ENVIRONMENTAL FACTORS AFFECTING THE SURVIVAL OF EGGS AND EARLY INSTAR NYMPHS OF SPITTLEBUGS *Zulia entreriana* (BERG) AND *Deois flavopicta* STAL DURING THE RAINY SEASON IN CENTRAL BRAZIL

George B. Hewitt[1]   Shashank S. Nilakhe[1]

RESUMO

Fatores ambientais que afetam a sobrevivência de ovos e ninfas recém eclodidas das cigarrinhas-das-pastagens *Zulia entreriana* (Berg) e *Deois flavopicta* Stal, durante a estação chuvosa, no Brasil Central

Observações e testes de campo foram empregados para documentar a predação de ovos e ninfas das cigarrinhas-das-pastagens, por cinco espécies de formigas: *Solenopsis* sp. (1 e 2), *Pheidole* sp., *Canomyrma* sp. e, *Cyphamurmex rinosus*. Essas cinco espécies de formigas carregaram 47 ovos e 15 ninfas durante um período de nove horas de observação, em dois locais. A mortalidade de ninfas em função de predadores, distúrbios do solo, doenças e fatores abióticos foi de 61% em um dos locais estudados. A incidência direta da chuva ocasionou o deslocamento de ovos, tendo sido recuperados menos de 35% dos mesmos, após ficarem expostos à chuva. Neste estudo, a predação efetuada pelas formigas sobre ovos e ninfas recém eclodidas foi o que teve maior efeito sobre o número de cigarrinhas.

INTRODUCTION

In Central Brazil two spittlebug species *Zulia entreriana* (Berg) and *Deois flavopicta* Stal are abundant and cause extensive damage to introduced grasses, mainly *Brachiaria decumbes* Stapf. The monocultures of these grasses cover exten-

sive areas and are vital to the beef cattle industry because
they grow well on the relatively infertile soil of the area.
These insects feed on the leaves and stems causing leaf yellow
ing and a reduction in forage quality and growth.

Diapause spittlebug eggs after having passed through the
dry season (June-September) hatch at the beginning of the rai
ny season (usually near the end of September). Upon hatching,
first instar nymphs search out and find stems or grass runners
on which to feed. Spittle is produced within a few   minutes
after the initiation of feeding. In this area of Brazil   D.
flavopicta usually has three generations a year and *Z. entre-
riana* may have 3-5 but usually has four (VALÉRIO & OLIVEIRA,
1982). The first adults usually appear in November and   the
generations overlap. Eggs are laid from November to May   and
hatching occurs after 14-18 days except the last   generation
of adults lays diapausing eggs during March, April, and   May
(KOLLER & VALÉRIO, 1985).

Only in recent years has research been initiated in   or-
der to determine what factors have the greatest influence on
survival of spittlebugs in Brazil. It is believed that   there
are at least two times in the life cycle of spittlebugs   when
mortality factors greatly influence population density;   du-
ring the egg stage and at the time of hatching before   nymphs
become established on plants and form spittle. In fact WIEGERT
(1964) studying the meadow spittlebug *Philaenus spumarius* L.
stated that estimates of adult mortality were small   compared
to mortality during all other stages. The present   research
approach is based on this assumption.

In general grazing is year-long in this area of   Brazil
and the low value forage resource does not allow for chemical
control of spittlebugs to be cost effective. Thus, other means
of supressing these insects must be found. One long-term goal
is to manipulate the grazing environment and cause micro-habi
tat changes which will be unfavorable for the growth and de-
velopment of spittlebugs. Before this can be   accomplished,
additional information is needed on the role of predators and
environmental factors in regulating spittlebug populations.

For example, ants destroyed nearly all 1st. instar nymphs
in one study where nymphs were used to screen   grasses   for
spittlebug resistance. This paper reports on studies   invol-
ving the survival of eggs and nymphs during the rainy   season
in Central Brazil with emphasis on the role of ants as   pre-
dators. According to WIEGERT (1964) both weather and   preda-
tion are probably the most important regulating factors   du-
ring the life cycle of spittlebugs.

