GRAZING MANAGEMENT AS A MEANS OF REGULATING SPITTLEBUG (HOMOPTERA: CERCOPIDAE) NUMBERS IN CENTRAL BRAZIL[1]

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ABSTRACT - Short duration, high intensity grazing was evaluated as a method of reducing spittlebug numbers in central Brazil. Intense grazing pressure during the nymphal period resulted in a temporary reduction in nymphal density but additional hatching of eggs allowed the density to increase. Intense grazing during the last generation of adults, prior to the start of the dry season drastically reduced the nymphal population. Grazing by cattle in general provided an unsuitable habitat for spittlebug egg survival as both grass height and plant cover decreased under all grazing treatments. In heavily infested pastures (> 20 nymphs/m^2) it is recommended to graze the grass short (< 10 cm) during the last generation of adults (April-July) in order to discourage oviposition by adults laying diapause eggs and to expose eggs to detrimental conditions during the dry season. In pastures with low spittlebug density (< 20 nymphs/m^2) it is recommended to maintain the forage height at 15 cm - 20 cm during the rainy season for maximum production and efficient use of the forage resource.

Index terms: Grazing pressure, nymphal density, oviposition, spittlebug control, *Brachiaria decumbens.*

MANEJO DE PASTAGEM COMO MEIO DE REGULAR O NÚMERO DE CIGARRINHAS (HOMOPTERA: CERCOPIDAE) NO BRASIL CENTRAL

RESUMO - Avaliou-se o efeito de curtos períodos de pastejo intensivo, como método de controle das cigarrinhas-das-pastagens. Tal procedimento durante o período ninfal reduziu temporariamente a densidade populacional de ninfas. No entanto, a posterior eclosão de ovos presentes na pastagem, permitiu o recrudescimento da população. Pastejo intensivo durante a última geração de adultos antes do início da estação seca reduziu drasticamente a população de ninfas. O pastejo pelo gado, em geral, propiciou um hábitat desfavorável à sobrevivência de ovos de cigarrinhas, pois tanto a altura da gramínea como a área coberta pelas plantas diminuiu em todos os tratamentos em que houve pastejo. Nas pastagens fortemente infestadas (> 20 ninfas/m^2) recomenda-se manter a forragem baixa (< 10 cm) durante a última geração de adultos (abril-julho), a fim de desestimular os adultos a porem ovos em diapausa, expondo-os assim, a condições desfavoráveis durante a estação seca. Em pastagens com baixa densidade de cigarrinhas (< 20 ninfas/m^2), recomenda-se manter a altura da forragem em 15 cm - 20 cm durante a estação chuvosa, para produção máxima e uso eficiente da pastagem.

Termos para indexação: pisoteio de pastagem, período ninfal, eclosão de ovos, altura da gramínea.

INTRODUCTION

In central Brazil year-long grazing of monocultures of introduced grasses has resulted in dynamic population increases of spittlebugs. This group of insects have sucking mouth parts and the adults inject a toxin into the leaves which interferes with chlorophyll synthesis. Insect feeding causes leaf yellowing and a decrease in forage production. Thus, there is direct competition between spittlebugs and livestock for the available forage resource during an eight month period when these insects are active. This period of insect activity coincides with the rainy season (October to April) in central Brazil during the time of peak forage production. During this time the spittlebugs pass through 3-4 generations, so from December to June both adults and nymphs are present.

Chemical control of these insects is not cost effective and so other control methods need to be found. However, very few options are available for manipulating the rangeland environment in order to reduce insect numbers under the present grazing system. Generally, pastures are grazed year-long and the stocking rate ranges from one animal per ha on pastures seeded to *Brachiaria* spp. to one animal per 10 ha on native pasture where trees and shrubs are present. One option that is available for altering the spittlebug habitat

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is the control of the number of grazing animals. This management option is probably the most important tool available to the rangeland manager in this area of Brazil.

