REVISTA DE CIÊNCIASAGRÁRIAS
Amazonian Journal
of Agricultural and Environmental Sciences
www.ajaes.ufra.edu.br

http://dx.doi.org/10.4322/rca.2013.053

ORIGINAL ARTICLE

# Spatial distribution and gallery depths of *Quesada gigas* nymphs in parica plantations

## *Distribuição espacial e profundidades de galerias de ninfas de Quesada gigas em plantios de paricá*

Odineila Martins Monteiro[1]
Alexandre Mehl Lunz[2*]
Roni de Azevedo[2]
Moisés Cordeiro Mourão de Oliveira Júnior[2]

[1]Universidade Federal Rural da Amazônia – UFRA, Programa de Pós-graduação em Ciências Florestais, Av. Tancredo Neves s/n, Terra Firme, 66077-530, Belém, PA, Brasil
[2]Empresa de Pesquisa Agropecuária - Embrapa Amazônia Oriental, Trav. Eneas Pinheiro s/n, CP 48, 66095-100, Belém, PA, Brasil

**Corresponding Author:**
*E-mail: alexandre.mehl@embrapa.br

**ABSTRACT:** In this study, we aimed to determine the spatial distribution of *Quesada gigas* (Hemiptera: Cicadidae) nymphs in parica (*Schizolobium parahyba* var. *amazonicum*, Fabaceae) plantations, as well as their most commonly found stages of development and gallery depths in the soil. Two plots were selected according to damage intensity – greater or smaller visible damages. An area of 10 × 12 m subdivided in quadrats of one square meter was chosen randomly in each plot. In these quadrats, we counted the number of nymphs and galleries, and measured their distances from the axes (X and Y) and their depths (Z). An approach to spatial distribution was performed with indexes of variance-to-mean. We observed that the nymphs of *Q. gigas* present gregarious habits, not necessarily around the attacked tree; are most commonly found at the fourth and fifth instars; and that gallery depths ranged from eight to 35 cm regardless of the attack intensities.

**KEYWORDS**
Forest entomology
Monitoring
Soil pests
Cicadas
*Schizolobium parahyba* var. *amazonicum*

**RESUMO:** *Objetivou-se determinar o padrão de distribuição espacial de ninfas de Quesada gigas (Hemiptera: Cicadidae) em plantios de paricá (Schizolobium parahyba var. amazonicum, Fabaceae), bem como os estádios de desenvolvimento mais comuns encontrados e as profundidades das galerias das ninfas no solo. Foram selecionados dois talhões em função da intensidade de dano, com mais e menos danos visíveis. Em cada um, foi escolhida aleatoriamente uma área de 10 × 12 m, subdividida em quadrantes de um metro quadrado. Nesses quadrantes, foram contabilizadas as ninfas, as galerias e suas distâncias dos eixos (X e Y) dos quadrantes, e as profundidades (Z) das galerias. Foi realizada uma abordagem da distribuição espacial, utilizando-se índices de variância/média. Observou-se que as ninfas possuem hábito gregário, não necessariamente ao redor da árvore atacada, que as mais comumente encontradas foram as de quarto e quinto ínstares e que a profundidade das galerias variou de oito a 35 cm, independentemente das intensidades de ataque.*

**PALAVRAS-CHAVE**
Entomologia florestal
Monitoramento
Pragas de solo
Cigarra
*Schizolobium parahyba* var. *amazonicum*

Received: 01/08/2013
Accepted: 05/14/2013

## 1 Introduction

*Schizolobium parahyba* var. *amazonicum* (Huber ex Ducke) Barneby (Fabaceae), commonly known as parica, presents multiple uses, ranging from commercial plantations for obtaining various products such as veneer and plywood, to mixed planting systems and recovery of degraded areas, being a cost effective alternative of high viability for rural developments in the north region of the country (BRIENZA JUNIOR; YARED, 1991; CARVALHO, 2006, 2007; BRIENZA JÚNIOR et al., 2008). It is one of the most commonly grown native species in northern Brazil, with approximately 85,000 ha of planted area (ABRAF, 2012).

The cicada, *Quesada gigas* Olivier (Hemiptera: Cicadidae), is the main pest in areas planted with parica, with losses of up to 20% (LUNZ et al., 2010). The damage is caused by the nymphs through the continuous suction of sap directly from the roots, which reduces the growth of trees and, in extreme cases, causes the mortality of entire plantations. The long nymphal development cycle of the species and the overlapping of generations intensify the damage and impair its control, because it is an insect-plant interaction still little known, with some information reported by Zanuncio et al. (2004).

