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Effect of Host Plant on the Fecundity of Spittlebug *Deois flavopicta* Stal (Homoptera: Cercopidae): Implications on Population Dynamics

E.R. Sujii[1], C.S.S. Pires[1], E.M.G. Fontes[1] and M.A. Garcia[2]

[1] *Embrapa Recursos Genéticos e Biotecnologia, Cx. postal 02372, 70.849-970, Brasília, DF*
[2] *Depto. Zoologia, UNICAMP, Cx. postal 6103, 13.903.970, Campinas, SP*

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Efeito da Planta Hospedeira na Fecundidade da Cigarrinha-das-pastagens *Deois flavopicta* Stal (Homoptera: Cercopidae): Implicações na Dinâmica Populacional

RESUMO – A cigarrinha das pastagens *Deois flavopicta* Stal (Hom.: Cercopidae) ocorre naturalmente em gramíneas nativas no Brasil Central em baixas densidades populacionais. Após a introdução de gramíneas africanas, principalmente do gênero *Brachiaria, D. flavopicta* passou a produzir explosões populacionais e tornou-se a principal praga das pastagens na região. Estudos visando comparar os efeitos da planta hospedeira nativa e da exótica sobre a fecundidade do inseto foram desenvolvidos. Fêmeas de *D. flavopicta,* mantidas durante a fase adulta em *Brachiaria ruziziensis*, produziram mais ovos e tiveram maior longevidade média que aquelas mantidas em *Axonopus marginatus,* independente da planta hospedeira em que foram criadas durante a fase ninfal. Devido aos danos causados pelos adultos na planta hospedeira, o efeito da densidade de indivíduos em sua própria fecundidade foi avaliado em gaiolas de oviposição contendo plantas de *B. ruziziensis* padronizadas no comprimento e quantidade de perfilhos. Densidades de um, dois, três, quatro e seis casais com fêmeas virgens foram avaliadas. A densidade populacional de três casais, equivalente a 150 adultos/m^2, ou maior que esta, reduziu a fecundidade das fêmeas. Estes estudos contribuíram para o entendimento dos mecanismos que influem para as baixas populações de cigarrinha observadas em gramíneas nativas e que promovem explosões populacionais em pastagens cultivadas com plantas introduzidas.

PALAVRAS-CHAVE: Insecta, dinâmica de populações, biologia reprodutiva, interação inseto-planta, surtos populacionais.

ABSTRACT – The spittlebug *Deois flavopicta* Stal (Hom.: Cercopidae) occurs naturally on native grasses in Central Brazil in low population densities. After the introduction of African grasses, mainly of the genus *Brachiaria,* for cattle raising, *D. flavopicta* began to produce population outbreaks and became a pest. Two studies were conducted, aiming to estimate the effects of a native and an exotic host plant on the fecundity of this insect. Females of *D. flavopicta* maintained during the adult stage on *Brachiaria ruziziensis* produced more eggs and lived longer than those maintained on *Axonopus marginatus* (a native grass widely distributed in Brazil), independently of the host plant on which the nymphs were reared. Due to the severe damage produced by adult *D. flavopicta* on the host plant, the effect of insect density on its own reproductive capacity was evaluated in oviposition cages containing plants of *B. ruziziensis,* standardized in height and stem number. Densities of one, two, three, four and six couples with virgin females were evaluated. Population densities of three couples, equivalent to 150 adults/m^2, or higher decreased insect's fecundity. These results contributed to the understanding of the mechanisms that determine low levels of spittlebug populations in the native grasses and promote population outbreaks in introduced ones.

KEY WORDS: Insecta, population dynamics, reproductive biology, insect-plant interaction, population outbreaks.

The spittlebug *Deois flavopicta* Stal is the predominant pasture pest species in the Central-West region of Brazil. This species originally fed on native grasses and exhibited low population density throughout its geographical range, in the Central-West and Southeast of Brazil (Pires *et al.* 2000c). With the introduction of exotic grasses for cattle feed, mainly of the genus *Brachiaria*, *D. flavopicta* populations rose to high levels on cultivated pasture (Fontes *et al.* 1995).

