International Journal of Research Studies in Biosciences (IJRSB)
Volume 5, Issue 7, July 2017, PP 60-68
ISSN 2349-0357 (Print) & ISSN 2349-0365 (Online)
http://dx.doi.org/10.20431/2349-0365.0507009
www.arcjournals.org

Are Leaf-Litter Ants (Formicidae) Distributed Differentiated between Inner Zones of Natural Treefall Gaps?

Marcelo Cesar Lima Peres[1,2,3], Kátia Regina Benati1[1], Marcelo Alves Dias[1], Daniela Uzel Sena[1,4], Alessandra Rodrigues S. de Andrade[1,3], Tércio da Silva Melo[1,3], Marcos Vinicius Alvim Guimarães[1] & Jacques Hubert Charles Delabie[5]

[1]Centro de Ecologia e Conservação Animal (ECOA) da Universidade Católica do Salvador (UCSal), Bahia, Brasil. E-mail: *marcelo.peres@ucsal.br*
[2]Programa de Pós-Graduação em Planejamento Ambiental (PPGPA) da Universidade Católica do Salvador (UCSal), Bahia, Brasil.
[3]Programa de Pós-Graduação em Ecologia e Biomonitoramento da Universidade Federal da Bahia, Salvador, Bahia, Brasil.
[4]Faculdade Estácio de Alagoas (FAL). Alagoas, Maceió, Brasil.
[5]Laboratório de Mirmecologia, UESC/CEPLAC, Centro de Pesquisas do Cacau, Ilhéus, Bahia, Brasil

Abstract: *This paper investigates the structure and distribution of the leaf-litter ant's assemblage between the inner zones of natural Treefall Gaps in a Atlantic forest remnant in Bahia southern. The study was conducted in the Ecological Reserve Michelin-REM a remnant of 180 ha. Samples of $1m^2$ litter were collected in the root, trunk and canopy areas in six natural Treefall Gaps, totaling $36m^2$ of litter from which the ants were extracted using mini-Winkler traps. We recorded 77 ant species distributed in 25 genus and six subfamilies. There wasn't significant difference in species composition and richness among the three zones. The leaf litter depth and the luminosity did not differ between the three areas, when treefall gaps had only one month of formation, but differed when the treefall gaps reached one year of formation. Different from what has been widely observed in plant organisms, the inner zonation of small Treefall Gaps (40 to $80m^2$) does not affect the structure of the leaf-litter ant assemblage in the Atlantic forest.*

Keywords: *Atlantic forest, Habitat selection, Natural disturbance, Neotropical fauna.*

1. INTRODUTION

The natural disturbances increase the heterogeneity of habitat, allowing the specialization and resources division between species, and thus prevent the competitive exclusion and promotes the diversity [1, 2, 3]. In tropical forests, the formation of Treefall Gaps is a common form of natural disturbance, caused by fallen of one or more trees. This process creates an opening in the canopy [4,5] and promotes significant changes in the environmental structure of these areas [6], which consequently generates substantial differences in the vegetation structure and composition [2,7].

The interaction of various components, such as, fall type, size, geometry, substrate and inner zonation, trigger complex changes within the natural clearings [8,9]. The structure of natural Treefall Gaps defining the microclimate conditions of its substrate [10; 11] and therefore may influence the colonization spatial and temporal distribution of the plant species [12.13]. Therefore, it can affect animals that interact with these organisms [14,15].

Among the several structural components of natural tree-fall gap, the zonation performs a significant role, because it makes its interior very heterogeneous [8, 9, 16].

The Treefall Gaps present inner zonation divided in root zone, trunk zone and canopy zone [10]. The root zone is typical of clearing originated by uprooting with enough soil upturned [17] and intense light. [18] So this is an area where pioneer species preferably are established [19]. (2) The trunk zone (adjacent to the fallen trunk) is common in clearings from various origins [20]. In this area, the soil disturbance is lesser and the light is variable because it depends on the survivor vegetation [20]. (3) The canopy zone is also common in clearings from diverse sources, is the area affected by the canopy of the fallen tree [20]. It presents a lesser disturbance in soil and variable light [18], similar to trunk area.