MATERIALS AND METHODS

Studies on ant predation of eggs and nymphs

Experiment 1: Observations were recorded on ant preda-
tion in two separate studies:

(A) This study was originally designed to screen grases   for
spittlebug resistance using newly-hatched spittlebug nym-
phs. The following three grasses were grown in   separate
pastures; *B. decumbens*, *B. brizantha* cv. Marandu,   and
Panicum maximum cv. Tobiatã and were infested with   newly
hatched (< 1 day old) nymphs of *Z. entreriana*.   In each
pasture 5, one m² areas, were infested with 50 nymphs/m².
The nymphs were placed on the soil in close proximity   to
grass stems and/or directly on the stems. The   infested
areas were enclosed in 1 m² saran covered cages.   Nymphal
counts were made the day following infestion. The   cages
were infested twice during one week and after the   second
infestation observations were made on ant predation.

(B) Observations on ant predation were also recorded from four
pastures, Santa Ana and Sebastião near Dourados—MS   and
California and CNPGC near Campo Grande-MS. At each of the
Campo Grande sites two potted plants (*B. decumbens*)   each
of which was infested with three first instar nymphs, we-
re placed in the ground so the base of the plant was   le-
vel with the ground surface. Twenty spittlebug eggs   were
placed on the soil surface on each side of the plants. On
ly eggs were observed in the fields near Dourados.   Both
eggs and nymphs were observed for a total of three   hours
at each of the sites near Campo Grande and eggs were   ob-
served for a total of 1.5 hours at each of the sites near
Dourados. Observations were carried out in 1.5 hour   time
periods at the Campo Grande sites and plants were reinfes-
ted with nymphs after the first 1.5 hour period. All ants
which were observed carrying away nymphs or eggs   were
collected and later identified.

Experiment 2: Mirex bait (.1% a.i.) was applied to ran-
geland near Dourados where both spittlebugs and ants were nu-
merous. Three of six pastures each 1/10 ha in size were trea-
ted with Mirex bait at the rate of 10 g/m² once in   November
and once in January. The untreated pastures served as checks.
Twenty egg samples were collected from each of the six pastu-
res on March 20 which was near the end of the oviposition pe-
riod. A sample consisted of a circular soil core and   little
7 mm in diameter and one cm deep. All samples were   collected
near *B. decumbens* plants. Eggs were separated from the   soil
and litter particles using the method described by   NILAKHE
et al. (1984).

Studies on spittlebug eggs

Eggs used in these experiments were laid either in circu
lar pans (30 cm in diameter 3.5 cm deep) in the laboratory or
directly into pasture soils. In the laboratory eggs were   ob-
tained by placing 20 females in cages set over   soil-filled
pans. Food was placed in the cages allowing the females to li
ve and oviposit during a three-day period. In some tests ste-
rilized litter was compacted on the soil surface. Pans contai
ning eggs were placed in pastures (B. *decumbens*) at the   soil
level. In others botton-less cages (7 cm in diameter) were in
fested with 20 females per cage and eggs could then be deposi
ted directly into the soil. Eggs were counted before and after
exposure in all tests. In these tests it was assumed that the
average number of eggs counted at the conclusion of   oviposi-
tion which   acted   as   control   was   the same as the   number
exposed in the treatments.

Experiment 3:   Four pans of Z. *entreriana* eggs were pla-
ced in the pasture under a coverting which was 15 cm above the
ground. In addition eggs from 4 pans were counted and used as
control eggs at the end of the 3-day ovipositional period. The
eggs placed in the pasture were counted after the 10 day expo
sure period.

Experiment 4:   Eggs were laid by Z. *entreriana* into   12
pans. Eight pans were placed in a pasture, four under a cove-
ring 15 cm above the ground and four on a level surface   com-
pletely exposed. Eggs in four pans were counted at the end of
the ovipositional period. Pans from the pasture were   brought
to the laboratory after 14 days and the eggs counted.

Experiment 5:   Twelve pans contained eggs of D. *flavopic*
ta. Four were placed in a pasture under a covering 15 cm abo-
ve the ground, four on a level surface completely exposed, and
eggs in four pans were counted at the end of the   ovipos(tio-
nal period. The eight pans from the pasture were brought   to
the laboratory after 14 days and the eggs counted.

