2006; Ebling *et al.*, 2021). The expansion of green desertification with eucalyptus plantations in recent decades has been justified for the production of pulp, paper and firewood (IBÁ, 2021).

This monoculture negatively impacts the diversity of terrestrial invertebrates associated with leaf litter due to the presence of toxic polyphenols, the high lignin content that slows down decomposition, and the eucalyptus leaf, with a thick and resistant cuticle that tends to hinder its decomposition (Zimmer; Kautz; Topp, 2003; Abelho *et al.*, 2010; Margida; Lashermes; Moorhead, 2020).

Terrestrial invertebrates perform a number of ecological functions vital to ecosystem functioning, such as the decomposition of organic matter, nutrient cycling, and plant pollination (Gullan; Cranston, 2000; Fujii; Berg; Cornelissen, 2020). Leaf litter, with its plant and animal residues, is an important habitat for these invertebrates and reflects changes in vegetation cover (Costa *et al*., 2010). In this way, the replacement of native forests by eucalyptus plantations can directly impact the community of terrestrial invertebrates associated with litter.

This research will contribute to the development of biodiversity conservation measures, encouraging the adoption of more sustainable agricultural practices, and the promotion of responsible use of natural resources. In addition, the results obtained can be used to collect data that can contribute to public policies with decisions related to the management of eucalyptus plantations in the Atlantic Forest region, aiming to minimize negative impacts on biodiversity and strengthen the sustainable development of this important preservation area. Therefore, it is essential to understand the possible impacts of eucalyptus plantations on the biodiversity of terrestrial invertebrates associated with the Atlantic Forest litter in order to contribute to the preservation of this biome.

1.3 Objectives

1.3.1 General objective

To evaluate litter production and terrestrial invertebrate diversity in Atlantic Forest and *Eucalyptus* cultivation in Bahia (Brazil), for 12 months (September/2022 to August/2023), to investigate possible impacts of green desertification on the area covered by the biome.

1.3.2 Specific objectives

To compare the edge effect on the production dynamics and litter composition in native and eucalyptus áreas.

To evaluate the ecosystem role of functional groups of terrestrial invertebrates in leaf litter in native and eucalyptus areas.

To identify possible seasonal effects of precipitation and temperature on litter production and on the spatiotemporal distribution of terrestrial invertebrates in both areas.

To evaluate the possible effect of green desertification of Eucalyptus cultivation on the diversity of terrestrial invertebrates in the Atlantic Forest biome, exposed to its impact of fragmentation and predatory management.

1.4 Hypothesis

Litter with substances toxic to microorganisms and invertebrates has low decomposition and accumulates on the soil, which reduces nutrient cycling, especially in areas of *Eucalyptus* spp. Cultivation. This accumulation negatively impacts the local diversity of invertebrates, affecting the composition, abundance and richness of species.

Therefore, eucalyptus litter can exert a detrimental effect on the diversity and functional groups of invertebrates, as well as the Lotka-Volterra model simulates the scenario in the two antagonistic environments of Eucalyptus cultivation and the native fragment of the Atlantic Forest.

2. THEORETICAL FOUNDATION

2.1 Atlantic Forest

The Atlantic Forest is one of the richest ecosystems in biodiversity and the most threatened in the world (Cunha; Guedes, 2013; Ribeiro *et al*., 2009). The occupation and the anthropic development of this ecosystem caused the destruction of native vegetation and fostered the disorderly growth of urban centers, the installation of industrial complexes and agricultural activities (Groppo *et al*., 2019). Due to the influence of human activities in this biome, currently about 12.4% of its original cover remains (Fundação SOS Mata Atlântica; INPE, 2021). The Atlantic Forest has the second highest biodiversity in the Americas and the largest number of species per area, being the third largest Brazilian biome (Tabarelli *et al*., 2005; Morellato; Haddad, 2000). It consists of ombrophilous (dense, open and mixed) and seasonal (semideciduous and deciduous) forests, in addition to the formations of restingas and mangroves (Brasil, 2022).

According to the SOS Mata Atlântica Foundation and INPE (2021), the area of this biome covers 72% of the Brazilian population, about 145 million people. Therefore, this population contingent depends on the conservation of the remnants of this forest to guarantee water supply, the regulation of the microclimate, soil fertility, among other environmental services (Dantas *et al*., 2017). These agencies have been documenting fragmented areas together with small native forest remnants without connectivity, surrounded by extensive eucalyptus monocultures and agriculture (Fundação SOS Mata Atlântica; INPE, 2014).

Despite the devastation, it is estimated that there are about 20 thousand plant species in the Atlantic Forest, including 8 thousand endemic and endangered species (Fundação SOS Mata Atlântica; INPE, 2018). In this way, the preservation of this biome plays an important role in the survival of flora and fauna, in addition to the maintenance of environmental services.

2.2 Tree stratum in litter production

Leaf litter is composed of plant material deposited on the surface of the forest floor, resulting from the fall of the aerial part of plants, leaves, branches, bark, trunks, and reproductive organs of plant species (Costa *et al.*, 2010; Arato; Martins; Ferrari, 2003). In addition, an accumulation of living organic material is formed in different stages of decomposition and residue of animal origin, such as feces and dead parts (Neto *et al.*, 2001). The litter works as a blanket that facilitates the entry of seeds and incorporation of the seed bank into the soil, and it does not leave the soil exposed to environmental inclement weather (Bauer; Santos; Schmitt, 2016).

Tree species provide plant material to leaf litter, which accumulates on the soil due to decomposition activity. Production is vital for nutrient cycling in the soil-plant system (Andrade; Tavares; Coutinho, 2003; Cunha Neto *et al.*, 2013; Andrade *et al.*, 2020). The decomposition of this organic matter is influenced by biotic and abiotic factors (Bani *et al.*, 2018; Scoriza *et al.*, 2012). The entry of this plant material by senescence or fall and its consequent accumulation influence the population dynamics of plant and animal communities (Portela; Santos, 2007).

Most of the nutrients extracted by trees from the soil return to the ecosystem via leaf litter, which is called nutrient cycling (Bauer; Santos; Schmitt, 2016). The seasonal drop of leaves and other plant parts is responsible for feeding both the microbiota and other organisms responsible for the decomposition of organic matter (Barreto, 2014). These organisms influence increased decomposition rates, and their populations are regulated by climatic factors such as precipitation and temperature (Sanches *et al.*, 2009; Jewell *et al.*, 2017).

Litter accumulation varies according to several elements, such as species composition, forest cover intensity, successional stage, age, canopy proportion and seasonal pattern (Lima *et al*., 2015). From this perspective, studies developed by Portela (2007) and Andrade *et al.* (2020), in fragments of the Atlantic Forest, found that the greater production, accumulation, and decomposition of litter were mainly related to seasonal factos. Among the seasonal factors, temperature and precipitation are elements that most affect the accumulation and decomposition of litter (Paudel *et al*., 2015).

Thus, it can be seen that litter production depends on physical, climatic and chemical characteristics to present an increase or reduction in decomposition rates in native or planted forests. The presence of tree stratum contributes to the reduction of erosion and water loss in the soil, in addition to assisting in nutrient cycling and maintaining organic matter, favoring litter production in a given area, it can be used as a bioindicator of recovery of degraded areas (Moraes, 2002).

2.3 Edge effect due to forest fragmentation

The edge effect consists of changes in the physical, chemical and biological parameters observed in the area of contact of the vegetation fragment with the surrounding matrix. Thus, it can be understood as the result of the interaction between two adjacent ecosystems, separated by abrupt transition (Forman; Godron, 1986; Murcia, 1995; Silva, 2010).

According to Murcia (1995), edge effects are divided into two types: abiotic and direct and indirect biological. Thus, abiotic effects involve changes in environmental climatic factors, changes in light regimes, greater exposure of the edge to the action of winds, high temperatures and low humidity (Pinto *et al.*, 2008). The direct biological effects involve changes in the abundance and distribution of species caused by abiotic factors in the vicinity of the edges, in addition to favoring the establishment of exotic plant species introduced by human action. Some native generalist species are favored by clearings or deforestation. Exotic species, on the other hand, benefit from the condition generated by the edge effect because they have a wide niche and the only thing that prevented the occupation of the habitat was a geographical barrier (Burgiel; Muir, 2010; Laranjeira, 2012). Indirect risks involve changes in the interaction between species, such as predation, parasitism, herbivory, competition, and seed dispersal (Kollmann; Buschor, 2003).

The edge effect alters the structure and dynamics of vegetation in forest fragments, causing changes in the ecosystem balance, such as changes in the trophic chain (Brown, 1971). It also favors changes in soil structure and moisture, and these effects are more pronounced at the edges of the fragments, leading to an increase in the number of individuals, whether they are damaged or dead plants or animals (Camargo; Kapos, 1995; Holanda *et al*., 2010).