The zonation of Treefall Gaps promotes spatially colonization differentiated of pioneer plants [8,17,19,21]. However, there isn't works relating the zonation of natural clearings with the animal's distribution. The few animals' studies compare Treefall Gaps with the mature forest. These studies revealed significant differences in the structure and composition of the birds and weaver's spider's assemblages between these two environments [7,22]. Studies also revealed spatio-temporal influence of Treefall Gaps on spider's assemblage [23]. For ants, the results were conflicting. In a study conducted in a forest in India, species richness differed among forest formations and natural clearings [24]. However, a study in a forest in Panama, abundance, species richness and composition were similar [25]. More recently, a study conducted in a forest in Costa Rica verified that the estimated richness (Chao 2) differed between Treefall Gaps and adjacent mature forest, even though the species composition didn't differ [26].

The ants (Hymenoptera: Formicidae) are among the animals most abundant and diverse [27] with 13,881 described species and 1,033 species are described in Brazil [28]. Studies indicate that the diversity of ants is strongly correlated with the structural complexity of the habitat [29,30,31]. The foraging activities and the distribution of nests is related to the light, humidity and temperature variations [21,32]. Disturbances also influence the richness and composition of leaf-litter ant [33].

The zonation of Treefall Gaps promotes differentiated microclimate within themselves [10,34]. This allows the different colonization of pioneer plants [19] and creates diverse habitats which allow the coexistence of the species in different niches [2,8].

This study investigated the structure and distribution of leaf-litter ants assemblages between inner zones (i.e. root, trunk and canopy) of Treefall Gaps in an Atlantic Forest remnant area in Northeast Brazil.

2. MATERIAL AND METHODS

2.1. Study Área

The study was conducted in the Ecological Reserve Michelin (REM) (13°50'S 39°10'W), located between the municipalities of Igrapiúna and Ituberá (Bahia), comprising a total area of 3,096 ha, and is distanced by 18 km from the Atlantic coast. The area of REM consists of a vegetation mosaic of different successional stages, characterized by different types of human disturbances from wood extraction, hunting and exploration of palm hearts. Beyond some areas converted to agriculture and pasture. Approximately 25% of the reserve is designed to syringe monoculture [35].

Inside the REM, the rain forest composes a mosaic with seringals and is divided into four fragments: Mata de Pacangê - 550 ha, Mata da Vila Cinco - 180 ha, Mata de Pancada Grande - 172 ha e Mata Luís Inácio - 140 ha [35].

We concentrated our efforts in one of four fragments of the Reserve (i.e., Mata da Vila Cinco; 180 ha) that consists of evenly reaches of primary forest (17 – 20 m forest canopy) located within its northern section. In southern section of this forest fragment, secondary forest is most characteristic, in which tree height typically ranges from 8 – 13 m. On the highest slopes there is a mature primary forest block with several long-lived trees. The palms tree of *Juçara*, bromeliads, vines and other epiphytes are abundant and widely distributed in this forest, crossed by a small river, two streams and several nascent. The forest is surrounded by cocoa plantations, banana and syringe and north by the "Forest River" [35].

The annual average precipitation is 2,051 mm and the temperature oscillates between 18 and 30 ° C, without dry season [35]. Between 1997 and 2002, the monthly average rainfall was 168 mm with the minimum in September (118 mm) and maximum in March (208 mm). In the same period, the temperature varied between 21 and 29 ° C (n = 47), (unpublished data from the meteorological station of Michelin Plantations of Bahia).

2.2. Sample Design

The Treefall Gaps were located in the northern sector of the "Mata da Vila Cinco", in a mature primary forest stretch. The most local trees present DAP over 25 cm, with moderate frequency of vines and bromeliads density, and other epiphytes among moderate to high, with abundant palms and moderately dense herbaceous vegetation [35].

Initially, 15 natural Treefall Gaps with similar structures in relation to age, origin, area and size class were selected. All had at most one month of formation, estimated based on the conditions of the fallen tree canopy, i.e., the presence of antlers and green foliage (see 19). All were originated by the uprooting of trees (see 36) and (3) presented the same size class, with a minimum area of $25m^2$ and a maximum of 150 m^2 (see 37).

We randomly selected six Treefall Gaps to the collections in the field in May 2009 and repeated the study in May 2010, when the natural clearings had already more than 1 year of formation. In each tree-fall gap, were distributed three points of $1m^2$ to the leaf litter collect, totaling $36m^2$ of samples. This points were distributed based in the inner zonation proposed by [10], establishing three zones: root, trunk and canopy.

