SAMPLING PROCEDURES FOR SPITTLEBUG ADULTS IN PASTURES OF PANICUM MAXIMUM[1]

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ABSTRACT - A sampling study of spittlebug adults in pastures of *Panicum maximum* cv. Colonião was conducted to find an appropriate number of sweep-net sweeps per sample and sample numbers. Based on the values of relative variation $(SE/\bar{X}) \times 100$, total number of sweeps, and number of samples, ten ten-sweep samples were considered to be better than five 40-sweep samples, five 20-sweep samples, or 20 ten-sweep samples. The number of samples required for a particular level of relative variation at population densities > 17 spittlebug adults/10 sweeps remained the same, whereas at densities < 17, the number increased inversely. A regression model to convert relative estimates obtained by sweep-net method to the absolute estimate was presented. The sampling efficiency of sweep-net and cage method was equal; however, the former was considered superior because of the shorter sampling time. The distribution pattern of numbers of spittlebug adults in samples of ten sweep or the numbers in 1 m^2 of the pasture, generally fitted the Poisson series. Suggestions on choosing sampling sites in a sampling area were given.

Index terms: *Zulia entreriana, Deois flavopicta*, Cercopidae, Colonião, sampling efficiency.

PROCEDIMENTO DE AMOSTRAGEM DE CIGARRINHAS ADULTAS EM PASTAGENS DE *PANICUM MAXIMUM*

RESUMO - Foi conduzido um estudo sobre amostragem de adultos de cigarrinhas em pastagens de *Panicum maximum* cv. Colonião, para determinar o número adequado de batidas de rede entomológica e o número de amostras. Considerando-se a variação relativa $(EP/\bar{X}) \times 100$, o número total de batidas na amostragem e o número total de amostras, o número de dez amostras de dez batidas mostrou ser melhor do que cinco amostras de 40 batidas, cinco amostras de 20 batidas, ou 20 amostras de dez batidas. O número de amostras necessárias para determinado nível de variação relativa nas populações de cigarrinhas > 17 adultos/dez batidas foi o mesmo, ao passo que nas densidades < 17, o número aumentou inversamente. Foi construído um modelo de regressão para converter a estimativa relativa obtida pelo método de rede entomológica em estimativa absoluta. A eficiência da amostragem dos métodos de rede entomológica e gaiola foi igual; entretanto, considerando-se o tempo gasto em amostragem, o método de rede entomológica foi considerado superior. O número de adultos de cigarrinhas em amostras de dez batidas, ou em 1 m^2 de pasto, em geral, mostrou uma distribuição do tipo Poisson. Foram sugeridos os locais adequados de amostragem na área de amostragem.

Termos para indexação: *Zulia entreriana, Deois flavopicta*, Cercopidae, eficiência de amostragem.

INTRODUCTION

The grass species, *Panicum maximum* Jacq. cv. Colonião is one of the most widely used grasses for fattening beef cattle in Brazil. Although no definite estimates are available, the area planted to this grass could easily be several million hectares. Spittlebugs belonging to genera *Zulia, Deois* and *Mahanarva* suck sap from the grass plants and inject toxins which cause "burning" and at times death of the plants. Although 'Colonião' hindered survival and development of nymphs of the spittlebug *Zulia entreriana* Berg., the grass' low tolerance to the adult damage might cause severe losses (Nilakhe et al. s.n.t.).

Relatively accurate estimates of spittlebugs populations in pastures of 'Colonião' would be useful in making appropriate pest management decisions and also would be valuable as well in planning research studies. In sampling, a small part of a population is studied, and based on sample information an inference about the population is made. Thus, in absence of an appropriate sampling procedure, one may spend too much efforts in reaching an inference and/or may reach an erroneous inference. Therefore, the methodology used in sampling is of fundamental importance. Generally, the objective in a sampling plan is to obtain the information with an acceptable level of precision or relative

[1] Accepted for publication on February 14, 1986.

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variation (proportion of standard error to mean expressed as a percentage) with the minimum possible effort. Considering this, sampling plans for spittlebug eggs (Nilakhe et al. 1984a, 1984c, 1985), numphs (Nilakhe 1982) and adults (Nilakhe et al. 1984b) in pastures of *Brachiaria decumbens* Stapf have been developed.