How the populations of *Q. gigas* are distributed among host plants is not scientifically known. The knowledge of spatial distribution, the way individuals of a population are dispersed in their habitat (RICKLEFS, 2003), is important because it allows the knowledge of the species ecology, the improvement of sampling procedures and, consequently, the integrated pest management in the cultivation of parica. Even among populations of the same species, there are variations in dispersion form in the habitat because of environmental or genetic factors (RODRIGUES; FERNANDES; SANTOS, 2010). According to Patil and Stiteler (1974), the identification of spatial distribution of insects at different instars is fundamental for the understanding of population ethology, and provides valuable subsidies on the main factors that determine numerical and even persistence oscillations in these environments.

Mathematical models are used to describe the spatial dispersion of insect pests, estimate the errors of population variables, and verify the effects of environmental factors on population parameters and population changes in time and space (BROWN; CAMERON, 1982). Martins et al. (2010) described three types of crop pest spatial distribution: focus (aggregated or contagious), regular (uniform), and random (scattered). Such distributions are called negative binomial, positive binomial, and Poisson, respectively (PERECIN; BARBOSA, 1992), and are classified based on the variance-to-mean ratio of data (ELLIOTT, 1979).

In this study, we aimed to determine the spatial distribution of *Quesada gigas* nymphs in parica plantations, as well as their most commonly found stages of development and gallery depths in the soil.

## 2 Materials and Methods

This study was carried out in July 2010 (28 °C average temperature; 15 mm rainfall) in a commercial area of 'Fazenda Rio Concrem', owned by 'Grupo Rio Concrem Ind. Ltda.',located in the municipality of Dom Eliseu (4° 01' 56" S; 47° 36' 19" W, 180 m above sea level), Pará state, Brazil. The area comprises 1300 ha cultivated with parica of various ages, and the experimental area was planted at 4.0 × 3.5 m spacing in 2004. The average temperature in the area was 28 °C at the time of assessment.

Two plots were selected according to the intensity of cicada attack observed: one plot with mild attack and one with more severe attack; this characteristic was evidenced by the greater number of dead trees in the plot and its surroundings. An area of 10 × 12 m subdivided in quadrats of one square meter was chosen randomly in each plot. Similarly to the method proposed by Lunz et al. (2010), a 7 cm deep topsoil layer was removed using hand tools to show the galleries and the nymphs of cicadas. The galleries were marked with 30 cm high wooden sticks for quantification and location (Figure 1). In each quadrat, we counted the number of nymphs and galleries, and measured their distances from the axes (X and Y) and their depths (Z) with the aid of 40 cm long graded metallic rods (Figure 2).

After the spatial distribution of galleries was determined through these coordinates and the presence of nymphs was marked, each gallery was plotted with the coordinates of the trees aiming to establish a pattern of influence on the occurrence of cicadas. Later, specific grids were prepared based on the


**Figure 1.** Marking of the galleries of *Q. gigas* nymphs in parica plantation with the aid of wooden sticks in the quadrats of the experimental area. Dom Eliseu, Para state. 2010.


**Figure 2.** Measurement of the coordinates (X and Y) and depths (Z) of galleries of *Q. gigas* nymphs in parica plantation with the aid of a measuring tape and a metallic rod, respectively. Dom Eliseu, Para state. 2010.

data plotted and counting was performed. Supported by these values, we obtained the following indices of aggregation based on the variance-to-mean ratio (LUDWIG; REYNOLDS, 1988; KREBS, 1989), considered as an approach to determine the spatial distribution of nymphs:

- The Index of Dispersion (ID), also known as the Variance-to-Mean Ratio (VMR), is the most common index used to exam the deviation from a random distribution. ID is expected to equal one, indicating a random spatial distribution, lower values indicate a uniform distribution, and higher values indicate a clumped distribution Rabinovich (1980), ID × ($n$ – 1) follows a $\chi^2$ test with $n$ – 1 degrees of freedom (ELLIOTT, 1979) (Equation 1).

$$ID = \frac{s^2}{\bar{x}} \quad (1)$$

- The Index of Cluster Size (ICS), also known as index of clumping (IC), is a direct function of the Index of Dispersion. Under a random distribution of points, ICS is expected to equal 0. Positive values indicate a clumped distribution; negative values a regular distribution (Equation 2).