Experiment 6:   Twelve bottomless cages were infested with
Z. *entreriana* females. Eight cages were placed over bare soil
and four cages were placed over litter. After oviposition was
completed all the cages were removed from the pasture.   At
that time the soil 1 cm deep was removed from beneath four of
the cages over soil and the eggs were counted. The   location
of the other eight cages was marked and after 10 days the eggs
were counted.

Experiment 7: Eggs were laid by *Z. entreriana* into 12 pans. Six pans were placed in a pasture completely exposed and six were kept in a screen house protected from predators. After four days the eggs were counted in all 12 pans.

Experiment 8: Twelve bottomless cages were infested with *Z. entreriana* females (A). All cages were placed over soil near grass plants. After oviposition was completed all the cages were removed from the pasture. At that time the soil 1 cm deep was removed from beneath four of the cages and the eggs were counted. The location of the other eight cages were marked and a covering 15 cm above ground was placed over four locations and four locations were left completely exposed. After 12 days the eggs were counted in the 12 locations.

This experiment was repeated using 15 cages (B) but was also slightly modified. After oviposition, the soil one cm deep was removed from beneath five of the cages, five cages were covered with a glass cover, and the location of five cages was marked after the cages were removed. After 12 days the eggs were counted in the remaining 10 locations.

Experiment 9: Eggs were laid by *Z. entreriana* in 24 soil filled clay pots that measured 17 cm across the top and 12 cm deep. After oviposition was completed the pots were placed into four treatments as follows: A - pots were left outdoors, exposed to direct sunlight and received natural precipitation. B - Same as A except these pots received 100 ml more of water once a day, on Monday, Wednesday, and Friday. C - - Pots placed under a roof with no direct sunlight or natural precipitation but 100 ml of water was applied once a day on Monday, Wednesday, and Friday. D - Same as C except 100 ml of water was applied twice a day and everyday except Saturday and Sunday. All pots were protected from surface predators such as ants by a water barrier. Temperatures at the soil surface in each treatment were taken at 0800 hrs. and 1300 hrs. Monday through Friday. The number of hours of direct sunlight was estimated each day for treatments A and B. After eight days the eggs in each pot were counted and the percent hatch determined.

Studies on spittlebug nymphs

Circular pans, as used in the studies with eggs, were filled with moist soil and seeds of *B. decumbens* were planted in a circle around the outside edge of the pans. When the seedling plants were about 2 cm tall, cages in the center of the pans were infested with 20 *Z. entreriana* females. When hatching occured the seedlings were 6-8 cm tall and first instar nymphs could establish on the seedlings after moving only a short distance on the soil surface.

Experiment 10: Twelve pans containing spittlebug   eggs
and seedling plants were held in the laboratory until two days
before hatching was expected and then were placed in a pastu-
re. Four pans were placed under a covering which was 15 cm a-
bove the ground, four were covered completely with nylon cloth
for protection against predators and scavengers, and four we-
re placed in the open, completely exposed. When hatching be-
gan the number of nymphs that established on the plants   in
each pan was recorded daily for three days at which time   the
test was destroyed by dogs.

Experiment 11: This experiment was similar to no. 10 ex-
cept that most of the eggs were allowed to hatch in the labo-
ratory before they were placed in the pasture. The nymphs   in
all 12 pans were counted and then the pans were divided   into
two groups, each containing six pans and about the same   num-
ber of nymphs. Six pans were completely covered with nylon and
six partially covered. The area around the base of the   par-
tially covered pans was left open to allow excess for   preda-
tors and scavengers. A daily record was kept of the number of
nymphs alive in each pan for 17 days. This experiment was al-
so carried out near Dourados-MS but only eight pans were used.
Four were completely covered with nylon and four partially co
vered. The pans were in the pasture at Dourados for eight days.

RESULTS AND DISCUSSION

Predation by ants

Experiment 1: A - Nymphal counts following the first day
of infestation revealed only one nymph present out of 750 ori
ginal nymphs placed in the cages. After the cages were infes-
ted the 2nd time direct observations showed that ants were rea
dily carrying the nymphs away. We were aware that nymphal sur
vival may be poor on some-grasses such a *B. brizantha* (NILAKHE
& PASCHOAL 1985) however, the failure of nymphs to   establish
on *B. decumbens* was a surprise.