In the past 12 years a substantial amount of quantitative information on the use of grazing animals as a means of controlling pasture pests has been accumulated (East & Pottinger 1983). Grazing animals bring about changes in the vegetation and microclimate through the effects of defoliation, trampling, and fertilization by dung and urine (Morris 1978, East & Pottinger 1983). These changes in turn influence rain water absorption, evaporation, soil temperature, and soil erosion (King & Hutchinson 1976, Walsingham 1978). Thus, the greatest impact of grazing on insect numbers appears to be indirect through effects on the microclimate and environmental conditions imposed on the insect habitat (Martin 1983). Several studies, mostly in New Zeland and Australia, using sheep, have shown that populations of several insects species can be reduced by grazing management (King & Hutchinson 1976, Kamm & Fuxa 1977, Walsingham 1978, Penman et al. 1979, Robertson et al. 1979, Roberts 1979, East & Willoughby 1980, Hutchinson & King 1980, Holmes 1981).

Fewer studies have reported on the effects of grazing animals on Homoptera or more specifically on spittlebug populations. Walsingham (1978) found that as the stocking rate of sheep increased the number of Homoptera decreased. He reasoned this may have resulted from 1. removal of food supplies, 2. removal of surface cover, or 3. an unfavorable change in the microhabitat such as a higher degree of soil compaction. A study in the United States compared insect density in pastures moderately grazed (40% herbage removal), heavily grazed (60% herbage removal), and ungrazed (Rottman & Capinera 1983). They reported that densities of Homoptera were significantly higher in moderately grazed pastures than in heavily grazed or ungrazed pastures. They suggested the greater insect biomass in the moderately grazed pastures may have been due to the higher food resources that occurred there. In Mexico, Oomen (1975) found that populations of two spittlebug species *Aeneolamia occidentalis* (Walk.) and *Prosapia simulans* (Walk.), were reduced by grazing. Fewer nymphs were found in grazed pastures. In Brazil, Botelho et al. (1985) studied the effects of grazing on the spittlebug *Zulia entreriana* (Berg.) in pastures of Buffel-grass (*Cenchrus ciliaris* L.). They reported that grazing had little effect on nymphal densities when spittlebug populations were low (10 nymphs/m^2) but populations increased as the stocking rate increased when nymphal populations were greater than 20/m^2. They recommended a stocking rate of 1.6 animals/ha for optimum forage production and minimal damage from spittlebugs.

Dixon & Campbell (1978) suggested managing stocking rates during critical times in the life cycle of invertebrate pasture pests as a possible control measure. The present study was initiated to determine the effect of grazing on spittlebug numbers in central Brazil where the two most common species are *Zulia entreriana* (Berg.) and *Deois flavopicta* Stal. The effect of short duration high intensity grazing on spittlebug eggs and nymphs was studied in relation to certain environmental factors such as grass height, plant cover, and the amount of litter present. Short duration grazing was also compared to year-long grazing and ungrazed conditions in order to recommend a suitable grazing management plan for areas where spittlebugs are a major problem.

MATERIAL AND METHODS

Two pastures (Telez & Santa Ana) each of which had been planted to *Brachiaria decumbens* were used as study sites and were located near Dourados, MS, Brazil. Grazing treatments were initiated at the Telez site in 1984 (Treatments A, B & C) and at both sites in 1985 (Treatments D, E, F & G at the Telez site and A, B, C at the Santa Ana site) (Table 1). It should be noted that grazing during the time spittlebug eggs are in the soil and during the time nymphs are present was of short duration (2-4 days). Information from one pasture of each treatment was obtained in 1984 at the Telez site. In 1985 information was obtained from two pastures of each treatment at both sites. Data from the continuous grazing treatment was obtained from a large pasture which was being grazed year-long.