Before proceeding with sampling of spittlebug adults with a sweep-net in pastures of 'Colonião', one needs to decide on: 1) number of sweeps per sample (5, 10, 20, 40 or 60 etc.); 2) number of samples; and 3) locations of these samples in the sampling area. Herein a study is reported that helps answer these three points. Studies about conversion of adult counts in a sweep-net sample (relative estimate) to the number per m^2 of the pasture (absolute estimate), and the mathematical distribution characteristics of the counts are also included. Absolute population estimates are necessary for standardization and calibration of relative sampling techniques. Since most economic threshold studies are based on the number of insects per unit area, the information on absolute population estimates in the field would be useful in the pest management decisions.

MATERIALS AND METHODS

The 18 fields of about 2.5 ha of 'Colonião' used in the study to determine the appropriate numbers of samples, and sweeps per sample were located within a 80 km radius of Dourados, MS, Brazil. Each field was a part of a larger pasture under grazing. The mean grass height based on 25 grass-plants/field varied from 13 cm - 68 cm with a grand mean of 36.5 cm and SE of 3.84. Seven of the 18 fields had grass height > 35 cm. To obtain the proportion of spittlebug species, a minimum of 100 adults/field were examined. Overall, 63% of the adults were *Z. entreriana*, and 27% were *Deois flavopicta* Stal; occasionally, adults of *Mahanarva fimbriolata* Stal were also found.

A sweep-net used to sample spittlebug adults had 40 cm diameter ring, a cone-shaped bag made of strong muslin 70 cm deep, and a handle about 130 cm long. For each sweep, the pasture in a semicircle of 1.3 m radius (distance between the person and the outermost point of the ring) was swept and the person walked a distance of 1.5 m (two small steps). Each field was divided into 36 equal-sized plots. Within each plot, one sample each of 5, 10, 20 and 40 sweeps of the sweep-net was taken in such a way that no overlapping of the area sampled occurred. The adults collected in sweep-net samples were usually counted in the field itself. At densities > 20 adults/10 sweeps, the insects were brought to the laboratory for counting. The sampling was done from October 1983 to January 1985.

By using the random-number table (Steel & Torrie 1960), 5, 10 and 20 samples were drawn from 36 samples of the field. This was done each for the 5, 10, 20 and 40 sweep samples. The distribution pattern of adults within a field was tested for conformity to the Poisson by calculating the index of dispersion (I_D). I_D is approximately distributed as X^2 with n-1 degrees of freedom (Southwood 1978). I_D values between limits of 0.95 and 0.05 for 35 degrees of freedom were considered as conforming to the Poisson distribution. Values of the negative binomial parameter (k) were determined as $k = \bar{x}^2/(s^2 - \bar{x})$ (Southwood 1978).

The mean grass height in an additional 19 fields of about 1 ha of 'Colonião' which were also used to compare sweep-net sampling to cage sampling varied from 13 cm to 83 cm, with a grand mean of 41.3, and SE of 4.95. Nine of the 19 fields had grass height > 35 cm. Overall, 78% of the adults were *Z. entreriana* and the rest *D. flavopicta;* occasionally adults of *M. fimbriolata* were also found. In 13 fields > 50% of the adults belonged to *Z. entreriana*.

Each of the 19 fields was divided into 16 equal-sized plots and in each plot a sweep-net sample of 10 sweeps and a cage sample were taken. The methodology for the sweep-net sample was given earlier. For each cage sample, a cage of 1 m^3 made with wooden frame and saran was used. The cage was hooked in the center of a 3 m-long, 3 cm-diameter light weight metal pipe, and was carried by two persons in arms upright position in such a manner that the cage remained about 1 m above the soil level until it was lowered to the area being sampled. Carrying cage in this manner did not alert the spittlebug adults present directly below the cage; thus no adult entered through the open end of the cage facing the pasture. Adults inside the cage were collected by using an aspirator. To obtain all adults, plants inside the cage were shaken vigorously. When adults in the cage were collected, the plants were clipped at ground level, and the clipped plants and the stubs were examined carefully for any remaining adults. The details of the cage method were given by Nilakhe et al. (1984b). The sampling was done from November 1983 to January 1985.