B - Observations of ants preying on   eggs
and newly hatched spittlebug nymphs was limited to a few hours
at two sites. However, these studies have documented that ants
indeed do carry off both eggs and nymphs. The number of   eggs
and nymphs carried off by different species of ants is   shown
in table 1.

Evidently several species of ants feed on insect eggs as
active predators or scavengers. In Texas the imported   fire
ant *Solenopsis invicta* Baren has been reported to consume 0.4

Heliothis eggs per ant (McDANIEL & STERLING 1979). These authors report that a conservative estimate is that 5 ants removed two eggs every 24 hours, thus ants would rank as major predators of *Heliothis* eggs. Direct observations and radioactive eggs were used in Florida soybean fields to determine predators of velvetbean caterpillar eggs (BUSCHMAN *et al.*, 1977). These authors reported that ants and earwigs were observed most frequently as eggs predators. Ants belonging to three genera (*Pheidole*, *Conomyrma* and *Solenopsis*) which were reported as egg predators in Florida of velvetbean caterpillar eggs are also recorded in Table 1 as predators of spittlebut eggs in Brazil. Since ants are one of the most numerous insects in Brazil, their effect on spittlebug populations could be significant. KEMPF (1972) records over 400 species of ants in the state of Mato Grosso.

TABLE 1 - Observations on ant predation of spittlebug eggs and 1st instar nymphs (*Deois flavopicta*) in *B. decumbens* pastures[1].

Ant species	Number of Eggs and Nymphs Removed[2]								
	CAMPO GRANDE				DOURADOS				
	CNPGC		FAZ. CALIF.		SANTA ANA		SÃO SEBASTIÃO		
	eggs	nymphs	eggs	nymphs	eggs	nymphs	eggs	nymphs	total
Solenopsis sp1		3			1				4
Solenopsis sp2							6		6
Pheidole sp	2	6			12		11		31
Conomyrma sp			4	6					10
Cyphomyrmex rinosus							11		11

[1] Observations were made in Sept. and Oct. 1984. Observation time totaled 6 hrs at the Campo Grande sites and 3 hours at the Dourados sites.

[2] All nymphs except one were taken before they produced spittle.

Other authors have reported that several species of ants forage for a 3-4 hour period in the morning and also in the afternoon (CARROLL & JANSEN, 1973; CLARK & COMANOR 1973, and ROGERS, 1974). Since it has been observed that spittlebug usu

ally hatch during the night or early morning they would be especially susceptible to predation by foraging ants (FAGAN & KUITERT, 1969). Field observations also indicate that most spittlebug nymphs fall prey to ants before the spittle is formed. Therefore, the time span between hatching and the formation of spittle by first instars is critical for survival.

Results of the study involving the application of mirex bait to control ants are inconclusive. More spittlebug eggs were expected in plots treated with mirex but in all the samples collected (120) only 17 eggs were recovered, 10 from treated plots and 7 from untreated plots. Shortly after the bait was applied ants were observed carrying the bait and later it was found stored in ant tunnels. However, rain showers occurred shortly after the bait was applied in November and January. It is possible that rain reduced the toxic effect of the bait.

Spittlebug egg survival

A total of six experiments were carried out with non-diapause eggs to determine egg survival under field condition and attempt to identify the factors causing mortality. The results of these experiments which show the average number of eggs recovered per 20 females before and after exposure to field conditions is shown in Table 2. In most experiments the average number of eggs recovered that were exposed but protected from effects of rain showers was equal or higher than the average number recovered following oviposition (control) (Table 2). Evidently the differences in the number of eggs laid in the pans was great. However, in all but one experiment (Experiment 8) the average number of eggs recovered that were fully exposed to environmental influences differed significantly from the average number of eggs recovered following oviposition (Table 2). When results of experiments 4, 5, 6, 7, and 8 are combined the actual reduction in recovered eggs between those in control groups and those fully exposed was 66%. Also when the results of experiments 4, 5, and 8 (experiments with the treatment labeled partial exposure) are combined the reduction in recovered eggs between those protected from rain showers by a cover and those that were fully exposed was 66%. This egg mortality is considerably higher than that reported for *Neophilaenus lineatus* (L.) by WHITTAKER (1971). He reported egg mortality to range from 25-31%. The large difference between eggs recovered after exposure and those protected from the effects of rain showers is believed to be due to the displacement effects of numerous showers that occur during the time eggs are being laid. For example, in experiments 4 and 5 only 2 eggs were recovered after being completely exposed for 14 days but 482 eggs were recovered from the pans that were protected from rain showers. Heavy rain showers occurred during both experiments with a total of 98.00 mm recorded during