In 1984 before grazing treatments were established at Santa Ana, some preliminary data was obtained; 25 measurements of grass height, plant cover, and the amount of litter present were made once in August and once in

September. A metal frame which measured 49.5 cm x 19 cm was placed 25 times at seven meters along a 50 meter tape. Three measurements of grass height were made within the frame and averaged to obtain one estimate per sample. Plant cover within the frame was estimated by one observer to the nearest 10%. Finally the litter within the frame was collected, dried, and weighted. Twenty-five soil samples were also collected each in August and September to determine spittlebug egg density. A sample consisted of the soil and litter in a circle seven cm in diameter and to a depth of two cm. Forty (1st. generation) nymphal density counts (0.0625 m^2) were recorded once in October and five times in November. Duncans multiple range test was used to compare differences in nymphal density between treatments.

In 1984 at the Telez site, the same information was recorded except it was obtained from each of the three pastures representing the three treatments. Plant measurements were made in each pasture before the grazing treatment was initiated and after the treatment was completed.

In 1985, egg density was determined only at the Telez site. Nymphal density counts were made in each pasture at both sites in the same manner as in 1984. In addition, 20 nymphal counts were made in May in pastures at the Telez site excluding the continuous grazed pastures. The procedure for measuring vegetation was slightly modified in 1985 at both sites. A wooden stake 12 cm in diameter and 60 cm long was partially buried near the center of each pasture but extended 16 cm above the ground. A rope was attached to the stake and 12 measurements (vegetation) within the metal frame were made in a circle equal distances out from the stake. These measurements were obtained from all pastures at both sites in April, near the beginning of the dry season, and in August near the end of the dry season before spittlebug eggs began to hatch.

Egg survival was also determined in 1985 by placing diapause eggs at 12 locations (around the center stake) in each pasture except the pastures in the treatment grazed during the nymphal stage. Eggs were placed in the pastures in May and recovered in September before hatching began. The eggs were originally laid in soil filled plastic cups in the laboratory and then the soil core containing the eggs was carefully removed from the cup and placed in holes in the pastures so that the eggs were level with the pasture surface. Locations of all eggs were marked by a small wooden stake so the exact soil sample could be recovered in September. The mean number of eggs per soil sample was determined by counting the eggs laid in 22 control cups following oviposition. The percent survival and the percent hatch was determined for each of the grazing treatments. Eggs were placed on moistened filter paper in petri dishes and the hatch recorded daily.

RESULTS

Telez site - (Nymphal density)

Numphal density recorded in the different grazing treatments for both 1984 and 1985 is

TABLE 1. Grazing and sampling schedule according to treatments, year, and site.

Grazing treatment	Pasture size (ha)	Stocking rate	Grazing period	Egg density	Nymphal density	Vegetation sampling	
1984 - Telez						Before treatment	After treatment
A Grazing during egg stage	1	50 AU/ha	11-14/Sept.	4/Sept.	Sampled 8 times	4/Sept.	19/Sept.
B Grazing during nymphal stage	1	50 AU/ha	22-23/Oct.	14/Sept.	From 9/10/84	14/Sept.	31/Oct.
C Continuous grazing	unlimited	1head/1 ha - 2 ha	year - long	14/Sept.	To 1/12/84	14/Sept.	31/Oct.
1985 - Telez					May 3	Beginning of dry season	End of dry season
D No grazing	1/4	0	none	-	Oct.-Nov.-Dec.	18/April	28/Aug.
E Grazing during egg stage	1/4	200 AU/ha	27-29/April	-	May 3 Oct.-Nov.-Dec.	9/April	28/Aug.
F Grazing during nymphal stage	1/4	200 AU/ha	4-6/Dec.	-	May 3 Oct.-Nov.-Dec.	23/April	28/Aug.
G Continuous grazing	unlimited	1 AU/ha	year - long	June-July-Aug.	Oct.-Nov.-Dec.	23/April	28/Aug.
1985 - Santa Ana							
A No grazing	1/4	0	none	-	Oct.-Nov.-Dec.	18/April	29/Aug.
B Grazing during egg stage	1/4	40 AU/ha	April-May	-	Oct.-Nov.-Dec.	10/April	29/Aug.
C Continuous grazing	unlimited	5 AU/ha	April-Dec.	-	Oct.-Nov.-Dec.	24/April	29/Aug.

