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SAMPLING MEHODS TO THE EVALUATION OF *Sirex noctilio* ATTACK LEVELS IN *Pinus taeda* STANDS AND TO THE MONITORING OF ITS NATURAL ENEMIES EFFICIENCY

Susete do Rocio Chiarello Penteado; Edilson Batista de Oliveira; Edson Tadeu Iede.
EMBRAPA Florestas. Estrada da Ribeira km 111, Cx. Postal 319, CEP 83.411.000.
Colombo, PR, BR. e-mail **susete@cnpf.embrapa.br**

1 INTRODUCTION

Brazil has about 5 million ha of forest plantations of which 2 million are planted with *Pinus* spp. South Brazil and São Paulo State have 1.2 million ha of pine plantations, mainly with *Pinus taeda* L. e *Pinus elliottii* Engelm. These forests are the raw material for pulp and paper, particleboard, ply and veneer, sawing and resin industries.

Due to the lack of proper forest management, there are large areas with pines in bad phytosanitary conditions which are prone to pest attacks and diseases. The wood wasp *Sirex noctilio* (Hymenoptera: Siricidae) is the pest with the largest damage registered in these forests. Natural of Europe, Asia and Northern Africa, it was detected in Brazil in February 1988. In 1997, the wood wasp could be found in 250,000 ha in located Rio Grande do Sul, Santa Catarina and Paraná States.

The nematode *Deladenus siricidicola* (Nematoda: Neotylenchidae) and the parasitode *Ibalia leucospoides* (Hymenoptera:Ibaliidae) are used to control the pest. *D. siricidicola* acts in the reproductive system of female *S. noctilio* making them sterile. *I. leucospoides* attacks eggs and 1^0 and 2^0 instar larvae.

This paper aims at defining sampling methods to the evaluation of damage caused by the wood wasp and to monitor the efficiency of its natural enemies.

2 METHODOLOGY

All field trials were carried out in *P. taeda* stands located at Encruzilhada do Sul, RS and Lages, SC. In each place, five attacked trees of *P. taeda* were inoculated with *D. siricidicola*. Subsequently, they were brought to the laboratory and divided into billets, which were stored in mashed cages.

2.1 Distribution of insects along the stems of *Pinus taeda*

All emerging adults of *S. noctilio* and *I. leucospoides* were collected and counted to determine the distribution of insects along the stems of *P. taeda*. *S. noctilio* adults were dissected and analyzed under a stereo microscope to the determination of presence of nematodes in the reproductive system

A regression analysis was used to determine insects distribution along the stem. Relative height of each billet was calculated by the distance of the mean point of the billet to the base of the tree divided by the total height of the tree.

Polinomial models up to the 4th degree were used in the regression analysis with number of insects as dependent variable and relative height, $\frac{hi}{H}$, as independent variable, where:

h_i = height of tree on point i

H = total height of tree

Besides, polinomial models up to the 4th degree using $\frac{hi}{H}$ as independent variable and $\frac{di}{BHD}$ as dependent variable were used to describe the variation **dos diameters along the stem** (di = diameter of stem **na** height hi e BHD = **Breast Height Diameter**. This analysis aimed at studying the occurrence of insects also in relation to stem tapper.

An analysis of percentual residue was made based in Neter & Wasserman (1974) to the determination of the variation of the number of insects in each billet in relation to the position of the billet in the stem.

2.2 Size of sample of *Pinus taeda*

The sample size for populational evaluation of *S. noctilio* and of parasitism with *D. siricidicola* e *I. leucospoides* was determined by a variance analysis using a mixed model of hierarchical model, with three stages, as Snedecor & Cochran (1978) e Lima (1979):

$$y_{ijk} = \mu + a_i + p_{ij} + t_{ijk}$$

where:

Y_{ijk} = observation in billet k, at position j, of tree i;

μ = populational mean;

a_i = effect of tree i (i = 1,2,3,4,5);

p_{ij} = effect of position j (j = upper, medium and lower) of tree i;

t_{ijk} = effect of billet k (k = 1,2,3,...,7) at position j of tree i.

