ATLANTIC FOREST SIZE EFFECT ON STRUCTURE AND COMPOSITION OF SOIL ARTHROPODS COMMUNITY, RJ, BRAZIL

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Abstract

Forest fragmentation may influence the soil fauna community. This study aimed to test the hypothesis that exists differences in the structure and composition of the soil arthropod communities among three Atlantic Rain Forest fragments with different sizes (SF: small; MF: medium and LF: large fragment) in Teresópolis, Rio de Janeiro, Brazil. The sample of the organisms occurred by means of random stratified installation of pitfall traps, during the rainy and dry seasons. The organisms were identified in taxonomic groups (mainly in order). The tested hypothesis was corroborated because the soil arthropod communities with more complex structure occurred in the MF (higher values of evenness and diversity) and in the LF (higher richness), which presented more similarity to each other, in comparison to the SF (higher total abundance). Collembola, Coleoptera, Chilopoda, Hymenoptera, Enchytraeidae and Blattodea featured the MF and the LF, whereas the SF favored Formicidae.
Keywords: Biodiversity; edge effect; forest fragmentation; soil fauna; tropical forests.

Resumo

Efeito do tamanho de fragmentos de Mata Atlântica sobre a estrutura e composição da comunidade de artrópodes do solo, RJ, Brasil. A fragmentação florestal pode influenciar a comunidade da fauna do solo. Este trabalho objetivou testar a hipótese de que existe diferença na estrutura e composição das comunidades de artrópodes do solo entre três fragmentos de Mata Atlântica com diferentes tamanhos (FP: fragmento pequeno; FM: fragmento médio; FG: fragmento grande) em Teresópolis, Rio de Janeiro, Brasil. A amostragem de organismos ocorreu por meio de armadilhas de queda instaladas de maneira aleatória estratificada, nas estações chuvosa e seca. Os organismos foram identificados em grupos taxonômicos (ordem, principalmente). A hipótese testada foi corroborada, uma vez que a comunidade de artrópodes do solo com estrutura mais complexa ocorreu no FM (maiores valores de uniformidade e diversidade) e no FG (maior riqueza), os quais apresentaram maior similaridade entre si, em comparação com o FP (maior abundância total). Collembola, Coleoptera, Chilopoda, Hymenoptera, Enchytraeidae e Blattodea caracterizaram o FM e o FG, enquanto que o FP favoreceu Formicidae.
Palavras-chave: Biodiversidade; efeito de borda; fragmentação florestal; fauna do solo; florestas tropicais.

INTRODUCTION

The original forest cover has been removed in order to attend different human activities, which results in a set of small forest fragments with different shapes and degrees of isolation and degradation. Edges are created around all these remnants, where solar radiation and winds are more intense, which results in increments of air and soil temperatures and decreases soil moisture, as compared with the interior of the forest fragments (SIQUEIRA et al., 2004). This phenomenon is called edge effect and in the Atlantic Rain Forest, it is responsible for high mortality of trees (SANTOS et al., 2008). Edge effect also influences the establishment of a tree community with high density of small individuals, mainly composed by pioneer species (RODRIGUES et al., 2014) and deciduous species that shed their leaves to minimize water loss in the dry season (HOLANDA et al., 2010).

There is limited information about the edge effect on some aspects of nutrient cycling in Atlantic Rain Forest. In Ibiúna, state of São Paulo, litterfall was lower at the edge of the forest fragments due to the massive presence of smaller trees, in comparison to the interior of the fragments (VIDAL et al., 2007). It was observed that litter decomposition was slower at the edge, because of the soil arthropods community involved in the process presented low diversity and it was mainly represented by microphagous organisms, compared to the interior where saprophagous-predator organisms predominated, in Pinheiral, state of Rio de Janeiro (PEREIRA et al., 2013). When comparing Atlantic Rain Forest fragments with different sizes, it was observed highest litterfall in small forest fragments (VIDAL et al., 2007). In Teresópolis, state of Rio de Janeiro, the concentrations and input of K and Mg via litterfall were higher in a medium fragment, while the concentration and input of Ca were higher in a small fragment (GOMES et al., 2010). The understanding of the edge effects on the soil arthropod community may contributes to taking measures of proper management of the remaining fragments. This study aimed to test the hypothesis that exists differences in the structure and composition of the soil arthropod communities among three Atlantic Rain Forest fragments with different sizes in Teresópolis, Rio de Janeiro, Brazil.