Thus, by modifying the natural environment, the edge effect on the perimeter of the forest alters the complexity of the niches, leading to the loss of biodiversity (Holanda *et al*., 2010; Haddad *et al*., 2015). As well as, it affects the production of litter, reduced due to the smaller size of the trees and lower survival rate due to greater exposure to abiotic elements, such as wind and solar radiation, impacting on the lower production and accumulation of biomass (Azevedo *et al*., 2011; Santana *et al*., 2021). This is different from the interior of the forest fragment, which produces more biomass related to the edge due to the greater size of the trees and favorable environmental conditions, such as humidity and temperature, sheltering a greater number of species with more specialized niches or that depend on greater spatial heterogeneity (Silva *et al*., 2019).

2.4 Eucalyptus cultivation

Silviculture is a term that refers to the cultivation of wild (native) species (Galindo; Almeida, 2021). Meanwhile, the plant of the species *Eucalyptus* spp. is not native to tropical biomes, but exotic to predatory management and will be treated as such in comparison to the native species of the tropical vegetation of the Atlantic Forest.

Homogeneous eucalyptus plantations are distributed throughout the national territory, especially in the Southeast, South and Northeast regions. The states of Minas Gerais, São Paulo, Mato Grosso do Sul and Paraná continue to be the main producers of this monoculture in the country (Vital, 2007; IBGE, 2022). In this scenario, degraded areas of the Atlantic Forest have been replaced by the exotic species *Eucalyptus* sp. instead of being recovered with native species suitable for the biome, favoring deforestation and the reduction of the natural area, in addition to the loss of habitats and biodiversity (Groppo *et al.*, 2019; Branco *et al*., 2021). This replacement by successive approximations of native species by invasive species of predatory management is the process of installation of green desertification.

The replacement of native vegetation by monocultures homogenizes the landscape, reducing structural complexity and affecting the variability of niches (Pádua;

Chiaravalloti, 2012). Eucalyptus estates install green desertification of predatory management. Eucalyptus plantations extend and compete for water demand, affecting groundwater and acting on soil impoverishment (Meirelles, 2006).

The rapid growth, with short rotation at planting, leads to high consumption of water and soil nutrients, contributing to low rates of decomposition and accumulation of litter (Gama-Rodrigues; Barros, 2002). Nutrient cycling is one of the limitations to the establishment of sustainable ecosystems in areas where the cultivation of *Eucalyptus* spp. (Lema *et al.*, 2007).

Batish *et al.* (2008) investigated the use of eucalyptus essential oils as natural pesticides, evidencing their biocidal effect against insects, mites and bacteria, which act in the decomposition of litter. Studies carried out by Maestri *et al*. (2013), in an area of native forest compared to a eucalyptus monoculture, indicated a greater presence of arthropodofauna in the native forest due to the heterogeneity of trophic resources in the environment, which contributes to the diversity and richness of species.

Gurgel *et al*. (2020) stated that eucalyptus plantations, especially on slopes near rivers with potential for regeneration in the Atlantic Forest biome, increase the risk of siltation, erosion, and habitat loss, highlighting the negative effects caused by *Eucalyptus* spp. monocultures.

2.5 Terrestrial invertebrates associated with litter

Forest leaf litter is the habitat of invertebrates, which interact with soil fauna and are influenced by environmental factors, such as humidity, temperature, and vegetation. Forests in advanced stages of succession have greater diversity of invertebrates in leaf litter than forests in early stages (Moço *et al.*, 2005; Menezes *et al.*, 2009; Machado, 2011). The great diversity of invertebrates is directly related to the fragmentation and decomposition of the material that naturally fertilizes the forest soil (Moço *et al.*, 2005).

In forest ecosystems, invertebrates represent an abundant group that performs primary functions such as decomposition of organic matter, seed dispersal, and decomposition (Correia, 2002). Generally, the action of decomposing organisms is stimulated by increased precipitation and temperature, especially in drier ecosystems (Alves *et al*., 2006; Bauer; Santos; Schmitt, 2016). These organisms use litter as a nutritional source and shelter, evidencing a mutualistic relationship that contributes to the maintenance of ecosystem processes (Pereira *et al*., 2013).

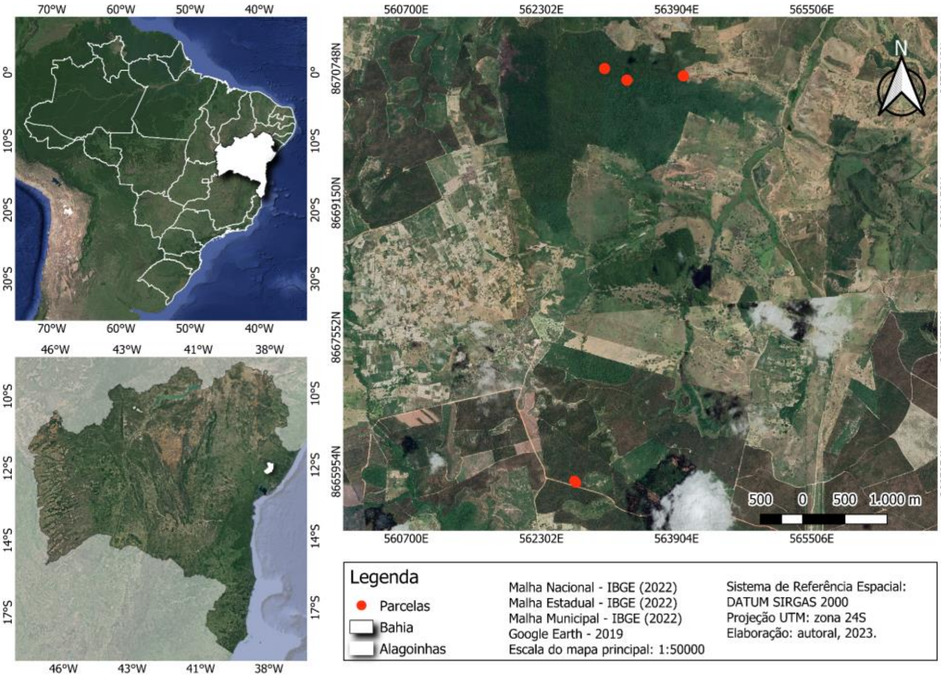
The invertebrate fauna contributes in different ways to the cycling of the plant material contributed. These organisms can be grouped into functional groups (FG) according to their morphology, feeding habits, and food capture, being categorized into predators, geophages, bioturbators, phytophages, coprofrages, and microphages (Pereira *et al*., 2013; Parron *et al*., 2015). Predators carry out population control of various organisms, detritivores feed on decomposing organic matter, phytophages feed on plant tissues, being considered agricultural pests, and microphages feed on fungi (Parron *et al*., 2015). Geophages and bioturbators promote soil aeration, increasing its porosity and recirculation of organic matter (Brown *et al*., 2015). In forest ecosystems, these organisms play essential roles in the maintenance of ecosystem processes and can serve as bioindicators of environmental quality (Andersen *et al*. 2004; Santos *et al*., 2019).

3. MATERIAL AND METHODS

3.1 Study areas

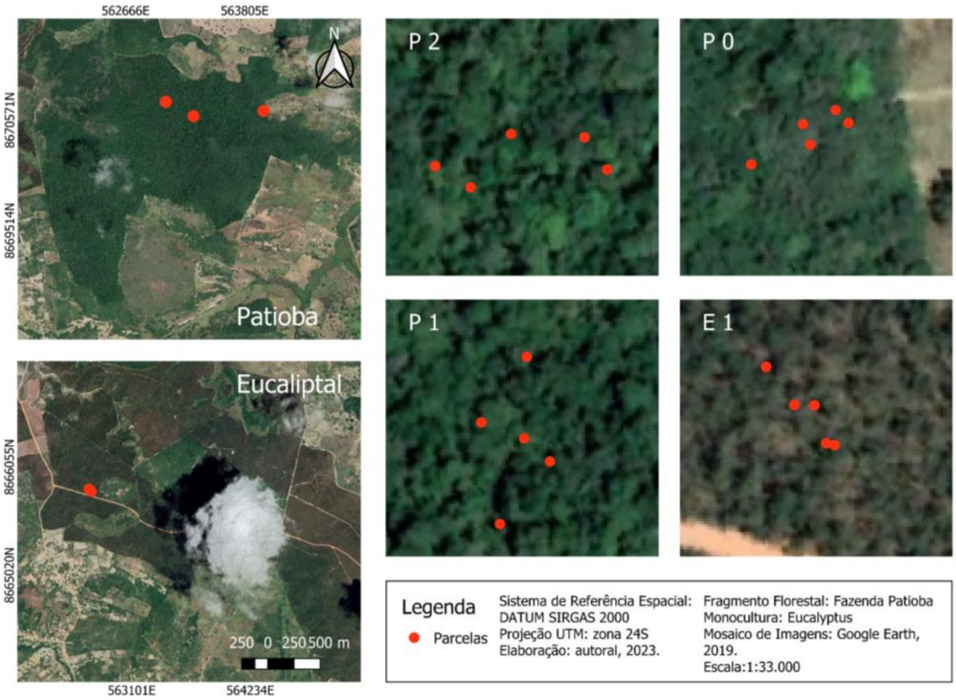
The study was carried out for 12 months (September/2022 to August/2023) in the native forest fragment of the Atlantic Forest at Patioba Farm and in Eucalyptus cultivation 3 km on the road to Catuzinho, municipality of Alagoinhas, a reference for the North Coast of the state of Bahia (Brazil) (Figures 1 and 2). In each plot, 5 monthly collections were made along an imaginary transect, avoiding the previous sampling points represented on the map (Figures 2 and 3).