A double entry table of variation coefficients built with the proposed model was used, considering that the number of trees varied from 1 to 5 (lines of the table) and billets

varied from 1 to 7 (columns of the table), with a fixed position of stem previously determined in the study of insects distribution along the stem.

2.3 Sequential sampling to the definition of *Sirex noctilio* attack level in *Pinus taeda* stands

Sequential sampling was chosen to the definition of *Sirex noctilio* attack level in *P. taeda* stands due to its cost effectiveness and good precision.

Theoretical approaches were based on Penteado et al. (1993) and Penteado (1995).

3 RESULTS

3.1 Distribution of insects along the stems of *Pinus taeda*

The model which best described distribution of insects in relation to tree height was:

$$\text{No. of insects} = a\left(\frac{hi}{H}\right) + b\left(\frac{hi}{H}\right)^2$$

The results indicate that although the largest amount of wood is in the first 30% of the stem, this area presented a smaller incidence of insects. From this point to the top of the tree, the distribution of insects is regular and proportional to the wood volume of each section. The low occurrence of *I. leucospoides* led to a not so marked curve, but the trend is similar to that seen for *S. noctilio* (Figures 1 and 2).

The non-preference of insects for the initial 30% of the stem may be related to the high humidity content. Humidity content analysis (Table 1) showed that the first third of the stem is where humidity is higher with 86.40% in Encruzilhada do Sul and 96.23% in Lages. Bark thickness could also act as a physical barrier to egg laying both to *S. noctilio* and to *I. leucospoides.*

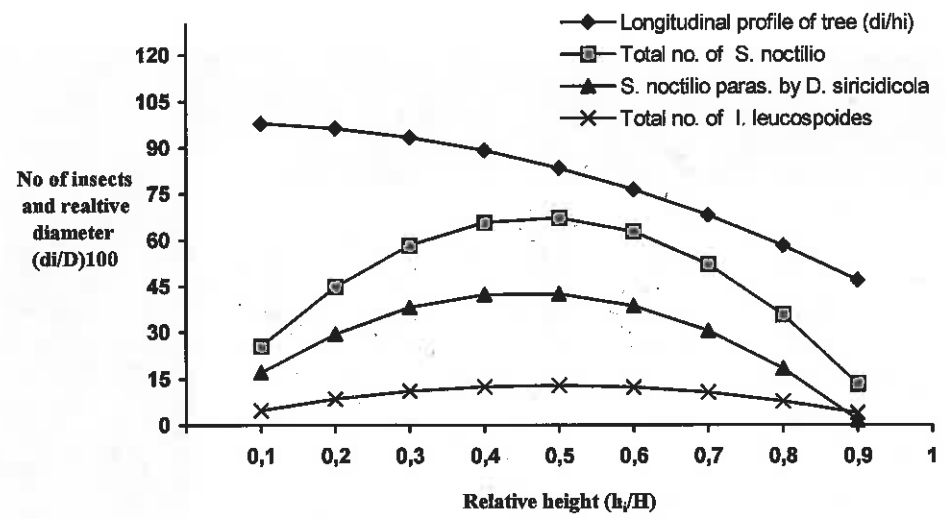

Figure 1 - Relation between the *Sirex noctilio* and *Ibalia leucospoides* total number with stem taper in *Pinus taeda* trees at Encruzilhada do Sul, RS.

