Floresta e Ambiente 2019; 26(3): e20180415
https://doi.org/10.1590/2179-8087.041518
ISSN 2179-8087 (online)

Original Article

Silviculture

Population Fluctuation of Coleobrocas (Coleoptera) in Six Forest Fragments in Atlantic Forest

Cleber Vinicius Vitorio da Silva[1], Acacio Geraldo de Carvalho[1], Josimar Ribeiro de Almeida[2], Luiz Alberto Santos Abreu[3], Karina Arruda da Silva[4], Rafael Tavares[5]

[1]Universidade Federal Rural do Rio de Janeiro – UFRRJ, Seropédica/RJ, Brasil
[2]Universidade Federal do Rio de Janeiro – UFRJ, Rio de Janeiro/RJ, Brasil
[3]Universidade do Estado do Rio de Janeiro – UERJ, Rio de Janeiro/RJ, Brasil
[4]Faculdade de Americana, Americana/SP, Brasil
[5]Helium Corporation Engenharia, Seropédica/RJ, Brasil

ABSTRACT

The objective of this work was to evaluate the forest restoration of Guapiaçu river basin in Macacu, RJ, using the families of coleobrocas as tools for environmental assessment. We analyzed the fluctuation of the families of Coleoptera: Cerambycidae, Lyctidae, Anobiidae, Bostrichidae and Curculionidae. Six sampling points were arranged along the river, five points being inferred in reforestation carried out in the basin and a point in the control area of natural regeneration the amount of Guapiaçu river. The collection period started in January 2013, and ended in December 2015. Through quali-quantitative data, there is a greater population density of sub-family Scolytinae in periods of high temperature and humidity and areas more populated by pioneer species used in forest restoration. After the end of the monitoring period, we proposed a model of environmental assessment through the frequency of occurrence of families of coleobrocas collected in forest fragments.

Keywords: forest entomology, conservation of natural areas, ecology of forest ecosystems.

1. INTRODUCTION AND GOAL

The insects can be used to determinate the anthropic interference in various ecosystems, in bio- monitoring. Therefore, there has been an interest to obtain information about their dynamics, thus gaining insight about the ecosystem quality (Cristo et al., 2019).

Coleopters can be used as bioindicators of environmental quality in fragments and reforestation, once in environments where disclimax, i.e., who have suffered changes like deforestation or fire, for example, tend to have a higher density of wood-eating insects (Bradley & Tueller, 2001; Galdino-da-Silva et al., 2016). The analysis of their populations' growth, fluctuations, size, and environmental factors is fundamental in the study of pestilent insects. Constant modifications in populations of insects lead to phytosanitary problems in forest stands. Generally, the beetles can play several roles in ecosystems, predators, pollinators and as biological indicators (Trevisan et al., 2004; Galdino-da-Silva et al., 2016).

Wood-eating beetles may suffer action of biotic factors such as competition, predation and the availability of food, as well as of abiotic factors, such as temperature, precipitation and relative humidity (Galdino-da-Silva et al., 2016). According to Carvalho & Trevisan (2015), the number of dead trees by wood-eating beetles action, especially in the sub-family Scolytinae, has increased significantly in recent years in all regions, mainly in forests damaged by storms, fires and poor conditions of management.

Especially in the Atlantic Forest biome, with only 7% of its original extension remaining. In the state of Rio de Janeiro, the biome covered about 97% of its total area. According to Cortines & Valcarcel (2009), until the end of the 1990's, 17% of the area of this territory still had forest cover. In some places, such as in Rio Grande do Norte, not even traces of it can be found. Today the majority of coastal area that was covered by the Atlantic Forest is occupied by large cities, pastures and agriculture. As a result of deforestation or excessive exploitation of the forest, the Atlantic Forest biome has its areas presenting different successional stages of regeneration or recovery (Cortines & Valcarcel, 2009). There are many attacks of restoration in this biome, however the monitoring of forest restoration, merely restricted to the phytosociological monitoring of restored areas, often ignores the relationship of fauna and flora, especially the relationship between insect-plant (Galdino-da-Silva et al., 2016).

The forest restoration actions undertaken in the collection area of the river in Guapiaçu in Cachoeiras de Macacu, State of Rio de Janeiro, are of great reference (Azevedo et al., 2018), the headwaters of the river Guapiaçu is located in a preserved area, at 1,200 m altitude, in the midst of the hilly slopes of the Serra do Mar (Azevedo et al., 2018). The basin has a territorial extension of 573.54 km^2, having as main soil formations of Dense Ombrophilous Forest (Cabral & Fiszon, 2004), forming three very diverse strata: emerging with canopy trees, reaching about 45 m of height, on the main canopy of 5 to 10 m and smaller under their shadows (Azevedo et al., 2018). The ecosystems: altitude fields, swamps, lakes and rivers have been observed in the basin area. The main river of the basin, the river Guapiaçu, in the past, used to be a navigable river. According to Azevedo et al. (2018), the rivers of the region were important logistical pathways of agricultural products and raw materials derived from forest extraction in the 18th century. Currently, a large part of restoration actions in the basin follow the guidelines Atlantic Forest Restoration Pact (Calmon et al., 2009), like the actions of forest restoration in the Ecological Reserve of Guapiaçu (REGUA).

The objective of this work was to use the families of Coleoptera: Cerambycidae, Lyctidae, Anobiidae, Bostrichidae and Curculionidae, and sub-families of Curculionidae: Scolytinae, Platypodinae, which were collected in five reforestation areas in Guapiaçu river basin and a in a control area, Monthly collections were carried out for for the period started in January 2013 to December 2015, with the aim of assessing the ecological quality of reforestations.