Several hypothesis have been proposed to explain explosive increase in the abundance of a given insect population (Berryman 1987). According to those hypothesis, outbreaks of phytophagous insects are caused by changes in biotic and/or physical factors of the environment. The management of an insect population, preventing its outbreak, requires the determination of the factors that have changed in the environment in relation to the problem insect (Sanders & Knigth 1968).

The occurrence of high densities of *D. flavopicta* has been related to various factors such as precipitation, temperature and evapotranspiration (Oomen, 1975, Milanez *et al.* 1981, Melo *et al.* 1984, Sujii *et al.* 1995, Pires *et al.* 2000a), and lack of natural enemies (Hewitt 1986, Hewitt & Nilakhe 1986, Sujii 1998). However, host plant availability and quality may also play a role on spittlebug population dynamics by directly affecting nymph and adult performance (Pires *et al.* 2000b). Knowledge of how plant quality influence the fecundity of *D. flavopicta* females are necessary to understand the population dynamics of this insect and its management.

This work has evaluated how different host plant species, such as *Brachiaria ruziziensis* Stapf and *Axonopus marginatus* (Trinius) Chase (Poaceae), influence adult fecundity in *D. flavopicta*. The effect of adult density per cage on fecundity was also studied.

Material and Methods

The Insect. In the Federal District of Brazil (Brasília), where this study was conducted, *D. flavopicta* presents three population peaks during the rainy season (October through May) and diapauses in the egg stage during the dry season (Fontes *et al*. 1995). The size and timing of population peaks of *D. flavopicta* vary from year to year. Generally, adults emerge in late November, January and March. Eggs are laid in the soil close to the roots of host plants. After hatching from eggs, nymphs must find a feeding site to start producing their characteristics spittle masses. They feed gregariously on roots and stems, close to the soil surface. Adults feed more frequently on leaves. Both nymphs and adults suck on the xylem and debilitate the plant, although severe damage results mostly from adult feeding. *D. flavopicta* develops through five nymphal stages, and the total nymphal cycle spans approximately 40 days (Milanez *et al.* 1981). According to Pacheco (1981), males and females of this insect live, on average, 9.8 and 12.5 days, respectively. In this study, newly emerged females and males were collected in the field inside the spittlemasses, on the host plants *B. ruziziensis* and *A. marginatus*.

The Host Plants. Densities of nymphs on natural grasslands and on cultivated pastures were used as a guide to select the host plants used in the experiments (Pires *et al.* 2000c). *Axonopus marginatus* is a C4, tall-growing perennial grass naturally distributed in Brazil, with a tussock habit and very narrow leaves (Klink 1994). *Brachiaria ruziziensis* is a C4 perennial grass introduced in Brazil from Africa, with prostate growth that forms a sward (Ferrufino & Lapointe 1989). Clones of the two grasses were collected in the field from adjacent areas and propagated vegetatively in pots with 3.6 l of capacity on unfertilized soil.

Host Plant X Fecundity. The spittlebug fecundity was measured on *B. ruziziensis* and *A. marginatus.* Newly emerged adults were collected in the field inside the spittlemass on plants of both species. A pair of male and female of spittlebugs was caged on potted plants within 24h after emergence. A total of 16 and 25 females were collected on plants of *A. marginatus* and *B. ruziziensis*, respectively and each female was used as a replication. The cages were checked daily until the death of the female. The average number of eggs laid on the two plant species was compared using Mann-Whitney test (Kuo *et al*. 1992).

Female Size X Fecundity. Teneral females reared on *B. ruziziensis* and *A. marginatus* plants had their weight and wing size measured and compared using *t*-test and Mann-Whitney test, when the data were non parametric. The relationship between the number of eggs laid and female size was tested by correlation analysis (Pearson Product Moment Correlation) (Kuo *et al*. 1992).