shown in Table 2. Density counts in 1984 were started on September 9 following the grazing treatment in pasture A (grazing pasture of spittlebug eggs). The counts on the first two dates (October 9 and 19) show that nymphal density was greater in the one pasture that had not yet been grazed (B). Total nymphal counts from October 9 and 19 show that there were 41 nymphs/m² in pasture B compared to 31 nymphs/m² in pasture A and 32 nymphs/m² in pasture C. Also density counts on October 26 following the grazing treatment (grazing pasture with nymphs) showed a decrease in nymphal density in the treated pasture. On this date, 8 nymphs/m² were recorded from pasture B compared to 20 in pasture A and 16 in pasture C. However, the average overall nymphal density during the first generation was about equal and there was no significant (P > 0,05) difference between treatments. As the rainy season progressed, additional eggs most likely hatched in all the treatments.

In 1985, immediately after pastures E were grazed near the end of April, it appeared that the grazing pressure had reduced the last generation (adults present in April and May that lay diapausing eggs) nymphal density. Therefore, on May 3 density counts were taken in pastures D, E, and F. The density in the two no grazing pastures D averaged 13 nymphs/m² compared to 14/m² in one pasture of F (which was to be grazed in December but cattle accidentally got into one pasture in F and nymphal counts were 0). No nymphs were counted in the two E pastures.

First generation (eggs began to hatch in October) nymphal density in 1985 was affected by dry conditions. Density was recorded from all treatments from November 8 until December 13, but December densities decreased in all treatments because of drought conditions. The average density from counts taken on November 8, 15, 23 and 29 showed only significant (P < 0,05) differences between treatments D, E, F and treatment G. Pastures in the F treatment were grazed in December following the decrease in density in all treatments, therefore the effects of the F treatment could not be separated from the effects of the drought conditions.

Telez site (Vegetation measurements)

Vegetational changes in 1984 before and following treatments are shown in Table 3. The grass height was generally equal in all treatments before pastures in treatments A and B were grazed.

TABLE 2. Nymphal density at the Telez study site in 1984 and 1985.

	Mean No. nymphs/m² [1]															
	1984			1985												
Date	Grazing egg stage A -	Grazing nymphal stage B -	Grazing continuous C -	Date	D - No grazing			E - Grazing egg stage			F - Grazing nymphal stage			G - Grazing continuous		
					Pasture 1	Pasture 2	x̄	Pasture 1	Pasture 2	x̄	Pasture 1	Pasture 2	x̄	Pasture 1	Pasture 2	x̄
09/10	17	22	7	03/05[2]	17	8	13	0	0	0	14	0	7	-	-	-
19/10	14	19	25													
26/10	20	8	16	18/10	< 1	0	0	1	1	1	-	-		0	0	0
03/11	8	18	18	25/10	0	3	2	0	3	2	-	-		0	0	0
10/11	16	14	26	01/11	50	59	55	16	41	29	-	-		1	0	1
17/11	7	4	3	08/11	36	71	54	14	25	20	16	35	26	2	0	1
23/11	12	8	13	15/11	48	40	44	33	39	36	34	26	30	2	1	2
01/12	9	22	10	23/11	30	32	31	35	50	43	42	19	31	3	4	4
				29/11	25	34	30	34	23	29	8	54	31	1	< 1	1
				06/12	6	11	9	6	6	6	1	1	1	0	0	0
				13/12	0	< 1	0	8	< 1	4	2	0	1	0	0	0
	x̄ ± SE 12.9 a 1.65	x̄ ± SE 14.4 a 2.46	x̄ ± SE 14.8 a 2.89				x̄ ± SE 79 a 11.38			x̄ ± SE 63 a 9.90			x̄ ± SE 59 a 2.53			x̄ ± SE 3b 1.31

[1] Means are based on 40 samples/date. Each sample = 0,0625 m², SE = Standard error; Means within a year from left to right followed by the same letter are not significantly different a (P > 0,05) - Duncans multiple range test. Density counts from 08/11 though 29/11 included in analysis.