2. MATERIAL AND METHODS

2.1. Characterization of the study area

The study area is located within the geographical limits of the 7380 ha of the Ecological Reserve of Guapiaçu - REGUA, between the coordinates UTM 23K 728783 7515700 m N and M L. located in the rural community of Guapiaçu, the district of the municipality of Cachoeiras de Macacu, Rio de Janeiro State. It encompasses part of the Basin of the river

Guapiaçu and block of forest remnants of the Serra do Mar. According to Köppen, the climate of the region is tropical with a rainy summer and a dry winter, classified as type AF. The work developed by Azevedo et al. (2018) on the same reservation determined the average annual temperature of 22.4 °C, with maximum in the months of January and February and minimum in June. The average annual rainfall is 2095 mm, December and January are the wettest months and June and July the least rainy. During this study, the average temperature was 23.1 °C and an average annual rainfall of 1307 mm, July was the driest month with 32 mm. The wettest month was December, with an average of 208 mm.

Six sampling points were set in the basin of the River Guapiaçu (Figure 1). P01 was the closest to the area of pastures and agricultural crops; the reforestation has been happening in this area for approximately six years. P02 had great density of fruit species, with a focus on the attraction of ornithon and chiropteran fauna; the reforestation had been carried out in this area for eight years. P03 had the most recent reforestation area, that is, five years, fruit species and pioneers were found in this area. P04 is the area that has the highest density of pioneer species; in these area the deployment of fast-growing species as *schinus terebinthifolia* Raddi and *Cecropia glaziovii* Snethl was maximized; reforestation has been happening in this area for six years. P05 is the area in which it the methodological framework of the Atlantic Forest Restoration Pact (Calmon et al., 2009) was applied., it is an area with a high density of non- pioneer and climax species, arranged in rows of quincunx, the reforestation has been happening there for seven years.

The control area is the P06, composed by those whose ecological characteristics are closer to the original not affected by anthropic pressure. Additionally, that is the area where access is the most difficult, the land with the highest topography.

For all sampling areas the history was the pasture for dozens of years, it is noteworthy that in P05, the perennation of a large body of water with lotic characteristics has been occurring, probably due to the reforestation.

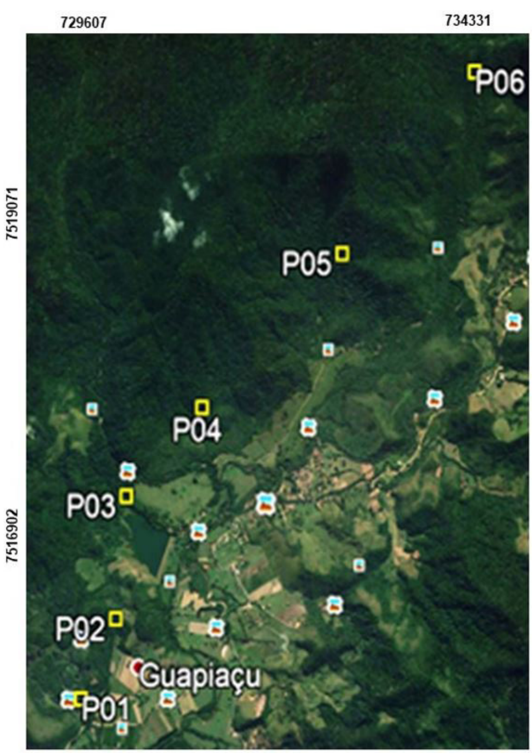

Figure 1. Sampling points in the Basin of the river Guapiaçu. Source: Area map made by Cleber Silva (2018). P01 = area P01; P02 = area P02; P03 = area P03; P04 = area P04; P05 = area P05; P06 = area P06.

2.2. Sample design and analysis

Fortnightly collections were made, with the trap model SEMIFUNIL (Carvalho & Trevisan, 2015). The trap (Figure 2) was installed in the interior of the

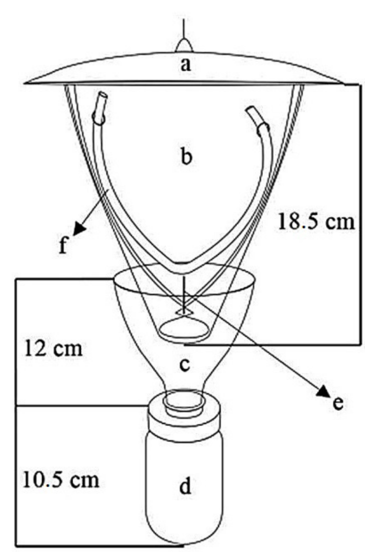

Figure 2. Front view: (a) covering plate; (b) interceptor panel "Semi-funnel"; (c) collector funnel; (d) collecting bottle; (e) wire fastener; (f) deposit of ethanol. Source: Carvalho & Trevisan (2015).

forests to 1.5 meters high, approximately 70 meters distant from the road, we used 3 traps per area studied, distant 10 m from one another. This was adapted and crafted, being basically a transparent plastic bottle type 'PET', set in a vertical position with the neck facing down, which secures the cover of a collector bottle, with the openings for the insects entrance (which originate plumes of odor, being attractive to the insects since they have the ability to direct toward the place where the odor is concentrated - site of the trap), they were made in a circular shape at opposite positions in the body of the bottle, at two levels; a plastic tube, with the purpose of partially providing the scent (bait attractive). A wire was attached to the bait in its upper inner part as a way to secure the baits positioning. As attractive bait, we used ethanol at a concentration of 96%, which was renovated after each collection of insects. The collections of insects were held at every fortnight. After being collected, the insects were taken to the Laboratory of environmental mapping at UFRRJ (LAMAGEDENASA), where they were subjected to screening, separated from plant residues and other animals. Later they were placed in Petri plates, being labelled by collection and traps. Later they were taken to an oven at 50° for 15 minutes to dry. Identification was performed by family comparing directly with the entomological collections of the Laboratory of environmental mapping of the Institute of Agronomy of UFRRJ and based on the literature. A score of the number of individuals and classification by families was performed with the aid of an optical microscope, due to the small size of some insects. The insects that do not belonging to families Bostrichidae, Cerambycidae, Anobiidae, Lyctidae, Curculionidae, and subfamilies Scolytinae, and Platypodinae were classified as "Other".