The reference for the distribution of sample points (PA) was the main tree - that originated the natural clearing. One sampling point is defined in each zone: (i) the root zone (ZR): The PA was located in the trunk base, adjacent to the root; (ii) the trunk zone (ZT): PA was established in the area adjacent to the center of the fallen tree trunk and (iii) canopy area (ZC): PA was established in the central area of the fallen tree canopy. The points were far between themselves approximately 4 m (Figure 1).

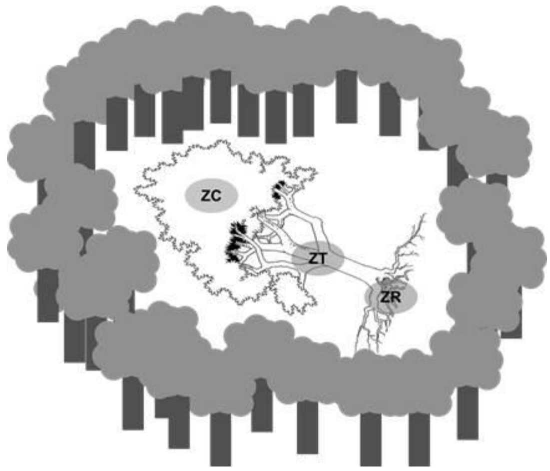

Figure1. *Inner zonation of Treefall Gaps - root zone (ZR), trunk zone (TZ) and canopy zone (ZC). The broken line represents the hypothetical outline of the tree-fall gap based on the opening of the canopy.*

Were measured the leaf litter depth and luminosity in inner zones of all Treefall Gaps, still young (May 2009) and when they reached about a year of formation (May 2010). The leaf litter depth was measured in centimeters at the center of the three quadrants ($1m^2$) with a plastic ruler inserted to reach the ground.The luminosity was measured in lux in the center of the three quardrants. We used a digital luxmeter positioned in the center of each quadrant in 1 meter above the substrate.

The ants were collected from leaf litter samples of $1m^2$ by traps type mini-Winkler [38]. The material was placed in the mini-Winkler, during 24 hours. In leaf litter of Atlantic forest it is possible to extract 90% of species of ants in 24 hours of exposure [39]. Thus, in order to reduce the time in the field and to increase the number of samples, we adopted the period of 24 hours to extract the ants in the trap. The ants were deposited in the entomological collection at CEPLAC, Ilhéus, Bahia (curator: Dr. Jacques Delabie).

2.3. Statistical Analysis

Considering the social behavior of ants, the matrix of species was constructed based on the presence (1) or absence (0) of the species in each sample point [see 40]. This matrix was used to compare the composition of ants species among the three inner zones (root zone, trunk and canopy) of natural clearings. We applied the Blocked Multi-Response Permutation Procedures (MRBP)-(PCORD© PC-6.0) and the Sorensen distance (Bray-Curtis). Given MRBP analyzes this data in blocks, this technique minimizes any effects associated to spacial dependence between samples, which, in this case, was distant from each other in only 4 m. The values were standardized (n / sum (n)) and the level of significance assumed was 0.05. When occurred significant difference among the tree zones of the Treefall Gaps, we verified the results of the peer-to-peer comparisons presented in the output of the analysis.

In order to compare the number of ants species, the leaf litter depth and the luminosity among the three zones, we applied ANOVA test using the GraphPad Instat program 3.0.

3. RESULTS

3.1. Natural Treefall Gaps Structure

The six natural Treefall Gaps present areas between 40 and 80 m2, therefore, they are inserted in the small size class (< $150m^2$ - see Brokaw 1985). The leaf litter depth and the luminosity didn't differ significantly between the inner zones where the gaps had only about one month formation, (F = 0,10 p = 0,90) (F = 1,6; p = 0,23) respectively. However, the difference was significant when gaps had about one year formation, leaf litter depth (F= 5.4, p= 0,01) e luminosity (F= 6,5, p= 0,00).

3.2. Ants Assemblage

In total, 77 ants species were collected that belonged to six subfamilies. The Myrmicinae subfamily had 35 species, followed by Ponerinae (n = 12). The *Pheidole* genus presented the highest species richness (n = 15) (Table 2). The specie most frequently (0-100%, n = 36) in natural clearings were *Nylanderia fulva* (Mayr 1862) (35%) and *Nylanderia guatemalensis* (Forel 1885) (27%).