MATERIAL AND METHODS

This study was conducted in the rural municipality of Teresópolis (22º17'61 "S and 42º52'58"W) in the State of Rio de Janeiro, Brazil. The climate is classified as hot and humid tropical, with average annual rainfall ranging between 1,250 and 1,500 mm (RADAMBRASIL, 1983). The region has a dry season (May-August) with average monthly rainfall of 100 mm, and a rainy season (September-April) with average monthly rainfall exceeding 200mm, while the average monthly temperature of 19.5°C shows little variation throughout the year (GOMES et al., 2010). The undulating relief has steep escarpments covered by Montane Ombrophilous Dense Forest, and the predominant class of soils is Red-Yellow Argisol (RADAMBRASIL, 1983). Forest fragments of three different sizes were selected: Small Forest Fragment (SF: approximately 3.2ha), Medium Forest Fragment (MF: 23.0ha) and Large Forest Fragment (LF: 62.0ha). SF and LF are inserted into an environmental matrix formed by agricultural crops, pasture, or rocky outcrops and they are insolated to at least 500m from other forest fragments. MF is connected to other forest fragments of less than 200m of distance (GOMES et al., 2010).

In each forest fragment three plots were demarcated (10m x 100m) located at a distance of 0-10m (first parcel), 60-70m (second parcel) and 160-170m (third parcel) from the edge. The soil arthropod community was sampled by means of five pitfall traps 20m apart from each other in each plot (N = 15 traps / forest fragment). The traps consisted of plastic containers (7cm tall, 5cm diameter) filled with 100mL of acetylsalicylic acid 3% solution and were buried in the soil with the opening close to the interface with the litter standing stock. The contents of the traps were stored in plastic vials with a solution of 70% ethyl alcohol until the analysis.

The traps remained in the field for a period of 10 consecutive days, during the rainy and dry seasons. The organisms were quantified and identified in taxonomic groups (order, in general). According to other studies, in this level of identification, it was possible to evaluate the influence of the edge effect (GOEHRING et al., 2002; DUARTE, 2004; PEREIRA et al., 2013), plant richness/diversity, stage of forest regeneration (NEGRETE-YANKELEVICH et al., 2006; MENEZES et al., 2009; CAMARA et al., 2012) or the climatic season (SILVA et al., 2012) on the soil fauna community. Although this approach does not allow the precise determination of the ecological functionality of certain groups, it has less laborious execution, provides a global knowledge of the variety of the organisms present (CORREIA; OLIVEIRA, 2000) and provides a simple indication of the ecological complexity of the soil fauna community (STORK; EGGLETON, 1992).

Total abundance (number of individuals trap-1 day-1), richness (S, total number of groups), evenness (U, Pielou index) and diversity (H', Shannon index) were calculated. The values of total abundance and abundance of the functional groups were subjected to analysis of variance and the averages were compared by Kruskal-Wallis non-parametric test at 5% significance, with BioEstat statistical 5.3 software version.

A cluster analysis was performed in order to identify possible similarities among the forest fragments in relation to the structure of the soil arthropod community. In this analysis, the average values of abundance, richness, evenness and diversity was considered and calculated between the climatic seasons, for each area, in order to obtain a dendrogram of similarity, by means of the method of the paired group and Morisita similarity measure. The principal components analysis (PCA) was also performed with the aim of identify the taxonomic groups that could be used to differentiate or to indicate similarities among the forest fragments with different size, within the climatic seasons. Thus, it was only considered the average abundance of the taxonomic groups that presented correlation coefficients up to 0.70% with the axis 1 or the axis 2. Both of these multivariate analyses were processed by using the PAST program.

We also employed the statistical analysis of a generalized linear model in order to evaluate the association among richness or total abundance of the community of the soil fauna (dependent variables) and the area of the forest fragments, richness of the tree community and average monthly rainfall in dry and rainy seasons (independent variables). This model is used in situations where the dependent variable obeys distributions other than Normal, or where the relationship between the dependent variable and the independent variables is not linear (CONCEIÇÃO et al., 2001). For this purpose, we used the program STATISTICA 8.0 version.