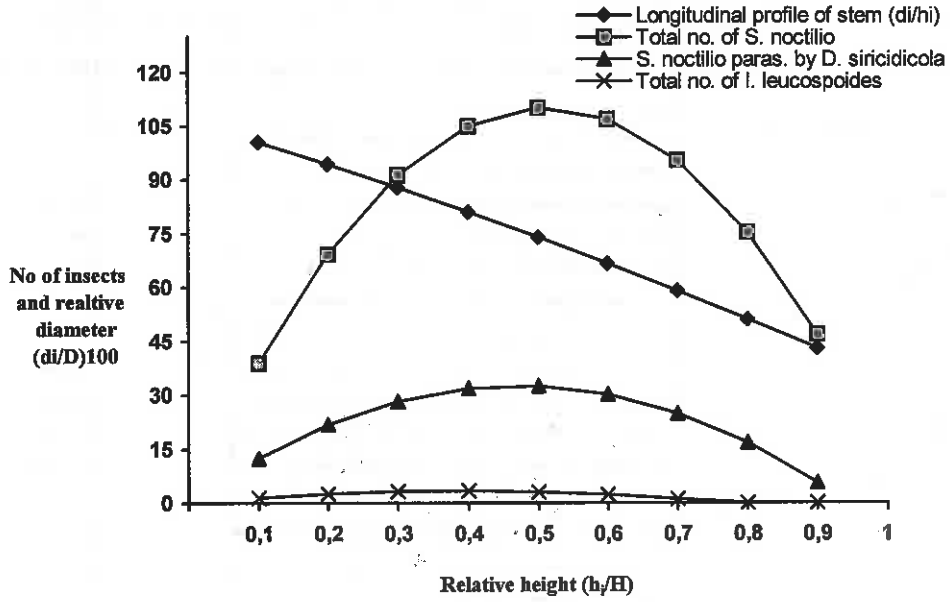

Figure 2 - Relation between the *Sirex noctilio* and *Ibalia leucospoides* total number with stem taper in *Pinus taeda* trees at Lages, SC.

Table 1.Breast height diameter (BHD), height and humidity (dry weight basis) of *Pinus taeda* trees selected to *Deladenus siricidicola* inoculation at Encruzilhada do Sul, RS e Lages, SC. 1993/94.

Place	DAP (cm)	Height (m)	Humidity Content (%)			Average
			Lower third	Medium third	Higher third	
Encruzilhada do Sul - RS						
Tree 1	19.00	12.30	119.86	29.78	22.68	57.44
Tree 2	18.70	9.70	64.15	29.77	23.17	39.03
Tree 3	16.30	9.70	72.28	29.30	23.14	41.57
Tree 4	20.40	11.30	80.07	31.61	23.64	45.11
Tree 5	16.00	10.80	95.64	29.37	23.02	49.34
Average	18.08	10.76	86.40	29.97	23.31	46.50
Lages - SC						
Tree 1	22.10	16.00	126.35	35.23	31.02	64.20
Tree 2	19.70	14.80	59.73	38.80	29.32	42.62
Tree 3	12.90	12.00	49.57	38.69	28.79	39.02
Tree 4	27.60	15.30	146.80	50.40	33.11	76.77
Tree 5	16.40	15.50	98.69	35.11	34.93	56.24
Average	19.74	14.72	96.23	39.65	31.43	55.77

The residues analysis (Figures 3 and 4) indicated that the samples had a high dispersion at the first third of the tree in relation to the curve of the regression equation. A large dispersion was also noted above 80% of tree height. The stem section between these two heights was the one with smaller errors. The larger variability noted at the base and at the top of the stem is related to a smaller occurrence of insects in these regions. Therefore, sampling should be made in the portion between 30% and 80% of the relative height of the tree.

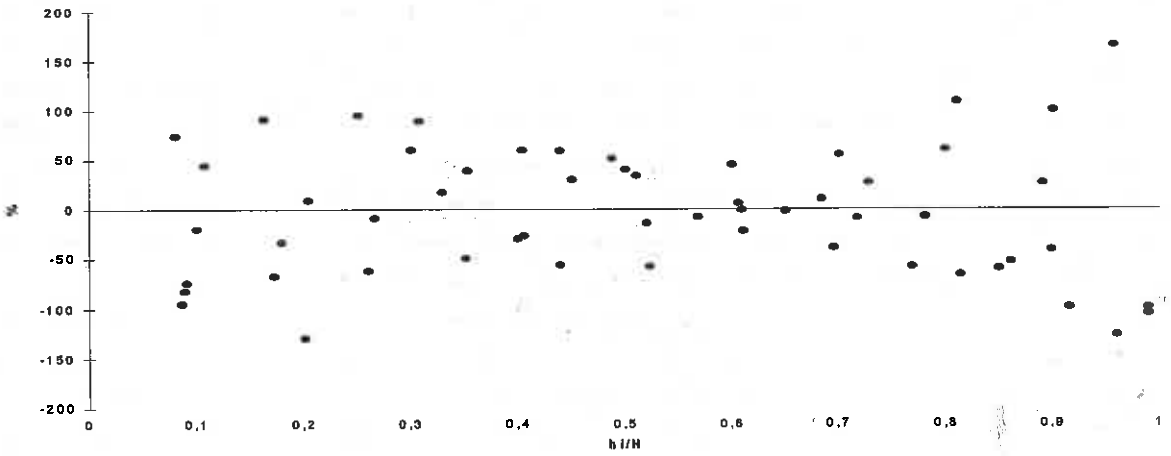

Figure 3 - Residue of total number of *Sirex noctilio* and *Ibalia leucospoides* in relation to *Pinus taeda* tree height. Encruzilhada do Sul, RS. 1993/94.