the time span of experiment 4 and 70. 1 mm during experiment 5. In experiment 7 where only 23.9 mm of precipitation was recorded the ratio between exposed eggs and protected eggs was closer. A total of 223 eggs were recovered following oviposition compared to 31 after exposure. The intensity of the rain showers probably has a greater effect on egg displacement than the amount of precipitation or the duration of the showers. Eggs displaced by rain showers could be washed down soil cracks, moved to low areas in the field, buried under soil and litter, or be left fully exposed (PICKLES, 1933).

TABLE 2 - Survival of spittlebug eggs following exposure to environmental influences, Campo Grande-MS, 1985.

Experiment Nº	Oviposition media	Precip. (mm)	Exposure (days)	Mean number of eggs recovered/20 ♀'s[1]	
				Treatment[2]	$\bar{x}$ S.E.
3.	litter + soil	-	10	Control Partial Exposure	30.50a ± 3.80 19.25b ± 2.02
4	soil	98.0	14	Partial Exposure Control Full Exposure	64.50a ± 0.65 30.75b ± 4.64 0.25c ± 0.25
5	litter + soil	70.1	14	Partial Exposure Control Full Exposure	56.00a ± 10.68 31.50b ± 6.76 0.25c ± 0.25
6	litter + soil	52.1	10	Control Full Exposure-litter Full Exposure-soil	84.00a ± 30.63 9.50b ± 1.55 2.25b ± 1.11
7	litter + soil	23.9	4	Control Full Exposure-litter	37.17a ± 2.18 5.17b ± 1.70
8 A	soil	48.5	12	Partial Exposure Full Exposure Control	76.25a ± 10.26 68.50a ± 9.02 52.75a ± 4.17
8 B	soil	-	12	Control Partial Exposure Full Exposure	7.2 a ± 4.84 7.2 a ± 2.78 0.6 a ± 0.40

[1] Means are based on 4, 5, or 6 replications with 20 ♀'s/replication.

S.E. = standard error.

Means within a column followed by the same letter are not significantly different (P<0.05, Duncans multiple range test).

[2] Control = Eggs were counted following oviposition.

Partial Exposure = Eggs were covered or partial covered in the field and thus not exposed to rain showers.

Full exposure = Eggs were fully exposed to environmental conditions.

Abiotic factors, such as those tested in experiment 9, also affect non-diapause egg survival and hatching. This experiment was designed to test the effect of a range of possible environmental conditions on egg hatch. The treatment variables involved differences in the amount of direct sun the eggs received, differences in soil surface temperature, and differences in the amount of water the eggs received. The per cent egg hatch recorded under these different treatments is shown in Table 3.

TABLE 3 - Effects of certain environmental factors on the hatching of non diapause eggs of *Zulia entreriana* , Campo Grande-MS, 1985[1]

| Treatment | Av. Temperature (°C) | | Av. hours Sunshine day | Water | | % hatch |
	0800	1300		Precip. (mm)	Addit. water (ml)	
A	24.8	29.5	4 hrs 33 min	78.8	0	10.7
B	24.9	29.5	4 hrs 33 min	78.8	400	75.6
C	22.4	24.3	0	0	400	69.1
D	22.5	24.7	0	0	1400	74.7

[1] Treatments A and B were placed outdoors in direct sunlight and treatments C and D were placed in a protected area with no sun or natural precipitation.

