IMPACT OF SOYBEAN PHENOLOGY ON VELVETBEAN CATERPILLAR (LEPIDOPTERA: NOCTUIDAE): OVIPOSITION, EGG HATCH, AND ADULT LONGEVITY[1]

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Abstract *Can. Ent.* 113: 113–119 (1981)

Adult females of the velvetbean caterpillar, *Anticarsia gemmatalis* Hübner, from larvae fed on progressively aged soybean, *Glycine max* (L.), foliage had variable reproductive characteristics. Mean oviposition rates ranged from 963.4 to 515.0 eggs/female when larvae fed on early vegetative and senescent leaves, respectively. Average daily oviposition peaked ca. 4 days after adult emergence, decreased sharply to day 10, and remained at a low level until adult mortality. Mean daily egg hatch decreased with female age, but female longevity was not affected significantly.

Résumé

Les femelles adultes d'*Anticarsia gemmatalis*, Hübner provenant de larves nourries de feuillage de plus en plus âgé de soya, *Glycine max* (L.), ont montré des caractéristiques reproductives variables. Les femelles obtenues ont déposé en moyenne 963.4 et 515.0 oeufs lorsque les larves ont été nourries de feuillage jeune et sénescent, respectivement. La ponte journalière moyenne a atteint un maximum environ 4 jours après l'émergence, pour ensuite diminuer rapidement jusqu'au jour 10, et demeurer à un faible niveau jusqu'à la mort des femelles. Le taux journalier moyen d'éclosion des oeufs a diminué avec l'âge des femelles, mais la longévité des femelles n'a pas été affectée significativement.

Introduction

Studies have demonstrated that "food quality" affects the population dynamics of phytophagous insects (e.g., Soo Hoo and Fraenkel 1966). Barfield *et al.* (1980) provided data illustrating significant variation in fall armyworm, *Spodoptera frugiperda* (J. E. Smith), larval consumption, and adult reproduction dependent upon peanut, *Arachis hypogaea* L., foliage age. Similar results have been obtained for velvetbean caterpillar, *Anticarsia gemmatalis* Hübner, larval consumption (Moscardi 1979) as a function of soybean, *Glycine max* (L.), phenology. Reid (1975) and Boldt *et al.* (1975) also investigated consumption by velvetbean caterpillar, but they did not relate it to soybean plant age.

An understanding of the consequences of nutrition on reproduction is essential to coupling plant and insect dynamics models (Barfield and Jones 1979). Therefore, our research was initiated to quantify the effects of soybean plant age (= crop phenology) on velvetbean caterpillar reproduction. Estimates of oviposition rate, egg hatch and adult longevity were designed to be compatible with the general structure of the model of Stimac and Barfield (1979).

Materials and Methods

Soybeans, *Glycine max* (L.) cv. 'Bragg', were planted 13 June 1978 in Gainesville, Florida according to standard agricultural practices. Completely developed leaves collected from the upper six nodes (top third) of plants were transported to the laboratory immediately. Foliage age was divided into early vegetative (V_2–V_5),

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late vegetative (V_5–V_8), flowering (R_1–R_2), pod set – pod fill (R_4–R_6), and senescent (R_7–R_8) (Fehr and Caviness 1977). Except for pre-plant herbicides, no pesticides were applied to the 0.4 ha area for the duration of the study.

Larvae were provided with sufficient soybean foliage daily, and no attempt was made to control total larval consumption. Successive foliage was provided until larval pupation. Plant age classes of 17–29, 34–44, 52–63, 78–89, and 97–109 days were used to represent the five phenological stages, respectively, of Table I (see Moscardi 1979). Adults derived from larvae fed on each soybean foliage class were collected and placed in a 46×38×34-cm Plexiglass® mating cage (Carlyle *et al.* 1975) and held at 26.7°±1°C with a 14L:10D photoperiod and > 80% R.H. Only males and females emerging on the same day were used in reproduction studies and their sex ratio was always ca. 1:1. A mixture of 1 g methyl *p*-hydroxybenzoate, 50 g sucrose, 5 cc unprocessed honey, and 0.1 g ascorbic acid per 100 ml demineralized water was provided for food (Leppla 1976).

At 3 days post-emergence, females were placed individually in 9×20-cm cylindrical screen cages. Light green paper, cut to fit the entire inside surface of the cylinder, provided an oviposition substrate. Plastic petri dish tops were used to close the cage at both ends. Fresh food was provided to the females every other day in cotton-filled 2-oz plastic cups. These cages were maintained in the same environment as the mating cage and left undisturbed during each scotophase.

The oviposition substrate was changed and egg counts made every morning. These substrates were numbered, dated, placed in plastic bags, and returned to their original environment for determination of egg viability. The oviposition rate, egg hatch, and adult female longevity were recorded for mated females only. Dead females were dissected for presence of spermatophores.

