SPITTLEBUG EGGS: COMPARISON OF SAMPLING EFFICIENCY OF SAMPLE UNITS OF DIFFERENT SIZES[1]

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ABSTRACT - The sampling efficiency of three sample units was compared to determine spittlebug egg densities in pastures of *Brachiaria decumbens* Stapf. To obtain the same level of precision, the total pasture area to be examined increased by 1.5 times when size of the sample unit was increased from 75 to 150 cm^2, and by 2.5 times when it was increased to 225 cm^2. Using the 75 cm^2 unit, the number of samples necessary for 10%, 15% and 20% levels of precision were estimated to be 170, 82 and 48, respectively. The distribution pattern of egg counts per 75 cm^2 of the pasture, fitted the negative binomial series. A study of sampling variation within 1 ha pastures, showed that differences between blocks, or plots within blocks were significant only in about 20% instances. Nevertheless, choosing of well-distributed sampling sites within the sampling area was suggested.

Index Terms: *Zulia entreriana, Deois flavopicta*, Cercopidae, *Brachiaria decumbens*, pasture.

OVOS DE CIGARRINHAS-DAS-PASTAGENS: COMPARAÇÃO DE EFICIÊNCIA DE AMOSTRAGEM EM RELAÇÃO AO TAMANHO DAS AMOSTRAS

RESUMO - Foram comparados três diferentes tamanhos de amostras em relação à eficiência da amostragem para se determinar a densidade de ovos de cigarrinhas em pastagens de *Brachiaria decumbens* Stapf. Para se obter um mesmo nível de precisão, a área de pastagem a ser examinada aumentou 1,5 vez quando o tamanho da unidade de amostragem aumentou de 75 para 150 cm^2 e de 2,4 vezes quando o aumento foi para 225 cm^2. Uma estimativa mostrou a necessidade de 170 amostras para se obter um nível de 10% de precisão, 82 para 15% e 48 para 20%. O número de ovos por unidade de 75 cm^2 de área de pastagem mostrou uma distribuição do tipo binomial negativa. Um estudo sobre a variação na amostragem nas áreas de 1 ha de pastagens mostrou que as diferenças entre os blocos, ou parcelas dentro dos blocos, foram significativas somente em cerca de 20% dos casos. Contudo, tomada de amostras bem distribuídas dentro da área de amostragem foi sugerida.

Termos para indexação: *Zulia entreriana, Deois flavopicta*, Cercopidae, *Brachiaria decumbens*, pastagem.

INTRODUCTION

Information about spittlebug egg densities in various parts of a pasture would be useful in control methods such as use of fire in selective areas (Martin 1983) and pasture management tactics where predictions about severity of the forthcoming infestation are necessary (Nilakhe 1983). Spittlebug eggs were sampled for detection of infestation levels in rice fields (Nilakhe 1985), and also for various studies such as life table, modelling, detection of extent of parasitism, diapause, etc.

The objective in a sampling plan is to obtain the information with an acceptable level of precision or relative variation (proportion of standard error to mean, expressed as a percentage) with a minimum possible effort. Considering these two criteria, the sampling units of different sizes could be compared to find the most efficient one. Thus, to sample spittlebug eggs, a sampling unit of 225 cm^2 of pasture was found to be superior to 625 cm^2 unit, and based on the 225 cm^2 unit, several sampling plans were presented (Nilakhe et al. 1984a). Because the examination of pasture samples for spittlebug eggs is a tedious process, the next logical step obviously then is to determine whether reducing the sample size further would improve the sampling efficiency or not.

Herein, we report on comparison of sampling

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efficiency of 225 cm^2 unit to that of 150 and 75 cm^2. Also included is the information on distribution pattern of spittlebug eggs in the field, number of samples necessary for various levels of precision, and choosing of sampling sites in the sampling area.

MATERIAL AND METHODS

The sampling was done during June-August of 1984 in pastures of *Brachiaria decumbens* Stapf near Campo Grande and in the region of Dourados in the state of Mato Grosso do Sul. The majority of spittlebug adults in these areas belong to species *Zulia entreriana* (Berg.) and *Deois flavopicta* Stal, therefore eggs sampled were assumed to belong to these two species also. In each of the 14 field pastures, an area of 100 m x 100 m was designated as the sampling area of the field. The field was divided in four blocks and each block was further divided by means of a 2 x 2 grid in four equal plots, thus giving a total of 16 plots per field. In each plot, two 75 cm^2 (9.8 cm diam), and two 150 cm^2 (13.8 cm diam) areas of the pastures were selected at random for obtaining spittlebug egg counts. A sample consisted of the above-ground portions of grass plants clipped at about 8 cm height and soil inside the metal ring up to 2.5 cm depth.