RESULTS

Mean number of adults and relative variation (RV) for samples of 5, 10, 20 and 40 sweeps-net are given in Tables 1, 2, 3 and 4, respectively. Considering the four tables together, as the number of samples increased, the RV values became smaller. For example, RV exceeded 40%, 11 times in 5 samples, and 4 times in 10 samples, whereas in the case of 20 samples the RV was always < 40%. In general the RV values tended to be higher only at the lower population densities. The author wanted to estimate population of spittlebug adults with the least possible work but also with acceptable value of RV (≤ 20%). Using this standard, the number of samples, and the total number of sweeps in the sampling (no. of samples x no. of sweeps per sample), the selection of the most appropriate number of sweeps per sample and the sample numbers was done. The number of fields out of 18 in which the RV was ≥ 20% are shown in Table 5. The sampling efficiency improved greatly when the sample numbers were increased from 5 to 10 than from 10 to 20. Likewise maximum gain was obtained when the sweeps per samples was increased from 5 to 10, whereas, very little was gained by increasing it from 20 to 40. In the samples taken with 40 sweeps, the RV was ≥ 20%, 4, 3, and 0 times for 5, 10 and 20 samples, respectively; however, the total number of sweeps taken were 200, 400 and 800, respectively. Although, 20 samples of 40 sweeps was better than all those tested, the total number of sweeps was 800, and thus for such a small gain in efficiency (in no field RV exceeded 20%) it is not worthwhile to increase the total number of sweeps two folds (in the case of 20 samples of 20 sweeps, the RV exceeded 20% only 2 times). Since 10 samples of 10 sweeps (a total of 100 sweeps) gave the same sampling efficiency as 10 samples of 20 sweeps (a total of 200 sweeps), 20 samples of 10 sweeps (a total of 200 sweeps) and 10 samples of 40 sweeps (a total of 400 sweeps), the combination of 10 samples of 10 sweeps was preferred because of its lowest number of total sweeps. In these 4 situations, the RV was ≥ 20% in either 3 or 4 fields. When all the combinations involving 100 sweeps were compared, the combination of 10 samples of

TABLE 1. Mean number of spittlebug adults in 5, 10 and 20 samples of 5 sweeps of a sweep-net, and the relative variation (RV) in pastures of *Panicum maximum*, Mato Grosso do Sul, 1983-85.

Field	No. of samples					
	5		10		20	
	$\bar{x}$ no. of adults	RV[1]	$\bar{x}$ no. of adults	RV	$\bar{x}$ no. of adults	RV
1	9.8	13.0	10.7	13.0	11.8	5.6
2	5.8	24.0	9.9	24.0	11.2	10.9
3	16.0	11.2	17.9	7.5	17.6	5.6
4	15.8	19.9	13.4	12.2	13.3	9.4
5	35.0	24.2	30.6	18.6	38.0	10.5
6	2.8	7.1	2.2	20.1	3.1	19.7
7	1.4	28.5	2.3	14.5	2.1	11.9
8	3.8	21.0	4.2	15.4	4.6	7.5
9	3.0	23.5	3.9	15.0	2.6	17.9
10	3.8	36.6	3.3	24.8	4.5	10.6
11	2.8	44.2	2.0	43.4	1.3	30.6
12	1.2	40.7	1.3	32.6	1.5	15.7
13	1.0	44.6	1.4	30.5	1.4	15.9
14	1.4	28.5	1.8	13.9	1.7	18.2
15	0.8	25.0	0.4	40.9	0.7	21.0
16	0.6	66.5	1.5	21.1	1.2	28.5
17	1.4	38.5	1.6	21.2	1.2	21.2
18	8.6	13.0	9.9	13.3	10.5	8.8

[1] RV = (SE/$\bar{x}$) x 100.

TABLE 2. Mean number of spittlebug adults in 5, 10 and 20 samples of 10 sweeps of a sweep-net, and the relative variation (RV) in pastures of *Panicum maximum*, Mato Grosso do Sul, 1983-85.

Field	No. of samples					
	5		10		20	
	$\bar{x}$ no. of adults	RV[1]	$\bar{x}$ no. of adults	RV	$\bar{x}$ no. of adults	RV
1	24.8	16.0	25.9	10.1	27.9	5.4
2	17.8	19.6	14.0	13.6	17.0	8.4
3	24.6	10.9	29.5	5.3	26.2	3.7
4	19.0	14.6	22.1	7.9	20.5	7.0
5	71.0	14.3	44.3	14.2	52.4	8.8
6	5.4	17.1	4.7	10.1	3.8	14.0
7	3.0	14.9	4.2	11.1	4.1	11.9
8	8.8	10.4	9.2	6.2	9.0	7.1
9	9.4	11.9	9.9	13.7	8.2	7.1
10	9.0	22.7	9.8	10.6	12.4	12.0
11	13.2	20.6	16.0	33.2	12.7	23.0
12	4.0	28.5	2.8	10.4	4.4	14.5
13	1.6	42.3	1.7	32.9	2.3	21.9
14	3.4	35.5	5.0	65.3	3.1	22.6
15	1.2	66.5	1.2	16.7	1.4	18.2
16	4.4	22.7	4.4	16.7	5.0	8.4
17	1.2	48.5	1.8	20.0	2.6	20.0
18	28.2	8.6	27.7	8.4	28.3	6.1

[1] RV = $(SE/\bar{x}) \times 100$.