Figure 1. Study areas with indications of the collection sites at the edge (P0), intermediate (P1) and inland (P2) of the native fragment of Atlantic Forest at Patioba Farm and in the *Eucalyptus* field on the road to Curralinho. Alagoinhas, Bahia (Brazil). September/2022 to August/2023.



Source: José Gabriel Ferreira dos Santos, 2023.

Figure 2. Detail of the sampling sites in the edge (P0), intermediate (P1) and interior (P2) plots of the native Atlantic Forest fragment at Patioba Farm and in *Eucalyptus* field on the road to Curralinho. Alagoinhas, Bahia (Brazil). September/2022 to August/2023.



Source: José Gabriel Ferreira dos Santos, 2023.

Figure 3. Vegetation structure in plots 0, 1 and 2 of the Atlantic Forest fragment of Patioba Farm. Alagoinhas, Bahia (Brazil). September/2022 to August/2023.

Source: authorial, 2022.

The native fragment of the Patioba is the largest in the municipality of Alagoinhas, with about 343 hectares, characterized as Dense Ombrophilous Forest, composed of evergreen trees (medium and large) with dense crowns, shrubby and subshrubby sizes, as well as lianas (Evangelista; Almeida, 2020; Dantas, 2021). Eucalyptus cultivation has trees with an average height of 8 meters in age estimated at 3 years based on the satellite image of 03/04/2020 showing the area without vegetation.

Precipitation (mm) and temperature (ºC) data for the municipality of Alagoinhas were obtained from the website Weather Spark (2023) (Table 1).

Table 1. Average monthly rainfall (mm) and temperature (ºC) in Alagoinhas, Bahia (Brazil). September/2022 to August/2023.

Variable	Sep/ 2022	Oct	Nov	Dec	Jan/ 2023	Feb	Mar	Apr	May	Jun	Jul	Aug
Precipitation (mm)	47.7	42.4	51.8	46.0	43.8	52.1	65.2	114.7	130.1	111.5	82.4	56.6
Temperature (ºC)	24.4	26.0	26.0	27.0	27.0	28.0	28.0	26.5	25.0	24.0	23.0	23.0

Source: adapted from the website Weather Spark (2022, 2023).

3.2 Litter production and composition

The litter samples were manually sorted with their stem, leaf and reproductive fractions (flower, fruit and seed) separated in identified paper envelopes, weighed on semi- and analytical scales to record fresh mass (g), dried in an oven at 60°C for 72 hours and weighed to record dry mass (g). These values were used to estimate the monthly biomass production (Figure 4).

Figure 4. Manual sorting, registration and drying of litter fractions from collectors in the Atlantic Forest fragment at Patioba Farm. Alagoinhas, Bahia (Brazil). September/2022 to August/2023.

Source: authorial, 2023.

The analyses were done with the open source software PAST Analyst (Paleontological Statistics), version 4.17.

3.3 Terrestrial invertebrates and functional groups

During the manual sorting of litter fractions, the terrestrial invertebrates found were counted, preserved in 70% alcohol with 5 drops of concentrated glycerin, and separated into morphotypes. The identification was made by Neves (2023) based on the specific literature of Paoletti and Hassall (1999), Baccaro (2006), Cardoso (2017), Brusca, Moore and Shuster (2018) and by comparisons with images from virtual collections.

With these taxonomic data, the captured terrestrial invertebrates were classified into 7 functional groups according to feeding habit and their assigned role in litter, namely: predator, phytophage, detritivore, saprophage, coprophage, parasite, and bioturbator, following the criteria of Podgaiski, Mendonça Jr. and Pillar (2011) and Parron *et al*. (2015). To avoid overlapping data of the multifunctional species in the simulation of the predator-prey relationship, the animals were considered only once in each group due to the occupied niche characteristics observed in the field and/or laboratory.

The analyses were done with the open source software PAST Analyst (Paleontological Statistics), version 4.17

The data was analyzed for diversity index calculations using the open source PAST Analyst (Paleontological Statistics), version 4.17 and only the monthly data was modeled by the free-to-use Populus 6.0 (ALSTAD, 2001).

The indices measure diversity (Simpson and Shannon-Wiener), equity (Pielou), wealth, and wealth projection (Chao-1, iChao-1, and ACE). Indices of dominance, diversity, richness and equity were used to estimate the ecological status of the terrestrial invertebrate community associated with litter (Table 2).

Table 2. Parameters, index, and reference values for population data analysis.

Parameters	Indexes	Reference values
Dominance	Simpson	0 - 1
Diversity	Shannon-Wiever	1.5 – 3.5
Richness	Margalef	3.81
	Menhinick	2.05
	Chao	2.5 – 97.5
Equity	Pielou	0.76

Source: authorial, 2023.

These ratios can also be calculated based on the following equations:

$$D = S\ _{Pi}^{2}$$

Where: D, Simpson index (1949); Pi, relative abundance (proportion) of species *i* in the sample. The Simpson index indicates the probability that two individuals randomly drawn belong to the same species.

$$H = -S\ _{Pi}*\ln_{Pi} \quad \text{and} \quad Pi = n\text{i}/\text{N}$$

Where: H, Shannon-Wiener index (1949); Pi, relative abundance; Ln, natural logarithm; N, total number of individuals; ni, number of individuals of each order.

The values of the rarefaction curve were obtained by means of combinatorial analyses, using Hurlbert's equation (1971), to verify how many possible combinations can be made and how many subsets can be obtained:

$$E(S_n) = {}^{S}{}_{i=1}\ [N]$$

Where: N, total number of individuals in the community; Ni, number of individuals of the ith species; n, number of individuals standardized for rarefaction.

The Chao-1 index is an abundance estimator of individuals belonging to a given class and estimates the species richness in a given ecological community from a sampling. The estimator's proposal is based on the frequency of rare species, that is, those that occur only once or twice in the samples (Chao, 1987). This index is useful to compare biological diversity between habitats or areas and to assess the sufficiency of the sampling effort in capturing most of the species present in the community (Sanos, 2006). The equation can be described as follows:

$$\text{Chao-1} = S_{\text{obs}} + F_1^2/2F_2$$

Where: S_{obs}, number of species observed; F_1, number of species occurring only once in the samples; F_2, number of species occurring twice in the samples.

The iChao-1 index assumes that the frequency of unique and duplicate individuals is proportional to the abundance of rare species in the community and that these rare species are the ones that contribute most to species richness. The iChao-1 is a robust and simple estimator that can be applied to different types of ecological data and performs well compared to other species richness estimators (Baldrian *et al.*, 2022). The iChao-1 can be calculated by the formula:

$$i\text{Chao-1} = S_{\text{obs}} + [n_1(n_1-1)/2(n_2+1)]$$

Where: S_{obs}, number of species observed; n_1, number of unique individuals; n_2, number of duplicate individuals.

The classical mathematical modeling of ecological systems was done with the expanded application of the simple Lotka-Volterra model to the case where there is intratrophic competition between detritivores (prey) and carnivores (predators) (Souza, 2017). The dynamics of predator-prey interaction were modeled in continuous flow and in prey dependence (prey-dependent) for edge (P0) and interior (P2) over 100 days, a period used as a comparative standard for monthly collections over 12 months.

4. RESULTS AND DISCUSSION

4.1 Litter production and composition

In general, the contribution of plant material from the litter was higher in the native forest than in the eucalyptus monoculture. This result was attributed to the greater density and diversity of the native tree stratum, which continuously contributes material to the vegetable litter. In turn, the exotic species of *Eucalyptus* sp. cultivation has a phenological cycle with a senescence phase different from the native species of the forest (Figure 5).

Within the Atlantic Forest forest fragment, the amount of accumulated litter was initially higher at the edge (P0) than in the interior (P2) (Figure 5).