Nymph and Adult Feeding X Fecundity. To evaluate how nymphal and adult food affect spittlebug fecundity, we measured female longevity and number of eggs laid in the following four treatments: adults reared on *B. ruziziensis* caged on *B. ruziziensis*; adults reared on *B. ruziziensis* caged on *A. marginatus;* adults reared on *A. marginatus* caged on *A. marginatus*, and adults reared on *A. marginatus* caged on *B. ruziziensis*. Eggs laid by spittlebug adults collected in the field were incubated in growth chambers and recently emerged nymphs were transferred to potted plants of both grass species. During a period of 90 days, teneral adults were collected inside the spittlemass on plants of both species and one couple was caged on a potted plant of both species following the four proposed treatments. Each couple was a replication and thirty replicates of each treatment were performed. Because *D. flavopicta* displays, on average, seven days of pre-ovipositional period (Stoporoli Neto *et al*. 1985), only females that lived a minimum of seven days were considered for fecundity evaluation. We compared the average number of eggs laid in the four treatments using Kruskal-Wallis nonparametric analysis of variance (Kuo *et al*. 1992).

Adult Density X Fecundity. Cages with plants of *B. ruziziensis* received different numbers of newly emerged (up to 24-h old) males and females, collected in a pasture with the same host plant, to evaluate the effect of density on adult fecundity. Each plant was clipped to provide approximately the same amount of resource and had 10 shoots of ca. 25 cm high. The number of eggs laid in cages containing one, two, three, four and six couples were recorded. The colections of teneral adults in the field at the same date alowed to perform six replicates of each treatment. We compared the average number of eggs laid in the five treatments using ANOVA following by Student-Newman-Keuls multiple comparison test (Kuo *et. al*. 1992).

Results

Host Plant X Fecundity. Females reared on *B. ruziziensis* laid in average 29.4 ± 6.11 eggs, N = 25, while females reared on *A. marginatus* laid in average 5.3 ± 2.05 eggs, N = 16), (Mann-Whitney test, T = 244.5, P = 0.015).

Female Size X Fecundity. There was no difference in wing size between females reared on *B. ruziziensis* (0.83 ± 0.03 mm, N = 25) and those reared on *A. marginatus* (0.80 ± 0.06 mm, N = 16) (Mann-Whitney test, T = 201, P = 0.082). However, there was a slight but statistically significant difference in the weight of females fed on *B. ruziziensis* (40.2 ± 4.97 mg, N = 25) and those fed on *A. marginatus* (35.5 ± 9.35 mg, N = 16) (*t*-Test, *t* = -2.04, df = 36, P = 0.048).

There was no correspondence between the length of female's wing or female weight and fecundity of individuals reared on both grass species (Table 1).

Nymph and Adult Feeding X Fecundity. Spittlebug fecundity was affected by the host plant during adult stage. Females maintained during the adult stage on *B. ruziziensis* showed higher reproductive capacity compared to females maintained on *A. marginatus,* independent of the food resource during the immature stage (ANOVA, F = 4.35, P = 0.008, d.f. = 3; Student-Newman-Keuls, P < 0.05; Fig. 1). The longevity of females was lower on the native host plant, *A. marginatus*, compared to the introduced host, *B. ruziziensis* (Kruskal-Wallis, H = 19.494, df = 3, P < 0.001; Fig. 2).

Adult Density X Fecundity. The damage produced by adults on leaves of *B. ruziziensis* did not affect female fecundity in the treatments containing one or two couples per cage, equivalent to population densities of 50 or 100 adults/m^2. There was a significant decrease on egg production on densities above two couples per cage (ANOVA, F = 5.59, P = 0.002, d.f. = 4; Student-Newman-Keuls, P < 0.05; Fig. 3).

