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Effects of different host-plant species on growth, development and feeding of the bud borer, *Epinotia aporema* (Lepidoptera: Tortricidae) in La Plata, Argentina

Efectos de diferentes especies de plantas hospederas en el crecimiento, desarrollo y alimentación del barrenador del brote, *Epinotia aporema* (Lepidoptera: Tortricidae) en La Plata, Argentina

PATRICIA C. PEREYRA and NORMA E. SANCHEZ

Centro de Estudios Parasitológicos y de Vectores (CEPAVE), UNLP - CONICET 2 N° 584 (1900) La Plata, Argentina
E-mail: postmaster@cepave.edu.ar

ABSTRACT

The oligophagous bud borer, *Epinotia aporema* (Walsingham) feeds on the Leguminoseae and is a major soybean pest in South America. The effects of different legumes (broad-bean, common bean, lupine, soybean and white sweetclover) on the developmental time, pupal weight, and nutritional indices for last instar larvae of *E. aporema* were analyzed in the laboratory. Nutritional indices include: relative consumption rates on dry and fresh weight basis, relative growth rate, gross and net efficiencies of conversion of food into biomass, and approximate digestibility. The relationships between leaf water content of the host plants and, consumption rate and net efficiency of conversion were examined. *Epinotia aporema* performed better when fed legume plants other than soybean. Those reared on broad-bean and common bean reached a higher efficiency of conversion and a higher pupal weight, consuming at a lower rate, compared with larvae fed soybean. Soybean and white sweet-clover, with a low water content, could be considered sub-optimal host-plants: *E. aporema* consumed them at a higher rate, both on dry and fresh weight. Results suggest that trap crop techniques using more suitable host plants than soybean should be considered for the management of this pest in soybean agroecosystems.

Key words: microlepidoptera, *Glycine max*, insect feeding indices, insect-plant interactions, soybean pests.

RESUMEN

El barrenador del brote *Epinotia aporema* (Walsingham), es una especie oligófaga que se alimenta de leguminosas y una de las principales plagas de la soja en América del Sur. Se analizó el efecto de diferentes leguminosas (soja, haba, poroto, lupino y melilotus) sobre el tiempo de desarrollo, peso pupal e índices nutricionales (tasas relativas de consumo seco y fresco, tasa relativa de crecimiento, eficiencias bruta y neta de conversión de alimento en biomasa, y digestibilidad aproximada) en el último estadio larval. El contenido de agua de las plantas hospederas fue relacionado con la tasa de consumo relativa y la eficiencia neta de conversión de alimento en biomasa. *Epinotia aporema* se desempeñó mejor al alimentarse con leguminosas diferentes de la soja. Las larvas criadas con haba y poroto, en contraposición a las criadas con soja, alcanzaron una mayor eficiencia de conversión y un mayor peso pupal, consumiendo a una tasa menor. Soja y melilotus, con menor contenido de agua, resultaron alimentos "subóptimos", y fueron consumidos por *E. aporema* a una mayor tasa, tanto en peso seco como en peso fresco. Los resultados sugieren que debería considerarse el uso de cultivos trampa de alguna leguminosa más adecuada que la soja para el manejo de esta plaga en el agroecosistema de la soja.

Palabras clave: microlepidoptera, *Glycine max*, índices nutricionales en insectos, interacción insecto-planta, plagas de la soja.

INTRODUCTION

The budborer *Epinotia aporema* (Walsingham 1914), is an oligophagous species of neotropical origin that colonized soybean when this crop was introduced into the new world (Correa Ferreira 1980, Kogan 1981, Ripa 1983). In addition to soybean, *E. aporema* feeds on many other natives and cultivated Leguminoseae, such as peanut,

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clover, alfalfa, pea, lotus, melilotus, lupine, broad-bean and common bean (Olalquiaga Fauré 1953, Caballero 1972, Correa Ferreira 1980, Kogan 1981, 1991).

Insects related to soybean in the Neartic and Neotropical Region are secondarily associated to this host-plant of oriental origin (Kogan & Cope 1974, Kogan 1981, 1986). In Argentina, soybean has been recently established, and the success and relative importance of *E. aporema* as a soybean pest, among several other factors, may depend on the presence and availability of other legume hosts.

Epinotia aporema undergoes four to five generations per year (Correa Ferreira 1980). At least two of them occur on soybean, and the others on different legume host plants. Larvae of *E. aporema* feed mainly on vegetative buds and can also bore into stems, floral buds, and pods. The damage caused to the buds is easily recognized since larvae attach the leaflets to one another, and persist among them until they pupate in the soil, making chemical control very difficult. Diapause seems to occur during the larval stage. Although preferred feeding sites are pubescent buds, most of the eggs are laid on glabrous nodes of the soybean plant (Pereyra et al. 1991, Sánchez et al. 1991).