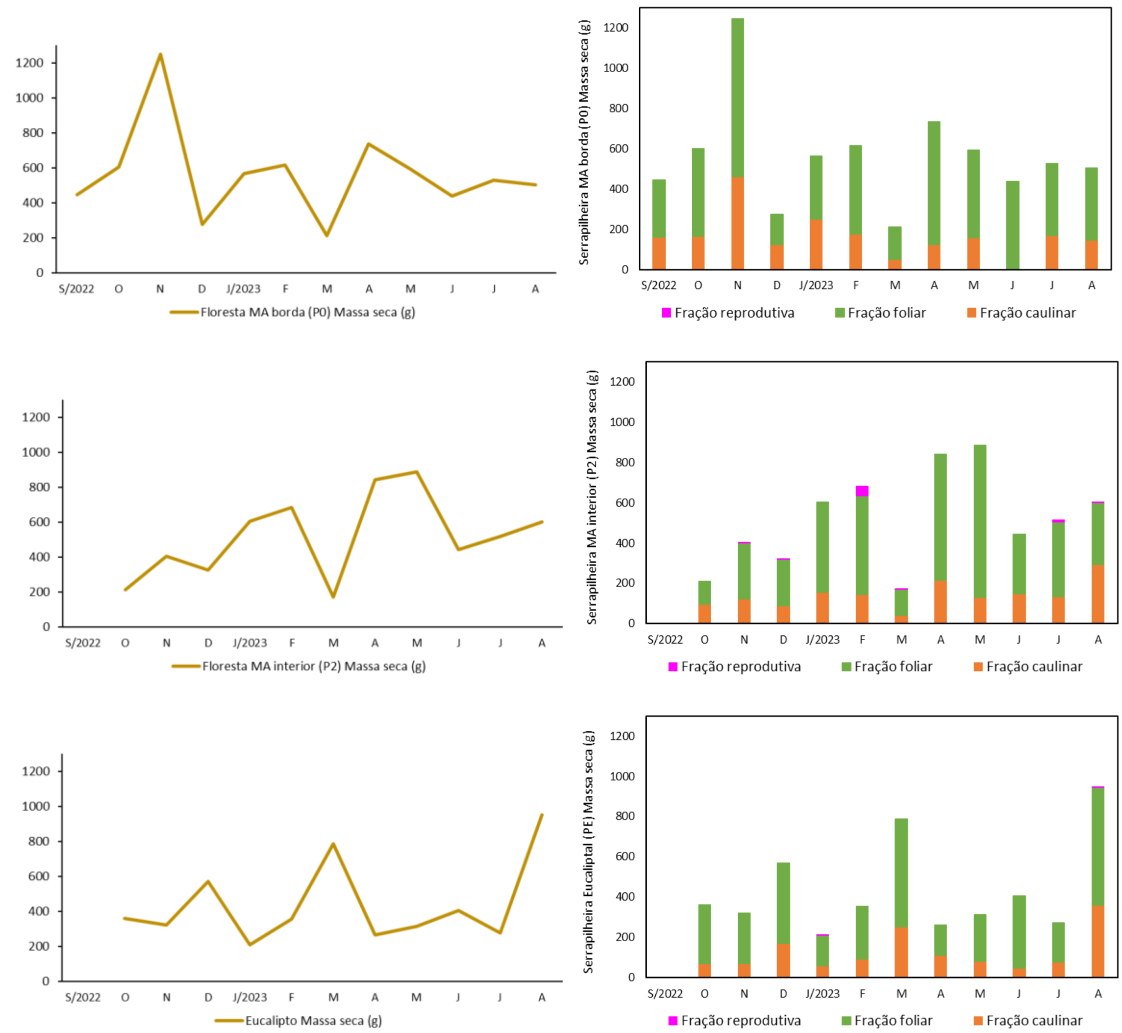
Among the fractions that constitute litter, foliar predominated in both study areas, as expected. An important fraction of reproductive material (flowers, fruits and seeds) was collected in the interior (P2), where native species with higher density and diversity usually have higher flowering. In the native fragment, a similar pattern was recorded the previous year by Sá (2023). In the eucalyptus field, an inverse pattern was observed to the native fragment (Figure 5).

The biomass production curve in eucalyptus, an exotic species, did not correspond to the rainfall curve throughout the year (Figure 6).

In eucalyptus, bactericidal substances can be in the form of non-water-soluble essential oil, reducing microbiotic activity for decomposition, compromising nutrient cycling in areas of this monoculture, and favoring the accumulation of plant material.

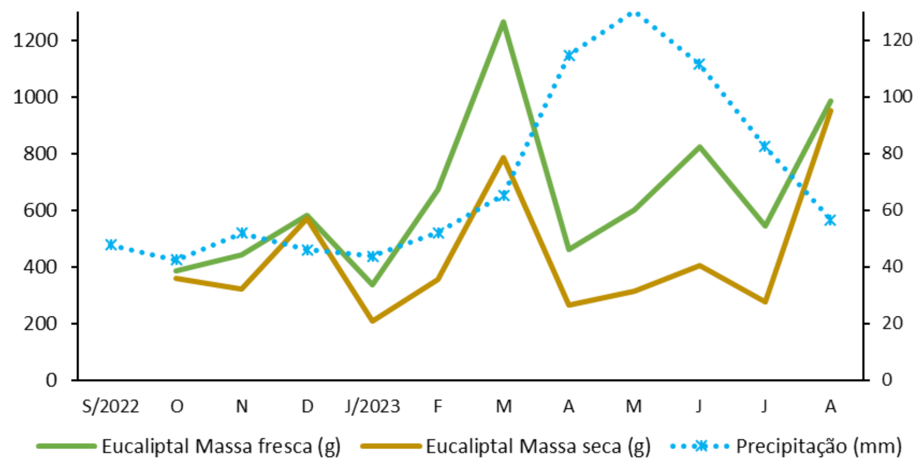
The moisture accumulated in the rainy months contributes to solubilize toxic polyphenol compounds from leaf litter, both in the native Atlantic Forest forest and in the eucalyptus, allowing the action of terrestrial invertebrates for their decomposition. The more diversified plant material accumulates greater moisture inside in relation to the edge more exposed to dehydration (Santos; Cabreira, 2019).

Figure 5. Production and fractions of leaf litter in edge (P0) and interior (P2) of the native fragment of the Atlantic Forest and in *Eucalyptus* field. Alagoinhas, Bahia (Brazil). September/2022 to August/2023.



Source: authorial, 2023.

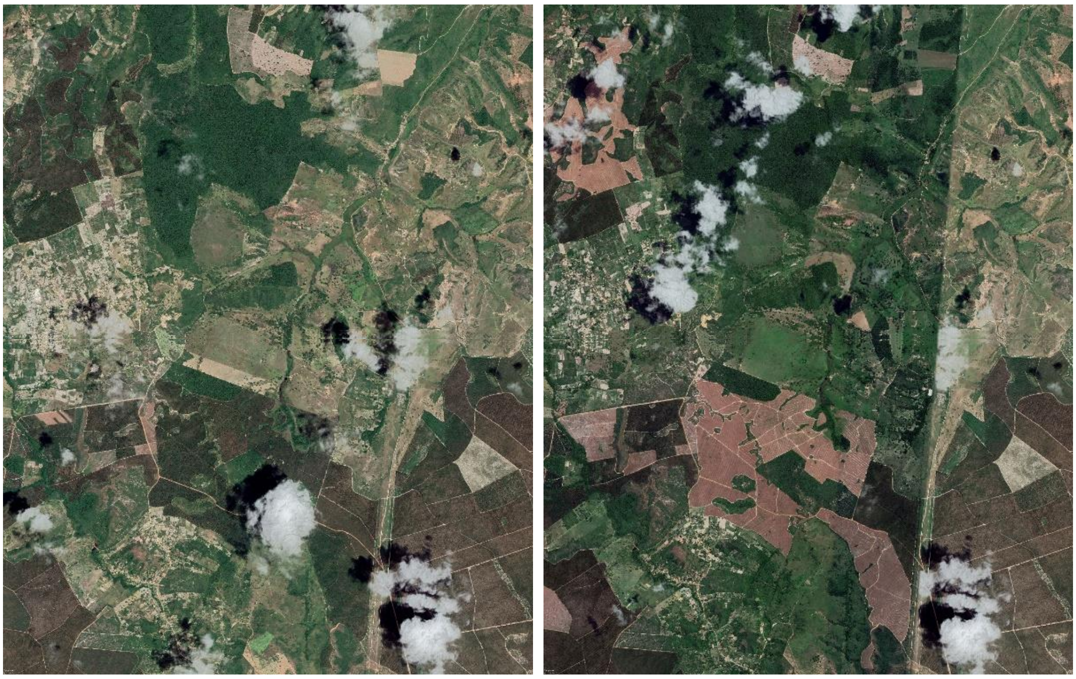
Figure 6. Litter production in *Eucalyptus* field and density of captured invertebrates Alagoinhas, Bahia (Brazil). September/2022 to August/2023.