We analyzed the Ecological parameter Relative Frequency (RF), adapting it to the average number of months of collection, which is the percentage of the occurrence of the taxon i by the sum of occurrences for all taxa of the component analyzed, where FO = (Oci/Σ x 100 OC), for the months of collection, the results found for the parameter frequency were essential for the creation of a table of evaluation of ecological quality, i.e., correlating the frequency of taxa with its auto-ecology.

The analysis of data was the transformation of average monthly frequency of sampling in a pattern of bioindication (%), evaluated by analysis of variance (ANOVA) at 5% of significance, and the averages were compared among themselves, in order to evaluate the homogeneity of variances to area, month and year levels. The Bartlett test was used, and the Tukey-Kramer test at 5% probability of error was used to match the results.

The multivariate analyses aim to reduce a large number of variables to a few dimensions with minimal loss of information, allowing the detection of main patterns of similarity and association between the sample units. With this purpose, we employed indirect ordination through the non-metric multidimensional scaling (MDS). The MDS is a sorting method that employs an iterative optimization algorithm to graphically represent (in one to three dimensions) the relations of similarity between the sample units. It differs from all other methods eigen (PCA, PCOA, CCA, etc.) by not assuming linear relationships between the variables and by better preservation of the relations of distances between the sampling units, often lost when reduced to orthogonal axes of greatest variation.

Stress is an index resulting from the analysis of MDS and represents the degree of adjustment of graphical distances between points to ecological distances between sample units. A stress ≤ 0.1 corresponds to a good ordination. In this study the chart MDS was elaborated from the bray-curtis similarity matrix, which in turn was derived based on data from seasonal abundance and frequency of each taxon raised by sampling unit. The Bray-Curtis index varies from 0 to 1, with lower values indicating more similar samples. This standardization in the interval between one and zero facilitates the interpretation and comparison. For the preparation of analyzes, it was used the statistical software Past and the multiplatform spreadsheet open source software Calc, distributed for free with the suites OpenOffice.org and NeoOffice.

3. RESULTS AND DISCUSSION

Along the seventy and two collections, we obtained a total of 21603 individuals collected in six areas in question (Table 1). Families and subfamilies in study, in addition to the classified as others comprise that total amount. The subfamily Scolytinae presented the largest number of collected individuals with 9117, followed by the family Bostrichidae with 4983 individuals, Curculionidae with 1863 individuals, Cerambycidae with 1859 individuals,

Table 1. Average monthly frequency of occurrence (FO). Calculated from the monthly average, between years (2013 to 2015), the number of individuals recorded for each family.

Point.Month	Ce	Sc	Cu	Pl	An	Ly	Bo
P1Jan	13.48	52.61	7.39	3.91	0.87	2.61	19.13
P1Feb	14.43	45.77	6.47	5.97	2.99	0.50	23.88
P1Mar	15.21	38.25	7.83	8.76	3.23	1.84	24.88
P1Apr	4.31	49.57	8.19	8.19	1.72	2.59	25.43
P1May	4.05	51.40	13.71	4.98	0.93	3.74	21.18
P1Jun	5.68	44.70	7.58	5.68	1.52	2.65	32.20
P1Jul	6.40	41.87	11.33	0.99	0.49	4.43	34.48
P1Aug	12.30	40.64	13.37	1.60	0.00	1.07	31.02
P1Sep	5.42	47.89	10.84	7.83	2.41	0.60	25.00
P1Oct	6.33	47.78	15.19	2.53	2.22	0.63	25.32
P1Nov	7.27	61.92	6.10	1.74	0.29	1.74	20.93
P1Dec	7.99	58.96	7.34	2.59	1.08	1.08	20.95
P2Jan	7.64	51.39	5.56	4.17	0.69	1.39	29.17
P2Feb	8.76	48.45	4.64	1.55	1.55	2.58	32.47
P2Mar	5.80	51.69	8.70	2.90	0.97	1.93	28.02
P2Apr	6.51	54.88	4.65	2.33	0.93	0.00	30.70
P2May	8.24	49.10	9.68	5.02	1.79	1.08	25.09
P2Jun	7.41	51.32	6.35	4.76	1.59	1.06	27.51
P2Jul	10.19	51.59	7.01	0.64	0.64	0.64	29.30
P2Aug	8.10	40.00	10.95	5.24	3.33	1.43	30.95
P2Sep	6.90	44.83	6.90	4.21	4.60	1.53	31.03
P2Oct	8.06	49.60	4.84	1.61	1.61	1.61	32.66
P2Nov	6.16	46.58	6.16	5.82	1.37	3.77	30.14
P2Dec	7.67	50.74	4.42	4.72	1.18	0.88	30.38
P3Jan	8.59	53.65	6.51	4.69	3.39	2.08	21.09
P3Feb	10.47	40.43	8.30	6.86	3.25	3.25	27.44
P3Mar	6.83	38.55	12.85	6.43	4.02	3.21	28.11
P3Apr	11.73	44.39	7.14	2.04	4.08	2.04	28.57
P3May	14.35	42.11	11.48	4.78	1.91	0.96	24.40
P3Jun	10.05	42.58	8.61	5.74	2.87	1.91	28.23
P3Jul	10.77	42.56	6.67	3.08	3.59	2.05	31.28
P3Aug	12.71	43.65	8.29	3.87	1.10	1.66	28.73
P3Sep	9.43	45.66	4.91	5.28	2.64	4.91	27.17
P3Oct	10.29	44.71	10.59	3.82	2.65	1.47	26.47
P3Nov	11.42	46.30	8.02	3.70	2.78	3.09	24.69
P3Dec	9.09	46.26	8.02	6.95	3.21	3.48	22.99
P4Jan	6.67	67.43	5.14	1.90	1.14	1.33	16.38
P4Feb	4.09	56.97	8.89	4.09	2.64	2.64	20.67
P4Mar	4.66	36.20	17.20	5.73	2.87	1.79	31.54
P4Apr	6.54	34.64	18.95	5.23	5.23	0.33	29.08
P4May	10.32	40.48	12.70	1.98	1.59	2.38	30.56
P4Jun	6.09	40.00	20.00	0.43	2.17	0.00	31.30
P4Jul	9.09	35.98	15.53	0.76	5.30	2.65	30.68
P4Aug	6.08	39.54	13.31	5.70	2.66	3.04	29.66
P4Sep	5.65	33.92	14.84	8.48	2.47	4.95	29.68
P4Oct	7.19	40.31	12.81	5.63	2.81	5.00	26.25
P4Nov	5.54	52.66	9.93	5.54	3.70	2.77	19.86
P4Dec	3.29	58.22	12.19	4.06	2.32	2.13	17.79