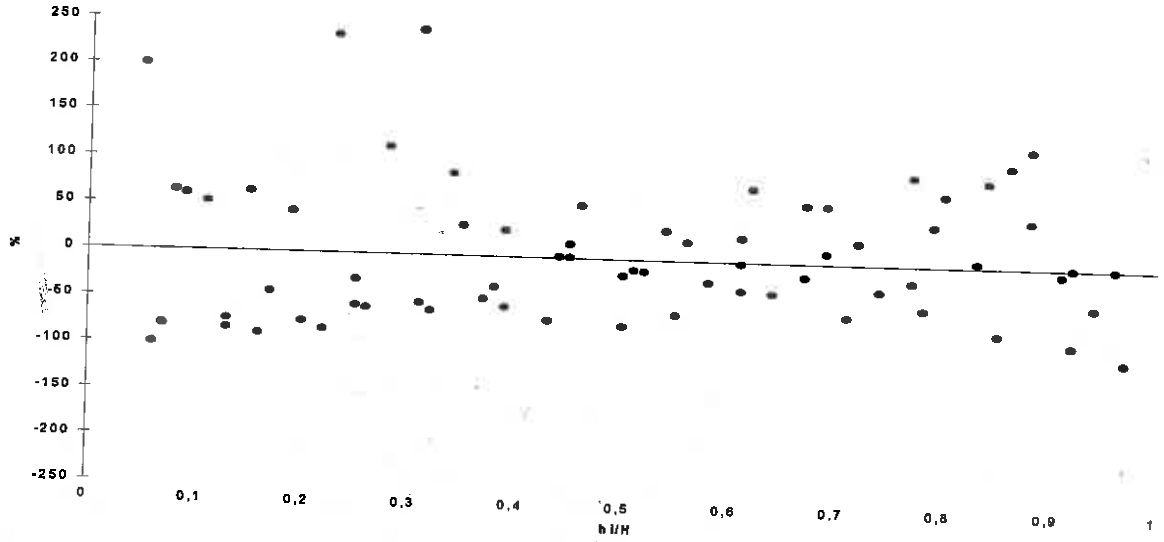

Figure 4 - Residue of total number of *Sirex noctilio* and *Ibalia leucospoides* in relation to *Pinus taeda* tree height. Lages, SC. 1993/94.

3.2 Size of sample of *Pinus taeda*

Table 2 presents the number of billets and trees that should be sampled to achieve a certain precision represented by a coefficient of variation.

The first step of sampling is the determination of the desired precision.

Table 2 - Coefficient of variation for total number of *Sirex noctilio* and *Ibalia leucospoides* as a function of number of trees and number of billets per tree of *Pinus taeda*.

NUMBER OF TREES	1	2	NUMBER 3 COEFFICIENT	OF 4 OF %	BILLETS 5 VARIATION	6	7
1	43,17	35,85	33,04	31,55	30,62	29,98	29,52
2	30,53	25,35	23,36	22,31	21,65	21,20	20,87
3	24,94	20,71	19,09	18,23	17,69	17,33	17,06
4	21,59	17,92	16,52	15,77	15,31	14,99	14,76
5	19,34	16,06	14,81	14,15	13,73	13,45	13,24

3.2.1 Use of the Coefficient of Variation Table (CV Table)

Operational ease and available room for sample storage should be considered to the use of the CV table. These two aspects will define the number of trees and billets that will be sampled.

The sampling of 3 trees and 3 billets gives a CV around 19% (Table 2) which can be considered appropriate to field conditions, *i.e.* the sample will have nine billets (three per tree). The number of billets can be reduced by increasing the number of trees. If 5 trees are sampled only one billet is necessary for each tree. The final sample will have only five billets (almost half the previous sample size) with the same CV.