Source: authorial, 2023.

This scenario is similar to the area surrounding the remnant of Atlantic Forest in Patioba. The destructive environmental management of Eucalyptus cultivation for timber harvesting, observed in the field, also hinders the development of pioneer native species installed over 5 years of eucalyptus, because the method used of chains between two tractors also uproots seedlings that are in this path of destruction. The damage can be worse than pasture or crop field with short production and harvest cycles, where native species of primary successional stage can colonize the edges and re-expand the edge of the native fragment, contributing to natural revegetation. Satellite images from 2019 and 2020 of the largest native forest fragment of the Atlantic Forest and the surrounding Eucalyptus cultivation in Alagoinhas give an idea of the advance of environmental degradation due to notorious forest fragmentation (Figure 7).

Figure 7. The largest native forest fragment of the Atlantic Forest at Patioba Farm and the *Eucalyptus* field that surrounds it in the municipality of Alagoinhas, Bahia (Brazil). 30/11/2019 (left) and 03/04/2020 (right).



Source: spatial data from Google Earth.

Eucalyptus had the highest growth in cultivated area in the last 30 years, with an increase of 847% in a current area of 4,808,520 hectares (ABAF, 2023). Contrary to this predatory economic activity due to the advance of fragmentation over tropical forest areas, there was a loss of 3,129,930 hectares (31.18%) of the Atlantic Forest biome in the same period.

4.2 Terrestrial invertebrates and functional groups

In 12 months, 524 terrestrial invertebrates were captured in the litter of the study areas. The native fragment of the Atlantic Forest with 435 specimens of 19 orders and 33 families in total of the three edge (P0) and interior (P1 and P2) environments. Eucalyptus cultivation with 89 specimens from 18 orders and 22 families. The terrestrial invertebrates collected in the samples of the Atlantic Forest litter and Eucalyptus cultivation are represented in morphospecies of a variety of taxonomic and functional groups higher in the Atlantic Forest litter compared to Eucalyptus cultivation (Table 3).

In the native forest fragment, the edge (P0) of the forest fragment had the highest number of invertebrates, with 184 specimens due to the greater abundance of armadillos *Philoscia muscorum* (Isopoda) and spiders (Araneae). In the orders with greater abundance, Isopoda, Blattodea, and Hymenoptera stood out, corresponding to more than 50% of terrestrial invertebrates. Among the groups, there was greater richness of ants (Hymenoptera), with a predominance of 3 subfamilies/families: Myrmicinae at the edge (P0), Formicidae at the intermediate point (P1) and Formicinae in the interior (P2) of the forest (Table 3, Figures 8 and 9). This may have been due to the ants' high ability to adapt to varied locations, including disturbed edge environments (Santos; Figueiredo, 2019) and degraded eucalyptus.

The highest indices of diversity and richness were recorded for the intermediate point (P1) within the forest fragment, followed by eucalyptus. The interior of the native fragment is home to rare species of the taxonomic groups Formicidae and Gastropoda, which depend on environmental conditions of greater structural complexity of a diverse and dense vegetation to retain greater moisture. These rare groups in the interior are strongly impacted by the environmental homogenization of eucalyptus, showing that these species are more adapted to the specificities of the native habitat.

Degraded areas, such as the edge and eucalyptus, are often visited and even explored by individuals of resilient species from adjacent native areas, seeking trophic resources during foraging. A high index of richness was recorded in the eucalyptus, but with the occurrence of only 1 individual/species or in very low frequency in the period of 12 months, the opposite of the high abundance of terrestrial invertebrates captured in the 3 plots of the native fragment (Tables 3 and 4).

This behavior can mask and attribute high levels of diversity and richness to degraded areas, distorting the ecological assessment. The low occurrence of the most resilient generalist orders in eucalyptus cultivation favored equitativeness, thus generating a high index of diversity in eucalyptus field that does not indicate environmental and zoological quality of the area.

Table 3. Checklist of terrestrial invertebrates captured in the Atlantic Forest fragment and in *Eucalyptus* field (Bahia, Brazil). September/2022 to August/2023.

Class	Order	Sub/family	Genus	Species	P0	P1	P2	PE
Malacostraca	Isopoda	Philosciidae	*Philoscia*	*P. muscorum*	65	7	3	9
Insecta	Blattaria/ Blattodea	Blaberidae			20	5	5	6
		Isoptera			0	15	0	0
	Thysanoptera				2	0	0	2
	Hymenoptera	Formicidae			11	17	1	6
		Formicinae			0	5	39	0
		Ponerinae	*Pachycondyla*	*P. striata*	0	3	0	4
			Odontomachus		0	2	0	0
		Dolichoderinae	*Dorymyrmex*		4	0	2	1
		Ectatomminae			0	2	2	0
		Myrmicinae	*Monomorium*	*M. pharaonis*	27	0	0	0
	Coleoptera				0	5	1	6
	Lepidoptera				1	0	0	1
	Diptera				0	1	1	3
	Orthoptera	Gryllidae			1	2	0	2
	Mantodea				0	0	0	1
	Embioptera	Anisembiidae			0	1	1	0
	Neuroptera	Myrmeleontidae			0	2	0	1
	Larvae				4	1	6	20
Arachnida	Araneae	Araneae			13	7	6	4
		Ctenidae			3	2	2	3
		Dictynidae			1	0	0	0
		Theraphosidae			0	1	0	0
		Phoneutria			0	1	0	0
		Salticidae			2	3	1	1
		Zodariidae			0	1	0	0
	Opiliones				5	0	0	2
	Scorpiones	Buthidae			0	0	0	1
	Pseudoscorpiones				1	0	0	0
Gastropoda	Stylommatophora	Achatinidae	*Achatina*	*A. fulica*	1	3	0	0
			Neobeliscus	*N. calcareus*	1	7	8	0
		Bradybaenidae	*Bradybaena*	*B. similaris*	9	19	16	1
				Sp. 1	2	24	4	1
Diplopoda	Spirostreptida				7	9	3	12
Chilopoda	Scolopendridae	Scolopendridae	*Rhysida*		2	1	1	1
Collembola					1	0	0	0
Entognatha	Diplura	Japygidae			1	3	0	1
			Total abundance		**184**	**149**	**102**	**89**

Source: authorial, 2023.

Table 4. Diversity indices of terrestrial invertebrates captured in the Atlantic Forest fragment and in *Eucalyptus* field (Bahia, Brazil). September/2022 to August/2023.

Diversity and wealth indices	MA edge (P0)	MA intermediary (P1)	MA interior (P2)	Eucalyptus (PE)
Taxa_S	23	27	18	23
Individuals	184	149	102	89
Dominance_D	0.1687	0.0756	0.1833	0.0914
Simpson_1-D	0.8313	0.9244	0.8167	0.9086
Shannon_H	2.3330	2.9040	2.2600	2.7740
Evenness_e^H/S	0.4481	0.6758	0.5324	0.6966
Brillouin	2.0960	2.5580	1.9440	2.3230
Menhinick	1.6960	2.2120	1.7820	2.4380
Margalef	4.2190	5.1960	3.6760	4.9010
Equitability_J	0.7440	0.8811	0.7819	0.8847
Fisher_alpha	6.9380	9.6410	6.3420	10.0500
Berger-Parker	0.3533	0.1611	0.3824	0.2247
Chao-1	28.57	30.48	21.71	34.12
iChao-1	31.82	31.87	25.43	41.54
ACE	32.81	32.29	23.15	35.08
Squares	34.15	31.04	24.96	33.47

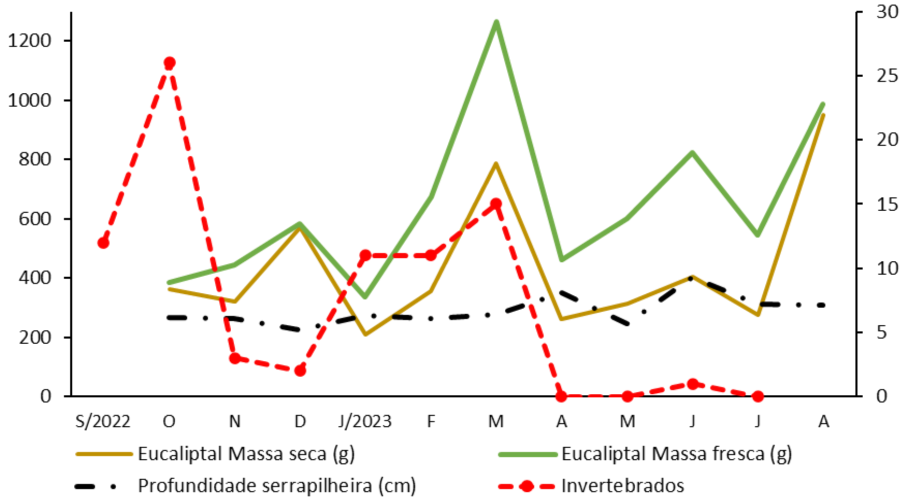
Source: authorial, 2023.