Ce = Cerambycidae; Sc = Scolytinae; Cu = Curculionidae; Pl = Platypodidadae; An = Anobidae; Ly = Lyctidae; Bo = Bostrichidae.

Table 1. Continued...

Point.Month	Ce	Sc	Cu	Pl	An	Ly	Bo
P5Jan	11.19	48.60	10.49	2.10	1.05	0.35	26.22
P5Feb	13.42	47.99	9.06	4.03	0.34	0.34	24.83
P5Mar	12.77	41.70	8.09	7.23	0.85	0.00	29.36
P5Apr	9.13	42.47	12.79	0.91	3.65	0.00	31.05
P5May	17.22	46.41	9.09	0.48	0.00	0.00	26.79
P5Jun	12.24	46.43	8.67	3.06	0.00	0.00	29.59
P5Jul	15.00	46.50	9.50	3.50	0.00	0.00	25.50
P5Aug	12.90	45.62	8.76	2.76	1.38	2.76	25.81
P5Sep	10.64	49.65	7.45	4.61	0.71	2.84	24.11
P5Oct	9.65	46.95	9.32	4.18	4.18	2.57	23.15
P5Nov	11.15	45.61	7.77	7.77	2.36	2.03	23.31
P5Dec	7.76	46.27	9.32	7.76	3.42	2.80	22.67
P6Jan	13.72	45.49	9.75	2.53	0.36	2.89	25.27
P6Feb	17.60	41.60	7.60	5.20	1.60	0.80	25.60
P6Mar	16.51	45.87	7.80	3.67	0.46	1.38	24.31
P6Apr	13.85	47.69	10.77	0.51	0.51	0.51	26.15
P6May	20.34	50.28	6.21	0.00	0.00	0.00	23.16
P6Jun	22.50	38.50	12.50	0.00	0.00	0.00	26.50
P6Jul	21.03	38.97	12.82	0.00	0.00	0.00	27.18
P6Aug	19.83	36.21	15.52	0.00	0.43	0.43	27.59
P6Sep	11.76	42.28	12.13	4.04	0.37	1.84	27.57
P6Oct	9.77	50.75	10.15	2.26	1.50	1.88	23.68
P6Nov	12.38	48.89	10.16	2.54	1.90	1.90	22.22
P6Dec	13.51	50.75	8.71	2.40	0.60	3.90	20.12

Ce = Cerambycidae; Sc = Scolytinae; Cu = Curculionidae; Pl = Platypodidadae; An = Anobidae; Ly = Lyctidae; Bo = Bostrichidae.

Platypodinae with 769 individuals, 378 and Lyctidae anobiidae individuals with 368 individuals.

The family with the highest frequency of occurrence (FO) was Scolytinae with 50.75% for the months of October and December, Bostrichidae presented FO of 27.59% for the month of August, Cerambycidae 22.50% for the month of June, and Curculionidae 15.52% for the month of August. There was no sampling of Platypodinae, Anobiidae And Lyctidae during the months of June and July.

The environment with lower frequency of occurrence (FO) to Scolytinae, was the control area P06 with 50.75%, examined for the months of October and December, the other areas presented similar results, except from the areas P04 and P06, whose results were FO 67.43% for the month of January, and 58.96% of populational peak in the month of November, respectively. Even during the winter period the population of Scolytinae is the most representative of families sampled for all areas.

In all sampling areas we saw a surge of Scolytinae (Table 1). It is known that the history of sampling areas and the surrounding area for the control area P06, is the pasture, therefore the ecosystems sampled were in a state of disclímax for decades, with ecological attributes: resilience, stability and elasticity, extremely reduced. Therefore, the practice of forest restoration was essential, in order to redeem the ecological functions of the ecosystem in Guapiaçu river basin (Carvalho et al., 2014). However the major Scolytinae population peaks in thesampled areas, in addition to their surge in the control area suggest that the ecosystem is still recovering its ecological attributes.