A decision can be taken at the field according to finality and convenience, *e.g.* if natural parasitism of *D. siricidicola* will be evaluated and felling of trees is required, a smaller number of trees and a larger number of billets may be the most operational choice. On the other hand, if parasitism of inoculated trees will be evaluated and trees have already been felled, there is no difference in taking more trees or billets. In both cases the limiting factor will be the storage and transport of a large number of billets in the final sample.

3.3 Sequential sampling to the definition of *Sirex noctilio* attack level in *Pinus taeda* stands

The method is based on the sequencial sampling technique where samples do not have a fixed size, which is determined at the time that intermediate results are obtained.

Table 3 is used to determine if the number of samples collected is enough or if it must be increased. With that, there is an economy of time and resources without losses in precision.

Table 3 -Definition of sample size to the evaluation of percentual of trees attacked by *Sirex noctilio* in *Pinus taeda* stands with the use of sequential sampling.

NUMBER OF SAMPLED TREES	NUMBER OF ATTACKED TREES	
	TREES ATTACKED IN THE SAMPLE	MINIMUM TO STOP SAMPLING
68		34
74		36
80		37
87		38
94		39
102		41
111		42
121		44
132		45
145		46
159		48
175		49
194		50
215		52
241		53
272		54
272		49
272		44
272		38
272		27
272		22
272		16
272		11
272		5
272		1

3.3.1 Use of the sequential sampling table

- start by sampling 68 trees;
- write the number of attacked trees;
- if the sample has 34 or more trees attacked, sample is complete;
- if there is less than 34 trees attacked, sample another 6 trees;
- if the sample has 36 or more trees attacked, sample is complete;
- if there is less than 36 trees attacked, sample another 6 trees;
- process continues until number in column 2 is equal or bigger than the corresponding number in column 3 or 272 trees have been sampled

Percentage of trees attacked by *S. noctilio* is given by:

$$\% \text{ attack} = 100\left(\frac{\text{no. of tres attacked}}{\text{no. of trees sampled}}\right)$$

4 CONCLUSION

- The first third of the stem is the least preferred by *S. noctilio* and its natural enemies;
- Samples to evaluation of *S. noctilio* population and parasitism levels of *D. siricidicola* and *I. leucospoides* should be collected in the area between 30 and 80% of stem length, *i.e.* in the medium third and in the lower half of the upper third of the stem;
- The use of CV table is a valuable tool in planing monitoring activities of wood wasp and its enemies. The precision of results, storage of samples and operational costs should be considered.
- Sequential sampling is a viable alternative to the evaluation of *S. noctilio* attack level in *P. taeda* stands. It is a fast, cost effective and reliable method;

5 RECOMENDATIONS

- The definition of number of trees and billets that should be collected is possible with the help of CV tables, but choice of trees is very important. It is recommended that only billets with resin drops should be collected. This is important to guarantee an reasonable number of insects in the billet,
- Variations among stands and within stands due to soil, age, management can interfere in the precision of results, and, if necessary, sampling should to each different condition;
- Sequential sampling requires homogeneous areas. If variations occur in the same stand, this should be stratified and evaluations made within each strata.

6 REFERENCES

IEDE, E.T.; PENTEADO, S.R.C.; BISOL, J.C. Primeiro registro de ataque de *Sirex noctilio* em *Pinus taeda* no Brasil. Colombo: EMBRAPA - CNPF, 1988b, 12p. (EMBRAPA - CNPF, Circular Técnica, 20).

LIMA, P.C. Método de amostragem para a avaliação do índice de infecção da ferrugem do cafeeiro (*Hemileia vastatrix*, Berk. E Br.). Piracicaba, 1979, 65p. Tese (Mestrado em Estatística e Experimentação Agrícola) - Escola Superior de Agricultura "Luiz de Queiróz".

MENDENHALL, W. Probabilidade e estatística. Rio de Janeiro: Campus, 1985. 489 p.

NETER, J.; WASSERMAN, W. Applied linear statistical models. Richard D. Irwin, Inc., 1974. 842 p.

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