BIOLOGY AND OVIPOSITION BEHAVIOR OF *CYDIA FABIVORA* (LEPIDOPTERA: TORTRICIDAE) IN SOYBEAN ON ECUADOR'S COASTAL PLAIN

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ABSTRACT

Cydia fabivora (Meyrick) is a neotropical pod and stem borer of common beans, lima beans, and soybeans. All its life stages are larger than those of four similar pod boring olethreutines which do not attack stems of their leguminous hosts. *C. fabivora* completed its life cycle in 29 days in the laboratory at ambient temperature on artificial diet supplemented during the first larval stadium with fresh soybean seeds. Generation time estimated from these results would allow three generations per soybean crop, first in stems and then in seeds. Cage studies showed that before flowering, leaf undersides were the predominant oviposition sites (55%), whereas pods were highly preferred (84%) when available. Flexibility in the use of either stems or pods allowed the insect to maintain itself throughout the crop cycle, increasing the risk to ripening seeds.

RESUMEN

Cydia fabivora (Meyrick) es un barrenador neotropical de tallos y vainas del fríjol y la soya. Todos sus estadíos de vida son más grande en comparación a cuatro barrenadores de vaina similares de la misma subfamilia que no atacan el tallo de sus huespedes leguminosas. *C. fabivora* completó su ciclo biológico en 29 días en el laboratorio a temperaturas ambientales, alimentándose con una dieta artificial suplementada en el primer estadío larval por granos tiernos de soya. Un tal desarrollo en el campo permitiria tres generaciones por ciclo de soya, primero en tallos y luego en vainas. En ensayos de jaula se observó que, antes de la floración, se encontraron más huevecillos (55%) en el envés de la hoja que en otra parte de la planta. Una vez disponibles, las vainas (84%) eran preferidas para la oviposición. Flexibilidad al uso de tallos o vainas permitió al insecto mantenerse durante todo el ciclo del cultivo aumentando el riesgo de daño al grano.

Soybean production has increased in recent years on Ecuador's coastal plain, where over 66,000 ha were planted in 1987 (del Salto & Tschirley 1988). Most of this production is concentrated in the central region within a 50 km of radius of Quevedo, where climatic and edaphic conditions allow 2 to 3 consecutive crops a year, each averaging ca. 2,000 kg/ha. Often, soybean at all stages of development can be found in close proximity. Such intensive cropping practices may have contributed to the increased incidence of certain pests in recent years, including *Cydia fabivora* (Meyrick). This species was first reported attacking stems and pods of soybean on the coast of Ecuador by Páliz & Mendoza (1980). *C. fabivora* is also known as a pest of soybean in other parts of tropical America including Brazil, where it was initially confused with *Epinotia aporema* Walsingham (Tortricidae: Olethreutinae) in many reports (Smith 1978). Forrester (1978) cited data

indicating the pest status of *C. fabivora* and the ineffectiveness of insecticidal control against it.

Laspeyresia fabivora was described by Meyrick (1928) from a single male specimen reared from common bean in Columbia. Synonyms of *C. fabivora* are *L. leguminis* which Heinrich (1943) had described from a series of specimens collected in Peru, Panama, and El Salvador (Clarke 1958), and *Eulia prosecta* Meyrick (Meyrick 1932, Clarke 1972).

Although the species is widespread throughout Central and South America on beans, lima beans, and soybeans (Clarke 1972), little further information exists in the literature aside from brief mention in a review of olethreutines attacking grain legumes (Perrin & Ezueh 1978). The objective of our study was to describe the insect's basic biology including oviposition behavior, because this latter might bear on the eventual site of larval feeding in either stems or pods.

Materials and Methods

All laboratory work was conducted at the Asociación de Productores de Ciclo Corto (APROCICO) in Quevedo, Los Rios Province. Field work was carried out at the Pichilingue experiment station of the National Agriculture and Livestock Research Institute (INIAP), 7 km SE of Quevedo (mean temperature = 24.3 °C, mean RH = 83%). Temperature and humidity, monitored in the laboratory with a mechanical hydrothermograph, averaged 25 C° (SD = 0.8, range = 24°C to 27°C) and 65% RH (SD = 19.3, range =42% to 96%).