For the test of homogeneity of variances (Table 2), the families Cerambycidae and subfamily Platypodinae are the only taxa with homogeneous variances to the level of area, month and year. Bostrichidae and Anobiidae showed homogeneity of variance at the level of moth and the other taxa analyzed, only showed homogeneity of variance at the annual level.

Thus, the occurrence of significant differences is due to the environmental effects generated by the different fragmented samples and the seasons of the year which influence directly on the livelihood strategies of taxa, as can be seen in Tables 3 and 4.

Table 2. Tests of homogeneity of variances for each group of dependent variables (families of Coleoptera) and each independent variable/grupadora (Point, month and year).

	Seating			Month			Year		
Taxa	Bartlett	Df	P	Bartlett	Df	P	Bartlett	Df	P
Cerambycidae	7.242	5	0.203	9.122	11	0.610	1.556	2	0.459
Scolytinae	82.916	5	**0.000**	179.621	11	**0.000**	4.630	2	0.098
Curculionidae	26.067	5	**0.001**	10.347	11	0.499	5.387	2	0.067
Platypodinae	9.349	5	0.095	26.151	11	**0.006**	5.688	2	0.058
Anobiidae	28.583	5	**0.001**	18.058	11	0.080	3.896	2	0.142
Lyctidae	14.664	5	**0.011**	20.847	11	**0.034**	1.126	2	0.569
Bostrichidae	14.413	5	**0.013**	11.564	11	0.397	2.089	2	0.351

The results in bold indicate that the variances are not homogeneous. Df = degrees of freedom; P = P-Value.

Table 3. Univariate Tests of significance for the families of Coleoptera (Sigma-restricted parameterization).

	Cerambycidae				
	SS	Of DEGR.	MS	F	P
Intercept	15999,45	1	15999,45	1308,595	**0.000**
Point	1126,19	5	225.24	18.422	**0.000**
Month	286.16	11	26.01	2.128	**0.0200**
Year	68.59	2	34.30	2.805	0.062
Error	2408,61	197	12.23		
	Scolytinae				
SS		Of DEGR.	MS	F	P
Intercept	384813,4	1	384813,4	1664,057	**0.000**
Point	7940,4	5	1588,1	6.867	**0.000**
Month	32250,1	11	2931,8	12.678	**0.000**
Year	410.9	2	205.4	0.888	0.412
Error	45556,3	197	231.3		
	Curculionidae				
	SS	Of DEGR.	MS	F	P
Intercept	16068,38	1	16068,38	939.513	**0.000**
Point	1680,1	5	336.02	19.647	**0.000**
Month	318.01	11	28.91	1.690	0.077
Year	75.25	2	37.63	2.199	0.113
Error	3369,26	197	17.10		
	Platypodinae				
	SS	Of DEGR.	MS	F	P
Intercept	2737,782	1	2737,782	361.538	**0.000**
Point	218.690	5	43.738	5.775	**0.000**
Month	445.940	11	40.540	5.353	**0.000**
Year	76.787	2	38.394	5.070	**0.007**
Error	1491,801	197	7.573		
	Anobiidae				
	SS	Of DEGR.	MS	F	P
Intercept	6.615.000	1	661.500	213.195	**0.000**
Point	1.715.556	5	34.311	11.058	**0.000**
Month	725.000	11	6.590	2.124	**0.020**
Year	91.944	2	4.597	1.481	0.229
Error	6.112.500	197	3.102		

The results in bold have statistical significance less than 0.05 (5%). SS = sum of squares; Of DEDR. = of degrees of freedom; MS = Mean squares; F = F ratio; P = P-value.

Table 3. Continued...

Lyctidae					
	SS	Of DEGR.	MS	F	P
Intercept	6.269.630	1	626.963	188.540	**0.000**
Point	829.815	5	16.596	4.990	**0.001**
Month	1.222.593	11	11.114	3.342	**0.001**
Year	47.037	2	2.351	0.707	0.494
Error	6.550.926	197	3.325		
Bostrichidae					
	SS	Of DEGR.	MS	F	P
Intercept	114955	1	114955	4502,228	**0.000**
Point	1200,8	5	240.2	9.406	**0.000**
Month	1584,5	11	144.0	5.641	**0.000**
Year	238.7	2	119.3	4.674	**0.010**
Error	5030	197	25.5		

The results in bold have statistical significance less than 0.05 (5%). SS = sum of squares; Of DEDR. = of degrees of freedom; MS = Mean squares; F = F ratio; P = P-value.

Table 4. Tukey test; Variable taxa. Approximate variables for post-hoc tests.