RESULTS AND DISCUSSION

In the Atlantic Rain Forest fragments, 32,214 of arthropods were sampled which corresponded to 537 ± 110 individuals trap-1 day-1, distributed in 25 taxonomic groups. In general, there were no differences among the forest fragments in terms of the abundance of the taxonomic groups (Table 1). However, the abundance of Coeloptera was significantly higher in the LF, in comparison to the MF (dry season). On the other hand, the abundance of Thysanoptera was significantly higher in the SF when compared to the LF (rainy season).

In contrast, in the SF the abundance of Orthoptera and Formicidae were significantly higher in comparison to the MF (rainy and dry season, respectively) (Table 1). The higher total abundance of the soil fauna community in the SF when compared to the MF, whereas there were no differences between them and the LF, in the dry season. There were no differences among the forest fragments in relation to the total abundance in the rainy season.

Richness tended to present higher values as increased the size of the forest fragments, in the rainy season (Table 2). This pattern also occurred in the dry season in the comparison between the MF and the SF, although the LF tended to present the lowest richness value. Evenness and diversity presented higher values in the MF that were more close to the values verified in the LF, and the lower values of both the indexes occurred in the SF, in both of rainy and dry seasons.

In general, the more preserved tropical forest fragments often present higher values of total abundance / density, richness, evenness and diversity in comparison to the less preserved ones. This result was obtained comparing larger forest fragments with the smaller ones, such as in areas of Atlantic Rain Forest in the Southern Brazil (DUARTE, 2004) and in the Northeastern Brazil (LEAL et al., 2012) and in the Brazilian Amazonia (VASCONCELOS et al., 2006). The same pattern occurred when comparing native forest fragments of Atlantic Forest with eucalyptus plantations in the state of Rio de Janeiro (CUNHA NETO et al., 2012); and forest fragments with different stages of natural regeneration of Atlantic Forest in the same state (MENEZES et al., 2009; CAMARA et al., 2012).

Several tropical forests areas are restricted to small, disturbed, and disconnected remnants distributed in matrices heavily impacted by human activities. This fragmentation culminates in the "edge effect". Thus, light intensity, air temperature and intensity of winds are higher on the edge of the forest remnants, which result in lower moisture in the air and in the soil, in comparison to the interior of these ecosystems (SIQUEIRA et al., 2004). As consequence of this condition, the structure of the tree community is smaller, with lower densities of taller trees and presents higher mortality on the edge, when compared to the interior of tropical rain forest fragments (RODRIGUES et al., 2014).

Low forest structure also results in decreasing canopy closure, litter production and thickness of the accumulated litter layer on the soil surface (NEGRETE-YANKELEVICH et al., 2006). These conditions may reduce the diversity of nesting sites and availability of resources for the soil arthropods (CAMPOS et al., 2007). Because of this fact, the reproduction and survival of the soil arthropod organisms are more difficult, as are results in low richness and abundance / density of this community, in comparison with those areas where the forest presents high structure complexity (MENEZES et al., 2009; CAMARA et al., 2012; SZINWELSKI et al., 2012; PEREIRA et al., 2013). However, no significant differences among the forest fragments was previously noted in terms of total annual litterfall (SF: 4.74, MF: 4.96 and LF: 4.40 t ha-1 year-1), which suggested no differences among them in relation to the forest structure (GOMES et al., 2010).

According to data of the seed rain obtained by other work, the richness of the vegetation cover was higher in MF (49 species), intermediate in SF (44) and low in LF (31), but the diversity was higher in SF (0.96), followed by MF (0.86) and much lower in LF (0.33) (GONDIM, 2005). The author of the referred study verified that this fact was due to the higher relative participation of species in the seed rain (more than 75% of the total seeds collected) in SF (five), in contrast to MF (three) and LF (one species). This was probable the reason why the MF presented the higher complexity of the soil arthropod community, although the area of this forest fragment (23.0ha) was three times smaller than that of the LF (62.0ha), whose area was 20 times higher than that of the SF (3.2ha). Thus, differences among the forest fragments in relation to the three species composition may be contributed to the result for soil arthropod community, since vegetation cover with higher diversity may host

a soil arthropod community with also higher diversity (DUARTE, 2004; MENEZES et al., 2009; CAMARA et al., 2012; CUNHA NETO et al., 2012).

Table 1. Average abundance (standard error) of soil fauna taxonomic groups in Atlantic Rain Forest fragments with different sizes (SF: small fragment; MF: medium fragment; LF: large fragment), in the rainy and dry seasons, Teresópolis, RJ*.