10 sweeps was still found to be superior. The designated RV value was exceeded in 6 fields in the case of 5, 20-sweep samples in comparison to 4 fields for the ten 10-sweep samples. The sampling efficiency of 20 samples of 5 sweeps (5 fields with RV > 20%) could be considered equal to that of 10 samples of 10 sweeps (4 fields with RV > 20%); however, the former involves sampling at 10 additional sites than the latter, therefore the latter is preferred. Five or 10 samples of 5 sweeps are not worth considering since the sampling efficiency was poor - 14 and 9 fields, respectively, exceeded the RV of 20%.

The efficiency of only 3 sample numbers (5, 10 and 20) was compared. However, for better understanding, the number of samples necessary for the 3 levels of precision at various population densities was calculated by using the 36 ten-sweep samples (Tables 6). The 10-sweep samples were chosen for this purpose because they adequately met the criterion about the sampling efficiency. The resulting sampling plan, illustrated graphically, shows that at densities of > 17 adults/10 sweeps, the number of samples required, for the precision, levels of 10, 15, and 20% was 13, 6 and 3 respectively (Fig. 1). At population levels < 17, th number of samples required was inversely proportional to the population density. Table 6 also shows that values of index of aggregation (k) were > 8 in 7 of 14 fields, indicating Poisson distribution in these 7 fields (Southwood 1978). In the remaining 7 field, excepting fields 11 and 15, the counts did not show a high degree of clumping also. Values of the index of dispersion (I_D) showed agreement to Poisson distribution in 6 of 18 fields (fields 6, 7, 9, 13, 15 and 18). Generally variance was greater than the respective mean. However, considering k and I_D values, for practical purposes, the mathematical distribution of counts of spittlebug adults in samples of 10 sweeps was considered

Poisson. A nonsignificant correlation coefficient (r = 0.29) (P > 0.05) for the mean and k values indicated that k was independent of density.

Since the spatial pattern of spittlebug adults was considered Poisson, variance was stabilized by using transformation $\sqrt{x + 0.5}$, where x is equal to the observed count. The analysis of variance for each of the 18 sets of data showed that differences between rows, and between columns were significant 4 times each.

The mean number of spittlebug adults obtained in a study about conversion of the sweep-net sample counts to absolute estimates are given in Table 7. The number of adults varied from 0.6 to 59.6 for the sweep-net samples of 10 sweeps and from 0 to 27.9 for the 1 m^3 cage sample. To obtain all the adults present inside the cage, simply shaking vigorously of the plants inside the cage was not enough. About 10% of all the adults inside the cage were recovered while clipping the plants and in examination of the clipped plants, stubs and the leaf litter.

The sampling efficiency of the sweep-net method was about equal to that of the cage method. In the sweep-net sampling, the RV values exceeded 20% in 7 of the 19 fields (fields 4, 5, 6, 7, 8, 9 and 11) and for the cage method in 7 of 18 fields (fields 2, 3, 4, 5, 7, 8 and 9). The RV values exceeded 20% at very low population densities - about < 3 adults/10 sweeps for the sweep-net sampling, and < 2 adults/1 m^3 for the cage method. A good association between the cage and the sweep-net method was obtained (r = 0.72) (P < 0.01). The regression model of the mean number of spittlebug adults collected by sweep-net and cage method is shown graphically in Fig. 2.

The variance of the counts of spittlebug adults by the cage method was greater than the corresponding mean, except in fields 3, 11 and 12. In 7 of the 11 cases the values of the k was > 8 indicating agreement with Poisson distribution. In the remaining 4 fields (fields 1, 2, 9 and 13) the k values were intermediate, indicating weak clump-

TABLE 3. Mean number of spittlebug adults in 5, 10 and 20 samples of 20 sweeps of a sweep-net, and the relative variation (RV) in pastures of *Panicum maximum*, Mato Grosso do Sul, 1983-85.