Treatments B and D received the most water and also had the highest percent hatch. Treatment C received regular amounts of water but not as much as treatments B and D and the percent hatch was 69%, only slightly less than B and D. The hatch was lowest (11%) in treatment A which received only natural precipitation and none was recorded the last four days of the test. There was little differences in percent hatch between treatment B, the exposed site, and treatments C and D,

shady sites. Therefore it appears that hatching will be suc-
cessful as long as the soil remains moist, even under exposed,
sunny, conditions. The temperature averaged slightly   higher
(2.4ºC at 0800 and 5.0ºC at 1200) at the sunny site but again
egg hatch appeared not to be affected as long as   adequate
moisture was present. Non-diapause eggs usually hatch in 14-
-18 days during the rainy season so it is doubtful that   soil
moisture will be a limiting factor during this period.   Howe-
ver, if precipitation does not occur for several weeks   egg
hatch could be prolonged.

Spittlebug Nymphal Survival

Experiment 10 was initiated in order to determine the mor
tality of eggs hatching in the field. Nymphal counts were ma-
de following egg hatch in the field in three different treat-
ments. During the 3-day period after eggs had started to hatch
no nymphs were observed in four pans of eggs that were fully
exposed, two were observed in the pans under cover, and   61
were observed in the pans that had been covered with   nylon
cloth. These results show that a high nymphal mortality   can
occur during the short time between hactching and the   forma-
tion of spittle for protection.

Mortality of newly hatched nymphs was also examined   un-
der field conditions (Experiment 11). A daily record of   the
number of nymphs alive on grass seedlings exposed to   field
condition compared to the number of nymphs alive that were pro
tected with nylon cloth at two locations, Campo Grande and Dou
rados is shown in Figure 1. At Campo Grande most of the   eggs
hatched in the laboratory and the nymphs established on   the
seedlings before the pans containing the nymphs were taken to
the field. However, additional hatching occurred once   the
pans were placed in the field. At Campo Grande 83   additional
eggs hatched in the field and the nymphs established on seed-
lings in the covered cages. No additional nymphs were observed
to survive in the partially covered cages. At Dourados   158
additional eggs hatched and the nymphs established in the co-
vered cages. No additional nymphs were observed in the   par-
tially covered cages. This indicates the high mortality   that
must often occur when hatching begins.

At Campo Grande mortality decreased at about the same ra
te in both groups of nymphs and near the end of the test   the
mortality was due to the inability of the seedlings to support
2nd instar nymphs. At Dourados the mortality was much greater
in the group of exposed nymphs, mainly because most of   the
eggs had not hatched when the pans of nymphs and eggs were ta
ken to the field. Thus, more newly hatched nymphs were   expo-
sed to predation, dessication, etc. At Campo Grande mortality
was determined by using the day with the highest total   nym-
phal count (234) in the covered cages and comparing it   with

the number of nymphs 10 days later (206). This shows mortali-
ty to be 12%. The mortality in the partially covered cages du
ring this time was 73%. The difference (61%) can be conside-
red the effect of predators, scavengers, disease, and abiotic
factors on newly hatched nymphs. However, WHITTAKER (1971) re
ported nymphal mortality of *Neophilaenus lineatus* in England
to be no more than 5%. He stated that nymphal mortality does
not seem to be a very important source of mortality because
the spittle protects the nymphs from most predators. This al-
so appears to be generally true for spittlebug nymphs in cen-
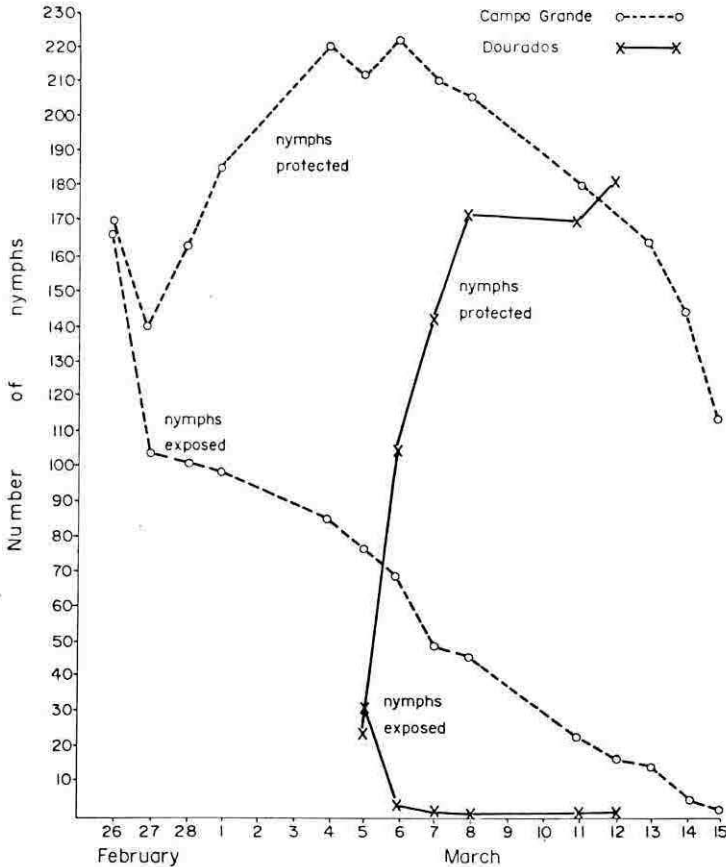tral Brazil except for newly hatched nymphs.