$$ICS = \frac{s^2}{\bar{x}} - 1 = ID - 1 \quad (2)$$

- Green's index (GI) is a modification of the Index of Cluster Size that is independent of $n$. It varies between 0 for random distributions and 1 for maximally clumped distributions (Equation 3).

$$GI = \frac{\frac{s^2}{\bar{x}} - 1}{n-1} = \frac{ICS}{n-1} \quad (3)$$

- The Index of Cluster Frequency (ICF) is a measure of aggregation and is equal to $k$ of the negative binomial distribution. ICF is proportional to the quadrat area and is related to the Index of Cluster Size (Equation 4).

$$ICF = \frac{\bar{x}}{\frac{s^2}{\bar{x}} - 1} = \frac{ICS}{\bar{x}} \quad (4)$$

- The Index of Mean Crowding (IMC) is the average number of other points contained in the quadrat that contains a randomly chosen point. It is related to the Index of Cluster Size (Equation 5).

$$IMC = \bar{x} + \frac{s^2}{\bar{x}} - 1 = \bar{x} + ICS \quad (5)$$

- - The Index of Patchiness (IP) is related to the Index of Cluster Frequency and the Index of Mean Crowding. It is a measure of pattern intensity that is unaffected by thinning (the random removal of points) (Equation 6).

$$IP = \frac{\bar{x} + \frac{s^2}{\bar{x}} - 1}{\bar{x}} = \frac{IMC}{\bar{x}} = 1 + \frac{1}{ICF} \quad (6)$$

- - Morisita's index (MI) is related to the Index of Patchiness. It is the scaled probability that two points chosen at random from the whole population are in the same quadrat. The higher the value, the more clumped the distribution (Equation 7).

$$I_M = \frac{n\sum x(x-1)}{n\bar{x}(n\bar{x}-1)} = \frac{n\bar{x}IP}{(n\bar{x}-1)} \quad (7)$$

Analyses were conducted using the software PASSaGE (ROSENBERG, 2003). After defining the pattern indicated by the indices of aggregation, an *alpha-hull* patchiness analysis was performed aiming to define possible foci or spots of attack. The measure of the average minimum distance and 1.5 times the measure of the average minimum distance were considered for the disclosure of attack foci.

## 3 Results and Discussion

We observed that the gallery depths of nymphs in the plots of parica varied according to the instars of the insects, regardless of the intensities of attack considered (Figure 3). Nymphs up to the third instar were found in shallower galleries, while nymphs at the fourth and fifth instars were found at greater depths. Values ranged from 8 to 35 cm, taking into account the seven centimeters removed manually from the sampled areas; this procedure was similar to that performed by Soares et al. (2008), who removed a soil surface layer of approximately 5 cm to reveal the galleries of cicada nymphs. Gonçalves and Faria (1989) found 94.2% of the cicada nymphs in coffee plantations within the maximum depth of 25 cm, corroborating the values found in this study.

The depths observed varied according to the penetration of the parica root system in the soil. Considering the known superficiality of parica root system, nymphs do not need to dig deeper galleries, as they do in coffee plantations where gallery depths of *Q. gigas* and other types of cicada nymphs vary from 20 to 100 cm (MARTINELLI, 2004), because the root system is deeper. Lunz et al. (2010), when sampling cicada nymphs using a soil scrapping implement in parica plantations, observed that nymphs of several instars were easily found sucking roots close to soil surface, in 10 cm deep galleries at most. It is suggested that the gallery depths of cicadas are directly proportional to the host plant root development.

The average depth of galleries with younger nymphs (up to the third instar) was significantly lower in both plots than the average depths of empty galleries and galleries with nymphs as from the fourth instar, which, in turn, did not differ significantly (Table 1). The greater number of empty galleries probably occurred because the experiment was conducted in the end of the rainy season in the region, which is subsequent to the period of emergence of cicadas, namely in the begging of the rainy season. However, the overlapping of generations previously observed in commercial reforestation of parica (LUNZ et al., 2010) favored the maintenance of the number of nymphs observed in the area.

