ENVIRONMENTAL FACTORS AFFECTING SPITTLEBUG EGG SURVIVAL DURING THE DRY SEASON IN CENTRAL BRAZIL[1]

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ABSTRACT - Spittlebug egg survival and hatching was compared in pastures where differences occurred in vegetative characteristics and grazing intensity. Egg samples were placed in pastures at the start of the dry season and recovered before hatching began. Significantly ($P < 0.05$) more eggs were recovered from areas where litter was present than from bare soil areas. Mortality from predators and scavengers was estimated at 73%. An additional 34% of the eggs were desiccated and 35% were nonviable. Egg survival was estimated to be 8.5% and was greater in pastures with the following characteristics: 1) canopy height > 30 cm; 2) abundant litter; 3) plant cover > 50%; 4) minimal or no grazing. More predators, especially spiders (Araneida) were also collected from these types of pastures. At one site more eggs hatched in a high grass pasture (74%) than in a low grass pasture (59%). Although high grass may receive less damage from spittlebug feeding the disadvantages of maintaining grass > 30 cm appear to outweigh the advantages.

Index terms: spider, *Araneida, Zulia entreriana, Deois flavopicta, Brachiaria decumbens.*

FATORES AMBIENTAIS QUE AFETAM A SOBREVIVÊNCIA DE OVOS DAS CIGARRINHAS-DAS-PASTAGENS DURANTE A ESTAÇÃO SECA, NO BRASIL CENTRAL

RESUMO - Foram comparadas a sobrevivência de ovos das cigarrinhas-das-pastagens e a eclosão de ninfas em pastagens com diferentes características vegetativas e intensidades de pastejo. Amostras de ovos foram colocadas no interior de pastagens, no início da estação seca, e recuperadas antes de se iniciarem as eclosões. O número de ovos recuperados nas áreas que apresentavam palha em decomposição foi significativamente maior ($P < 0,05$) do que nas áreas descobertas. O índice de mortalidade por predadores foi estimado em 73%. Dos ovos recuperados, 34% estiveram ressecados e 35% inviáveis. A sobrevivência de ovos foi estimada como sendo de 8,5% e foi maior nas pastagens com as seguintes características: 1) altura do capim > 30 cm; 2) abundância de palha em decomposição; 3) área coberta pela forrageira > 50%; e 4) pastejo mínimo ou ausente. Mais predadores, particularmente aranhas (*Araneida*), também foram coletados neste tipo de pastagem. Em um dos locais houve maior percentual de eclosões (74%) nos ovos mantidos no pasto alto, em comparação ao pasto baixo (59%). Embora o pasto alto seja menos danificado por cigarrinhas, as desvantagens de mantê-lo com altura superior a 30 cm parecem sobrepujar as eventuais vantagens.

Termos para indexação: aranha, *Araneida, Zulia entreriana, Deois flavopicta, Brachiaria decumbens.*

INTRODUCTION

Two spittlebug species, *Zulia entreriana* (Berg) and *Deois flavopicta* (Stal) cause extensive damage to *Brachiaria decumbens* Stapf. pastures in Central Brazil. The dry season in this area of Brazil usually extends from April to September. During this time precipitation averages about 50 mm/month. Diapause spittlebug eggs which are in the soil and litter usually begin to hatch near the end of September as rain showers become more frequent. However, during the dry season several environmental factors may influence egg survival and subsequent hatching.

It has been stated that imported forages such as *B. decumbens* can better withstand adult spittlebug damage when maintained at a moderate height (15 cm- 30 cm) as compared to a low height (< 15 cm) (Martin 1983, Ramiro et al. 1984). However, little is known about the influence of habitat factors found in pastures maintained at different plant heights on spittlebug egg survival and hatching. Such information should be most beneficial in planning spittlebug control strategies. Thus, this study compares egg survival and hatching in *B. decumbens* pastures where differences occur in grass height, plant cover, amount of litter, potential invertebrate predators, and grazing intensity.

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MATERIAL AND METHODS

Two study sites were selected; one site was located near Campo Grande, MS and one near Dourados, MS, Brazil. Each site contained two pastures (*B. decumbens*), one with high grass (> 30 cm) and one with low grass (< 20 cm). Environmental measurements and sampling was carried out from May to September at both sites. Eggs and adults of *Zulia entreriana* were used in the study.