Discussion

The host plant *B. ruziziensis* affected positively the performance of *D. flavopicta* enhancing female longevity and fecundity compared to the host *A. marginatus*. Plant traits such as toxicity, content of nutrients, feeding deterrents and physical characteristics may explain these results. Apparently, native grasses from Cerrado vegetation, such as *A. marginatus*, have nutritional constraints that reduces fitness of spittlebug when compared to several introduced *Brachiaria* species. Plants of *A. marginatus* have higher percentage of fiber (Pires *et al.* 2000b) and high amounts of silica bodies in the tissue (Sendulsky & Labouriau 1966, Cavalcante 1968) which increase their toughness. Increase in tissue hardness can prevent the spittlebugs from reaching the feeding sites, since xylem sucking insects insert their stylets into xylem elements by mechanical means rather than by enzymatic dissolution (Raven 1983). In addition, grasses from the genus *Brachiaria* are associated with nitrogen-fixing rhizobacteria in the soil (Boddey & Victoria 1986, Döbereiner & Pedrosa 1987) and present higher response to nitrogen absorption (Pires *et al.* 2000b). These characteristics increase the source of organic nitrogen in the vessel tissues, which are essential to xylem-sucking feeders as spittlebugs (Thompson 1994).

Table 1. Correlation between egg production and female size of *D. flavopicta* in different host plants.

Host plant	Wing size		Weight of teneral female	
	Pearson coefficient	(N)	Pearson coefficient	(N)
A. marginatus	r = 0.33; P > 0.05	(15)	r = 0.54; P > 0.05	(12)
B. ruziziensis	r = 0.06; P > 0.05	(17)	r = 0.03; P > 0.05	(25)

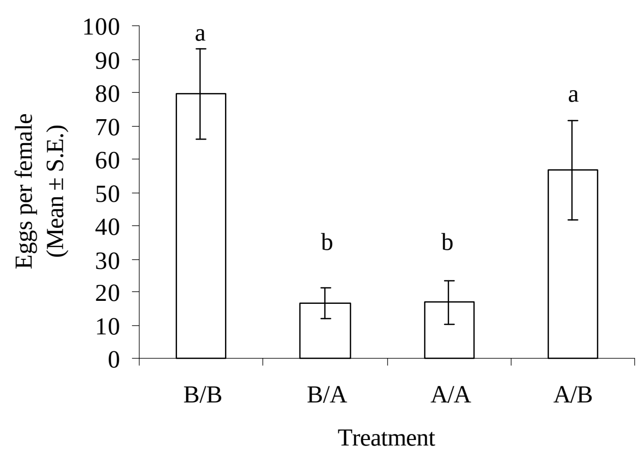

Figure 1. Effect of host plant species on the fecundity of *D. flavopicta*. Treatments: B/B = nymphs and adults reared on *B. ruziziensis*, B/A = nymphs reared on *B. ruziziensis* and adults reared on *A. marginatus*, A/A = nymphs and adults reared on *A. marginatus*, A/B = nymphs reared on *A. marginatus* and adults reared on *B. ruziziensis*. Same letters above the bars indicate no significant difference among the means (Student-Newman-Keuls, P < 0.05; ANOVA, F = 4.35, P = 0.008, d.f. = 3)

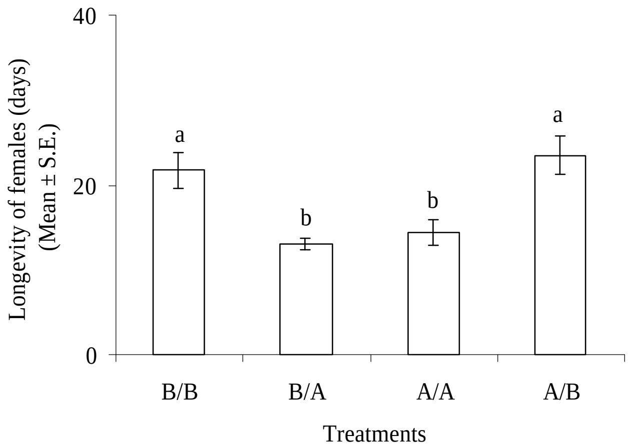

Figure 2. Longevity of female *D. flavopicta* reared on different host plant species. Treatments: B/B = nymphs and adults reared on *B. ruziziensis*, B/A = nymphs reared on *B. ruziziensis* and adults reared on *A. marginatus*, A/A = nymphs and adults reared on *A. marginatus*, A/B = nymphs reared on *A. marginatus* and adults reared on *B. ruziziensis*. Same letters above the bars indicate no significant difference among the means (Dunn's Test, $P < 0.05$; Kruskal-Wallis, $H = 19.494$, df = 3, $P < 0.001$)