Results and Discussion

Mean oviposition rates, percentages of egg eclosion, adult longevity, and net reproductive rates for velvetbean caterpillar females that as larvae fed on progressively older soybean foliage are presented in Table I. Mean oviposition rates generally declined as the host plants aged, varying from 963 eggs/female on early vegetative to 515 on senescent leaves. Larvae fed early vegetative foliage produced adults with significantly (α = .05) higher oviposition rates than those fed on flowering, pod

Table I. Mean oviposition rate, egg hatch, longevity, and net reproductive rate (R_o) for velvetbean caterpillar females resultant from larvae fed excised leaves of successive soybean phenological stages. Temperature, 26.7°±1°C; photoperiod, 14L:10D; humidity > 80%

Plant stage	No. of mated females	Mean eggs/female ± S.E.[a]	Mean % egg hatch ± S.E.[a]	Mean longevity (days) ± S.E.[a]	R_o[b]
Early vegetative	22	963.41 ± 51.66*a*	71.06 ± 2.55*b*	16.91 ± 0.70*ab*	364.82
Late vegetative	28	895.46 ± 41.75*ab*	73.64 ± 1.63*ab*	17.39 ± 1.10*a*	346.15
Flowering	31	759.68 ± 36.13*c*	74.21 ± 1.79*ab*	17.55 ± 0.97*a*	304.23
Pod set – pod fill	21	820.29 ± 35.18*bc*	77.46 ± 1.74*a*	16.38 ± 1.09*ab*	330.23
Senescent	16	515.00 ± 21.53*d*	75.47 ± 1.53*ab*	14.06 ± 0.83*b*	199.24

[a]Means followed by the same letter, in any given column, are not significantly different according to Duncan's New Multiple Range Test (α = 0.05).
[b]R_o = net reproductive rate (Laughlin 1965).

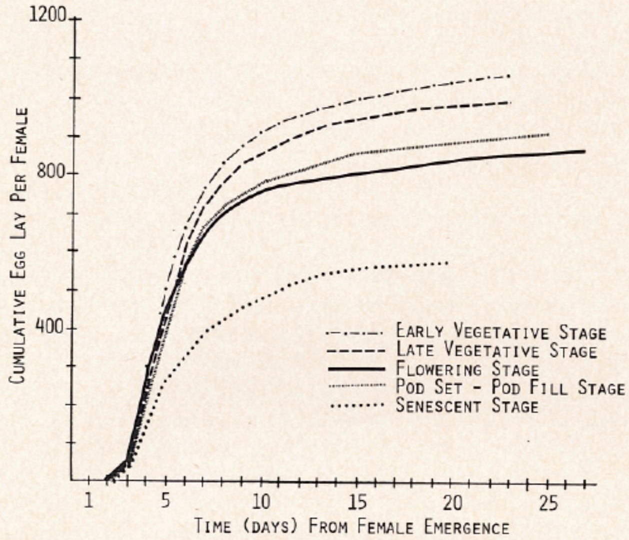

FIG. 1. Cumulative average egg lay for velvetbean caterpillar females resultant from larvae fed excised leaves from successive soybean phenological stages. Temperature, 26.7°±1°C; photoperiod, 14L:10D; R.H. > 80%.

set – pod fill, or senescent leaves. Despite a general decline in the oviposition of adults from larvae fed on these successive soybean phenological stages, only senescent leaves caused a drastic reduction.

Our findings generally agree with others reporting a reduction in insect oviposition with aging of host plants (Blais 1952; Grison 1958; Johansson 1964; Englemann 1970). Adverse effects often have been attributed to the reduced nutritive value of later plant stage leaves. Investigations by Hanway and Weber (1971*a*, *b*), Hammond *et al*. (1951), and Henderson and Kamprath (1970) showed a downward trend in N, P, and K concentrations in vegetative parts (all leaves considered) of soybean growth processes. In addition, Hanway and Weber (1971*b*) found that wide divergence exists in the percentages of these elements in leaves depending on position on the plant. Younger plant parts had a higher nutrient content than did older ones located lower on the stem. Furthermore, the top portions of soybean plants maintained a relatively high N content until maturity. In the field, larvae feed primarily on the top portion of soybean plants (Reid 1975). We also found that, given a choice, larvae feed on more tender leaves in the top part of the plant, leaving tougher lower leaves almost untouched. These findings may explain the relatively high oviposition rates maintained by females derived from larvae fed on leaves of the first four phenological stages.

Observed differences in mean oviposition of velvetbean caterpillar are not thought to have been caused by variable consumption of soybean leaf biomass. Moscardi (1979) showed that mean consumption of large larvae did not differ significantly (α = .05) among all soybean plant stages, except the flowering stage where consumption was less. We feel that effects of total consumption on parameters measured in this study are minimal.