In the laboratory, the sample was emptied in a 30 mesh sieve which was placed above a 60 mesh sieve. The sample was washed and dried as reported earlier (Nilakhe et al. 1984a), passed through a seed blower to remove the plant debris (Nilakhe et al. 1984c) and examined for spittlebug eggs by spreading in small quantities on black paper.

The distribution pattern of spittlebug eggs within a field was tested for conformity to the Poisson distribution by calculating the index of dispersion I_D.I_D is aproximately distributed as X^2 with n-1 degrees of freedom and is calculated as $s^2(n-1)/\bar{x}$. The negative binomial parameter (k) was calculated as $k=\bar{x}^2/(s^2-\bar{x})$ (Southwood 1978). To study the importance of variation between blocks, and plots within blocks, the egg counts from each field were subjected to an analysis of variance. The variation between rows and between columns was also evaluated in this manner. Because the spatial pattern of spittlebug eggs within a field conformed to the negative binomial distri-

TABLE 1. Mean number of spittlebug eggs in 75 cm^2 areas in pastures of *Brachiaria decumbens*, sampling variability, mathematical distribution characteristics of the counts and estimates of numbers of samples required for 3 levels of precision, Mato Grosso do Sul, 1984.

Field	$x \pm SE$[1]	Variance (s^2)	CV[2]	RV[3]	Index of aggregation (k)[4]	Index of dispersion (I_D)[5]	No. of samples required for SE of a certain percentage of mean[6]		
							10	15	20
1	0.8 ± 0.19	1.2	129	22	2.2	43	166	74	42
2	1.9 ± 0.22	1.5	63	11	-	24	40	18	10
3	3.4 ± 0.50	8.1	84	15	2.5	74	71	32	18
4	3.4 ± 0.96	29.5	159	28	0.4	269	253	112	63
5	4.0 ± 0.99	31.2	139	25	0.6	240	193	86	48
6	4.3 ± 0.94	28.1	122	22	0.8	200	149	66	37
7	5.9 ± 0.99	31.3	95	17	1.4	164	90	40	23
8	6.8 ± 2.18	152.6	181	32	0.3	692	328	146	82
9	8.2 ± 1.70	92.7	118	21	0.8	351	139	62	35
10	9.0 ± 2.01	128.9	126	22	0.7	444	159	71	46
11	10.8 ± 2.20	149.6	113	22	0.8	430	128	57	32
12	11.8 ± 2.22	108.9	88	16	1.4	286	77	34	19
13	16.9 ± 2.29	168.6	77	14	1.9	310	59	26	15
14	17.9 ± 2.97	283.4	94	17	1.2	490	88	39	22

[1] Mean based on 32 samples; SE = Standard error
[2] CV = (Std. dev./$\bar{x}$) x 100
[3] RV = (SE/$\bar{x}$) x 100
[4] $k=\bar{x}^2/(s^2-\bar{x})$. In field 2, the k was negative
[5] $I_D=s^2(n-1)/\bar{x}$
[6] No. of samples for SE of a certain probability (P) = $(CV/P)^2$

TABLE 2. Mean number of spittlebug eggs in 150 cm² areas in pastures of *Brachiaria decumbens*, sampling variability, mathematical distribution characteristics of the counts and estimates of numbers of samples required for 3 levels of precision, Mato Grosso do Sul, 1984.

Field	$\bar{x} \pm SE$[1]	Variance (s^2)	CV[2]	RV[3]	Index of aggregation (k)[4]	Index of dispersion (I_D)[5]	No. of samples required for SE of a certain percentage of mean[6]		
							10	15	20
2	0.9 ± 0.17	0.9	106	19	41.4	32	112	50	28
1	2.8 ± 0.45	6.4	90	16	2.2	70	81	36	20
8	4.5 ± 0.74	17.6	92	16	1.2	120	85	38	21
5	5.2 ± 0.75	18.3	83	15	2.0	110	69	31	17
4	8.2 ± 1.65	87.1	114	20	0.8	331	130	58	32
3	9.9 ± 1.67	89.1	95	17	1.2	279	90	40	23
12	11.7 ± 2.38	181.8	115	20	0.8	481	132	59	33
7	12.2 ± 1.94	120.7	90	16	1.4	306	81	36	20
6	13.0 ± 2.60	215.8	113	20	0.8	514	128	57	32
14	15.3 ± 2.25	162.1	83	15	1.6	329	69	31	17
10	18.6 ± 2.21	157.2	67	12	2.5	262	45	20	11
11	20.9 ± 2.52	203.6	68	12	2.4	302	46	21	12
9	24.2 ± 3.06	299.5	72	13	2.1	384	52	23	13
13	37.1 ± 4.91	772.4	75	13	1.9	645	56	25	14

[1] Mean based on 32 samples; SE = Standard error
[2] CV = (Std. dev./$\bar{x}$) x 100
[3] RV = (SE/$\bar{x}$) x 100
[4] $k = \bar{x}^2/(s^2 - \bar{x})$
[5] $I_D = s^2(n-1)/\bar{x}$
[6] No. of samples for SE of a certain probability (P) = $(CV/P)^2$

bution (discussed in the next section), the variance was stabilized by transforming the data as log (x + 1), where x was the observed count.