Growth, development and reproduction of herbivores depend, among other factors, on the quantity and quality of vegetable food consumed. Leaf water content of the host-plants also plays a key rol affecting the herbivorous performance, and may influence consumption rates (Scriber & Slansky 1981). Information on the consumption and utilization of food, and on patterns of insect pests association to specific host-plants is essential for the development of effective management programs for pests species (Tabashnik & Slansky 1987). Strategies employing more natural and less environmentally disruptive tactics are needed to avoid the problems resulting from the pesticides used to control *E. aporema*. There are some studies on the biology (Caballero 1972, Morey 1972) and ecology (Pereyra et al. 1991, Sánchez et al. 1991, 1997) of *E. aporema* but information about nutritional ecology and suitability of different host-plants is lacking.

The purpose of this research was to determine the effect of soybean and other legume species on growth, development, and feeding of *E. aporema* in the laboratory, since this knowledge may help to develop more effective control strategies.

MATERIALS AND METHODS

Host-plants used in the experiments were: lupine (*Lupinus albus* L.), common-bean (*Phaseolus vulgaris* L.), broad-bean (*Vicia faba* L.), white sweet-clover (*Melilotus alba* Desr.) and soybean (*Glycine max* (L.) Merrill. var. Hood). Freshly collected buds from plants in the vegetative growth stage were brought from field plots near La Plata (Buenos Aires Province, Argentina).

To assess the effect of the host-plant species on growth and development of the budborer, we used a completely randomized design with newly hatched larvae of both sexes, reared on the host-plants used in the experiments, under a 16 L: 8 D photoperiod and a temperature of 25 ± 2 °C. For each individual that survived to pupation, we recorded the developmental time (days from hatch to pupation) and the pupal fresh weight at 48 h. Effects of host plants on growth and development were analyzed using ANOVA and all means were compared using Tukey's test (Sokal & Rohlf 1995).

Nutritional indices were measured through newly-molted larvae of the last-instar (5th) that were kept individually in Petri dishes (10 cm diam.). Moist filter paper was placed in the bottom of each dish and each larva was fed with the same plant species as the previous instars. Unequal numbers of larvae were used for each treatment (host-plant); fresh initial weight of larvae and food were measured. The following consumption, growth and food utilization indices (Waldbauer 1968, Scriber 1977) were calculated on a dry weight basis for a 48 h period:

Relative Consumption Rate (RCRd) = mg biomass ingested / mg larval biomass / day

Relative Growth Rate (RGR) = mg biomass gained / mg larval biomass / day

Efficiency of Conversion of Ingested Food (ECI) = (mg biomass gained / mg food ingested) x 100

Efficiency of Conversion of Digested Food (ECD) = (mg biomass gained) / (mg food ingested - mg feces) x 100

Approximate Digestibility (AD) = (mg food ingested-mg feces) / (mg food ingested) x 100.

Uneaten leaf material, larvae and feces were dried (60 °C) during 72 h, and weighed. Dry / fresh weight ratios necessary for calculating initial dry weights, were based on 5 control larvae and 5 control leaves per host-plant. The mean larval dry weight was calculated as the average of the initial and final weights.

Relative consumption rate (RCRf) (mg f / mg d / day) was also calculated on a fresh weight basis. Effects of host plants on RCRd and RCRf were analyzed using ANOVA and all means were compared by Tukey's test (P = 0.05) (Sokal & Rohlf 1995).

When data of nutritional indices (ECI, ECD and AD) did not conform to the assumptions of ANOVA, analogous non parametric test (Kruskal-Wallis, P = 0.05) were used for host effect and means were compared by pairs of host-plants (Mann Whitney U test, P = 0.05) (Sokal & Rohlf 1995).

The mean water contents (%) of 5 buds of each host-plant were estimated after drying the samples for 72 h at 60 °C. To assess the relationship between consumption and amount of water of the leaves, we first used one-way ANOVA to compare the water content of the five legumes. We then calculated the regression of the relative consumption rate (RCRd) and net efficiency of conversion (ECD) on the water content of the leaves.

RESULTS

Pupal weights were significantly higher on common bean and broad-bean than on soybean, lupine and sweet-clover (ANOVA: F = 44.57; d.f.= 4, 89; P < 0.001) (Table 1). Developmental time was shortest for larvae reared on common bean and broad-bean, and longest for those reared on soybean (ANOVA: F = 3.916; d.f.= 4, 89; P < 0.006) (Table 1).

Consumption (RCRd) was significantly higher in larvae fed on soybean and white

TABLE 1

Pupal weight (mg) and developmental time (days) ($\bar{X}$ ± S.E.) of *E. aporema* fed with different legume host-plants.