Experiment 1 - Campo Grande, MS

The grass in one pasture averaged > 30 cm in height in May (high grass pasture) and < 20 cm in the other pasture (low grass pasture). The pastures were separated by an unimproved road. Each pasture contained six heifers during the time of the study. Since the pastures were different sizes the stocking rate was 1.05 AUM's in the high grass pasture and 1.75 AUM's in the low grass pasture.

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. The stakes were used as permanent reference points for measuring environmental factors and for locating spittlebug eggs that were placed in the pastures. A rope was attached to the stake and measurements were made in a circle equal distances out from the stake. For example, twelve measurements of grass height, plant cover, and the amount of litter in a 50 cm^2 area were made in May and September in both pastures. Each measurement of grass height was an average at three heights and plant cover (%) was estimated. Spittlebug eggs were placed in the pastures in May and recovered in September. Three methods of placing eggs in the pastures area described as follows: (1) females were allowed to lay eggs in soil-filled plastic cups in the laboratory. The soil core containing the eggs was then carefully removed from the cup and placed in a hole (so the eggs were at ground level) at marked locations in each pasture; (2) a known number of eggs were placed in small (8 cm x x 4 cm) nylon sacks and these in turn were placed in the pastures; (3) females were caged in each pasture and allowed to oviposit directly into the pasture soil or litter.

A total of 24 soil samples containing eggs laid in the laboratory were placed in each pasture. Litter was placed over 12 samples to a depth of 0.5 cm. The other 12 samples were placed in the ground and left exposed. The mean number of eggs per soil sample was determined by counting the eggs in 12 control cups following oviposition.

The nylon sacks each contained 20 diapause eggs. Sixteen sacks were placed in each pasture; eight were closed to protect the eggs from predators and eight were kept open at one end by extending two small sticks through the opening. Four of the open sacks were covered with litter and four were covered with soil to a depth of 0.5 cm. The same was true for the eight closed sacks.

Twenty females were placed in each cage and allowed to lay eggs for a period of three days after which time the cages were removed. In each pasture four cages were placed over soil and four over litter. The mean number of eggs deposited in each pasture in soil and litter was determined by counting the eggs laid in eight additional control cages following oviposition.

Locations of all eggs placed or laid in the pastures were marked by a small stake so the exact soil sample could be recovered in September. The percent hatch was determined from all eggs recovered in September except for the eggs recovered from the small open sacks. Eggs were placed on moistened filter paper in petri dishes and the hatch recorded daily. Monthly precipitation was recorded during the dry season. Twenty-first generation nymphal counts (0.0625 m^2) were made one time in each pasture on October 11. Sweep net samples of miscellaneous insects were collected from each pasture seven times from July 19 to November 1. Five samples were obtained on each date. A sample consisted of 15 (180°) sweeps with a 45 cm diameter sweep net.

Experiment 2 - Dourados, MS

The vegetation in both pastures at this site was equal in terms of grass height, plant cover, and amount of litter present when the natural spittlebug population of the pastures were ovipositing in March and April. Before this experiment was initiated the grass in one pasture (low grass pasture) was trampled and grazed to the extent that very little upright vegetation was present. The mean height of the grass in the other pasture (high grass pasture) was > 50 cm. The grass height and plant cover (%) were measured at twelve locations in each pasture in May and August. Forty-first generation nymphal counts (0.0625 m^2) were made weekly beginning in November in each pasture. No cattle were in either pasture during the test.

Ten cages in each pasture were each infested with ten females in May and eggs were laid directly into the soil. After three days the cages were removed and their locations marked with small stakes. Ten additional cages were also infested and after three days the eggs were counted to give a mean number of eggs per cage. In August the eggs remaining beneath the other 20 cages were recovered and the percent survival determined.

RESULTS

Experiment 1

The mean number of eggs recovered from both pastures following oviposition and at the end of the dry season is shown in Table 1. The percentage of eggs hatching in all treatments is shown in Table 2.