Mean percentage egg eclosion varied from 71.1 for adults that as larvae fed on early vegetative stage foliage to 77.5 for those on pod set – pod fill. These results suggest that soybean crop phenology did not have an appreciable effect on egg hatch. The average longevity of mated females ranged from 14.1 days when larvae fed on senescent leaflets to 17.6 days on the leaves of flowering plants. Thus, similar results were obtained for all plant stages. The net reproductive rate (R_0), computed from fertility tables constructed for adult females (Laughlin 1965; Southwood 1978), ranged from 199.2 for larvae fed on senescent leaflets to 364.8 for those on the early vegetative stage. All R_0 values were considerably higher than those determined by Leppla *et al.* (1977) for adults reared from larvae fed artificial diet.

Cumulative average daily oviposition for females corresponding to each phenological stage is shown in Fig. 1. Females resulting from larvae fed on early vegetative stage leaves had the highest cumulative average, and the lowest rate occurred on the senescent stage. Cumulative average oviposition increased sharply from days 4 to 8 post-emergence for all treatments; few eggs were deposited thereafter.

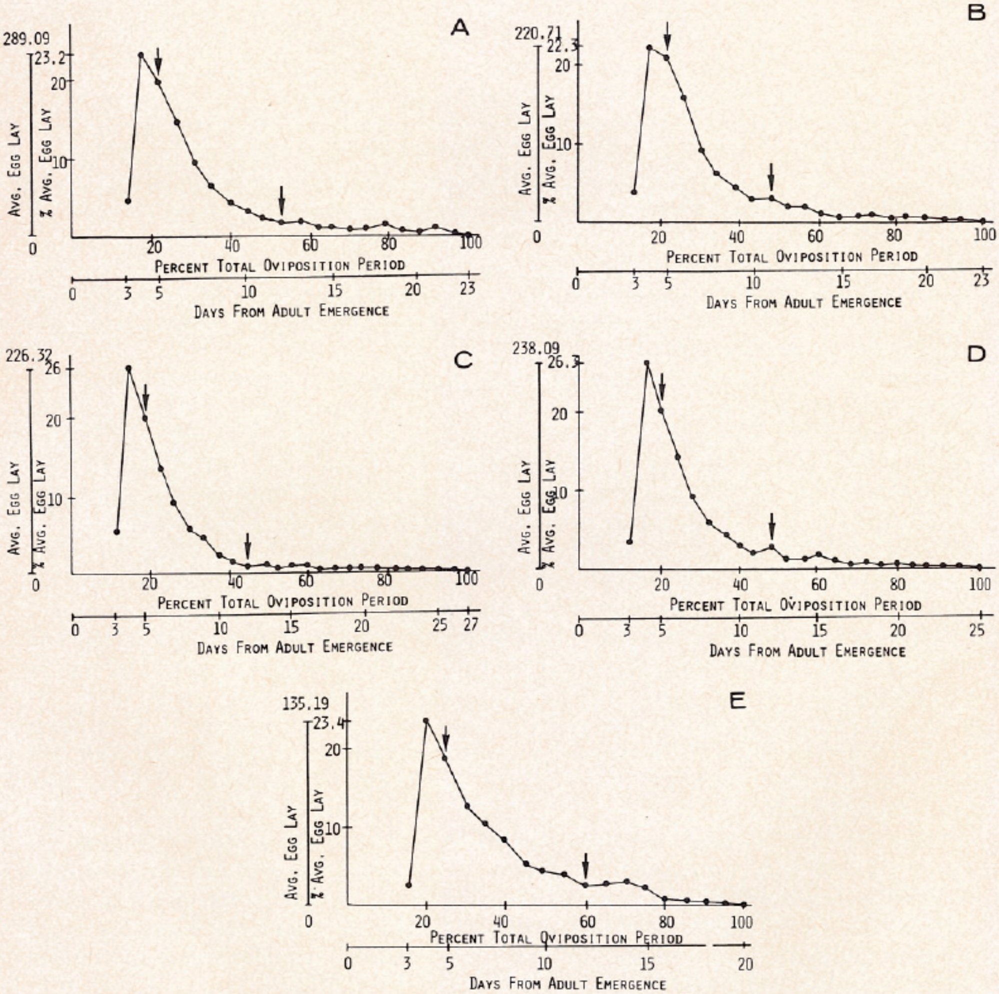

FIG. 2. Average daily oviposition and percentage average daily oviposition for velvetbean caterpillar females resultant from larvae fed excised leaves from successive soybean phenological stages. Arrows indicate 50 and 90% cumulative oviposition. Plant stages are early vegetative (A), late vegetative (B), flowering (C), pod set – pod fill (D), and senescent (E). Temperature, 26.7°±1°C; photoperiod, 14L:10D; R.H. > 80%.