FIG. 1 — Nymphal and egg mortality of *Z. entreriana* in cages
completely protected from predators and scavengers
vs mortality in cages partially open to predators and
scavengers at Campo Grande-MS and Dourados-MS, 1985.

Observations indicate that great differences occur   in adult densities and eggs laid even within pastures   composed of the same grass species. These differences occur because (1) females select a favorable egg laying enrivonment   (HEWITT, 1985) and areas unsuited for oviposition are ignored (2) once the eggs are in the pasture other environmental influences ei ther favorable or unfavorable operate to determine the number of eggs hatching and survival of nymphs to the adult   stage. For example, mortality factors which operate in the life   cy- cle of spittlebugs are shown in Table 4. Certainly these mor- tality factors will vary with time and place. In the   present study the predation of spittlebug eggs and newly hatched nym- phs, mainly by ants, appeared to have greatest effect on spit tlebug numbers. Intensive rain showers displaced   spittlebug eggs but the actual egg mortality could not be determined.

TABLE 4 - Mortality factors which may operate during the spittlebug life cycle and influence population density.

Life Stage	Causative Agents	Operative Period
Egg (non-diapause) (a) Eggs consumed or destroyed	invertebrate predators and parasites	14 – 18 days
(b) Eggs failed to hatch	inviability, disease, dessication	
Nymph (a) Hatching period	invertebrate predation, disease, weather influences	Time of hatch up to 2 hours.
(b) Spittle period	vertebrate and inverte brate predators, para- sites, disease	25 – 40 days
Adult (a) Mobile period	vertebrate and inverte brate predators, para- sites, disease	8 - 16 days

It should be understood that, in general, a very favorable habitat exists for spittlebugs in central Brazil. Very few stressful influences are present. The habitat is relatively stable with year-long grazing, there is a minimum of crop rotations and land renovations, and the food is unlimited during the rainy season when the spittlebugs are active. We would like to suggest that this relatively stable pasture environment and the year-long grazing management plan needs to be reevaluated in terms of maximizing beef production and providing an unfavorable habitat for spittlebugs. Little is know about the effects of crop rotation, grazing pressure, or rotational grazing on insects such as spittlebugs and ants. This study points out the need for additional research on the factors that determine ant numbers. Also, the advantages or disadvantages of increasing ant numbers needs to be evaluated as a possible means of spittlebug suspression.

ACKNOWLEDGEMENTS

LITERATURE CITED

BUSCHMAN, L.L.; WHITCOMB, W.H.; HEMENWAY, R.C.; MAYS, D.L.; NGUYEN, Ru; LEPPLA, N.C.; SMITTLE, B.J. Predators of velvetbean caterpillar eggs in Florida soybeans. *Environ. Ent.* *6:* 403-407, 1977.

CARROLL, C.R. & JANZEN, D.H. Ecology of foraging by ants. *Ann. Rev. Ecol. Systemat.* *4:* 231-257, 1973.