Peso pupal (mg) y tiempo de desarrollo (días) ($\bar{X}$ ± E.E.) de *E. aporema* alimentada con diferentes leguminosas hospederas.

Host-plant	n	Pupal weight	Developmental time
soybean	15	7.89 ± 0.45 b	17.20 ± 0.26 a
lupine	15	9.26 ± 0.55 b	16.13 ± 0.40 ab
common bean	15	13.75 ± 0.37 a	15.13 ± 0.41 b
broad-bean	22	14.34 ± 0.44 a	15.45 ± 0.41 b
w. sweet-clover	27	9.51 ± 0.33 b	16.15 ± 0.31 ab

Means with the same letter in a column are not significantly different (P < 0.05, ANOVA and Tukey test).

sweet-clover, and lower on lupine, common bean and broad-bean (ANOVA: F = 9.682; d.f.= 4, 53; P < 0.001 and Tukey test) (Table 2). Relative consumption rate (RCRf) measured on a fresh weight basis, showed the same pattern as RCRd did, except for broad-bean. Larvae fed this host-plant had statistically equal fresh consumption rate than those fed white sweet-clover (ANOVA: F = 3.08; d.f.= 4, 53; P < 0.023 and Tukey test) (Table 2).

Larvae of *E. aporema* grew (RGR) slower when fed with white sweet-clover (Kruskall-Wallis: H [4, N = 58] = 14.278, P < 0.006) compared with those reared with common bean, lupine and broad-bean. However, white sweet-clover does not differ from soybean (Mann Whitney "U" test) (Table 3).The gross

TABLE 2

Relative dry (RCRd) and fresh (RCRf) consumption rates ($\bar{X} \pm$ S.E.) for last instar larvae of *E. aporema* fed five legume host-plants.

Tasas relativas de consumo seco (RCRd) y fresco (RCRf) ($\bar{X} \pm$ E.E.) del último estadio larval de *E. aporema* alimentadas con las cinco leguminosas hospederas.

Host-plant	n larvae	RCRd	RCRf
soybean	8	6.83 ± 0.59 a	27.56 ± 3.22 a
lupine	10	3.07 ± 0.26 b	17.10 ± 1.45 b
common bean	9	3.28 ± 0.22 b	17.51 ± 1.18 b
broad-bean	11	3.47 ± 0.39 b	21.26 ± 2.81 ab
w. sweet-clover	20	5.23 ± 0.48 a	19.28 ± 1.57 ab

Means with the same letter in a column are not significantly different (P < 0.05, ANOVA and Tukey test).

TABLE 3

Relative growth rate (RGR) and food utilization indices ($\bar{X} \pm$ S.E.) for last instar larvae of *E. aporema* fed five legume host-plants.

Tasa de crecimiento relativo (RGR) e índices de utilización del alimento ($\bar{X} \pm$ E.E.) de las larvas del último estadio de *E. aporema* alimentadas con las cinco leguminosas hospederas.

Host-plant	n	RGR	ECI (%)	ECD (%)	AD (%)
soybean	8	0.50 ± 0.06 ab	8.12 ± 1.72 c	15.51 ± 6.13 bc	66.12 ± 5.07 b
lupine	10	0.57 ± 0.04 a	10.47 ± 1.01 b	31.59 ± 3.76 a	60.70 ± 4.93 b
common b.	9	0.60 ± 0.03 a	18.72 ± 1.40 a	37.13 ± 5.32 a	54.16 ± 3.83 b
broad-b.	11	0.51 ± 0.07 a	18.68 ± 2.74 a	39.13 ± 8.94 a	60.77 ± 6.05 b
w.sweet-cl.	20	0.42 ± 0.02 b	8.45 ± 0.58 bc	9.69 ± 0.78 c	88.80 ± 1.13 a

Means with the same letter in a column are not significantly different (P < 0.05, Kruskall-Wallis test and Mann Whitney "U" test).

efficiencies of conversion of food into biomass (ECI) were higher for individuals fed common bean and broad-bean (Kruskall-Wallis: H [4, N = 58] = 24.918, P < 0.001 and Mann Whitney "U" test), and lower for those fed soybean. The net efficiencies of conversion of food into biomass (ECD) were higher for individuals fed common bean, lupine and broad-bean (Kruskall-Wallis: H [4, N = 58] = 29.614, P < 0.001) and lower for those reared with soybean and white sweet-clover. Soybean and white sweet-clover do not differ significantly (Mann Whitney "U" test) (Table 3). White sweet-clover was significantly more digestible (AD) than other plants (Kruskall-Wallis: H [4, N = 58] = 32.206, P < 0.001 and Mann Whitney "U" test).