Tabela 1. Abundância média (erro-padrão) dos grupos taxonômicos da fauna do solo em fragmentos de Mata Atlântica com diferentes tamanhos (FP: fragmento pequeno; FM: fragmento médio; FG: fragmento grande, nas estações chuvosa e seca, Teresópolis, RJ*.

Taxonomic group	**SF**	**MF**	**LF**	**SF**	**MF**	**LF**
	Rainy season			Dry season		
Collembola	6.163 A (1.132)	6.590 A (1.278)	6.613 A (1.643)	0.197 A (0.054)	0.183 A (0.053)	0.140 A (0.042)
Diptera	3.793 A (0.780)	3.730 A (0.721)	4.700 A (1.149)	0.100 A (0.025)	0.223 A (0.052)	0.213 A (0.213)
Heteroptera	0.090 A (0.032)	0.120 A (0.052)	0.037 A (0.015)	0.020 A (0.011)	0.003 A (0.003)	0.020 A (0.012)
Homoptera	0.130 A (0.035)	0.107 A (0.032)	0.077 A (0.026)	0.030 A (0.021)	0.003 A (0.003)	0.040 A (0.012)
Orthoptera	0.507 B (0.134)	1.187 A (0.176)	0.710 AB (0.129)	0.273 A (0.109)	0.027 A (0.010)	0.137 A (0.071)
Araneae	0.493 A (0.109)	0.357 A (0.056)	0.540 A (0.122)	0.020 A (0.009)	0.037 A (0.013)	0.023 A (0.012)
Chilopoda	0.000 A (0.000)	0.003 A (0.003)	0.000 A (0.000)	0.000 A (0.000)	0.000 A (0.000)	0.000 A (0.000)
Hymenoptera	0.000 A (0.000)	0.020 A (0.011)	0.093 A (0.071)	0.000 A (0.000)	0.000 A (0.000)	0.000 A (0.000)
Opilionida	0.043 A (0.040)	0.017 A (0.011)	0.017 A (0.008)	0.007 A (0.005)	0.003 A (0.003)	0.013 A (0.010)
Pseudoscorpionida	0.003 A (0.003)	0.007 A (0.005)	0.003 A (0.003)	0.000 A (0.000)	0.000 A (0.000)	0.000 A (0.000)
Scorpionida	0.007 A (0.007)	0.000 A (0.000)	0.010 A (0.010)	0.000 A (0.000)	0.000 A (0.000)	0.003 A (0.003)
Blatodea	0.023 A (0.011)	0.003 A (0.003)	0.003 A (0.003)	0.037 A (0.013)	0.023 A (0.012)	0.037 A (0.025)
Diplopoda	0.087 A (0.024)	0.100 A (0.028)	0.110 A (0.032)	0.000 A (0.000)	0.010 A (0.007)	0.000 A (0.000)
Enchytraeidae	0.000 A (0.000)	0.000 A (0.000)	0.007 A (0.007)	0.000 A (0.000)	0.000 A (0.000)	0.000 A (0.000)
Isopoda	0.320 A (0.071)	0.550 A (0.123)	0.290 A (0.074)	0.193 A (0.099)	0.203 A (0.046)	0.110 A (0.041)
Oligochaeta	0.020 A (0.010)	0.037 A (0.012)	0.047 A (0.016)	0.000 A (0.000)	0.000 A (0.000)	0.000 A (0.000)
Symphyla	0.010 A (0.006)	0.073 A (0.039)	0.000 A (0.000)	0.000 A (0.000)	0.007 A (0.005)	0.000 A (0.000)
Thysanura	0.003 A (0.003)	0.000 A (0.000)	0.003 A (0.003)	0.000 A (0.000)	0.000 A (0.000)	0.003 A (0.003)
Coleoptera	3.237 A (0.536)	2.103 A (0.292)	2.507 A (0.619)	0.137 AB (0.036)	0.113 A (0.041)	0.527 B (0.160)
Coleoptera's larvae	0.500 A (0.137)	0.290 A (0.067)	0.457 A (0.114)	0.013 A (0.008)	0.010 A (0.007)	0.017 A (0.008)
Diptera's larvae	0.087 A (0.026)	0.057 A (0.031)	0.077 A (0.029)	0.003 A (0.003)	0.017 A (0.012)	0.013 A (0.008)
Formicidae	36.190 A (17.877)	3.230 A (0.348)	13.577 A (7.091)	2.170 A (0.606)	0.490 B (0.092)	0.887 AB (0.233)
Isoptera	0.067 A (0.021)	0.030 A (0.013)	0.047 A (0.013)	0.007 A (0.005)	0.023 A (0.020)	0.110 A (0.47)
Lepidoptera's larvae	0.010 A (0.007)	0.000 A (0.000)	0.007 A (0.005)	0.000 A (0.000)	0.000 A (0.000)	0.007 A (0.005)
Thysanoptera	0.103 A (0.046)	0.003 AB (0.003)	0.000 B (0.000)	0.000 A (0.000)	0.000 A (0.000)	0.000 A (0.000)
Total	51.883 A (17.215)	18.617 A (1.965)	29.997 A (7.214)	3.207 A (0.630)	1.377 B (0.139)	2.300 AB (0.398)