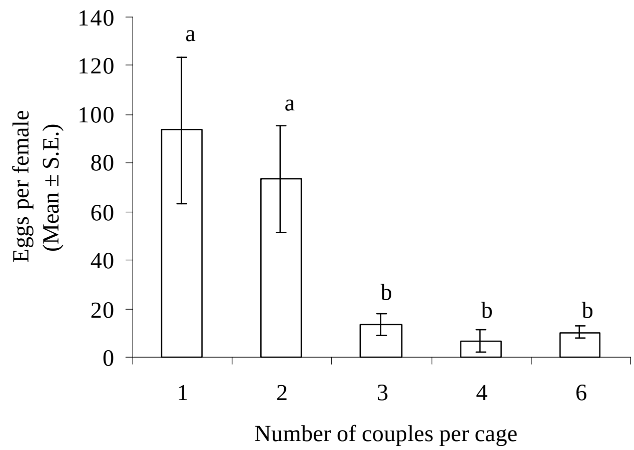

Figure 3. Effect of adult density on *D. flavopicta* fecundity. Same letters above the bars indicate no significant difference among the means (Student-Newman-Keuls, $P < 0.05$; ANOVA, $F = 5.59$, $P = 0.002$, d.f. = 4)

The spittlebug fecundity was more affected by the food taken during adult stage. Nymphs fed on low quality plant, such as *A. marginatus*, produced female slightly smaller than those reared on *B. ruziziensis*. However, there was no correlation between female size and fecundity. These results showed that, differently from other insect groups, e.g. Lepidoptera (Haukioja 1993), for *D. flavopicta,* growth during nymphal stage is not critical for egg production. Consequently, the potential reproductive capacity depends on resources obtained by the female. Because *D. flavopicta* has a pre-ovipositional period of around seven days, the low nutritional features of the nymphal food could be compensated by a different food source during adult stage. This feature favored the successful colonization of other grass species with higher nutritional quality as observed in the *Brachiaria* genus. The increase in the reproductive capacity promoted a quick establishment of *D. flavopicta* in the new habitats provided by pastures cultivated with *Brachiaria* spp. in Central West Region and South East of Brazil.

Fecundity of *D. flavopicta* decreased when the insect was exposed to population densities above two couples per cage. This could be a consequence of damage to the leaves due to adult feeding. Adult feeding frequently provokes dryness of the leaves due to the injection of salivary secretions that cause phytotoxemy (Valério 1988). Densities of two and three couples per cage are equivalent to population densities in the field of 100 and 150 adults/m² respectively. Limited food supply reduces female fitness and, consequently, population size in the next generation in a density-dependent way, as proposed by Begon & Mortimer (1986). Our results support the idea that intraspecific competition may self-regulate the spittlebug population in densities above 150 adults/m². In a previous study, when nymph population reached densities above 200 individuals/ m², the females did not full develop ovaries and mass emigrated from a *B. decumbens* pasture (Fontes *et al.* 1995). This observation suggests that intraspecific competition may regulate spittlebug population, leading to a severe local reduction in the populational level due to depletion of food supply in the same season of an outbreak. However, the self-regulation of *D. flavopicta* population on *Brachiaria* pastures apparently occurs above the economic threshold of 20-30 adults/m² (Menezes *et al*. 1983), and it can not be used as an indicator in programs of pest management.

Colonization of the introduced host plant species by *D. flavopicta* reduced the environment resilience to the expression of the insect's biotic potential and increased its population intrinsic growth rate. In addition, planting large areas with a single species increased the carrying capacity of the system for this potentialy pest species. This partially explains how *D. flavopicta*, endemic and rare on native grasses (Pires *et. al*. 2000a), became an outbreak pest species on introduced grasses of the genus *Brachiaria*.

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