Figure 8. Invertebrates captured in the leaf litter of the Atlantic Forest fragment, Alagoinhas, Bahia (Brazil). Caption: 1. Blaberidae, 2. ant *Odontomachus* sp., 3. Gryllidae, 4. *Bradybaena similaris*, 5. Spirostreptida 1, 6. Spirostreptida 2, 7. Coleoptera, 8. spider Ctenidae, 9. grasshopper, 10. scorpion.

Source: authorial, 2023.

In the plant-animal relationship of litter and terrestrial invertebrates, the occurrence of animals suffers seasonal effect of rainfall, considering Eucalyptus cultivation as an open field exposed to greater irradiation and desiccation, with litter being a layer of protection for this fauna (Figure 9).

Figure 9. Relationship between wet and dry litter masses in *Eucalyptus* field with captured invertebrates. Alagoinhas, Bahia (Brazil). September/2022 to August/2023.

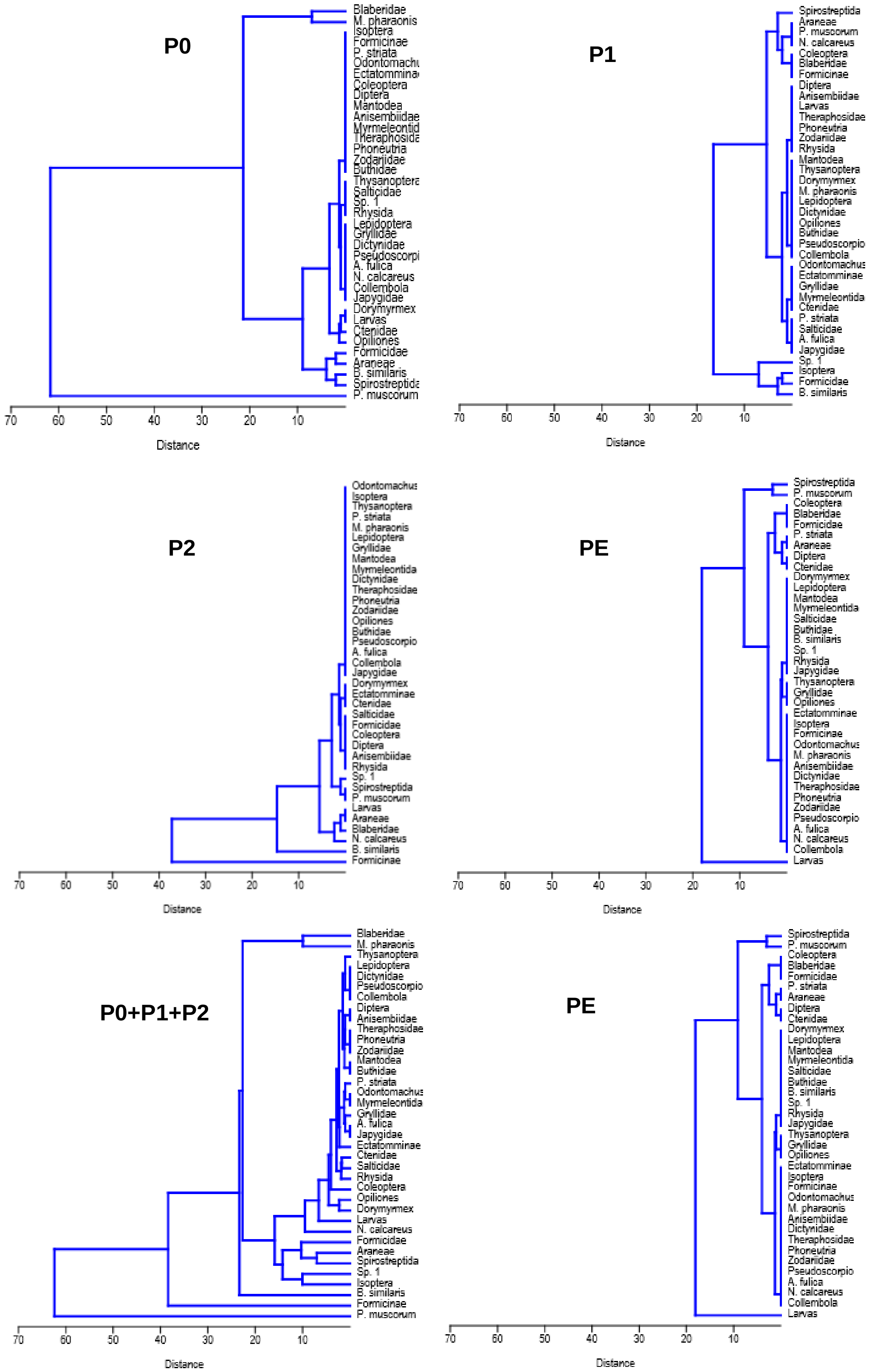


Source: authorial, 2023.

In the forest remnant, there was a higher density of invertebrates at the edge (P0) of the fragment, due to the order Isopoda with great abundance of only 1 species. This result was corroborated by Neves (2023) and Sá (2023). There was not the same prominence of this species in the degraded area of eucalyptus. A high abundance of *Philoscia muscorum* (Isopoda) may be related to the proximity of pastures at the edge of the fragment and the high presence of bovine feces, which serve as food for these coprophagous organisms (Paoletti; Hassall, 1999; Frouz Pižl; Tajovsky, 2007). The occurrence of gastropods inside the fragment was similar to Silva (2023), a result attributed to the presence of plants of the botanical family Myrtaceae, which produce a leaf litter rich in the nutrient calcium, necessary for the manufacture of shells.

The analysis of taxonomic groups (cluster) showed the isopod domain (*Philoscia muscorum*, Isopoda) at the edge (P0) along with ants (Hymenoptera), spideres (Araneae) and gastropods (Stylommatophora) in the inland plots (P1 and P2) of Atlantic Forest, as opposed to insect larvae in Eucalyptus cultivation (PE) (Figure 10). The occurrence of terrestrial invertebrate groups in Eucalyptus cultivation may indicate their use for foraging, only with scorpions (Scorpiones, Buthidae) with a predilection for eucalyptus.

Figure 10. Cluster analysis of terrestrial invertebrate orders collected in native fragment plots and *Eucalyptus* field. Alagoinhas, Bahia (Brazil). September/2022 to August/2023.

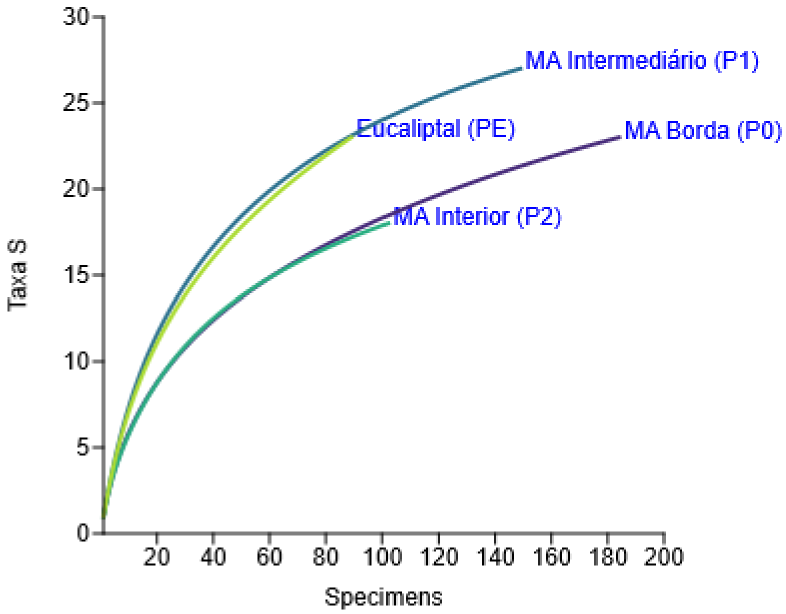


Source: authorial, 2023.

The impact on the dynamics of natural decomposition can reduce niches with consequent loss of density and even biodiversity in native areas (Gonçalves *et al*., 2012; Andrade *et al*., 2020).