*Average values (15 replicates) followed by the same letter, in the line (same climatic season), are not significantly different at P = 0.05, according to the Kruskal-Wallis test.

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In addition, the higher complexity of the soil arthropod community in MF also reflected the fact that this area is connected to some other forest fragments by less than 200m of distance, while the LF is isolated by at least 500m from other forest fragments (GOMES et al., 2010). In this case, the migration of the soil organisms from the other forest remnants to the MF was probable favored in comparison to the LF, which presented higher negative effects of the isolation effects promoted by the intervening impermeable human-modified matrix to dispersal of the soil arthropods.

Table 2. Structural attributes of the soil arthropod community in Atlantic Rain Forest fragments with different sizes (SF: small fragment; MF: medium fragment; LF: large fragment), in the rainy and dry seasons, Teresópolis, RJ*.

Tabela 2. Atributos estruturais da comunidade de artrópodes do solo em fragmentos de Mata Atlântica com diferentes tamanhos (FP: fragmento pequeno; FM: fragmento médio; FG: fragmento grande), nas estações chuvosa e seca, Teresópolis, RJ*.

SF			**MF**			**LF**		
S	U	H'	S	U	H'	S	U	H'
Rainy season								
14	0.40	1.51	21	0.60	2.65	23	0.51	2.29
Dry season								
14	0.48	1.83	16	0.69	2.78	12	0.67	2.42

*Average values (15 replicates) followed by the same letter, in the line, are not significantly different at P = 0.05 according to Kruskal-Wallis test. S: richness; U: Pielou evenness index; H': Shannon diversity index.

The similarity dendogram indicated that the three sizes of forest fragments presented high similarity (approximately 88%) (Figure 1). Despite this, the highest similarity in terms of the strucuture of the soil arthropod community (total abundance, richness, evenness and diversity) occurred between MF and LF (approximately 98%).

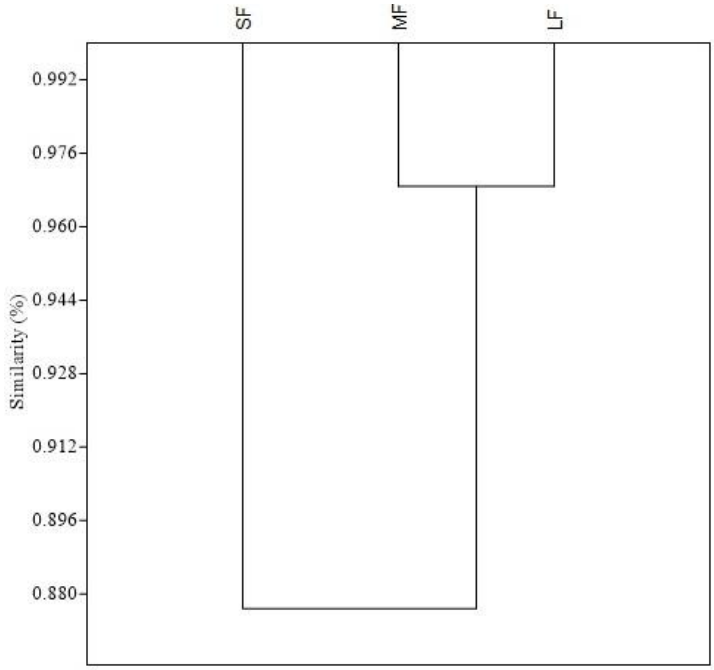

Figure 1. Similarity dendrogram obtained with the average values of total abundance, richness, evenness and diversity of the soil arthropod community in Atlantic Rain Forest fragments with different sizes (SF: small fragment; MF: medium fragment; LF: large fragment), in the rainy and dry seasons, Teresópolis, RJ.