When the Treefall Gaps had about one month, were recorded 34 species in the canopy zone, 29 in the trunk zone and 24 in the root zone. When the Treefall Gaps had about one year, were collected 46 species: 26 in the canopy zone, 23 in the trunk zone and 21 in the root zone. In both periods, the differences weren't significant (F = 1.3; p = 0, 30), (F = 1.2; p = 0, 20), respectively. There wasn't significant difference (MRBP: p= 0.26, A= 0.40, T= -0.61) in the composition of ant species between the inner zones (root, trunk and canopy) of the Treefall Gaps when they had only one month of formation or even after a year of formed, (MRBP: p= 0.26, A= 0.40, T= -0.61), (MRBP: p= 0.08, A= 0.20, T= -1,42), respectively.

Table1. *Mean and standard deviation of leaf litter depth and luminosity on the inner zones of Treefall Gaps in the Mata da Vila Cinco- Ecological Reserve Michelin (Igrapiúna- Bahia). ZR= root zone, ZT= trunk zone e ZC= canopy zone. Data collected in May 2009 and May 2010. Age = estimated age of formation of Treefall Gaps.*

Environmental variables	Age	ZR	ZT	ZC
Thickness of the litter(cm)	1 Month	3,9 (1,1)	3,7 (0,7)	4,1 (2,4)
Thickness of the litter(cm)	1 Year	1,8 (0,6)	3,2 (0,8)	2,6 (0,5)
Luminosity (LUX)	1 Month	1823 (597)	1924 (489)	2405 (696)
Luminosity (LUX)	1 Yaar	869 (237)	2031 (577)	747 (197)

Table2. *Species frequency (0- 100%, n = 18) of ants in the Mata da Vila Cinco- Ecological Reserve Michelin (Igrapiúna- Bahia). ZR= root zone, ZT= trunk zone e ZC= canopy zone. Data collected in May 2009 and May 2010.*

		ZC	ZR	ZT
AMBLYOPONINAE				
	Prionopelta antillana Forel 1909	0	0	1
DOLICHODERINAE				
	Dolichoderus imitator Emery 1894	1	1	1
	Tapinoma melanocephalum (Fabricius 1793)	1	0	0
ECTATOMMINAE				
	Gnamptogenys sp1	1	0	0
	Gnamptogenys mediatrix Brown 1958	1	0	0
	Gnamptogenys moelleri (Forel 1912)	0	0	1
	Gnamptogenys regularis Mayr 1870	1	0	0
FORMICINAE				
	Acropyga fuhrmanni (Forel 1914)	1	0	1
	Nylanderia guatemalensis (Forel 1885)	1	1	1
	Nylanderia fulva (Mayr 1862)	1	1	1
	Nylanderia sp.1	1	1	1
	Nylanderia sp.2	0	0	1
	Nylanderia sp.3	0	1	0
MYRMICINAE				
	Acanthognathus ocellatus Mayr, 1887	1	0	0