Soil containing eggs that were placed in pastures - Significantly ($P < 0.05$) more eggs were recovered following oviposition than those recovered from the field four months later. Egg reduction was 90% or greater in both pastures in both the litter and soil treatments using this method of egg placement. Of the eggs remaining in the ground in both pastures for the four-month period significantly ($P < 0.05$) more eggs which were covered with litter were recovered in the low grass pasture than in other treatments.

Eggs laid directly into pastures - In the high grass pasture more eggs were recovered following oviposition than after four months but the differences were not significant ($P > 0.05$). In the low grass pasture significantly ($P < 0.05$) more eggs were recovered following oviposition in the litter treatment than in the other treatments. Also, significantly ($P < 0.05$) more eggs were recovered after four months in the litter than those laid in the soil. The egg reduction averaged 58% after four months in both pastures using this method of egg placement. The egg reduction after four months in both pastures was greater in the treatments where eggs were laid directly into the soil than those laid into litter over soil.

Small sacks of eggs placed in pastures - The overall egg reduction using this method averaged 73%. Five open sacks could not be found after four months so survival in soil or litter or between pastures could not be determined.

In the high grass pasture the canopy height in May averaged 34 cm and in September 23 cm. The plant cover was 65% in May and 61% in September. The litter decreased from an average of 64 g per quadrat in May to 55 g in September.

In the low grass pasture the canopy height in May averaged 16 cm and 9 cm in September. The plant cover decreased from 57% in May to 43% in September. The average amount of litter was 12 g per quadrat in May and 15 g in September.

Precipitation (mm) before and during the test was as follows: April (69.2), May (56.7) June (11.7), July (80.4), August (21.7), and September (33.0). Throughout the dry season a moderate to heavy rain shower (> 20 mm) occurred every 3-4 weeks. During the last week in September some precipitation (6.0 mm) resulted in a partial egg hatch but the majority of eggs began to hatch following 43.1 mm of precipitation during the period of October 8-11. At this time nymphal density in the high grass pasture was $14/m^2$ and $8/m^2$ in the low grass pasture.

Collections of general insects from the Campo Grande pastures which may include potential predators of spittlebugs are shown in Table 3. Many more spiders (Araneida) were collected in the tall grass pasture than in the low grass pasture. It is possible that some of the spiders and mantids might prey on either spittlebug nymphs or adults. The short grass pasture provided a favorable habitat for grasshoppers (Acrididae) and their presence is significant since they along with spittlebugs compete with livestock for the available forage.

Experiment 2

There were no significant differences ($P > 0.05$) in the mean number of eggs recovered following oviposition (2.9 ± S.E of 1.01) and those recovered later in the high grass pasture (3.3 ± 1.37) and the low grass pasture (0.3 ± 0.21). First generation nymphal density on Nov. 1 in the high grass pasture was $55/m^2$ and $16/m^2$ in the low grass pasture.

In May, canopy height in the high grass pasture averaged 52 cm, and near the end of August 28 cm. The plant cover was 58% in May and 63% in August. The grass height in May in the low grass pasture averaged 58 cm (before grazing) and 12 cm in August. The plant cover decreased from 62% in May to 10% in August as a result of heavy grazing and trampling prior to the start of the study.

DISCUSSION

Based on the results of these two experiments it is apparent that usually there is a large reduction in spittlebug egg numbers from the time of oviposition in March or April to the time of hatching in September and/or October. The one exception in this study occurred in the ungrazed pasture at Dourados, where grass height and plant cover remained high during the dry season. At this site 33 eggs were recovered in August from the high grass pasture compared to 3 in the low grass pasture. A total of 29 eggs were recovered following oviposition in May, indicating no egg reduction in the high grass pasture.

TABLE 1. Survival of diapause eggs during the dry season in two pastures near Campo Grande, MS, Brazil, 1985.