Figura 1. Dendrograma de similaridade obtido com os valores médios de abundância total, riqueza, uniformidade e diversidade da comunidade de artrópodes do solo em fragmentos de Mata Atlântica com diferentes tamanhos (FP: fragmento pequeno; FM: fragmento médio; FG: fragmento grande), nas estações chuvosa e seca, Teresópolis, RJ.

Collembola, Formicidae, Coleoptera and Diptera were the taxonomic groups that presented the highest relative participation in the three sizes of the forest fragments (from 73% to 95% of the total abundance), in both rainy and dry seasons. The exception occurred in the SF in the dry season, when Isopoda and Orthoptera presented the highest relative participation, besides Collembola and Formicidae. However, the relative participation varied as a function of the size of the forest fragments. According to the average of the climatic seasons, the relative participation of Formicidae decreased as the size of the forest fragments increased (SF: 69%; MF: 27 %; LF: 42%). On the other hand, the relative participation of Collembola (SF: 9 %; MF: 24 %; LF: 14%) and Coleoptera (SF: 5%; MF: 10 %; LF: 16%) increased as the size of the forest fragments increased, in relation to the average of the climatic seasons. Formicidae, Collembola and Coleoptera are soil organisms indicators of ecological changes in the Atlantic Forest, according to a review that considered data from 56 studies conducted in tropical forest areas in different countries (BROWN JR, 1997).

The higher abundance of the soil arthropod community in SF may be explained by the sampling of an elevated number of individuals of Formicidae. In fact, the abundance of this taxonomic group in SF was approximately eight times and three times higher than in MF and LF, respectively, when considering the average between both the climatic seasons. The striking relative participation of Formicidae in SF (approximately 70% in both climatic seasons) influenced the lower value of the eveness index in this forest fragment, which in turn caused the lowest diversity in SF in comparison to the other forest fragments. This was probably a response of this group to the prevailing climatic conditions in the SF, which presented the highest degree of disturbance when compared to the MF and LF.

Formicidae presents high participation in the soil arthropod community in different forest ecosystems (CUNHA NETO et al., 2012). However, the dominance of the ants diminishes gradually as the stage of natural regeneration of Atlantic Rain Forest advanced in areas impacted by different anthropogenic activities (MENEZES et al., 2009; CAMARA et al., 2012). The same pattern also occurred in the interior of a fragment of Atlantic Forest in the State of Rio de Janeiro, where the relative participation of Formicidae was lower in comparison to the edge (PEREIRA et al., 2013). Density of Formicidae was higher near the border and decreased as the distance in the interior of the forest from the border increased, in a remnant of the Atlantic Rain Forest in the Northeastern Brazil (WIRTH et al., 2007).

Collembola and Coleoptera also featured more preserved ecosystems in previous works. As the size of tropical forest fragments increased, higher was the relative participation of Collembola in Costa Rica (GOEHRING et al., 2002) and of Coleoptera in the Southern Brazil (DUARTE, 2004). In Atlantic Forest areas in the Southeast Brazil, the relative participation of Collembola, mainly represented by Entomobryomorpha, and of Coleoptera increased as the stage of the natural forest regeneration advanced (CAMARA et al., 2012). The relative participation of Collembola, represented by Entomobryomorpha, Poduromorpha and Symphypleona groups, and Coleoptera was higher in a fragment of Atlantic Forest than in a plantation of hybrid eucalyptus in Southeastern Brazil (CUNHA NETO et al., 2012).

Eight taxonomic groups (32% of the total) presented restricted occurrence in the Atlantic Rain Forest fragments. Enchytraeidae was sampled only in the LF, whereas Chilopoda and Hymenoptera were sampled only in the MF and LF; Symphyla and Thysanoptera occurred only in the SF and MF; Scorpionida, Thysanura and larvae of Lepidoptera, were sampled only in the SF and LF. This occurs because of the adjustment of the organisms in relation to the environmental conditions, such as patterns of temperature, humidity, competitors and predators, defined by the degree of the adaptation of each species or taxonomic group, within their limits (RICKLEFS, 2003). The occurrence of predators, such as Chilopoda and Hymenoptera, demonstrates a more complex structure of the community (BEGON et al., 2005), because they have high-energy requirements and so are predicted to decline in small fragments. The composition of the soil arthropod community and the presence of certain functional groups have great potential to assess the quality of soil, the level of degradation caused by anthropogenic abundances (PAOLETTI, 1999) and demonstrate the effectiveness of biological measures employed in environmental recovery processes (PARR; CHOWN, 2001).