RESULTS

Mean number of spittlebug eggs obtained in the 75 cm² and 150 cm² samples are presented in Tables 1 and 2, respectively. The means indicated that a good representation of variyng levels of densities was found in this study. Values of the relative variation for the 75 cm² sample unit (Table 1) exceeded 20% in 8 of the 14 instances and in 3 instances for the 150 cm² sample unit. This indicated that with equal sample numbers, the 150 cm² unit showed better precision than the 75 cm².

Values of the index of aggregation (k) except for field 2 (Table 2) were in the neighborhood of two or less, indicating that the egg counts obtained by using either 75 cm² or 150 cm² sample unit conformed to the negative binomial distribution. Values of the index of dispersion (I_D) conformed to the Poison distribution in 3 of the 28 instances (field 1, 75 cm² sample unit, and field 2, both 75 cm² and 150 cm²). A contagious distribution of eggs was also supported by the variance mean ratios, since in all except one case (field 2, 75 cm² sample unit) the ratio was > 1.

Tables 1 and 2 also show the number of samples required for the 3 levels of precisions for the 75 cm² and 150 cm² sample units, respectively. The resulting sampling plans illustrated graphically (Fig. 1 and 2) show that the number of samples required to examine for a certain level of standard was inversally proportional especially at the lower egg densities.

The majority of fields (12 of 14) had egg densities of > 2 in case of 75 cm² sample unit, and > 4 for 150 cm² unit. Therefore, the number of samples required to be examined for various levels of precision at these densities were obtained from Fig. 1 and 2 and are presented in Table 3. The number of samples for the 225 cm² sample unit were obtained from Nilakhe et al. (1984a). The time required to obtain a sample of either size was about the same.

However, the time spent in processing the sample and examining for eggs increased proportionally as the sample size increased. To obtain a relative variation value of 20%, the total pasture area needed to examine for 75 cm² unit would be 3600 cm² (75 x 48), for 150 cm² unit 4800 cm² (150 x 32), and 8550 cm² (225 x 38) for the 225 cm² unit. Thus, these calculations showed that for the 20% level of precision, the sampling done with the use of the 75 cm² unit would reduce the time necessary in obtaining the egg counts by 50% in comparison with the 150 cm² unit, and by 138% in comparison with 225 cm² unit. Such and advantage of the 75 cm² unit would increase further for the lower relative variation values and at egg densities > 2.

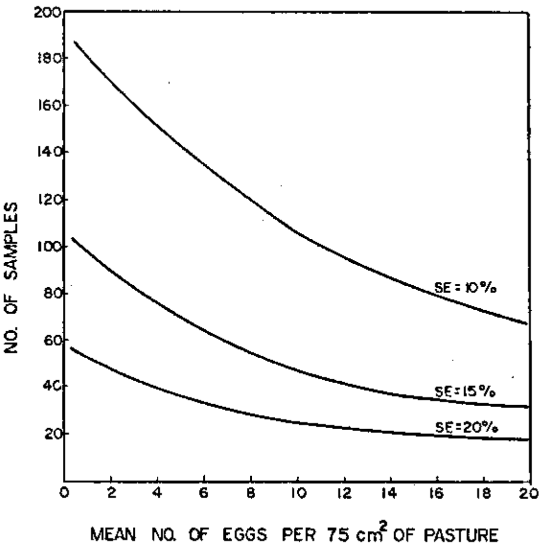

FIG. 1. Relation between population density and number of samples necessary for three levels of precision (proportion of standard error to mean expressed as a percentage) for spittlebug eggs sampled with the 75 cm² sample unit in pastures of *Brachiaria decumbens*.

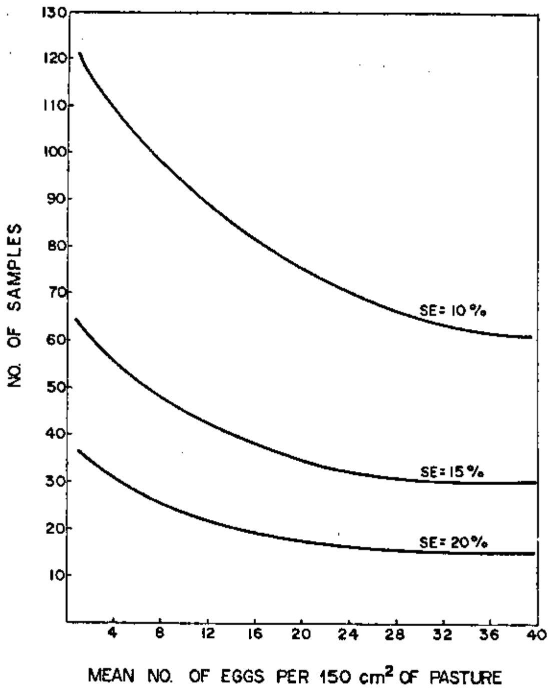

FIG. 2. Relation between population density and number of samples necessary for three levels of precision for spittlebug eggs sampled with the 150 cm² sample unit in pastures of *Brachiaria decumbens*.