Cerambycidae						
Seating	P01	P02	P03	P04	P05	P06
Area P01		0.310	0.310	0.976	**0.026**	**0.001**
Area P02	0.310		**0.001**	0.777	**0.001**	**0.001**
Area P03	0.310	**0.001**		0.0578	0.914	**0.001**
Area P04	0.976	0.777	0.057		**0.001**	**0.001**
Area P05	**0.026**	**0.000**	0.914	**0.001**		**0.013**
Area P06	**0.001**	**0.000**	**0.001**	**0.000**	**0.013**	
Scolytinae						
Seating	P01	P02	P03	P04	P05	P06
Area P01		0.152	0.554	0.202	0.487	0.110
Area P02	0.152		0.976	**0.001**	0.987	0.999
Area P03	0.554	0.976		**0.001**	0.999	0.950
Area P04	0.202	**0.000**	**0.001**		**0.001**	**0.001**
Area P05	0.487	0.987	0.999	**0.001**		0.970
Area P06	0.110	0.999	0.950	**0.001**	0.970	
Curculionidae						
Seating	P01	P02	P03	P04	P05	P06
Area P01		**0.001**	0.746	**0.001**	0.909	0.998
Area P02	**0.001**		0.121	**0.001**	0.050	**0.007**
Area P03	0.746	0.121		**0.001**	0.999	0.936
Area P04	**0.001**	**0.001**	**0.001**		**0.001**	**0.001**
Area P05	0.909	0.050	0.999	**0.001**		0.991
Area P06	0.998	**0.007**	0.936	**0.001**	0.991	
Platypodinae						
Seating	P01	P02	P03	P04	P05	P06
Area P01		0.411	0.998	0.935	0.983	0.003
Area P02	0.411		0.188	0.053	0.837	0.494
Area P03	0.998	0.188		0.995	0.876	0.001
Area P04	0.935	0.053	0.995		0.580	0.001
Area P05	0.983	0.837	0.876	0.580		0.036
Area P06	0.003	0.494	0.001	0.001	0.036	

Table 4. Continued...

Anobiidae						
Seating	**P01**	**P02**	**P03**	**P04**	**P05**	**P06**
Area P01		1.000	**0.016**	**0.001**	0.999	0.461
Area P02	1.000		**0.016**	**0.001**	0.999	0.461
Area P03	**0.016**	**0.016**		0.800	**0.025**	**0.001**
Area P04	**0.001**	**0.001**	0.800		**0.001**	**0.001**
Area P05	0.999	0.999	**0.02547**	**0.001**		0.377
Area P06	0.461	0.461	**0.001**	**0.001**	0.377	
Lyctidae						
Seating	**P01**	**P02**	**P03**	**P04**	**P05**	**P06**
Area P01		0.78931	0.752	0.183	0.673	0.854
Area P02	0.789		0.085	**0.004**	0.999	0.999
Area P03	0.752	0.085		0.927	0.050	0.118
Area P04	0.183	**0.004**	0.927		**0.001**	**0.006**
Area P05	0.673	0.999	0.050	**0.001**		0.999
Area P06	0.854	0.999	0.118	**0.006**	0.999	
Bostrichidae						
Seating	**P01**	**P02**	**P03**	**P04**	**P05**	**P06**
Area P01		1.000	0.999	**0.001**	0.984	0.241
Area P02	1.000		0.997	**0.001**	0.990	0.275
Area P03	0.999	0.997		**0.001**	0.901	0.105
Area P04	**0.001**	**0.001**	**0.001**		**0.001**	**0.001**
Area P05	0.984	0.990	0.901	**0.001**		0.653
Area P06	0.241	0.275	0.105	**0.001**	0.653	

In general, the Tukey test (Table 4) indicates that area P04 has major differences with other areas for all the families surveyed, with the exception of family Cerambycidae which showed major differences for the control sample area P06, a fact that can be connected to the diversity of this group in preserved areas of Atlantic Forest, demonstrating the family's potential for evaluation of preserved areas. The families Curculionidae, Anobiidae, Lyctidae, Bostrichidae and subfamily Scolytinae, had higher relations and distinctive behaviors as the population fluctuation, with the P04, which has great density of pioneer and senescent species, indicating the relationship of these families with disclímax environments. The subfamily Platypodinae, showed no significant differences for any of the sampling areas.

The graph generated by the analysis MDS (Figure 3), indicates that there are simaliridades among families Curculionidae and Cerambycidae, it should be emphasized that these families despite having many pestilent species, are also responsible as environmental actors of different ecosystems associated with the Atlantic Forest biome, being found in many environments with status of resilience, elasticity and stability (Calmon et al., 2009). Families Anobiidae And Lyctidae, as well as the family Bostrichidae and

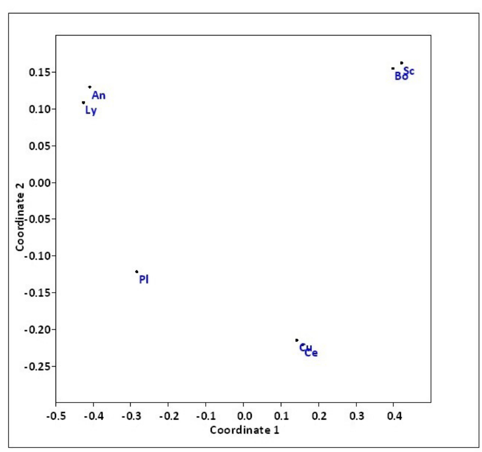

Figure 3. Graph of non-metric multidimensional analysis (MDS) drawn from the bray-curtis similarity matrix, on the basis fo % of families of coleobrocas. Stress = 0. Ce = Cerambycidae; Sc = Scolytinae; Cu=Curculionidae; Pl=Platypodidadae; An=Anobidae; Ly = Lyctidae; Bo = Bostrichidae.

Scolytinae showed similarities; however, it should be emphasized that these families are associated with the environments on disclímax (Carvalho & Trevisan, 2015), being regarded as environmental indicators, usually associated with negative impacts. The subfamily Platypodinae presented no similarity with any other family or subfamily sampled. Still, it can be assumed that the forest environment offers the subfamily Platypodinae some kind of resistance which does not occur in a homogeneous environment for the other areas analyzed.