	Apterostigma acre Lattke 1997	0	1	1
	Apterostigma andense Lattke 1977	0	0	1
	Apterostigma auriculatum Wheeler 1925	1	0	0
	Apterostigma urichi Forel 1893	0	0	1
	Apterostigma sp.1	1	0	0
	Basiceros balzani (Emery 1894)	0	0	1
	Carebara sp.1	0	1	0
	Crematogaster acuta (Fabricius 1804)	0	1	0
	Crematogaster carinata Mayr 1862	0	0	0
	Crematogaster limata Smith 1858	1	1	0
	Crematogaster victima Smith 1858	0	1	0
	Cyphomyrmex rimosus (Spinola 1853)	0	1	1
	Cyphomyrmex transversus Emery 1894	1	1	0
	Cyphomyrmex minutus Mayr 1862	1	1	1
	Tabela 2 –			
	Hylomyrma immanis Kempf 1973	1	0	1
	Megalomyrmex drifti Kempf 1961	1	0	1
	Megalomyrmex iheringhi Forel 1911	1	0	1
	Megalomyrmex goeldii (Forel 1912)	1	1	1
	Monomorium floricola (Jerdon 1852)	1	0	1
	Mycocepurus smithii (Forel 1893)	1	1	1
	Pheidole arhuaca Forel 1901	1	0	0
	Pheidole flavens Roger 1863	1	1	1
	Pheidole midas Wilson 2003	1	1	1
	Pheidole pholeops Wilson 2003	0	0	1
	Pheidole sospes Forel 1908	1	1	0
	Pheidole (complexo flavens) sp.1	1	1	1
	Pheidole (complexo flavens) sp.3	0	1	1
	Pheidole (complexo flavens) sp.7	1	1	1
	Pheidole (complexo flavens) sp.10	1	0	0
	Pheidole (complexo tristis) sp.3	1	1	0
	Pheidole (complexo tristis) sp.4	1	0	1
	Pheidole (grupo fallax) sp.13	1	1	0
	Pheidole (grupo fallax) sp.5	1	0	0
	Pheidole (grupo fallax) sp.6	1	0	1
	Pheidole radoszkowskii Mayr, 1884	0	0	1
	Sericomyrmex sp.3	0	1	0
	Sericomyrmex sp.4	1	1	0
	Solenopsis sp.1	1	1	0
	Solenopsis sp.2	0	1	1
	Solenopsis sp.3	1	1	1
	Solenopsis sp.4	1	1	0
	Solenopsis sp.5	0	0	1
	Solenopsis virulens (Fr. Smith 1858)	1	0	1
	Strumigenys alberti (Forel 1893)	0	0	0
	Strumigenys denticulata Mayr 1887	1	1	1
	Strumigenys eggersi Emery 1890	1	0	0
	Strumigenys elongata Roger 1863	1	0	0
	Trachymyrmex cornetzi (Forel 1912)	1	0	1
	Trachymyrmex sp.1	1	0	0
	Wasmannia auropunctata (Roger 1863)	1	1	1
	Wasmannia lutzi Forel 1908	0	1	1
PONERINAE				
	Hypoponera foreli (Mayr 1887)	1	1	1
	Hypoponera sp.1	0	1	1
	Hypoponera sp.2	1	0	1
	Hypoponera sp.3	1	1	1
	Odontomachus haematodus (Linnaeus 1758)	1	1	1
	Odontomachus meinerti Forel 1905	1	1	1

	Pachycondyla concava Mackay & Mackay 2010	1	0	0
	Pachycondyla constricta (Mayr 1861)	1	0	0
	Pachycondyla ferruginea (Fr. Smith 1858)	0	1	0
	Pachycondyla harpax (Fabricius 1804)	1	1	0
	Pachycondyla laevigata (Smith 1858)	1	0	1
	Pachycondyla venusta (Forel 1912)	0	0	1
	Richness	**53**	**39**	**45**

4. DISCUSSION

The high number of species in Myrmicinae and Ponerinae subfamilies had been reported in the REM [42]. Myrmicinae has 6,087 described species, globally being the most diverse subfamily of ants [43]. The *Pheidole* genus is commonly reported in several studies as richer in number of species [44,45,46,47]. A study in Ecological Reserve Michelin showed *Pheidole* as the richest genus locally [42]. *Nylanderia* is the fifth most common genus recorded in leaf litter in the world, being well distributed in tropical forests (Ward 2000). They are ants that nest in leaf litter or rotten wood. [27] Overall, the most common genus and that presented higher specie richness are reported as dominant in leaf litter of tropical forests.

The zonation of Treefall Gaps promotes differentiated colonization by species or plant groups [8] because they offer distinct sites for seedling establishment and affect the distribution of pioneer species [17,19,21]. However, we didn't find relationship between the distribution of leaf litter ants and the inner zones of natural clearings. This result is surprising, since the ants are associated with plant organisms [48,49] and respond to disturbances in soil and light [33,50] that differ between the inner zones of natural clearings [8.10]. The light affects the foraging activity and distribution of ant nests [32,50,51] and natural disturbances influence strongly the richness and composition of ant litter [33].

The structural habitat complexity is closely related to the diversity of ants [52]. Therefore, it was expected that the ants assemblage differed among the three inner zones, especially after a year of formation of the Treefall Gaps, since in this period we have identified significant difference in luminosity and leaf litter depth between the three areas, supporting the proposed by [8.10]

In principle, our results show that the distribution of leaf litter ants doesn't respond to the inner heterogeneity of Treefall Gaps in the rainforest. Different from what has been widely applied to plant organisms in larger gaps than $150m^2$ [8,17,19.21]. Therefore, we agree with [53], i.e., we argue that the high dispersal ability and high growth rates of ants, leads these organisms to respond differently to disturbances. Furthermore, the reduced size of the Treefall Gaps studied (40 to 80 m^2) contributes to this absence of differentiation in the composition of ants between the zones. Finally, we argue that the inner zones of small Treefall Gaps (<150m2) doesn't affect the richness and species composition of leaf litter ants in the Atlantic forest.