The rarefaction curve showed that sample sufficiency was reached for the edge (P0) and the midpoint (P1) of the native fragment (Figure 11). Due to the density and richness recorded in the plots in 12 months, both the monthly collections at the edge (P0) and the quarterly collections in the intermediate environment (P1) of the native fragment were sufficient to achieve a sample of the diversity occurring at these points.

Figure 11. Sample sufficiency rarefaction curve between the collection areas in the forest fragment and in the *Eucalyptus* field. Alagoinhas, Bahia (Brazil). September/2022 to August/2023.



Source: authorial, 2023.

The greater complexity of native vegetation ensures a more heterogeneous forest floor, contributing to the structural complexity of niches for exploration by a greater diversity and abundance of species (Maestri *et al*., 2013).

The seasonal pattern can interfere with the plant-animal interaction (litter-invertebrate dynamics), where variations in temperature, humidity, and also the depth of the litter are factors that favor the predominance of these myrmecofauna organisms (Gontijo *et al.*, 2007). Another important factor is the presence of possible prey that serves as food for ants, as they have a varied diet, using other animals as a source of protein in their diet, such as myriapods and crickets that are prey to ants of the subfamilies Ponerinae and Myrmicinae (Fowler *et al*., 1991; Feitosa *et al*., 2008).

Regarding the invertebrates found in the eucalyptus, despite the low diversity and abundance, organisms of the subfamilies Dolichoderinae, Formicidae and Ponerinae were found, as well as the orders Blattaria and Isopoda. This low occurrence is due to the environmental degradation caused by eucalyptus plantations, which alter the environment and cause environmental disturbances, negatively impacting biodiversity (Baretta *et al.*, 2014). The low quality of litter is also a factor that contributes to a lower abundance of invertebrates, this is due to the fact that monoculture has low plant heterogeneity, affecting the edaphic/litter fauna and nutrient cycling (Pereira *et al.*, 2015).

The functional groups of terrestrial invertebrates are presented in tables 5 and 6, respectively for the native fragment of the Atlantic Forest and the eucalyptus.

Detritivores (armadillos) and predators (ants and spiders) dominated in relation to the other functional groups at the edge (P0) of the native Atlantic Forest fragment. In eucalyptus, detritivores, important for the decomposition of litter and nutrient cycling for the trophic web, did not stand out for their abundance, despite being present as in the Atlantic Forest. The balance between prey (detritivores) and predators (carnivores) in the forest and in Eucalyptus cultivation was mainly due to the groups of ants (Hymenoptera) and spiders (Araneae). In this approach of functional groups, the predatory organisms of the orders Hymenoptera and Araneae stood out in the biological control, especially of the detritivorous prey, predominant in both areas.

For the analysis of functional groups, due to their ecological importance, three orders were also considered at the lower taxonomic level of family or subfamily, such as Blattaria, with termites (Isoptera) highlighted by their characteristic abundance; Hymenoptera with the families Ponerinae, Formicidae, and Myrmicinae; Stylommatophora with the families Achatinidae, Bradybaenidae, Scolopendridae, and Japygidae, in which some specimens were found. This strategy gives value to smaller categories with equivalence to orders (Tables 5 and 6).

In eucalyptus cultivation, 6 distinct functional groups were found, with organisms represented in only three orders: Isopoda, Blattaria, and Hymenoptera (Table 6).

Table 5. Functional groups of terrestrial invertebrates in litter (plots P0, P1 and P2) of the Atlantic Forest fragment at Patioba Farm. Alagoinhas, Bahia (Brazil). September/2022 to August/2023.

Ordem	**Subordem Família Subfamília**	**Grupos Funcionais**						
		Predador	**Fitófago**	**Detritívoro**	**Saprófago**	**Coprófago**	**Parasita**	**Bioturbador**
Isopoda	Philoscidae			X	X	X		
Blattaria	Blaberidae			X				X
	Isoptera			X				X
Thysanoptera	Thrips	X	X					
Hymenoptera	Formicidae	X	X					X
	Formicidae	X		X				X
	Ponerinae	X	X	X				X
	Dolichoderinae	X						X
	Ectatomminae	X	X					X
	Myrmicinae	X						X
Araneae	Araneae	X						
	Ctenidae	X						
	Dictynidae	X						
	Theraphosidae	X						
	Phoneutria	X						
	Salticidae	X						
Opiliones		X						
Stylommatophora	Achatinidae			X				
	Bradybaenidae			X				
Orthoptera	Gryllidae		X					
Diplopoda	Spirostreptida		X	X	X			X

Source: authorial, 2023.

Table 6. Functional groups of terrestrial invertebrates in *Eucalyptus* field, Alagoinhas, Bahia (Brazil). September/2022 to August/2023.

Ordem	**Subordem Família Subfamília**	**Grupo funcional**						
		Predador	**Fitófago**	**Detritívoro**	**Saprófago**	**Coprófago**	**Parasita**	**Bioturbador**
Isopoda	Philoscidae			X	X	X		
Blattaria	Blaberidae			X				X
Thysanoptera	Thrips	X	X					
Hymenoptera	Formicidae	X						
	Ponerinae	X	X	X				X
	Dolichoderinae	X						
Coleoptera		X	X	X	X	X		X
Diptera		X	X					
Ortoptera		X	X					
Mantodea		X						
Neuroptera	Myrmeleontidae	X						
Araneae	Araneae	X						
	Ctenidae	X						
	Salticidae	X						
Opiliones		X						
Scorpiones	Buthidae	X						
Stylommatophora	Bradybaenidae			X				
Spirostreptida			X	X	X			X
Chilopoda	Scolopendridae						X	
Entognatha	Diplura			X				

Source: authorial, 2023.

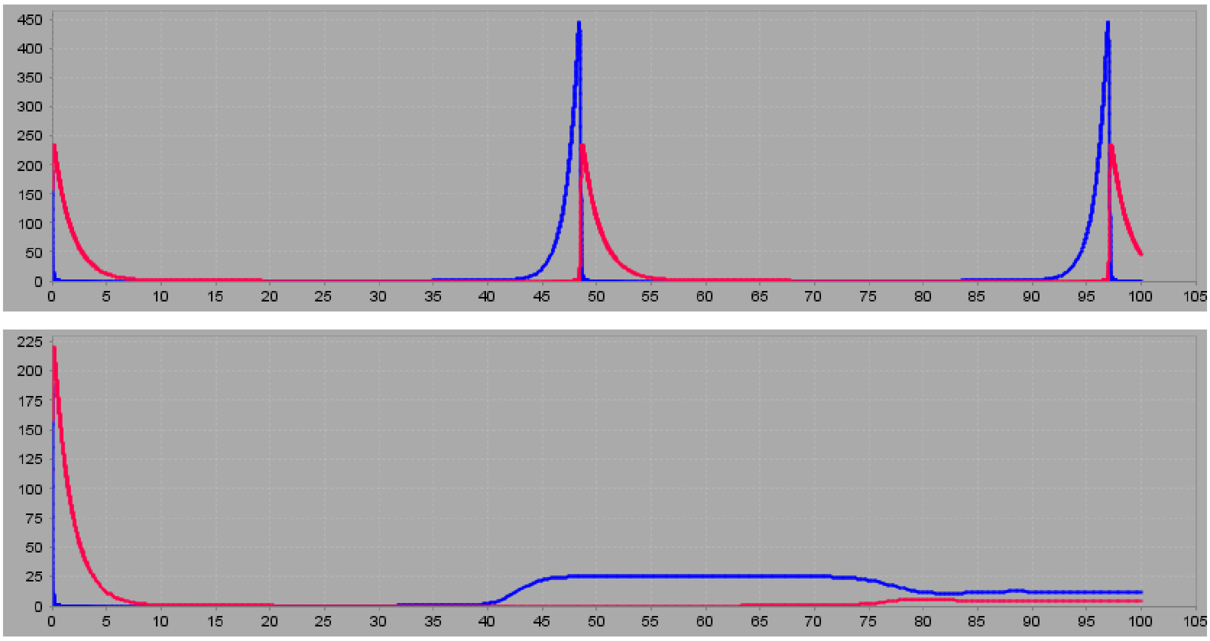
In addition to being predators, ants also play an important role as bioturbators in pedogenesis, especially leaf litter and soil ants. By turning over the litter and the soil, the ants accumulate residual plant matter as a source of nutrients and thus contribute to soil fertilization, increase porosity, and with it the aeration and permeability of the soil for the transport of water to the rhizosphere and the edaphic fauna (Gunadi; Verhoef, 1993; Offenberg *et al*., 2019). The group of bioturbators also includes termites (Blattaria: Isoptera) and cockroaches (Blaberidae). These organisms are important because they turn over and transform the soil, through transport and ingestion, promoting its aeration, recirculation of organic matter, increasing porosity and water input, being considered bioindicators of edaphic quality (Brown *et al*., 2015; Amazonas *et al*., 2018).