CLARK, W.H. & COMANOR, P.L. A quantitative examination of spring foraging of *Veromessor pergandei* (Mayr) in northern Death Valley, California (Hymenoptera: Formicidae). *Am. Midl. Nat.* *90:* 467-474, 1973.

FAGAN, E.B. & KUITERT, L.C.   Biology of the two-lined spitt-
lebug _Prosapia bicincta_, on Florida pastures   (Homoptera:
Cercopidae), _Fla Ent. 52:_ 199-206·, 1969.

HEWITT, G.B.   Ovipositional preferences of the spittlebugs _Zu_
lia entreriana (Berg) and _Deois flavopicta_ Stal. (Homopte
ra: Cercopidae). _An. Soc. Ent. Brasil_ _14_(2): 197-204,1985.

KEMPF, W.W.   Catálogo abreviado das formigas da região neotro
pical (Hymenoptera: Formicidae) _Studia Entomol. 15:_3-512.
1972.

KOLLER, W.W. & VALÉRIO, J.R.   Períodos de incubação de   ovos
de _Zulia entreriana_ (Berg, 1879) (Homoptera: Cercopidae)
obtidos em diferentes épocas. Campo Grande-MS,   EMBRAPA-
-CNPGC, 1985. 5p. (EMBRAPA-CNPGC. Pesquisa em   Andamento,
27).

McDANIEL, S.G. & STERLING, W.L.   Predator determination   and
efficacy on _Heliothis_ in east Texas cotton using 32p.   _En-_
viron. Ent. 8: 1083-1087, 1979.

NILAKHE, S.S. & PASCHOAL, G.O.   Survival and development   of
spittlebug adults on different grasses. _In_: International
Grassland Congress, 15, Kyoto, Japan, 1985.   _Proceedings_
(in press).

NILAKHE, S.S.; MARTIN, P.B.; VALÉRIO, J.R.; KOLLER, W.W.; SOU
ZA FILHO, J.A.G.; SILVA, A.A.   Sampling plans for spittle
bug eggs in pastures of _Brachiaria decumbens_. _Pesqui.   A-_
grop. bras. 19: 935-941, 1984.

PICKLES, A.   Entomological contributions to the study of the
sugarcane froghopper. II. The influence of host relations
and of cultural operations in limiting blight incidence a-
mongst plant canes. _Trop. Agric. Trin. 10:_ 240-245,   286-
-295, 1933.

ROGERS, L.E.   Foraging activity of the western harvester ant
in the shortgrass plains ecosystem. _Environ. Ent. 3:_ 420-
-424, 1974.

VALÉRIO, J.R. & OLIVEIRA, A.R.   Cigarrinhas-das-pastagens: es
pécies e níveis populacionais no Estado de Mato Grosso do
Sul e sugestões para o seu controle. Campo Grande, MS. EM-
PAER, 1982. 20p. (EMBRAPA-CNPGC. Circular Técnica,   90.
(EMPAER, Circular Técnica, 1).

WHITTAKER, J.B.   Population changes in _Neophilaenus lineatus_
(L.) (Homoptera: Cercopidae) in different parts of its ran
ge. _J. Anim. Ecol. 40:_ 425-443, 1971.

WIEGERT, R.G.   Population energetics of meadow spittlebugs -
(_Philaenus spumarius_ L.) as affected by migration   and
habitat. _Ecol. Monogr. 34:_ 217-241, 1964.

ABSTRACT

Observations and tests were used to document predation of
spittlebug eggs and nymphs by five species of ants: *Solenopsis*
sp.1, sp.2, *Pheidole* sp., *Canomurma* sp., and *Cyphamyrmex rino
sus*. These five species carried off 47 eggs and 15 nymphs du-
ring an observation time of nine hours at two sites. Nymphal
mortality resulting from predators, scavengers, disease, and
abiotic factors at one site was determined to be 61%. Eggs we
re displaced by rain showers and less than 35% were recovered
following exposure. In this study predation of spittlebug eggs
and newly hatched nymphs by ants had the greatest effect   on
spittlebug numbers.