ACKNOWLEDGMENTS

The authors are grateful to the Ecological Reserve Michelin for their excellent support, by providing us with necessary infrastructure and logistics during field campaigns. To Lacerta Ambiental by lending field equipment. M. C. L. P. is supported by Programa de Regime de Tempo Contínuo (RTC) of Universidade Católica do Salvador. J.H.C.D. is a CNPq fellow.

REFERENCES

[1] Connell, J.H. (1978) Diversity in Tropical Rain Forests and Coral Reefs. *Science, New Series*, **199**, 1302–1310.

[2] Denslow, J.S. (1980) Gap partitioning among tropical rain forest trees. *Biotropica*, **12**, 47-55.

[3] Pickett, S.T. and White, P.S. (1985) the ecology of natural disturbances and patch dynamics. Academic Press, New York.

[4] Green, P.T. (1996) Canopy gaps in rain forest on Christmas Island, Indian Ocean: size distribution and methods of measurement. *Journal of Tropical Ecology,* **12**, 427-434.

[5] Richard, P.W. (1996). The tropical rain forest: an ecological study. Cambridge, London, Cambridge University Press.

[6] Whitmore, T.C., Brown, N.D., Swaine, M.D., Kennedy, D., Goodwin-Bailey, C.I. and Gong, W.K. (1993). Use of hemispherical photographs in forest ecology, measurement of gap size and radiation totals in Bornean tropical rain forest. *Journal of Tropical Ecology,* **9**, 131-159.

[7] Levey, D.J. (1988) Tropical wet forest treefall gaps and distributions of understory birds and plants. *Ecology,* **69**, 1076-1089.

[8] Brandani, A.; Hartshorn, G.S. & Orians, G.H. (1988). Internal heterogeneity of gaps and species richness in Costa Rican tropical wet forest. *Journal of Tropical Ecology* **4**, 99--119.

[9] Dalling, J.W. & Hubbell, S.P. (2002). Seed size, growth rate and gap microsites conditions as determinants of recruitment success for pioneer species. *Journal of Ecology* **90**,557-569.

[10] Orians, G.H. (1982). The influence of tree-falls in tropical forest in tree species richness. *Tropical Ecology* **23**, 255--279.

[11] Denslow, J.S. and Hartshorn, G.S. (1994) Treefall Gap Environments and Forest Dynamic Process. In: McDade, L. A., Bawa, K.S., Hespenheide, H.A., Hartshorn, G.S., Eds., *La Selva-Ecology and Natural History of a Neotropical Rain Forest*, The University of Chicago Press, Chicago, 120-127.

[12] Whitmore, T.C. (1989) Canopy gaps and the two major groups of forest trees. *Ecology,* **70**, 536-538.

[13] Schnitzer, S.A., Carson, W.P. (2001) Treefall gaps and the maintenance of species diversity in a tropical forest. *Ecology,* **82**, 913-919.

[14] Thompson, J.N. (1980) Treefalls and colonization patterns of temperate forest herbs. *American Midland Naturalist*, **104**, 176-184.

[15] Dunn, R.R. (2004) Recovery of faunal communities during tropical forest regeneration. *Conservation Biology*, **18**, 302-309.

[16] George, L.O. & Bazzaz, F.A. (1999) The fern understory as an ecological filter: emergence and establishment of canopy-tree seedlings. *Ecology* **80**, 833-845.

[17] Lawton, R.O. & Putz, F.E. (1988) Natural disturbance and gap-phase regeneration in a wind-exposed tropical cloud forest. *Ecology* **69**, 764--777.

[18] Hubbell, S.P. & Foster, R.B. (1986) Canopy gaps and the dynamics of a Neotropical forest. In: Crawley, M.J., Ed., *Plant ecology*, Blackwell, Oxford, 77-96

[19] Tabarelli, M. and Mantovani, W. (1999) Clareiras naturais e a riqueza de espécies pioneiras em Floresta Atlântica Montana. *Revista Brasileira de Biologia,* **59**, 251-261.