The orders Isopoda, Stylommatophora and Diplopoda are representatives of the detritivorous organisms that act in the decomposition of organic matter and, consequently, in the regeneration of the plant community (Jordano; Bascompte; Olesen, 2003). The detritivorous action of isopods in nutrient cycling contributes to the restoration of degraded environments (Quadros, 2010).

The presence of the organisms in Eucalyptus cultivation is due to the resilience/tolerance capacity of these groups to degraded environments. Despite this diversity of groups, there was a low density in the taxonomic orders, probably due to high predation due to the lack of niches for refuge in the stressful environmental conditions caused by the predatory management of this eucalyptus monoculture plantation (Ferreira; Marques, 1998).

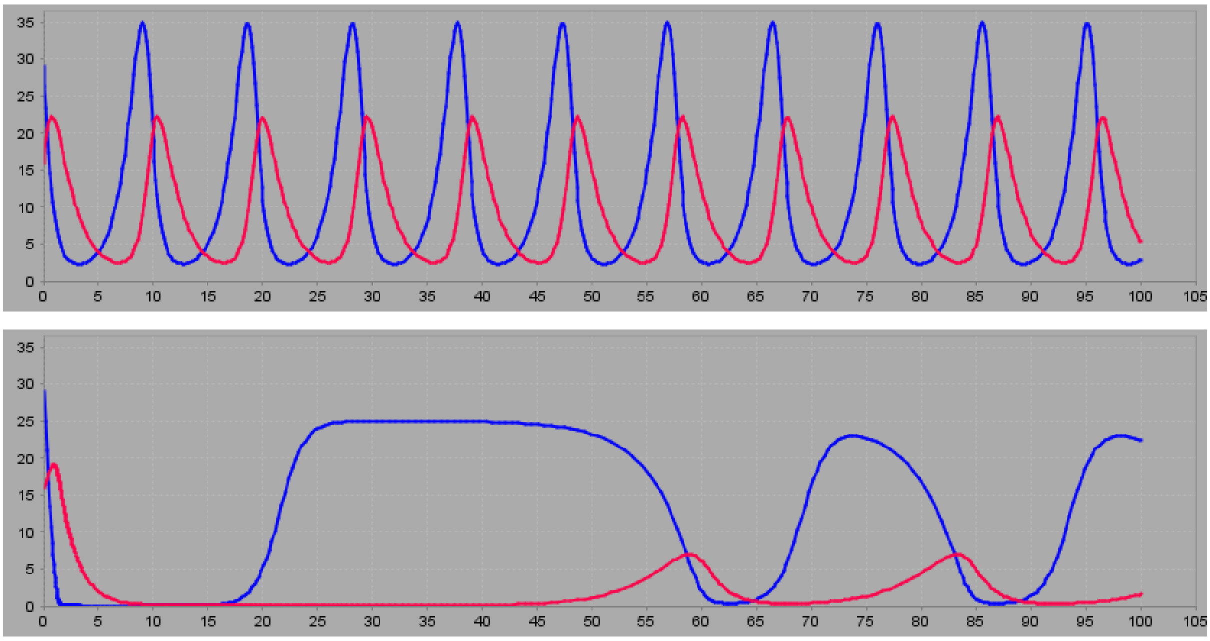
In a hypothetical scenario of simulation of the predator-prey relationship, there are two possible situations represented based on the abundance data of invertebrates captured in litter samples during one year. The simple Lotka-Volterra simulation for the ratio of 158 predators to 187 prey showed the recovery of prey in up to 50 days. In the natural environment, this situation may represent chaos given the complexity of possible ecological interactions even in the universe of terrestrial invertebrates associated with litter (Figure 12). The larger the group of prey, the lower the pressure exerted by predators and the faster the recovery of invertebrate populations in this functional group. In the degraded environment of the eucalyptus, the interaction of 16 predators and 29 prey, discreet due to the very low abundance, required only 5-15 days for the recovery of its community if the sources of stress cease (Figure 13).

Figure 12. Simple Lotka-Volterra simulation for the relationship of 158 predators and 187 prey among terrestrial invertebrates associated with leaf litter in the native forest fragment of the Atlantic Forest at Patioba Farm in Alagoinhas, Bahia (Brazil). September/2022 to August/2023. Continuous flow (top) and prey-dependent (bottom).



Source: authorial, 2023.

Figure 13. Simple Lotka-Volterra simulation for the relationship of 16 predators and 29 prey among terrestrial invertebrates associated with litter in Eucalyptus cultivation in Alagoinhas, Bahia (Brazil). September/2022 to August/2023. Continuous flow (top) and prey-dependent (bottom).



Source: authorial, 2023.

5. CONCLUSIONS

The amount of litter accumulated at the edge (P0) can be attributed to a lower decomposition activity in relation to the interior (P2) of the Atlantic Forest fragment. The amount of plant material contributed to the litter in Eucalyptus cultivation is lower than in the forest and the exotic species follows a different phase of senescence from the native species of the forest.

In the relationship between leaf litter and terrestrial invertebrates, the occurrence of animals was seasonally affected by rainfall in eucalyptus cultivation as an open field exposed to greater irradiation and desiccation, and litter was important as a protection of this fauna.

The amount of plant material in the litter of eucalyptus was lower than in the forest with the exotic species following a different senescence phase from native species. Among the constituent fractions of the litter, foliar predominated, as expected in the native fragment and in the eucalyptus, and the reproductive fraction was recorded in the summer after spring only in the native fragment.

In 12 months, 524 terrestrial invertebrates were captured in the litter of the study areas. In the native fragment of the Atlantic Forest, there were 435 specimens of 19 orders and 33 families in the litter between the three environments of the edge (P0) and the interior (P1 and P2). Eucalyptus cultivation had 89 specimens of 18 orders and 22 families in the litter of the degraded eucalyptus environment.

In the native forest fragment, the edge (P0) of the forest fragment had the highest number of invertebrates, with 184 specimens, where the greatest abundance was represented by the garden armadillos *Philoscia muscorum.* In the orders with the highest abundance, Isopoda, Blattodea and Hymenoptera stood out, corresponding to more than 50% of terrestrial invertebrates.

The highest indices of diversity and richness were recorded for the intermediate point (P1) within the forest fragment, followed by eucalyptus, where the species were usually represented by 1 individual each, unlike numerous groups in the native area. Groups of greater rarity and dependent on greater environmental complexity were found within the native fragment, while degraded areas, such as edge and eucalyptus, usually harbor visiting species from adjacent areas, given the high richness index, but with most species occurring only 1 individual over 12 months, as opposed to numerous groups of some species in the native fragment. The low abundance of the most resilient generalist orders in *Eucalyptus* cultivation favored equity, thus generating a high level of diversity, which does not necessarily indicate higher environmental and zoological quality of the area.

The analysis of taxonomic groups (cluster) showed the isopod domain (*Philoscia muscorum*, Isopoda) on the edge along with ants (Hymenoptera), spiders (Araneae) and gastropods (Stylommatophora) in the interior of the Atlantic Forest fragment, in contrast to insect larvae in the eucalyptus. The occurrence of terrestrial invertebrate groups recorded in Eucalyptus cultivation can be attributed to the use of *Eucalyptus* cultivation for foraging and capturing food, but no groups with a predilection for eucalyptus were recorded.

The terrestrial invertebrates captured were classified into seven functional groups: predator, phytophage, detritivore, saprophage, coprophage, parasite and bioturbator. Detritivores (armadillos) and predators (ants and spiders) dominated in relation to the other functional groups at the edge (P0) of the native Atlantic Forest fragment. In Eucalyptus cultivation, seven distinct functional groups were found, with organisms represented in only three orders: Isopoda, Blattaria and Hymenoptera. The presence of these organisms in this area is due to the ability of these groups to tolerate different environments. The detritivores, important for the decomposition of litter and the cycling of nutrients for the trophic web, although present, did not stand out for their abundance as in the Atlantic Forest.

The balance between prey (scavengers) and predators (carnivores) in the forest and in Eucalyptus cultivation was mainly due to groups of ants (Hymenoptera) and spiders (Araneae). In this approach of functional groups, the predatory organisms of the orders Hymenoptera and Araneae stood out in the biological control, especially of the detritivorous prey, predominant in both areas of study.

Simple Lotka-Volterra simulation for predator-prey ratio shows prey recovery within 50 days. In the natural environment, this situation may represent chaos given the complexity of possible ecological interactions even in the universe of terrestrial invertebrates associated with litter. In a degraded eucalyptus environment, the discreet predator-prey interaction due to the very low abundance requires only 5-15 days for the recovery of its community.

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