The indices of aggregation (Table 2) and the spatial distribution (Figure 4) showed that *Q. gigas* nymphs in parica plantation present gregarious habits, regardless of the infestation area selected. We first assumed that this aggregation would occur around the parica trees because of the greater availability of roots (SOARES et al., 2008), but this fact was not verified. For unknown reasons, clumping of nymphs was verified in random areas of the plots near and far from the trees. This fact is important for the development of integrated management strategies for *Q. gigas*, because it confirms the importance of the usual practice of actions to monitor populations of cicadas in large planted areas, limiting the amount of insecticide application only to areas with proved larger populations of cicadas.

The use of the soil scrapping implement proposed by Lunz et al. (2010) for the monitoring of *Q. gigas* nymphs in parica plantations, suggested that the insect galleries were randomly and heterogeneously distributed throughout the plots measured. The present study confirmed this hypothesis, recording aggregation of galleries and nymphs with no apparent connection with any visible aspects of planting.

The spatial distribution of a given insect varies according to the environmental or genetic factors of the population

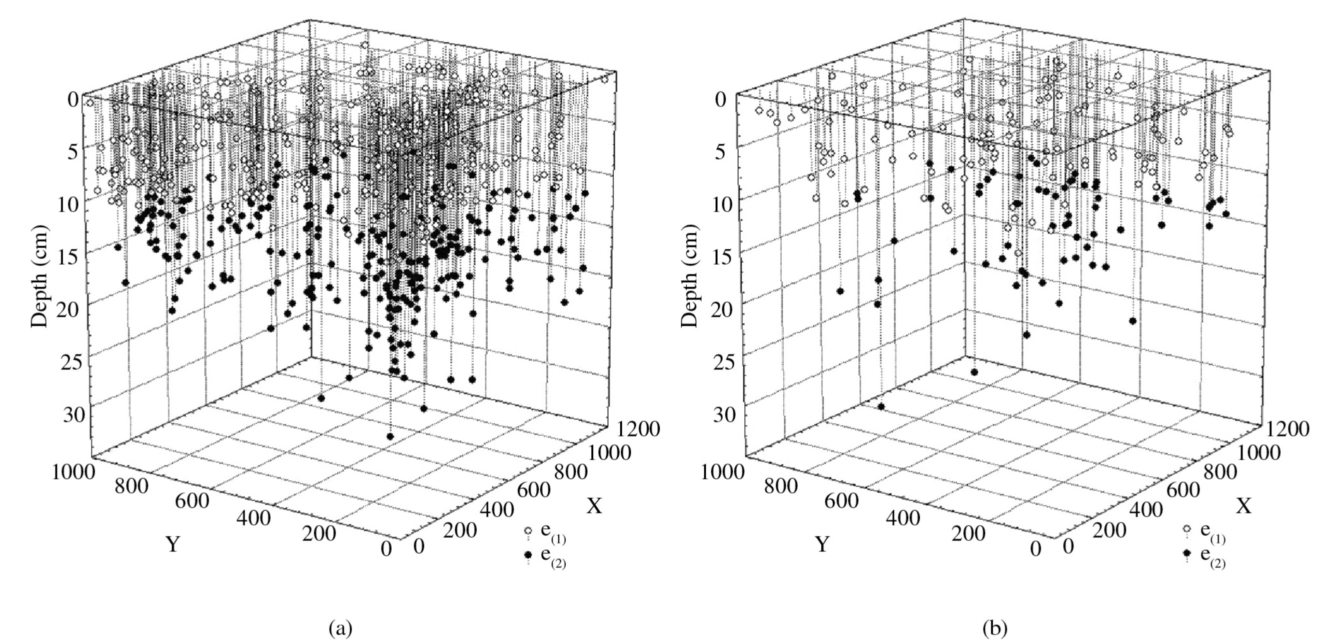


**Figure 3.** Spatial distribution of galleries of *Q. gigas* nymphs in experimental areas with parica plantation more (a) and less (b) attacked, where $e_{(1)}$ = galleries with nymphs up to the 3rd instar, and $e_{(2)}$ = galleries with nymphs as from the 4th instar. Dom Eliseu, Para state. 2010.