Field	No. of samples					
	5		10		20	
	$\bar{x}$ no. of adults	RV[1]	$\bar{x}$ no. of adults	RV	$\bar{x}$ no. of adults	RV
1	58.0	7.7	57.1	3.8	58.7	4.1
2	19.6	13.9	28.2	8.6	25.3	5.9
3	43.2	6.4	52.8	5.0	54.7	4.2
4	47.6	16.0	42.4	9.9	43.9	8.5
5	92.4	16.2	145.2	7.8	118.9	6.9
6	7.6	7.9	6.7	17.1	7.3	7.6
7	7.2	17.2	5.5	11.6	7.6	6.4
8	15.6	5.6	14.6	7.3	14.3	5.7
9	12.8	17.7	11.5	10.8	12.2	4.2
10	21.4	24.8	18.8	16.6	21.0	9.8
11	14.4	24.2	12.3	25.3	8.9	12.1
12	5.8	14.8	4.8	12.0	4.7	11.4
13	1.0	63.1	0.6	44.5	0.8	23.8
14	5.2	40.9	3.9	18.5	4.2	15.0
15	2.4	40.8	2.9	18.2	3.3	14.1
16	2.2	44.0	2.6	24.5	2.3	19.7
17	9.2	11.6	5.9	17.2	6.6	11.5
18	52.2	5.2	56.6	6.0	55.6	4.8

[1] RV = (SE/$\bar{x}$) x 100.

ing. Values of I_D indicated agreement to the Poisson distribution in 13 of the 19 fields (fields 2, 3, 4, 5, 7, 14 and 19). Thus, considering k and I_D values, for practical purposes, the mathematical distribution of counts of spittlebug adults per m^2 of pasture was considered Poisson. Again the k was independent of mean ($r = 0.35$) ($P > 0.05$).

DISCUSSION

When sampling spittlebug adults in pastures of 'Colonião', the sample size of 10 sweeps of a sweep-net was generally found to be as efficient as 20 or 40 sweeps. Thus, using 10 sweep samples, a relationship between spittlebug population density and number of samples necessary for different levels of precision was shown. Because the number of samples required for a particular level of precision at population densities of < 17 adults/10 sweeps, was inversely proportional to the density, it is difficult to suggest one particular number of samples for all the population levels. Generally, 10 samples of 10 sweeps could provide precision level between 10 and 15%. In areas where the population densities are always < 17 adults/10 sweeps, one may consider taking more samples. In the absence of similar studies on other grasses, e.g., *Brachiaria humidicola* (Rendel) Schwickerdt, *Cenchrus ciliaris* L., *Hyparrhenia rufa* (Ness) etc., the same sample size could be used.

In the present study, RV value of 20% was chosen as a bench mark for deciding about efficiency of a particular sampling procedure, i.e., number of sweeps per sample and sample numbers. One may chose other RV values such as 10 % or 15% to achieve the same goal. It is doubtful that by doing so the conclusions will change much. For example, if one uses the acceptable value of RV as < 10%, then using the RV values from Tables 1 to 4, the best combinations of samples numbers x sweeps

TABLE 4. Mean number of spittlebug adults in 5, 10 and 20 samples of 40 sweeps of a sweep-net, and the relative variation (RV) in pastures of *Panicum maximum*, Mato Grosso do Sul, 1983-85.

Field	No. of samples					
	5		10		20	
	$\bar{x}$ no. of adults	RV[1]	$\bar{x}$ no. of adults	RV	$\bar{x}$ no. of adults	RV
1	91.6	2.3	97.4	2.7	96.2	3.4
2	40.8	8.8	46.2	5.9	42.7	4.5
3	111.0	11.9	116.0	11.7	133.9	4.9
4	76.2	23.1	75.3	16.7	60.5	6.6
5	162.4	15.5	184.0	8.5	198.4	6.9
6	11.6	11.1	11.1	8.7	15.3	7.0
7	10.6	15.4	10.1	3.1	11.5	7.0
8	24.8	3.5	25.0	12.9	25.4	5.4
9	17.4	18.1	22.4	7.5	20.9	5.2
10	20.6	36.9	21.7	14.2	26.8	13.9
11	15.4	19.8	14.9	13.2	15.9	13.9
12	13.6	29.4	12.1	15.2	10.4	10.9
13	2.0	35.3	1.7	29.2	1.8	19.2
14	5.2	16.5	4.7	28.2	4.9	16.1
15	5.6	18.4	4.5	19.1	4.7	11.7
16	12.4	16.4	8.7	15.2	9.0	10.7
17	15.0	15.5	12.8	21.6	13.4	15.5
18	82.2	3.8	80.6	4.1	83.2	2.8

[1] RV = $(SE/\bar{x}) \times 100$.

per samples in terms of sampling efficiency were 20 samples of 10, 20 or 40 sweeps. In these sampling procedures, number of the fields with RV ≤ 10% were 9, 8 and 8 respectively. This still showed that 10 sweeps was more efficient than 20 or 40.