It can also be seen in practically all areas and years of sampling, that Scolytinae, Platypodinae, Lyctidae and Anobiidae had a population drop during the dry season (Table 1), while Bostrichidae, Cerambycidae and Curculionidae present greater population stability, even equating Scolytinae number in this seasonal period. It is possible that these more resilient taxa exploit a wider range of habitats and micro-habitats for their survival, or simply that their auto- ecology provides them with stability to endure water deficit and thermal inversion.

For other wood borer beetles, we can see a higher population density for Bostrichidae and Scolytinae, as it can be seen in (Galdino-da-Silva et al., 2016). In the sampling area of the river Guapiaçu and in neighboring municipalities, the forest restoration has focusedon the fauna, especially on bird fauna and bat fauna. Part of the Community of these groups are omnivores or simply insectivorous, thus contributing to the control of the population of beetles. However, Scolytinae and Bostrichidae representatives are in millimetric scale, which hinders its predatism by terrestrial tetrapoda, leaving the invertebrate parasitoids, predators and pathogens as environmental resistance (Xavier et al., 2018).

The MDS graph generated by the monthly average of the FO % per sampling point for each family of Choleopteran analyzed (Figure 4) demonstrates that P04 is the most different area, with 6 sample areas for a total of 12 differing from the others for the months of January, February, April, June, July and September, followed by the sample area P06, for the months of May, June, July and August. The fluctuations in stocks tend to stabilize more in the rainy season, however the sample areas P05 and P03, showed a reasonable similarity in their monthly FO when compared to P06, differing from the other areas of sampling. It is not incorrect to say that Coleobrocas are a natural force acting on the forest ecosystem, that is, as well as storms, fires

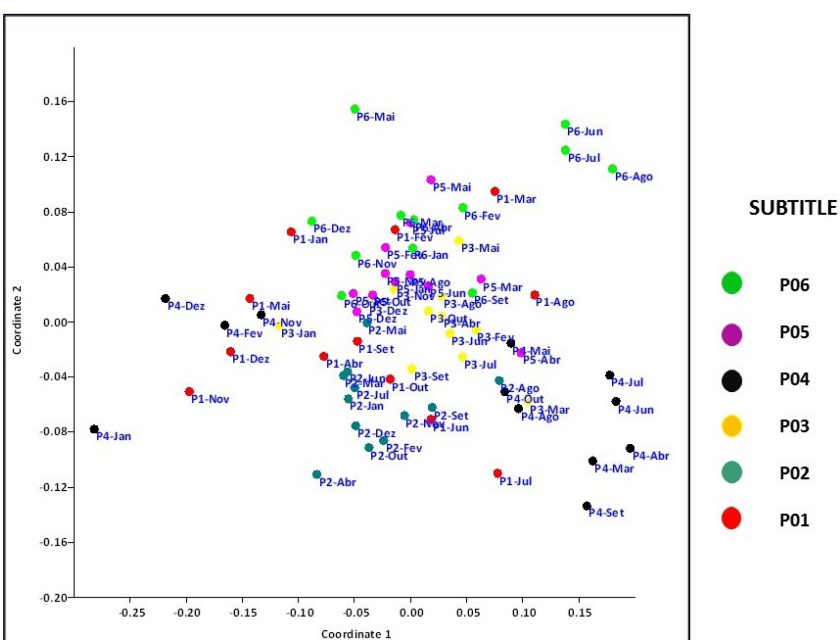

Figure 4. Graph of non-metric multidimensional analysis (MDS) drawn from the bray-curtis similarity matrix, on the basis FO % per sampling point for each family of Choleopteran. Stress = 0.1932.

Table 5. TTWBEM (Rate Table of Woodboring Beetles for the Environmental Monitoring).

Taxa	Little disturbed environments - FO%	Environments with medium - FO% disturbance	Very disturbed environments - FO%
Scolytinae	≤ 40% FO	≤ 50% FO	≥51% FO
Bostrichidae	≤ 20% FO	≤ 30% FO	≥31% FO
Cerambycidae	≤15% FO	≤20% FO	≥21% FO
Curculionidae	≤ 15% FO	≤ 20% FO	≥21% FO
Platypodinae	≤10% FO	≤ 10% FO	≥11% FO
Anobiidae	≤ 10% FO	≤ 10% FO	≥11% FO
Lyctidae	≤10% FO	≤ 10% FO	≥11% FO

Frequency of occurrence (FO %).

and disclimax in general, directly influence in the fitophysiognomy, corroborating with the edge effect and the general physiognomy of the studied ecosystem.

With the purpose of creating a method of ecological assessment focusing on the main taxa of the assembly of wood borers beetles found in environments of native forest, we developed a table (Table 5), entitled TTWBEM (Rate Table of Woodboring Beetles for the Environmental Monitoring) with a focus on average monthly frequencies of occurrence (FO), of the taxa sampled in this study and other studies cited here in the Atlantic Forest biome.

To correlate the TTWBEM with Table 1, one can notice that in a quali-quantitative context, environments sampled in the bas in of the river Guapiaçu exhibit environments with low to moderate levels of disturbance. However, the area that exhibited higher levels of 67.43% and 31.54% for Scolytinae and Bostrichidae, a fact disturbance was the area P04, with a FO% of that is probably a reflection of cultivation that has not followed the methodological framework in the Atlantic Forest Restoration Pact.