**Table 1.** Mean values, standard deviation, number of observations, and minimum and maximum values of the depth of *Q. gigas* nymph galleries according to stage of development and intensity of attack in the experimental area planted with parica in the municipality of Dom Eliseu, Para state. 2010.

| Galleries | Less attacked area | | More attacked area | | Overall | |
|---|---|---|---|---|---|---|
| EG | 8.18±5.57 (120; 8-35) | Aa | 8.01±5.35 (417; 8-34) | Aa | 8.04±5.39 (537; 8-35) | A |
| $E_{(1)}$ | 3.13±3.68 (8; 8-17) | Ba | 5.34±4.98 (35; 8-26) | Ba | 4.93±4.81 (43; 8-26) | B |
| $E_{(2)}$ | 10.69±4.54 (61; 10-34) | Aa | 12.42±4.96 (196; 8-35) | Aa | 12.01±4.91 (257; 8-35) | A |
| Overall | 8.77±5.43 (189; 8-35) | A | 9.2±5.65 (648; 8-35) | A | 9.1±5.6 (837; 8-35) | |

Where: EG = empty gallery; $E_{(1)}$ = galleries with nymphs up to the 3rd instar; $E_{(2)}$ = galleries with nymphs as from the 4th instar; values in parenthesis = number of galleries (n); and minimum and maximum depth values. Means followed by uppercase letters vertically indicate the effect of classes of insect development; means followed by lowercase letters horizontally indicate the effect of intensity of attack; values preceded by the same uppercase letters vertically and the same lowercase letters horizontally do not significantly differ by the Tukey test at 5% probability level.

**Table 2.** Mean, variance, and indices of aggregation of galleries of *Q. gigas* nymphs plotted in specific grids in more or less attacked experimental areas of parica plantations in the municipality of Dom Eliseu, Para state. 2010.

| | Less attacked area | | | | More attacked area | | | |
|---|---|---|---|---|---|---|---|---|
| | EG | $E_{(1)}$ | $E_{(2)}$ | Overall | EG | $E_{(1)}$ | $E_{(2)}$ | Overall |
| Mean | 0.783 | 0.050 | 0.308 | 1.142 | 3.058 | 0.292 | 1.517 | 4.867 |
| Variance | 1.499 | 0.048 | 1.022 | 2.711 | 13.702 | 0.477 | 7.395 | 34.990 |
| ID | 1.914 | 0.958 | 3.314 | 2.375 | 4.480 | 1.636 | 4.876 | 7.190 |
| ICS | 0.914 | –0.042 | 2.314 | 1.375 | 3.480 | 0.636 | 3.876 | 6.190 |
| GI | 0.008 | –0.0004 | 0.019 | 0.012 | 0.029 | 0.005 | 0.033 | 0.052 |
| ICF | 102.048 | –141.610 | 15.857 | 98.844 | 104.570 | 54.551 | 46.569 | 93.562 |
| IMC | 1.697 | 0.008 | 2.622 | 2.516 | 6.539 | 0.928 | 5.392 | 11.057 |
| IP | 2.166 | 0.160 | 8.505 | 2.204 | 2.138 | 3.181 | 3.555 | 2.272 |
| MI | 2.189 | 0.192 | 8.741 | 2.220 | 2.144 | 3.275 | 3.575 | 2.276 |

Where: EG = empty gallery; $E_{(1)}$ = galleries with nymphs up to the 3rd instar; $E_{(2)}$ = galleries with nymphs as from the 4th instar; ID = Index of Dispersion; ICS = Index of Cluster Size; GI = Green's Index; ICF = Index of Cluster Frequency; IMC = Index of Mean Crowding; IP = Index of Patchiness; MI = Morisita's Index.