TABLE 3. Number of samples required for different levels of precision for sampling of spittlebug eggs in *B. decumbens* pastures.

Sample size (cm²)	Egg density/ sample[1]	No. of samples required for SE of a certain percentage of mean[2]		
		10	15	20
75	> 2	170	82	48
150	> 4	170	90	32
225	> 6	110	64	38

[1] Majority of fields sampled had these egg densities.
[2] The no. of samples required for the sample units of 75 cm² and 150 cm² was obtained form Fig. 1 and 2, respectively. Data for the sample of 225 cm² unit was from Nilakhe et al. (1984a).

The analyses of variance showed that blocks were significant in 3 of the 14 instances for the

75 cm^2 sample unit, and in 2 instances for the 150 cm^2 unit. Differences between plots within blocks were significant in 4 cases for the 150 cm^2 unit, and in 3 cases for the 75 cm^2. Rows or columns were significant in 3 of the 28 instances for the both units.

DISCUSSION

Considering the sampling efficiency, the results showed that for sampling of spittlebugs eggs, the sample unit of 75 cm^2 of pasture was superior over the 150 cm^2 or 225 cm^2 units. For sampling of spittlebug nymphs, Nilakhe (1982) found that the smaller unit (25 cm x 25 cm) was more efficient than the larger ones (50 cm x 50 cm and 1 m x 1 m). For sampling of spittlebug adults, a sample of 10 sweeps of a sweep net was more efficient than 20 or 40 sweeps but not 5 (Nilakhe et al. 1984b). Working with soil insects, Fleming & Baker (1936), Burrage & Gyrisco (1954), and Guppy & Harcourt (1973) found that the 0,09 m^2 unit was more efficient than 0,36 m^2 or 0,81 m^2 units. Yates & Finney (1942) and Finney (1946) also found a greater sampling efficiency with smaller sampling units than the larger ones. However, for sampling of wireworms, Jones (1937) found that a sampling unit of 0,09 m^2 to be more efficient than 0,0225 m^2 and 0,0056 m^2 units. For sampling of spittlebug eggs, the next obvious question then is that whether reducing the size of the 75 cm^2 unit further will improve the sampling efficiency or not. It is probable that with smaller units, such as 25 cm^2 or 50 cm^2, the number of samples with no eggs will increase, and thus there may not be any gain in comparison with the sampling efficiency of the 75 cm^2 unit. However, such a hypothesis remains to be tested. Nevertheless, in absence of other informations, the use of the 75 cm^2 unit is suggested.

It is hoped that sample numbers 170, 82 and 48 taken with the 75 cm^2 unit would provide the precision levels of 10%, 15% and 20%, respectively. For most intensive sampling programs, relative variation of $<$ 10 is considered adequate, whereas for extensive sampling 20% to 25% may be adequate (Pedigo et al. 1972, Hillhouse & Pitre 1974, Southwood 1978, Nilakhe & Chalfant 1982).

Analyses of variance of egg counts obtained with the 75 cm^2 unit showed that variation neither between blocks nor between plots was of much importance (significant in 3 of the 14 instances). This was in contradiction with the results obtained with 225 cm^2 unit, where blocks were significant 7 times and differences between plots in 11 of the 14 cases (Nilakhe et al. 1984a). The 75 cm^2 unit was cylindrical, whereas the 225 cm^2 unit was a square. It is not known whether the shape of a sampler would influence the egg counts or not. From a practical viewpoint, unless for some specific reason, blocking within the sampling area may not be necessary, however, choosing well-distributed sampling sites may be beneficial. The sampling procedure given here may be adequate for sampling areas of about 1 ha. However, studies are needed to develop sampling procedures for the larger pastures areas.

A metal ring was used to mark the 75 cm^2 area. Later it was found that a sampler made of a piece of metal pipe driven in the ground (one end of the pipe was sharpened) was easier to work with and saved some sampling time also. The egg extraction efficiency was checked on several occasions, and was found to be always > 90%.

Values of the negative binomial parameter (k) given here could be used for calculation of a common k, which then could be used to develop sequential sampling plans. The details about the development of such plans were given elsewhere (Nilakhe 1982, Nilakhe et al. 1982).

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