[20] Lima, R.A.F. (2005) Estrutura e regeneração de clareiras em Florestas Pluviais Tropicais. *Revista Brasileira de Botânica* **28(4)**, 651--670.

[21] Putz, F.E. 1983. Treefall pits and mounds, buried seeds, and the importance of soil disturbance to pioneer trees on Barro Colorado Island, Panama. Ecology 64: 1069--1074.

[22] Peres, M.C.L., Silva, J.M.C. and Brescovit A.D. (2007) The influence of treefall gaps on the distribution of web building and ground hunter spiders in an Atlantic Forest remnant, Northeastern Brazil. Studies on Neotropical Fauna and Environment, 42, 49-60.

[23] Peres, M.C.L; Benati, K.R., Andrade, A.R.S.; Guimaraes, M.V.A; Melo, T.S. Brescovit A.D. and Delabie, J.H. (2014) Treefall Gaps Effects on Spider (Araneae) Assemblages in an Atlantic Forest Landscape in Northeastern Brazil. *Open Journal of Animal Sciences*, **4**,118-133.

[24] Basu, P. (1997) Seasonal and Spatial Patterns in Ground Foraging Ants in a Rain Forest in the Western Ghats , India. *Biotropica*, **29**, 489–500.

[25] Feener Jr., D.H. and Schupp, E.W. (1998) Effect of treefall gaps on the patchiness and species richness of Neotropical ant assemblages. *Oecologia*, **116**, 191–201.

[26] Patrick, M., Fowler, D., Dunn, R.R. and Sanders, N.J. (2012) Effects of Treefall Gap Disturbances on Ant Assemblages in a Tropical Montane Cloud Forest. *Biotropica,* **44**, 472-478.

[27] Hölldobler, B. & Wilson, E.O. (1990). The ants. Harvard University Press, Cambridge, Mass.

[28] Agosti, D. & Johnson N.F. (2005) Antbase. World Wide Web publicação eletrônica. Disponível em http://antbase.org/; acesso em 22 jul. 2015.

[29] Santana-Reis, V.P.G. & G.M.M. de Santos. (2001). Influência da estrutura do habitat em comunidades de formigas em Feira de Santana, Bahia, Brasil. *Sitientibus* **1**, 66-70.

[30] Lassau, S. A. & Hochuli, D. F. (2004) Effects of habitat complexity on ant assemblages. *Ecography* **27(2)**, 157–164.

[31] Hites, N. L.; Mourão, M. A. N.; Araújo, F. O.; Melo, M. V. C.; Biseau, J.C. & Quinet, Y. (2005) Diversity of the ground-dwelling ant fauna (Hymenoptera: Formicidae) of a moist, montane forest of the semi-arid Brazilian Nordeste. *Revista de Biologia Tropical* **53(1-2)**, 165-173.

[32] Levings S.C. (1983) Seasonal, annual, and among-site variation in the ground ant community of a deciduous tropical forest: some causes of patchy species distributions. *Ecological Monographs* **53**, 435—455.

[33] Campos, R.B.F.; Schoereder J. H. & Sperber, C.F. (2007) Small-scale patch dynamics after disturbance in litter ant communities. *Basic and Applied Ecology* **8**, 36-43.

[34] Whitmore, T.C. (1996) A review of some aspects of tropical rain forest seedling ecology with suggestion for further enquiry. In: Swaine, M.D., Ed., The ecology of tropical forest tree seedlings. UNESCO/Parthenon, Paris, 3-39.

[35] Flesher, K. M. (2006) The biogeography of the medium and large mammals in a um an dominated landscape in the Atlantic Forest of Bahia, Brazil: evidence for the role of agroforestry systems as wildlife habitat. Ph.D. Thesis, The State University of New Jersey, New Jersey.

[36] Brokaw, N.V.L. (1982a) the definition of treefall gap and its effect on measures of forest dynamics. *Biotropica*, **14**, 158-160.

[37] Brokaw, N.V.L. (1985) Gap-phase regeneration in a tropical forest. *Ecology*, **66**, 682-687.

[38] Bestelmeyer, B.T.; Agosti, D; Alonso, L.E.; Brandão, C.R.F.; Brown, W.L., Jr; Delabie, J.H.C. & Silvestre, R. (2000) Field techniques for the study of ground-living ants: an overview, description, and evaluation. *In*: J.D Agosti; L. Majer; A. Tennant & T. Schultz (orgs), Ants: Standard Methods for Measuring and Monitoring Biodiversity. Smithsonian Institution, Washington, p. 122--144.