[2] Last generation nymphal density at start of dry season. Density counts made one time.

TABLE 3. Vegetation measurements at the Telez site before and after grazing, 1984.

Type of measurement	Mean vegetation measurement[1]		
	Treatment		
	A Grazing during egg stage	B Grazing during nymphal stage	C Continuous grazing
Grass height (cm)			
Before treatment	14	13	13
After treatment	10	10	14
Plant cover (%)			
Before treatment	38	32	28
After treatment	28	24	32
Litter present (g)			
Before treatment	19	13	13
After treatment	24	22	17

[1] Means are based on 25 measurements/treatment.

Following the grazing, grass height decreased 29% in pasture A, 23% in pasture B, and increased slightly (7%) in pasture C. Also plant cover decreased 26% in pasture A, 25% in pasture B and increased 12% in pasture C. Litter increased in all treatments.

Vegetational changes in 1985 as measured at the beginning of the dry season (April) and near the end of the dry season (August) are shown in Table 4. The mean grass height decreased in all treatments between April and August. The largest decrease (80%) was in the E pastures and the lowest decrease (30%) was in the ungrazed pastures (D). Plant cover also decreased the most (86%) in the E pastures compared to 8% in the G pastures, an increase of 12% in the ungrazed pastures (D), and a 17% increase in the F pastures. The amount of litter increased in all pastures but most in the E pastures (70%). It was assumed that measurements in pastures D and F would be similar since D was ungrazed and F would not be grazed until December.

Telez site (Egg density)

Egg density in 1984 was estimated as follows: pasture A (3067 eggs/m^2), pasture B (2568 eggs/m^2), and pasture C (696 eggs/m^2). In 1985 egg density during July and August averaged 155 eggs/m^2 from pasture C; a 78% decrease from the previous September.

Santa Ana site (Nymphal density)

First generation nymphal density for 1984 and 1985 is shown in Table 5. Density was much lower at this site in 1985 mainly as a result of very dry conditions. There was no significant (P > 0,05) difference in density between the three treatments established in 1985. Density counts after November 14 were not included in Table 5 because second generation nymphs were present, however density was very low in December because of drought conditions.

Santa Ana site (Vegetation measurements)

Grazing pressure at this site was slightly higher (one animal/1 ha - 2 ha) in 1984 than in 1985 (one animal/3 ha - 4 ha). Nevertheless forage was abundant during both years. Vegetation measurements were similar (Table 6). For example average grass height in August 1984 under continuous grazing was 17 cm compared to 19 cm in 1985. Plant cover averaged 55% in August 1984 and 59% in 1985. There was no change in the amount of

TABLE 4. Vegetational measurements at the Telez study site at the beginning and end of the dry season, 1985.

Type of measurement	D No grazing Pasture 1	D Pasture 2	D X̄	E Grazing-egg stage April Pasture 1	E Pasture 2	E X̄	F Grazing-nymphal stage-December Pasture 1	F Pasture 2	F X̄	G Continuous grazing Pasture 1	G Pasture 2	G X̄
Grass height (cm)												
April	56	57	57	41	58	50	52	63	58	23	26	25
August	39	40	40	8	12	10	28	19	24	9	10	10
Plant cover (%)												
April	66	53	60	49	62	56	58	52	55	51	55	53
August	67	68	68	5	10	8	63	68	66	29	68	49
Litter present (g)												
April	11	10	11	20	12	16	15	11	13	10	9	10
August	23	15	19	36	69	53	25	26	·26	18	15	17

Mean vegetation measurements[1] by treatment.

[1] Means are based on 12 measurements per pasture.

TABLE 5. First generation nymphal density at the Santa Ana study site in 1984 and 1985.