4. CONCLUSIONS

It is essential to prioritize aspects that support the conception of actions focused on forest conservation, aiming to give an swers and maximize the ecologically balanced environment with the production of ecosystem services. Thus, the environmental monitoring synthesized for the 6 forest fragments analyzed, traced a chain of environmental events inspected from the families of coleobrocas collected, associated with the climate, with the plant communities and with the characterization site. This analysis of integrated environmental monitoring has prompted the following statements:

The Atlantic Forest is a hot spot of biodiversity, many are the actions of forest restoration carried out in their ecosystems, therefore a biome of priority to conservation and environmental preservation, the recovery of degraded areas becomes relevant to have the proper provision of environmental services, however the metho dologies deployed in this restoration must be reassessed, since this study showed that the large deployment of pioneer species may compromise the ecological health of their ecosystems.

Families Scolytinae and Bostrichidae showed great similarity in the ecological aspects analyzed, as well as families and Lyctidae anobiidae, which are recognized in the literature as families associated with the environments of disclimax. Conversely, families Cerambycidae and Curculionidae were associated with more preserved environments, a fact that can be connected to the diversity of species representative of balanced environments.

The results of the FO% for the taxa of wood-boring beetles sampled during three years, correlated to data in the literature for the Atlantic Forest biome, enabled the creation of TTWBEM (Rate Table of Woodboring Beetles for the Environmental Monitoring), aiming to assess the environmental restoration in that biome. In the quali-quantitative context of the environments sampled in the basin of the river Guapiaçu, low to moderate levels of disturbance were observed.

ACKNOWLEDGEMENTS

I thank the faculty of the Postgraduate Program in Environmental and Forest Sciences at UFRRJ for their teaching especially to Dr. Acacio Geraldo de Carvalho my advisor, I thank the egregious council of PPGCAF of which I was a part, Thank you for all your support during the synthesis of my academic master's degree and thank the funding of this academic research by CNPQ.

SUBMISSION STATUS

Received: 22 oct., 2018
Accepted: 16 apr., 2019

CORRESPONDENCE TO

Cleber Vinicius Vitorio da Silva
Universidade Federal Rural do Rio de Janeiro – UFRRJ, Rodovia BR 465, Km 07, s/n, Zona Rural, CEP 23890-000, Seropédica, RJ, Brasil
e-mail: clebervitorio88@gmail.com, klebervinicius88@gmail.com

FINANCIAL SUPPORT

Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq (Grant/Award Number: 04870001).

REFERENCES

Azevedo AD, Camara R, Francelino MR, Pereira MG, Leles PSS. Estoque de carbono em áreas de restauração florestal da Mata Atlântica. *Floresta* 2018; 48(2): 183. http://dx.doi.org/10.5380/rf.v48i2.54447.

Bradley T, Tueller P. Effects of fire on bark beetle presence on Jeffrey pine in the Lake Tahoe Basin. *Forest Ecology and Management* 2001; 142(1-3): 205-214. http://dx.doi.org/10.1016/S0378-1127(00)00351-0.

Calmon M, Lino CF, Nave A, Pinto L, Rodrigues R. Pacto pela restauração da Mata Atlântica: um movimento pela restauração da floresta. In: Cavalcanti R, Fujihara MA, Guimarães A, Garlipp R, editores. *O valor das florestas*. São Paulo: Terra das Artes; 2009.

Carvalho AG, Trevisan H. Novo modelo de armadilha para captura de Scolytinae e Platypodinae (Insecta, Coleoptera). *Floresta e Ambiente* 2015; 22(4): 575-578. http://dx.doi.org/10.1590/2179-8087.105114.

Carvalho ID, Oliveira R, Pires AS. Medium and large-sized mammals of the Reserva Ecológica de Guapiaçú, Cachoeiras de Macacu, RJ. *Biota Neotropica* 2014; 14(3): 1-9. http://dx.doi.org/10.1590/1676-06032014007414.

Cabral DC, Fiszon JT. Padrões sócio-espaciais de desflorestamento e suas implicações para a fragmentação florestal: estudo de caso na Bacia do Rio Macacu, RJ. *Scientia Forestalis* 2004; 66: 13-24.

Cristo SC, Vitorino MD, Arenhardt TCP, Klunk GA, Adenesky E Fo, Carvalho AG. Leaf-litter entomofauna as a parameter to evaluate areas under ecological restoration. *Floresta e Ambiente* 2019; 26(2): e20170295. http://dx.doi.org/10.1590/2179-8087.029517.

Cortines E, Valcarcel R. Influence of pioneer-species combinations on restoration of disturbed ecosystems in the Atlantic Forest, Rio de Janeiro, Brazil. *Revista Árvore* 2009; 33(5): 925-934. http://dx.doi.org/10.1590/S0100-67622009000500015.

Galdino-da-Silva T, Trevisan H, Carvalho AG. Análise da ocorrência de seis grupos de coleoptera em dois ecossistemas perturbados ecologicamente. *EntomoBrasilis* 2016; 9(3): 187-192. http://dx.doi.org/10.12741/ebrasilis.v9i3.612.

Trevisan H, Nadai J, Lunz AM, Carvalho AG. Consumo foliar e aspectos biológicos de *Urbanus acawoios* (Lep.: Hesperiidae) alimentado com folíolos de Clitoria fairchildiana (Leguminosae: Faboideae) em três níveis de maturidade. *Ciência Rural* 2004; 34(1): 1-4. http://dx.doi.org/10.1590/S0103-84782004000100001.

Xavier RL, Souza TS, Trevisan H, Coimbra HT, Porto CML, Aguiar-Menezes EL et al. Interceptação de *Sinoxylon unidentatum* (Coleoptera:Bostrichidae) no Rio de Janeiro, Brasil. *Pesquisa Florestal Brasileira* 2018; 38: 1-4. http://dx.doi.org/10.4336/2018.pfb.38e201701522.