Average, percentage average, and peak percentage average oviposition in relation to days from adult emergence are shown in Fig. 2. Arrows indicate the day or percentage total oviposition period at which 50 and 90% of cumulative mean oviposition occurred. Peak average oviposition occurred on the fourth day post-emergence for adults resulting from larvae fed on all plant stages. However, the magnitude of the peak varied from 135.2 eggs/female for the senescent stage to 248.1 for the early vegetative. In every case, decline in average oviposition occurred following day 4. The average rate of oviposition fell to ca. 3 eggs/female on day 10 and remained at a low level thereafter. Peak percentage average oviposition was 23.2, 22.3, 26.0, 26.3, and 23.4, and it occurred at 17, 17, 14, 16, and 20% of the total oviposition period for the respective female populations. Regardless of treatment, ca. 50% of the eggs were laid during the first 5 days after female emergence (20–25% of the female oviposition period). For the respective soybean stages, 90% of the eggs were laid by day 12, 11, 12, 12, and 12.

Soybean phenological stage apparently did not have a marked effect on the distribution of average daily oviposition. Leppla (1976) and Leppla *et al.* (1977) studied velvetbean caterpillar fecundity for adults resulting from larvae reared on artificial diet at 26.7°C and found that peak average oviposition occurred on the fourth day post-emergence. Our populations peaked on the fifth day. Also, we obtained mean oviposition values much higher than the 402 eggs/female they reported.

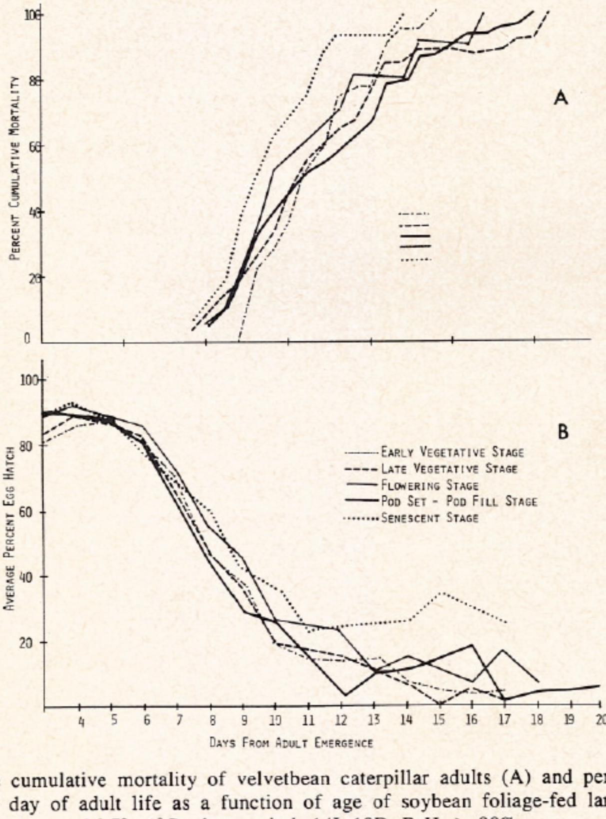

FIG. 3. Percentage cumulative mortality of velvetbean caterpillar adults (A) and percentage egg hatch (B) daily for each day of adult life as a function of age of soybean foliage-fed larvae. Temperature, 26.7°±1°C; photoperiod, 14L:10D; R.H. > 80%.

Percentage average egg eclosion, as a function of female age, showed progressive decline for all treatments (Fig. 3A). Initial values of 81 to 90% remained high through day 6 but sharply decreased to ca. 15% by day 11 post-emergence. Thereafter, egg fertility remained at a low level. Also, females corresponding to senescent stage foliage died at a faster rate and reached 100% mortality sooner than the others (Fig. 3B). However, as discussed previously (Table I), results for the senescent stage differed significantly (α = .05) only from those corresponding to late vegetative and flowering stages.

We found early phenological stages of soybean to be the best food for developing larvae and subsequent adults. However, in Florida (Strayer 1973) and South Carolina (Turnipseed 1973), the annual occurrence of velvetbean caterpillar in significant numbers most frequently coincides with the flowering stage. Perhaps the moths are unable to disperse northward as rapidly as the plants mature, or maybe nectar utilized by the adults is more abundant in older plants. Unfortunately, winter survival and the mechanisms controlling dispersal of this insect are not well understood (Barfield and Stimac in press). Reports by Watson (1916) and Buschmann *et al.* (1977) indicate that velvetbean caterpillar apparently survives the winter on non-agricultural host plants in south Florida, but no one has determined the basic host plant - insect relationships. It is assumed that the natural scattering and possibly low nutritional value of these plants would preclude rapid development of migratory populations. However, as the soybean is planted further south in Florida, these relationships might be altered.

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