Mean nº nymphs/m^2 [1]

1984[2] Continuous grazing Date	Pasture 1	1985 Date	A - No grazing Pasture 1	A Pasture 2	A X̄	B - Grazing-egg-stage Pasture 1	B Pasture 2	B X̄	C - Continuous grazing Pasture 1	C Pasture 2	C X̄
25/10	156	17/10	46	49	48	49	35	42	57	51	54
01/11	137	24/10	32	74	53	44	52	48	68	70	69
10/11	88	31/10	63	72	67	48	44	46	42	52	47
16/11	47	07/11	42	38	40	25	36	31	32	36	34
23/11	36	14/11	26	41	33	25	29	27	22	17	19
30/11	22										
					X̄ ± SE			X̄ ± SE			X̄ ± SE
					96.6 a			77.4 a			89.4 a
					11.64			8.41			16.89

[1] Means are based on 40 samples per date, Each sample = 0.0625 m^2; SE = Standard error; Means from left to right followed by the same letter are not significantly different (P > 0,05) - Duncan multiple range test.

[2] Grazing treatments were not established at the Santa Ana site in 1984 but some preliminary information (nymphal counts) was obtained.

TABLE 6. Vegetational measurements at the Santa Ana study site at the beginning and end of the dry season, 1985.

Type of measurement	Mean vegetation measurements[1]								
	Treatment								
	C - No grazing			B - Grazing egg stage			C - Continuous grazing		
	Pasture 1	Pasture 2	X̄	Pasture 1	Pasture 2	X̄	Pasture 1	Pasture 2	X̄
Grass height (cm)									
April	26	34	30	29	31	30	20	32	26
August	29	32	30	22	21	22	17	20	19
Plant cover (%)									
April	72	72	72	77	67	72	72	68	70
August	86	81	84	74	66	70	59	58	59
Litter present (g)									
April	21	22	22	28	19	24	14	23	19
August	•	22	22	30	33	32	21	25	23

[1] Means are based on 12 measurements per pasture.

litter in the continuously grazed pastures between years.

In 1985 there was no change in the average grass height in treatment A between April and August but the grass height decreased 27% in the other two treatments. Plant cover also decreased between April and August in both treatments where grazing was carried out (B and C) but increased 14% in the no grazing treatment (A). The average amount of litter increased by 25% in treatment B, 17% in treatment C, and there was no change in treatment A.

Early (February) in 1985 cattle were removed from the continuously grazed pastures and put back in again in April, 1985. General observations at the end of August (near the end of the dry season) showed three levels of grazing based on grass height. Grass was highest in the no grazing pastures (A), lowest in the continuously grazed pastures (C), and intermediate between A and C in the other treatment (B). In general, there appeared to be very little difference in the amount of forage between treatments.

Santa Ana site (Egg density)

In 1984 (August and September) soil sample showed that egg density averaged 3170 eggs/m^2. Following hatching in 1984, the highest nymphal density was recorded on October 25 as 156.4 nymphs/m^2. Thus egg and nymphal mortality at this site was estimated to be 95%.

Egg survival and hatch

The percent survival and hatch of spittlebug eggs which were placed in the treatments at both sites is shown in Table 7. Survival and hatch in both pastures of each treatment were averaged in order to compare differences between treatments. Survival was lowest in the continuously grazed pasture at both sites; 20% at Telez and 15% at Santa Ana. Survival was high in the no grazing treatment (55%) at Telez and the treatment grazed during the egg stage (57%) at Santa Ana. However, the information on survival at Telez is more meaningful because the differences in vegetation measurements resulting from the grazing pressure were greater at Telez.

TABLE 7. Spittlebug egg survival during dry season in different grazing treatments at two study sites (Telez and Santa Ana), 1985.