Water content was higher in broad-bean and lupine, and lower in soybean and white sweet-clover (ANOVA F = 26.06, d.f.(4, 26), P < 0.001) (Table 4). This variable was positively correlated with the net conversion efficiency (ECD) (r = 0.94, b ± S.E. = 2.05 ± 0.435, P = 0.018, n = 5) and negatively related to consumption (RCRd) (r = - 0.85, b ± S.E. = - 0.23 ± 0.08, P = 0.065, n = 5).

DISCUSSION

Although *Epinotia aporema* is an important soybean pest in Argentina and Brazil (Rizzo 1972, Aragón 1979, Calderón & Foerster 1979, Correa Ferreira 1980), this study showed that soybean could be considered a sub-optimal host-plant. This could be probably due to nutritional defficiencies or toxic allelochemicals, since larvae fed soybean had the longest developmental time, a lower efficiency of conversion of food into biomass, as well as produced the smallest pupae.

Larvae fed soybean and white sweet-clover consumed at a higher rate (RCRd) than those fed on lupine and beans, counter-balancing the lower efficiency of conversion of food into biomass, and in consequence a lower relative growth rate. Leaf water content, considered a key nutrient for growing insects (Scriber 1977, 1978, Scriber & Slansky 1981), was lower in soybean and white sweet-clover compared with other host plants. Larvae of *E. aporema* consumed host-plants of lower water content at a higher rate.

Efficiency of conversion of digested food into biomass (ECD) was closely related to the percentage of water of the host plants. Relative growth rate (RGR) depends in part upon the net efficiency (Slansky & Rodríguez, 1987), then the amount of water of the leaves seems to affect the performance of this insect. Increased food consumption, either by increasing feeding rates or prolonging the

TABLE 4

Leaf water content (%) of the five legumes ($\overline{X}$ ± S.E).

Contenido de agua (%) de las cinco leguminosas ($\overline{X}$ ± E.E.).

Host-plant	n	percentage of water
soybean	5	72.36 ± 0.72 c
lupine	8	82.22 ± 1.34 ab
common bean	5	79.88 ± 0.73 b
broad-bean	8	85.59 ± 0.87 a
w. sweet-clover	5	71.90 ± 0.84 c

Means with the same letter in a column are not significantly different (P < 0.05, ANOVA and Tukey test).

feeding period, is a common response of forb eaters to suboptimal nutrient levels in foliage (Tabashnik & Slansky 1987).

An increased feeding to obtain additional water when dietary moisture levels decline is a response apparently lacking in most lepidopterous larvae (Slansky 1993). However, *E. aporema* eats at a higher rate as water content decreases. This should not be considered as a compensatory behavior, which is defined as an increase in fresh weight food consumption in association with a decrease in the proportion of dry weight of the leaves (Slansky 1993).

Consumption calculated on a fresh weight basis, gives a more general understanding of the feeding behavior of *E. aporema* and a more realistic measure of the amount of food actually consumed and processed. These values indicate that larvae of *E. aporema* consume between 17 and 27 times, their own dry weight of lupine and soybean leaves per day, respectively. Values of other legumes tested fall within this range.

Relative consumption rate of larvae fed soybean, measured on a fresh basis (RCRf), is 4 - fold greater than RCRd, and for all the legume species tested, RCRf were 3.7 to 6.1 - fold greater than RCRd. Considering that high consumption rates are of great importance from an economic point of view, this knowledge may contribute in assessing the impact of insect feeding, and therefore, to determine more precise economic thresholds for this pest.

Approximate digestibility (AD) and net efficiency (ECD) are inversely related (Waldbauer 1968, Scriber & Slansky 1981) and this is demonstrated when larvae fed white sweet-clover. Lower efficiencies of conversion of food into biomass (ECI and ECD) in white sweet-clover was compensated by a higher AD.

Although preferences for different host-plants were not measured in this study, performance and preference are variables often positively correlated (Crawley 1983). *Epinotia aporema* may show some preference for particular host-plants, depending on the temporal and spatial availability of those plants.

Successful management of *E. aporema* requires knowledge of the factors influencing its food consumption and growth. Pest performance could be altered to our benefit by taking appropiate actions to produce pest population changes. For example, understanding the relationships between the attributes of crop plants, their consumption and utilization, and pest performance, is a prerequisite for the development of host-plant resistance (Slansky 1993), and cultural control techniques such as trap crops with a long history of successful use (Newsom et al. 1980). Larvae of *E. aporema* reared on legumes like common bean, broad bean and lupine, performed better than those fed soybean. These more suitable host-plants might be useful as trap crops to draw *E. aporema* away from soybean. Early planting and maturing legume trap crops in small patches, could be tested at grower-scale field trials for attracting and concentrating populations of *E. aporema*. The purpose should be to effectively reduce immigration of the pest to the soybean by appropiately timed insecticide applications to the trap crop. Those trap crops could become a preventive control strategy, economically and ecologically acceptable and highly compatible with other components of an integrated pest management of this pest.

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