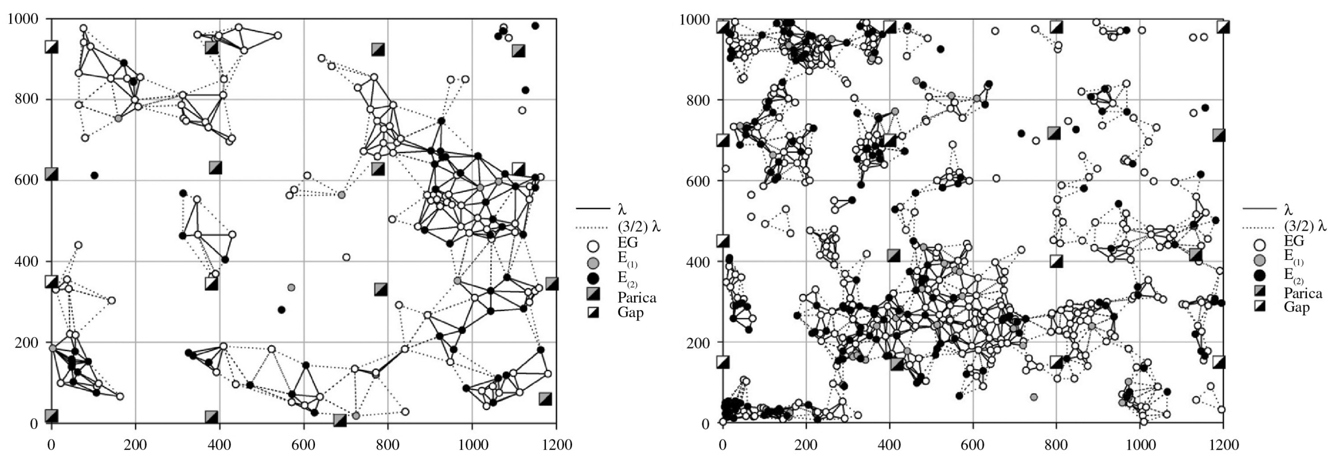


**Figure 4.** Spatial distribution of galleries of *Q. gigas* nymphs in less attacked (top) and more attacked (bottom) experimental areas of parica plantations, where: λ = average distance between galleries (solid line); (3/2) λ = 1.5 times the average distance (dotted line); EG = empty gallery; $E_{(1)}$ = galleries with nymphs up to the 3rd instar; $E_{(2)}$ = galleries with nymphs as from the 4th instar. Dom Eliseu, Para state. 2010.

(RODRIGUES; FERNANDES; SANTOS, 2010), besides being influenced by its dispersion capacity (GILBERT; GRÉGOIRE, 2003), so that insects with lesser mobility, such as *Q. gigas* nymphs, tend to cluster in foci. Soares et al. (2008) confirmed this assumption by finding weak spatial dependence for the number of cicada nymphs per tree.

## 4 Conclusions

In parica plantations, the nymphs of *Q. gigas* present gregarious habits, not necessarily around the attacked trees. There is sharp variation of gallery depths, ranging from 8 to 35 cm, where nymphs up to the 3rd instar are found in shallower galleries, while nymphs at the 4th and 5th instars are found in deeper galleries.

## Acknowledgements

We are grateful to CNPq for the scholarship DTI-3 (nº 556763/2009-2) granted to the first author and to 'Rio Concrem Industrial Ltda' for permission to use the area and assignment of field employees to aid with the experimental area preparation.

## References

ASSOCIAÇÃO BRASILEIRA DE PRODUTORES DE FLORESTAS PLANTADAS - ABRAF. *Anuário estatístico da Associação Brasileira de Produtores de Florestas Plantadas 2012*: ano base 2011. Brasília: ABRAF, 2012. 150 p.

BRIENZA JUNIOR, S.; YARED, J. A. G. Agroforestry systems as an ecological approach in the Brazilian Amazon development. *Forest Ecology and Management*, v. 45, p. 319-323, 1991. http://dx.doi.org/10.1016/0378-1127(91)90226-L

BRIENZA JÚNIOR, S.; PEREIRA, J. F.; YARED, J. A. G.; MOURÃO JÚNIOR, M.; GONÇALVES, D. A.; GALEÃO, R. R. recuperação de áreas degradadas com base em sistema de produção florestal energético-madeireiro: indicadores de custos, produtividade e renda. *Amazônia*: Ciência e Desenvolvimento, v. 4, p. 197-219, 2008.

BROWN, M. W.; CAMERON, E. A. Spatial distribution of adults of *Ooencyrtus kuvanae* (Hymenoptera: Encyrtidae), an egg parasite of *Lymantria dispar* (Lepidoptera: Lymantriidae). *Canadian Entomologist*, v. 114, p. 1109-1120, 1982. http://dx.doi.org/10.4039/Ent1141109-12

CARVALHO, P. E. R. *Espécies arbóreas brasileiras*. Brasília: Embrapa Informação Tecnológica; Colombo: Embrapa Florestas, 2006. v. 2, 627 p.

CARVALHO, P. E. R. *Paricá*, *Schizolobium amazonicum*. Colombo: Embrapa Florestas, 2007. 8 p. (Circular técnica, n. 142).

ELLIOTT, J. M. *Some methods for the statistical analysis of sample benthic invertebrates*. Ambleside: Freshwater Biological Association, 1979. 157 p.