Treatment	Pasture	Telez Survival (%)	Telez Hatch (%)	Santa Ana Survival (%)	Santa Ana Hatch (%)
No grazing	1	47	28	36	42
	2	62	24	26	17
	$\bar{X}$	55	26	31	32
Grazing during egg stage	1	30	62	65	60
	2	64	76	50	62
	$\bar{X}$	47	72	57	61
Continuous grazing	1	28	42	12	20
	2	13	72	18	23
	$\bar{X}$	20	51	15	22

The average percent hatch of recovered eggs ranged from a low of 22% in the continuously grazed pastures at Santa Ana to a high of 72% in the pastures grazed during the egg stage at Telez. The mean percent hatch was low in the no grazing pastures at both sites; 26% at Telez and 32% at Santa Ana.

DISCUSSION

During 1984 and 1985 differences between grazing treatments at the Telez site were much greater than at the Santa Ana site. Following the grazing treatments involving eggs and nymphs, the vegetation was consumed and trampled to the extent that very little green forage was available for livestock consumption. Also at the Telez site the continuously grazed pastures remained fairly low throughout both years of the study. These differences between treatments were more noticeable in 1985 when precipitation was much below normal. During the first generation nymphal period in 1985 precipitation totaled 225.5 mm compared to 605.9 mm during the same period in 1984.

Effect of grazing on nymphal density

In general in all of the treatments where grazing was used at both sites first generation nymphal density declined compared to density in the ungrazed treatments. Density counts taken soon after a grazing treatment was completed showed fewer nymphs/m^2 in that particular treatment. However, this reduction in first generation density was generally temporary as additional eggs hatched as the rainy season progressed. The opposite was true regarding last generation adults. Pastures grazed just before the start of the dry season when adults and nymphs were still present showed an average density of 13 nymphs/m^2 in three ungrazed pastures compared to 0/m^2 in three pastures that had been grazed and trampled. The effect of this grazing treatment should last until diapause eggs begin to hatch at the beginning of the rainy season.

At the Telez site in November 1985 there was a large difference in nymphal density between the continuously grazed pastures and the densities in the other treatments. Some possible reasons for such a difference might be the following:

1. When the counts were taken there was considerable less forage in the continuously grazed pastures. Of the other treatments, only one had been grazed and that was in April, 1985. Females may have laid more eggs in the treatments with higher grass.

2. Egg survival is greater in pastures with higher grass.

3. The spittlebug population might have been decreasing from a cyclic peak since egg density at this location decreased 78% in the continuously grazed pastures from 1984 to 1985.

These results agree in general with the findings of other researchers. Morris (1967, 1968, 1969) reported in England higher densities of homopterans in ungrazed areas than in grazed areas. Oomen (1975) studied two species of spittlebugs in Mexico and reported he found the highest nymphal density in undisturbed pastures where there was considerable debris. In one experiment he removed high grass and debris from an area two weeks before the rains started and later found nymphal density to be $11.1/m^2$ in the treated area compared to $160.4/m^2$ in the untreated area. More homopterans were reported from moderately grazed pastures on short-grass rangeland in the United States than in heavily grazed or ungrazed pastures (Rottman & Capinera 1983). One study in Brazil showed that nymphal and adult density was about the same in pastures with different stocking rates (Botelho et al. 1985). However, they reported more damage in the pastures with high stocking rates bacause of the concentration of spittlebugs on less forage.

The effects of drought on nymphal density was also reported on by Oomen (1975). He stated that when very dry warm weather comes after a successfull hatch than severe nymphal mortality can be expected. In the present study this occurred at the Telez site in 1985. The average nymphal density in three treatments (excluding the continuously grazed pastures) on November 29 was $30/m^2$ and on December 6, $5/m^2$; an 83% reduction. Nymphal density continued to remain low throughout December until enough precipitation occurred to initiate more hatching.