[39] Delabie, J.H.C; Agosti, D. & Nascimento, I.C. (2000) Litter and commmunities of the Brazilian Atlantic rain forest region. *In*: D. Agosti, J. Majer, L. Alonso & T. Schultz, eds. Sampling ground-dwelling ants: case studies from the world's rain forests. Curtin University School of Environmental Biology Bulletin N. 18, Perth, Australia. p. 1--18.

[40] Longino, J. T. (2000) What to do with the data. In: D. Agosti; J.D. Majer; L. E. Alonso and T. R. Schultz (eds.). Ants: standard methods for measuring and monitoring biodiversity. Smithsonian Institution Press, p.186-203.

[41] Mccune, B. and Mefford, M.J. (1999) Multivariate Analysis of Ecological Data. Version 4.25, MjM Software, Gleneden Beach, Oregon, U.S.A.

[42] Resende, J.J.; Santos, G.M.M.; Nascimento, I.C.; Delabie. J.H.C. & Silva, E. M. 2011. Communities of Ants (Hymenoptera: Formicidae) in Different Atlantic Rain Forest Phytophysionomies. Sociobiology 58(3), 770-799.

[43] Bolton, B. 2015. Ant Web. The California Academy of Sciences, USA. Disponível em http://www.antweb.org/; acess 22 jul. 2015.

[44] Marinho, C.G.S.; Zanetti, R.; Delabie, J.H.C.; Schlindwein M.N. & Ramos L.S. (2002) Diversidade de formigas (Hymenoptera: Formicidae) da serapilheira em eucaliptais (Myrtaceae) e área de cerrado em Minas Gerais. *Neotropical Entomology* **3**, 187-195.

[45] Delabie, J.H.C.; Paim, V.R.L.M.; Nascimento, I.C.; Campiolo, S. & Mariano, C.S.F. (2006) As formigas como indicadores biológicos do impacto humano em manguezais da costa sudeste da Bahia. *Neotropical Entomology* **35(5)**, 602--615.

[46] Pacheco, R.; Silva, R.R.; Morini M.S.C & Brandão, C.R.F. (2009) A Comparison of the Leaf Litter Ant Fauna in a Secondary Atlantic Forest with an Adjacent Pine Plantation in Southeastern Brazil. *Neotropical Entomology* **38(1)**, 55--65.

[47] Silvestre, R., Demétrio, M.F. & Delabie, J.H.C. (2012) Community Structure of Leaf-Litter Ants in a Neotropical Dry Forest: A Biogeographic Approach to Explain Betadiversity. *Psyche: A Journal of Entomology* **2**, 1--15.

[48] Schupp G.W. & Feener D.H. JR. (1991) Phylogeny, lifeform, and habitat dependence of ant-defended plants in a Panamanian forest. In: Huxley CR, Cutler DF (ed) Ant-plant interactions. Oxford University Press, Oxford, pp. 175-197.

[49] Quintero, A.M.; Becker, V.O. & Delabie J.H.C. (2012) Ant (Formicidae) Assemblages Associated With Piper Spp. (Piperaceae) In The Undergrowth Of An Atlantic Rainforest Remnant In Southeastern Bahia, Brazil. *Sociobiology* **59(3)**,1--14.

[50] Kaspari, M. & Weiser, M.D. (2000) Ant activity along moisture gradient in a Neotropical forest. Biotropica **32**, 703-711.

[51] Hölldobler, B. and Wilson, E.O. (1990) The ants. Harvard University Press, Cambridge, Mass.

[52] Delabie, J.H.C.; Jahyny, B.; Nascimento, I.C.; Mariano, C.S.F. Lacau, S.; Campiolo, S.; Philpott, S.M. & Leponce, M. (2007) Contribution of cocoa plantations to the conservation of native ants (Insecta: Hymenoptera: Formicidae) with a special emphasis on the Atlantic Forest fauna of southern Bahia, Brazil. *Biodiversity and Conservation* **16**, 2359--2384.

[53] Andersen, A. N. (1995) a classification of Australian ant communities, based on functional groups which parallel plant life-forms in relation to stress and disturbance. *Journal of Biogeography* **22**, 15--29.