TABLE 5. Number of fields out of 18 in which the relative variation was ≥ 20%.

No. of sweeps/ sample	Sample numbers		
	5	10	20
5	14	9	5
10	9	4	4
20	6	3	2
40	4	3	0

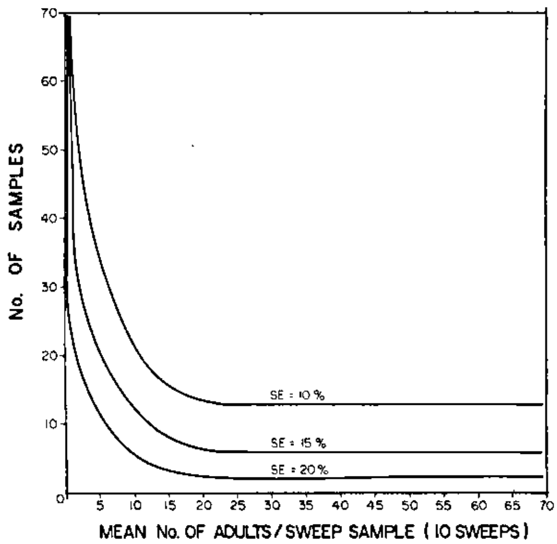

FIG. 1. Relation between population density and number of samples necessary for three levels of precision for sampling of spittlebug adults in pastures of *Panicum maximum* cv. Colonião.

The population densities of spittlebug adults varied from 1 to 60/10 sweeps. At times higher densities were encountered. However, in terms of the sampling efficiency, this would not be a problem; generally, with higher densities the efficiency would improve also. On an average, differences between rows and between columns were significant in 4 of the 18 instances. Thus, unless for specific reason, blocking within the sampling area may not be necessary; however, choosing well-distributed sampling sites may be beneficial.

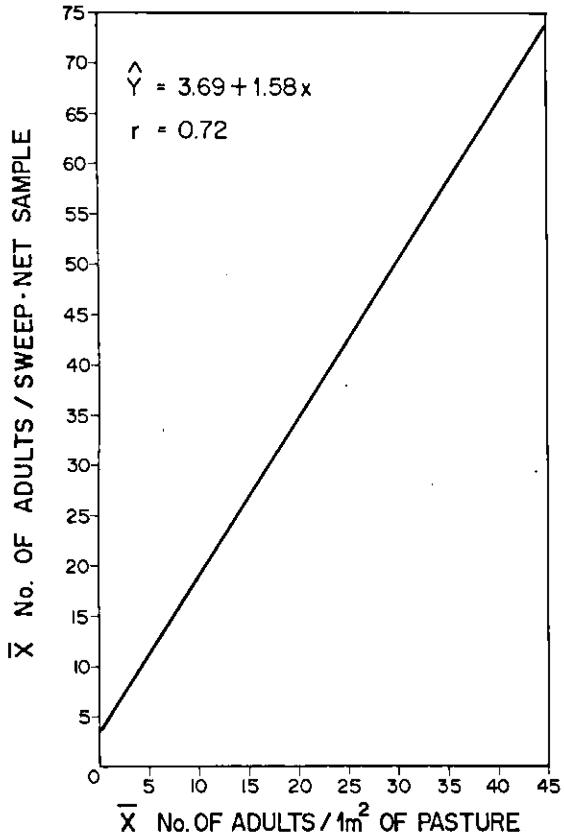

FIG. 2. Regression model of the mean number of spittlebug adults collected by sweep-net (10 sweeps/ sample) and the cage method in pastures of *Panicum maximum* cv. Colonião.