In the principal component analysis graphic, the variables (taxonomic groups abundance) were divided into two axes that explained 89.51% of the total variability among the different sizes of forest fragment, whithin the climatic seasons (69.27% for axis 1 and 20.24 % for axis 2). Along the axis 1 (main axis), it can be easily noticed that in the dry season all of the forest fragments were grouped in the left portion, while in the rainy season the three forest fragments were grouped in the right portion (Figure 2). This fact indicated the important effect of the climatic seasons upon the abundance of the soil arthropod taxonomic groups in all of the forest fragments. However, in the dry season the SF and MF were both positioned very close to each other under the axis 1 and almost overlap each other. In contrast, the LF positioned over the axis 1. This pattern suggested that the edge effects on the soil fauna community was probable higher in SF and MF, in comparison to LF.

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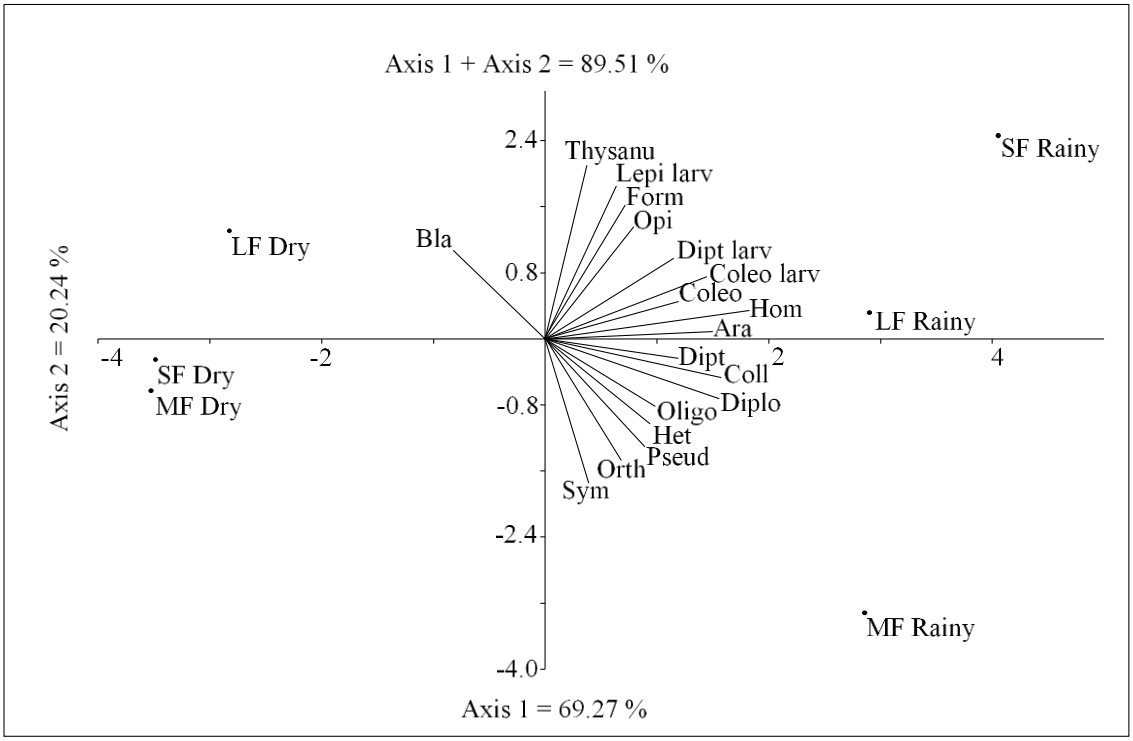

Figure 2. Principal component analysis of the abundance of the soil arthropod taxonomic groups in Atlantic Rain Forest fragments with different sizes (SF: small fragment; MF: medium fragment; LF: large fragment), in the rainy and dry seasons, Teresópolis, RJ. Ara: Araneae; Bla: Blattodea; Coll: Collembola; Coleo: Coleoptera; Coleo larv: Coleoptera's larvae; Diplo: Diplopoda; Dipt: Diptera; Dipt larv: Diptera's larvae; Form: Formicidae; Het: Heteroptera; Hom: Homoptera; Lepi larv: Lepidoptera's larvae; Oligo: Oligochaeta; Opi: Opilionida; Orth: Orthoptera; Pseud: Pseudoscorpionida; Sym: Symphyla; Thysanu: Thysanura.