Effect of grazing on vegetation

In general, grazing resulted in a reduction in grass height, plant cover, and an increase in litter. At the Santa Ana site grass height was not reduced as much as at the Telez site. Even after grazing at Santa Ana the grass was 19 cm - 22 cm high. At Telez it was 10 cm - 14 cm high in 1984 and 10 cm - 24 cm high in 1985. However the grass at the Telez site (excluding the continuously grazed pastures) was higher before the grazing treatments im 1985 so the reduction from grazing was greater. The short duration, high intensity grazing at the Telez site resulted in temporary destruction of the forage resource in 1985. This degree of forage destruction was not justified in terms of the insect control received. However, pasture recovery was rapid once the rainy season began. Barker et al. (1981) stated that over and under grazing which weakens the grass stand should be avoided. Ramiro et al. (1984) reported that short pastures of *B. decumbens* that had been intensively grazed resulted in a decrease of nymphal density but also a reduction in available forage due to feeding by spittlebugs. Therefore it appears that pastures of *B. decumbens* should be maintained at an optimum height for maximum beef production (probably 15 cm - 20 cm) in central Brazil. High forage (> 30 cm) and low forage (< 10 cm) does not provide the best utilization of the forage resource. Botelho et al. (1985) suggested that pastures of buffel-grass (*Cenchrus ciliaris* L.) stocked with 1.6 animals/ha will provide good yield, persistance and minimal losses by spittlebugs.

Effects of grazing on egg density and survival

In September 1984 egg density at the Telez site in the continuously grazed pasture was much lower than in the other two treatments. Since the entire study area was not fenced into treatments in June 1984, at the end of the oviposition period, it is assumed that eggs were equally distributed throughout the area at that time. Treatments A and B were enclosed by a fence in early July. It is believed that conditions within the fenced area (taller grass, more shade, higher % plant cover, no grazing etc.) increased egg survival during the time period from July to September. Oomen (1975) studied spittlebugs on rangeland in Mexico and reported that diapausing eggs during the dry season have the best chance of survival if they are protected by a layer of debris. He felt high temperature during the dry season could reduce egg survival and thus affect the size of the first generation.

Hewitt (unpublished) also found that grazing and trampling by livestock during the time the eggs are in the ground is not favorable for survival. He found egg survival was greater in pastures with the following characteristics: (1) grass height > 30 cm, (2) a well defined litter layer, (3) plant cover > 50% and (4) minimal or no grazing. Hewitt also (unpublished) documented the predation of both eggs and small nymphs by ants. Ants apparently prefer open areas with sparse vegetation. The shading effect of high or rank vegetation may limit ant distribution (Doncaster 1981). Hutchinson & King (1980) reported that at a stocking rate of 30 sheep/ha ants were the only large invertebrate group that did not decrease. Thus, it appears that ants which can maintain their numbers under heavy grazing may be an important predador of eggs and nymphs in pastures that are intensively grazed.

In this study fewer eggs were recovered in the continuously grazed pastures at both sites. Cattle grazed these pastures more or less continuously during the time of the study and the grass height was always shorter compared to pastures in the other treatments. Egg recovery from the short duration, intensively grazed treatment at Telez was 47% at the end of the dry season. Fifty five percent of the eggs were recovered in the pastures with no grazing. The percent of eggs hatching from the various treatments was variable; apparently factors other than grazing pressure cause differences in egg viability.

CONCLUSIONS

1. Short duration - high intensity grazing by cattle may temporarily reduce the density of first generation nymphs. However, when grazing pressure is removed spittlebug eggs continue to hatch and nymphal density increases.

2. Short duration - high intensity grazing near the end of the rainy season when the last nymphal generation is developing can drastically reduce nymphal populations which are not replaced.

3. Generally grazing by cattle:
   a. decreased grass height
   b. decreased plant cover
   c. increased litter
   d. decreased the first generation nymphal density

4. Ungrazed pastures supported a higher first generation nymphal density and seemed to be favored for oviposition by adult females than grazed pastures.

5. Extremely dry conditions that follow a period of spittlebug egg hatching can cause a high nymphal mortality.

6. Egg and nymphal mortality can be greater than 90% during the hatching period (based on comparing egg density before hatching with resulting nymphal density).

7. Diapause egg survival during the dry season is greater in pastures undisturbed by grazing.

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