The spatial distribution of counts of spittlebug adults collected in 10 sweeps was in general Poisson. This finding agreed to that of the distribution pattern of spittlebug adults in pasture of *B. decumbens* (Nilakhe et al. 1984b), cercopids of *Aeneolamia* species in pastures of *Digitaria decumbens* Stent and *Cynodon plectostachys* (Bianco 1982), and sugarcane froghopper; *Aeneolamia varia saccharina* (Distant) on sugarcane stems (Evans

1974). A higher degree of clumping was reported for spittlebug nymphs (Nilakhe 1982). Since the k values were independent of spittlebug adult density, the calculation of a common k would be justified (Rudd 1980). Using this common k value, sequential sampling plans could be developed (Nilakhe 1982).

On an average, the sweep sample of 10 sweeps required 5 min, which was much less than the average 15 min. of the cage sample. In terms of precision (RV values), both mehods were about equal. Because the cage method required longer time than the sweep-net method, the latter was considered superior.

Sampling in the present study was done from 8-11 A.M. and 1-4 P.M.; however, no sampling was done when the foliage was wet with rain drops or dew, or in severe windy conditions. Thus, whenever possible, it would be appropriate to sample during the same two periods. One may sample half the number of replications during the morning and the remaining half during the afternoon. This would give more confidence in the results obtained by use of the regression model (Fig. 2).

To evaluate the influence of grass-height on the capture of adults in the sweep-net, the following calculations were made: for the shorther grass (grass-height < 35 cm), the total number of adults per sweep-net sample in fields 2, 5, 6, 10 and 14 to 19 was 199.1 and the total for cage samples from the same fields was 85.6. Similarly, the totals for the taller grass (the remaining 9 fields) were 29.6 and 14.9, respectively (Table 7). Thus, for the shorter grass, the number of adults in the cage samples was 43.0% as that of the sweep-net samples, whereas for the taller grass the respective percentage was 50.3%. However, it was felt that this difference of 7.3% was not large enough to

TABLE 6. Mean number of spittlebug adults in 36 samples of 10 sweeps of a sweep-net in about 2.5 ha fields of *Panicum maximum*, variance, coefficient variation (CV), estimate of no. of samples for three levels of precision, and the mathematical distribution characteristics of the counts, Mato Grosso do Sul, 1983-85.

Field	± SE	s^2	CV	No. of samples required for SE of[1]			Index of aggregation (k)[2]	Index of dispersion (I_D)[3]
				10	15	20		
1	27.7 ± 1.1	42.5	23.5	6	2	1	51.8	53.7
2	15.9 ± 1.1	38.6	40.0	16	7	4	11.1	85.0
3	28.3 ± 1.4	71.7	29.9	9	4	2	18.5	88.7
4	21.8 ± 1.1	40.5	29.2	9	4	2	25.4	65.1
5	60.3 ± 3.4	463.1	35.7	13	6	3	9.0	268.8
6	3.9 ± 0.3	3.3	46.3	21	10	5	–	29.6
7	4.1 ± 0.3	3.2	43.8	19	9	5	–	27.5
8	8.5 ± 0.4	5.0	26.3	7	3	2	–	20.6
9	7.6 ± 0.6	10.9	43.5	19	9	5	17.3	50.3
10	11.2 ± 1.0	35.0	52.8	28	12	7	5.3	109.3
11	9.1 ± 1.2	49.6	77.4	60	27	15	2.0	190.9
12	3.3 ± 0.4	6.1	74.7	56	25	14	3.9	64.5
13	1.4 ± 0.2	1.1	75.3	57	25	14	–	27.8
14	3.0 ± 0.4	5.5	77.9	61	27	15	3.7	63.7
15	1.0 ± 0.2	1.0	101.4	103	46	26	0	35.0
16	4.2 ± 0.5	7.9	66.7	44	20	11	4.8	65.5
17	2.6 ± 0.3	4.0	77.2	60	27	15	4.8	54.1
18	27.4 ± 1.1	39.7	23.0	5	2	1	61.0	50.7

[1] No. of samples for SE of a certain probability (P) = $(CV/P)^2$.
[2] $k = \bar{x}^2/(s^2-\bar{x})$. In fields 6, 7, 8 and 13 the k was negative.
[3] $I_D = s^2(n-1)/\bar{x}$

TABLE 7. Mean number of spittlebug adults in a sweep-net (10 sweeps) and cage (1 m^3) sample, and distribution characteristics of the counts in about 1 ha fields of *Panicum maximum*, Mato Grosso do Sul, 1983-85[1].