Figura 2. Análise de principais componentes da abundância de grupos taxônomicos de artrópodes do solo em fragmentos de Mata Atlântica com diferentes tamanhos (FP: fragmento pequeno; FM: fragmento médio; FG: fragmento grande), nas estações chuvosa e seca, Teresópolis, RJ. Ara: Araneae; Bla: Blattodea; Coll: Collembola; Coleo: Coleoptera; Coleo larv: larvas de Coleoptera; Diplo: Diplopoda; Dipt: Diptera; Dipt larv: larvas de Diptera; Form: Formicidae; Het: Heteroptera; Hom: Homoptera; Lepi larv: larvas de Lepidoptera; Oligo: Oligochaeta; Opi: Opilionida; Orth: Orthoptera; Pseud: Pseudoscorpionida; Sym: Symphyla; Thysanu: Thysanura.

In the present study, practically all of the individuals were sampled during the rainy season (up to 93%), when compared to the dry season. Chilopoda, Enchytraeidae, Hymenoptera, Oligochaeta, Pseudoscorpionida and Thysanoptera were sampled only in the rainy season, whereas no taxonomic group was restricted to the dry season. The temperature and precipitation are higher in the rainy season, which favor the soil arthropods (SILVA et al., 2012). This pattern was reinforced by the generalized linear model analysis for richness of the soil fauna community, which explained approximately 77% of the variance ($R^2 = 0.769058$), and the total abundance of the soil fauna community, which explained approximately 27% of the variance ($R^2 = 0.268071$). According to them, there was a significant effect ($P < 0.05$) on the association of both of these variables with the average monthly rainfall (Table 3). With regard to the total abundance of the soil fauna community, there was also a significant influence of the area (size) of the forest fragment and the richness of the tree community.

In the figure 2, in the dry season, there was a higher association of Blattodea with the LF, while any taxonomic group presented association with SF and MF (Figure 2). In the right group (rainy season) of this figure, LF favored Collembola, Araneae, Diplopoda, larvae of Coleoptera, Coleoptera, Homoptera and Diptera. On the other hand, Orthoptera, Pseudoscorpionida, Oligochaeta, Symphyla and Heteroptera were associated to MF. Formicidae, Opilionida, Thysanura and Lepidoptera larvae were favored in SF.

Table 3. Results obtained from the general linear model analysis for evaluating the association among richness or total abundance of the soil fauna with the area of the forest fragments, the richness of the tree community and the average monthly rainfall in the rainy and dry seasons, Teresópolis, RJ*.

Tabela 3. Resultados obtidos da análise do modelo linear generalizado para avaliar a assciação entre a riqueza ou abundância total da comunidade da fauna do solo e a área dos fragmentos florestais, riqueza da comunidade arbórea e a precipitação média mensal nas estações chuvosa e seca, Teresópolis, RJ*

Effect on richness	**SS**	**Degrees of freedom**	**MS**	**F**	**p**
Intercept	0.6881	1	0.6881	0.2892	0.592128
Area of the forest fragment	0.4871	1	0.4871	0.2047	0.652096
Richness of tree community	0.0579	1	0.0579	0.0243	0.876386
Rainfall	680.6250	1	680.6250	286.0421	0.000000
Error	204.6333	86	2.3795		
Effect on total abundance	SS	Degrees of freedom	MS	F	p
Intercept	142569	1	142569	1.68484	0.197753
Area of the forest fragment	470487	1	470487	5.56007	0.020643
Rainfall	2189928	1	2189928	25.87990	0.000002
Richness of tree community	362886	1	362886	4.28848	0.041369
Error	7277223	86	84619		

CONCLUSIONS

- The soil arthropod community with more complex structure occurred in the MF (higher values of evenness and diversity) and in the LF (higher richness), which presented more similarity to each other, in comparison to the SF (higher total abundance).
- Collembola, Coleoptera, Chilopoda, Hymenoptera, Enchytraeidae and Blattodea featured Atlantic Forest fragments that presents less degree of perturbation (medium and large-sized), whereas Formicidae is a taxonomic group that featured the Atlantic Forest fragment with high degree of perturbation (small forest fragment).

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