GILBERT, M.; GRÉGOIRE, J. C. Site condition and predation influence a bark beetles success: a spatially realistic approach. *Agricultural and Forest Entomology*, v. 5, p. 87, 2003. http://dx.doi.org/10.1046/j.1461-9563.2003.00167.x

GONÇALVES, W.; FARIA, A. M. Inseticidas sistêmicos granulados no controle das ninfas móveis das cigarras e seus efeitos na produtividade de cafeeiros. *Bragantia*, v. 48, p. 95-108, 1989. http://dx.doi.org/10.1590/S0006-87051989000100009

KREBS, C. J. *Statistical Ecology:* A Primer on Methods and Computing. New York: John Wiley & Sons, 1989. 325 p.

LUDWIG, J. A.; REYNOLDS, J. F. *Statistical Ecology*: A Primer on Methods and Computing. New York: John Wiley & Sons, 1988. 325 p.

LUNZ, A. M.; AZEVEDO, R.; MOURÃO JÚNIOR, M.; MONTEIRO, O. M.; LECHINOSKI, A.; ZANETI, L. Z. Método para monitoramento de ninfas de cigarras e controle com inseticidas em reflorestamentos com paricá. *Pesquisa Agropecuária Brasileira*, v. 45, p. 631-637, 2010. http://dx.doi.org/10.1590/S0100-204X2010000700001

MARTINELLI, N. M. Cigarras associadas ao cafeeiro. In: SALVADORI, J. R.; ÁVILA, C. J.; SILVA, M. T. B. (Ed.). *Pragas de solo no Brasil*. Passo Fundo: Embrapa Trigo; Dourados: Embrapa Agropecuária Oeste; Cruz Alta: Fundacep Fecotrigo, 2004. p. 517-541.

MARTINS, G. L. M.; VIEIRA, M. R.; BARBOSA, J. C.; DINI, T. A.; MANZANO, A. M.; ALVES, B. M. S.; SILVA, R. M.: Distribuição espacial de *Tenuipalpus heveae* Baker (Acari: Tenuipalpidae) na cultura da seringueira. *Neotropical Entomology*, v. 39, p. 703-708, 2010. PMid:21120376. http://dx.doi.org/10.1590/S1519-566X2010000500005

PATIL, G. P.; STITELER, W. M. Concepts of aggregation and their quantification: a critical review with some new results and applications. *Researches on Population Ecology*, v. 5, p. 238-254, 1974.

PERECIN, D.; BARBOSA, J. C. Amostragem e análise estatística de dados de distribuição de contágio. *Revista de Matemática e Estatística*, v. 10, p. 207-216, 1992.

RABINOVICH, J. E. *Introducción a la ecologia de problaciones animales*. México: Continental, 1980. 313 p.

RICKLEFS, R. E. *A economia da natureza*. 5. ed. Rio de Janeiro: Guanabara Koogan, 2003. 470 p.

RODRIGUES, T. R.; FERNANDES, M. G.; SANTOS, H. R. Distribuição espacial de *Aphis gossypii* (Glover) (Hemiptera, Aphididae) e *Bemisia tabaci* (Gennadius) biótipo B (Hemiptera, Aleyrodidae) em algodoeiro Bt e não-Bt. *Revista Brasileira de Entomologia*, v. 54, p. 136-143, 2010. http://dx.doi.org/10.1590/S0085-56262010000100019

ROSENBERG, M. S. *Passage*: Pattern Analysis, Spatial Statistics, and Geographic Exegesis. version 1.1. Tempe: Department of Biology, Arizona State University, 2003. 141 p.

SOARES, V. P.; ZANETI, L. Z.; SANTOS, N. T.; LEITE, H. G. Análise espacial da distribuição de cigarras (*Quesada gigas* Olivier) em povoamentos de paricá (*Schizolobium amazonicum* Huber ex Ducke) na região de Dom Eliseu, PA. *Revista Árvore*, v. 32, p. 251-258, 2008. http://dx.doi.org/10.1590/S0100-67622008000200008

ZANUNCIO, J. C.; PEREIRA, F. F.; ZANUNCIO, T. V.; MARTINELLI, N. M.; PINON, T. B. M.; GUIMARÃES, E. M. Occurrence of *Quesada gigas* on *Schizolobium amazonicum* trees in Maranhão and Pará states, Brazil. *Pesquisa Agropecuária Brasileira*, v. 39, p. 943-945, 2004. http://dx.doi.org/10.1590/S0100-204X2004000900015