Field	$\bar{x}$ grass height ± SE (cm)	$\bar{x}$ no. of adults/ sweep-net sample ± SE	Counts of adults in cage samples			
			$\bar{x}$ ± SE	s^2	Index of aggregation (k)[2]	Index of dispersion (I_D)[3]
1	68.2 ± 5.64	8.8 ± 1.34	5.2 ± 0.95	14.4	2.9	42.1
2	24.8 ± 2.61	3.8 ± 0.50	1.8 ± 0.39	2.4	5.3	20.1
3	48.0 ± 3.29	2.4 ± 0.40	0.8 ± 0.17	0.5	–	9.3
4	55.4 ± 3.53	0.6 ± 0.18	0.1 ± 0.09	0.1	–	13.7
5	27.4 ± 2.24	2.2 ± 0.56	0.4 ± 0.16	0.4	–	13.5
6	27.2 ± 2.17	0.6 ± 0.18	0			
7	47.0 ± 4.57	1.4 ± 0.42	0.2 ± 0.10	0.20	–	12.8
8	83.2 ± 4.79	1.4 ± 0.39	0.3 ± 0.19	0.6	–	12.8
9	78.8 ± 5.06	3.1 ± 0.81	0.7 ± 0.24	0.9	2.3	19.5
10	30.6 ± 2.00	7.9 ± 1.07	3.4 ± 0.53	4.5	10.0	20.0
11	51.2 ± 4.23	2.9 ± 0.59	1.9 ± 0.29	1.4	–	10.6
12	55.0 ± 4.16	4.1 ± 0.6	2.3 ± 0.40	2.2	–	14.5
13	61.9 ± 4.04	4.9 ± 0.92	3.4 ± 0.57	5.2	6.4	23.0
14	20.0 ± 1.02	28.1 ± 1.48	11.9 ± 0.72	18.7	20.8	23.5
15	22.6 ± 1.04	17.8 ± 1.10	5.8 ± 0.46	7.8	17.3	46.7
16	34.0 ± 1.87	30.4 ± 1.98	27.9 ± 2.55	104.0	10.2	55.9
17	13.0 ± 1.11	59.6 ± 5.50	10.5 ± 1.21	23.4	8.4	33.7
18	14.7 ± 1.03	23.1 ± 1.51	13.3 ± 1.28	26.2	13.9	29.4
19	22.5 ± 1.37	25.6 ± 1.54	10.6 ± 0.97	15.5	24.8	21.4

[1] Each field was divided in 16 equal sized plots, and a cage and a sweep sample per plot was taken.
[2] $k = \bar{x}^2/(s^2)$. The k values were negative for fields 3, 4, 5, 7, 8, 11 and 12.
[3] $I_D = s^2(n-1)/\bar{x}$.

warrent separate regression models for the shorter and the taller grass. The regression model presented here (Fig. 2) should be used for the 'Colonião' pastures with mean grass-height of about 80 cm or less.

Delong (1932) listed several factors that may influence the sweep-net sampling. In the present study, sweeping method, i.e., sweep-net, distance covered while sweeping and length of the sweep-net stroke were standardized. While sweeping an attempt to cover the entire grass height was made (in plants taller than 40 cm, the top 40 cm). As much as possible, the sweep-net ring was kept perpendicular to the ground. However, the denser grass plants provide more resistance and this in turn causes the net ring to be oblique to the ground and plant area swept is reduced accordingly. Apparently, more oblique the net ring becomes, fewer will be the adults collected. It was felt that force applied in sweeping would cause most of the variation in sweep-net sampling. Such a variation due to the human factor could be reduced by allowing one sampler to sample the entire replication of the experiment. Although sweep-net sampling has its problems, it is still the most economical and reliable sampling procedure for spittlebug adults.

Information about sampling in large pastures (for example, 100 ha) is limited. However, the following approach is suggested: sampling should be done sufficiently far from the field edge to avoid a "border effect". Choose well-distributed 5 locations along a "Z" pattern in the field, and take five, 10 sweep samples at each location. In subsequent samplings rotate the "Z" in such a way that all sides of the field are covered. In case a greater precision is required, the number of samples and locations could be increased to ten.

ACKNOWLEDGEMENT

This work was conducted while on assignement with Inter-American Institute for Cooperation on Agriculture, Organization of American States, San José, Costa Rica, and Empresa Brasileira de Pesquisa Agropecuária on PNP Diversificação Agropecuária project number 800.81.057/4. The author wishes to thank agricultural technicians Alcir A. da Silva and Irineu Cavicchione and field-helpers Antonio Carlos Garcia and Brito da Silva for the field assistance.

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