Soil samples containing eggs placed in pastures			Eggs laid directly into pastures	
Treatment		Mean number of eggs recovered $\bar{x} \pm$ S.E.	Treatment	Mean number of eggs recovered[1] $\bar{x} \pm$ S.E.
A. Eggs recovered from all treatments			A. High grass pasture	
including control			1. Control in litter - following oviposition	3.5a ± 1.94
1. Control - following oviposition		71.6a ± 4.30	2. Control in soil - following oviposition	3.3a ± 1.49
2. Low grass pasture - in litter		7.5b ± 1.35	3. In litter - after 4 months	2.0a ± 2.00
3. High grass pasture - in litter	After	3.9b ± 1.26	4. In soil - after 4 months	0.8a ± 0.75
4. High grass pasture - in soil	4	3.8b ± 1.44		
5. Low grass pasture - in soil	months	1.8b ± 0.76	B. Low grass pasture	
B. Eggs recovered from treatments left			1. Control in litter - following oviposition	22.3a ± 3.20
in ground 4 months			2. In litter - after 4 months	12.8b ± 4.66
1. Low grass pasture - in litter		7.5a ± 1.35	3. Control in soil - following oviposition	7.5bc ± 1.04
2. High grass pasture - in litter		3.9b ± 1.26	4. In soil - after 4 months	0c ± 0
3. High grass pasture - in soil		3.8b ± 1.44		
4. Low grass pasture - in soil		1.8b ± 0.76		

[1] Means within a column followed by the same letter are not significantly different ($P > 0.05$), Duncans Multiple Range test), S.E. = Standard Error.

TABLE 2. The percentage of eggs hatching after remaining in the pastures during the dry season, Campo Grande, MS, Brazil, 1985.

Type of egg placement	Treatment	Hatch/ litter or soil	Hatch/ pasture	Hatch/ placement litter	Hatch/ placement soil	Hatch in both pastures/ placement
A. Eggs laid in laboratory & placed in pastures	High pasture:					
	Eggs in litter	77	84			
	Eggs in soil	91		69	73	71
	Low pasture:					
	Eggs in litter	66	60			
	Eggs in soil	36				
B. Small closed sacks containing a known number of eggs placed in pastures	High pasture:					
	Eggs in litter	74	65			
	Eggs in soil	56		72	58	65
	Low pasture:					
	Eggs in litter	69	65			
	Eggs in soil	59				
C. Adults caged in pastures and eggs laid directly into field	High pasture:					
	Eggs in litter	38	55			
	Eggs in soil	100		49	–	52
	Low pasture:					
	Eggs in litter	51	51			
	Eggs in soil	–				
	All treatments combined					
	High grass = 74%, soil = 66%					
	Low grass = 59%, litter - 66%					

First generation nymphal counts on Nov. 1 also showed that more nymphs were present in the high grass pasture (55/m^2) than in the low grass pasture (16/m^2) at the Dourados site. Since both pastures were nearly equal in terms of vegetative characteristics when the eggs were being laid by the natural spittlebug population, then first generation nymphal counts should be a good indicator of egg survival between the two pastures. Thus, egg reduction would be 71% based on nymphal counts.

Also in the Campo Grande pastures more nymphs were counted in the high grass pasture (14/m^2) than in the low grass pasture (8/m^2). However, these pastures were not equal in terms of vegetative characteristics when the adults were laying diapause eggs, and so more eggs could have been laid in the high grass pasture. Therefore, these nymphal counts do not necessarily reveal egg survival between high and low grass pastures but may indicate a preference for ovipositing in high grass pastures. Lower nymphal counts in the low grass pasture may also be due to greater grazing pressure.

Thus, it appears that grazing and the trampling effect of livestock during the time the eggs are in the ground is unfavorable to egg survival. Also at the Campo Grande site more eggs that were laid in litter or were covered with litter were recovered in September than eggs that were laid in soil. Pastures with a well-defined litter layer and minimum grazing pressure should be most favorable for egg survival.

At the Campo Grande site when all the treatments were combined the percentage of eggs hatching was the same (66%) for those recovered from the soil and those recovered from the litter. However, the hatch was higher in the tall grass pasture (74%) than in the low grass pasture (59%) (Table 2).

If spittlebug control is a major consideration then short grass pastures with fairly heavy grazing pressure should decrease egg survival and thereby reduce the overall spittlebug population. However, in central Brazil most pastures are grazed so that forage height is maintained between 15 cm - 20 cm. This height seems to provide maximum forage production and quality resulting in optimum beef gains. Therefore, the disadvantages of maintaining grass > 30 cm appear to outweigh the advantages. Likewise, grass height maintained below 10 cm will not provide the best utilization of the forage resource. Wiegert (1964) pointed out that the availability of food for spittlebugs is related to the rate of plant production and not necessarily to the standing crop. This could explain why tall grass (not high production forage) receives less feeding damage than shorter faster growing forage (Martin 1983, Ramiro et al. 1984).

TABLE 3. Some invertebrates collected from "LOW" and "HIGH" grass pastures from July to November. Campo Grande, MS, Brazil, 1985.

Date collected	Number of invertebrates collected				
	Family or order				
	Acrididae	Araneida	Chrysopidae	Mantidae	Totals
			Low grass pasture		
19/07	32	18			50
02/08	15	15	2		32
16/08	16	9			25
10/09	35	3			38
02/10	36	7			43
10/10	30	3			33
01/11	35	3			38
Totals	199	58	2		259
			High grass pasture		
19/07	4	23	1		28
02/08	10	48	2	2	62
16/08	1	34		3	38
10/09	8	11			19
02/10	16	14		1	31
10/10	13	38		1	52
01/11	6	5			11
Totals	58	173	3	7	241

A major part of this study was an attempt to determine the number of spittlebug eggs surviving the dry season and the degree of hatch. In another study (unpublished) the author determined that there was a 66% reduction in egg numbers during the rainy season in central Brazil. In the present study three methods were used to place eggs in pastures and evaluate egg survival. The average percent egg reduction per method was as follows: small sacks containing a known number of eggs (73%), egg laid directly into the pasture by caged females (58%), and eggs laid in cups in the laboratory and placed in the pasture (94%). The method using small sacks of eggs was thought to be the most reliable since known numbers of eggs were placed in the pastures. This method is used to estimate egg survival till hatching began, as follows:

Disregarding the location of the sacks in pastures (under litter or soil), a total of 16 closed sacks and 16 open sacks were placed in pastures at the Campo Grande site. Each sack contained 20 diapause eggs. After four months only 15 closed sacks could be found and thus the total eggs recovered should have been 300. However, 65 eggs were missing from the closed sacks, or 4.3 eggs per sack. Only 11 open sacks were found which originally contained 220 eggs. Using correction factor of 4.3 eggs missing per sack 173 eggs (4.3 x 11 = 47; 220 - 47 = 173) should have been foud in the open sacks, assuming that no predation occurred. Actually, a total of 46 eggs were found in the open sacks, thus 73% egg mortality could be ascribed to predators, scavengers, etc. This is in close agreement with the 71% egg mortality determined for the low grass pasture at Dourados based on nymphal counts between the two pastures. Of the 235 eggs (300-65) recovered from the closed sacks, 81 (34%) were desiccated. Of the remaining 154 placed to hatch, 54 (35%) failed to hatch and were labeled nonviable.

With this information it is possible to estimate egg survival. Assume that 235 eggs are in a pasture at the beginning of the dry season. After four months, 73% of the eggs are lost to predators and scavengers, so 53 are left to hatch. However, 69% of the 63 eggs will not hatch (34% desiccated + 35% nonviable). Thus only 20 of the original 235 eggs or 8.5% survived the dry season. It would be possible to estimate first generation nymphal densities if egg densities are known.

CONCLUSIONS

Generally there is a large reduction in diapause egg numbers between the time of oviposition and the time of hatch. The survival rate was estimated at 8.5%. Spittlebug eggs seem to have a higher survival rate and hatching success in pastures with the following characteristics: (1) grass height >30 cm; (2) abundant litter; (3) plant cover > 50%; (4) minimal or no grazing. First generation nymphal counts at the start of the rainy season also showed that nymphal density was higher in pastures with the above characteristics. This indicates that high grazing pressure resulting in a low canopy cover will be unfavorable for spittlebug egg survival. However, pastures with a grass height of 15 cm - 20 cm appear to produce high quality forage necessary for optimum beef production. Therefore, it may not be economically advantageous to maintain grass plants below 15 cm while at the same time plants over 30 cm high increase spittlebug egg survival.

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