Rearing

A small laboratory colony was started from field-collected late instar larvae which were placed in pairs in 59 ml clear plastic cups partly filled with sugarcane borer diet (Bioserve Product "F" 9775). Reared pupae were placed in open petri dishes in rectangular emergence/oviposition cages 35 cm high, by 45 cm square. The cages were framed with lacquered wood, had hardware cloth tops and bottoms and a plywood side fitted with a cloth sleeve and three glass sides. The insides were lined with wax paper for oviposition. Eggs were cut from the lining, disinfected with a spray of 0.16% of benomyl and drained on paper toweling for 5 min. Eggs were held on moistened filter paper inside sterilized, parafilm-sealed glass petri dishes (105 x 15cm) that contained a moistened cotton ball. Neonate larvae were fed fresh young soybean seeds that were replenished every other day. Second instars were transferred with a camel hair brush to 59 ml plastic cups where they were maintained on sugarcane borer diet until pupation. A pinto bean diet (Leppla 1985) was sometimes substituted for sugarcane borer diet in routine colony maintenance. Otherwise, the same methods were employed for biological studies as for routine rearing.

Biology

Head capsule width, egg length and egg width were measured with a stereoscopic microscope fitted with an ocular micrometer. Head capsule size and the presence of exuviae were noted every 12 h to determine the duration of each stadium for 20 individuals which survived from egg to pupa. Larvae were weighed immediately after molting with an electronic analytic balance accurate to 0.1 mg.

Pairs of laboratory-reared moths used to initiate the study were placed in square 450 ml wide-mouth glass jars (height = 15 cm, width = 10 cm) lined with wax paper and closed with nylon netting fastened with a rubber band. Cotton balls soaked in a 3:1

water to honey mixture provided a food source. Eggs were counted, measured and then observed every 12 h to record color changes, viability, and incubation time. Neonate larvae were maintained in groups of fives on fresh soybeans until the first molt and then placed individually in diet cups. Pupae were sexed, measured (length and maximum width), weighed and then placed in pairs on moistened filter paper in 450 ml oviposition jars. Wingspan of adults was measured by spreading the wings on millimeter paper under the microscope. Comparisons between male and female pupae and adults using Student's T-test were made on the basis of 20 randomly chosen individuals of each sex.

Ovipositional Patterns

Six pots, each containing 2 soybean plants of the same age were placed in 1 m^3 wood frame cages covered with wire window screen. There were three cages, one for plants in each of three development stages: vegetative (V8), flowering (R2), and pod-filling (R6) (Fehr & Caviness 1977). Five moth pairs between 2 and 3 days old were released into each cage and left for 48 h, after which the moths were removed and the plants examined for eggs, noting the plant part on which oviposition had occurred.

Field Observations

Affected plant parts were dissected to determine the stage present and the site and extent of damage. Field-collected eggs and larvae were reared in the laboratory as previously described, and parasites collected.

Results and Discussion

Biology

Courtship and copulation took place ca. 48 h post-emergence; the pair assumed an end to end position. Females began ovipositing almost immediately afterward, continuing for 2 to 4 d (mean = 2.6 d, SE = 0.69). Eggs were glued to the substrate, either singly or occasionally in small groups of 2 to 4. Mean egg production was 44 per female (range = 32-56, SE = 1.5). The ventrally flattened eggs measured 0.89 mm in length (range = 0.75-0.95, SE = 0.016) and 0.66 mm in width (range = 0.60-0.75, SE = 0.011), were pale yellow initially and covered with a raised hexagonal reticulation. Red spots appeared below the chorion within 24 h of oviposition. These eventually coalesced to make the entire egg red. Incubation period varied between 4 and 5 d (mean = 4.6 d, SE = 0.05), and viability was 82% (N = 100).

The larval integument was basically without pigment except for the prominent prothorax and heart-shaped head, although neonate larvae were light orange in color. Approximately 48 h of the last larval stadium was spent as a non-feeding prepupa. Length, weight, development time, and head capsule width for the five larval instars are given in Table 1.

The pupa had two conspicuous transverse bands of spines on abdominal sterna 3 through 9. Females were larger and heavier than males (Table 2). The pupal stage was completed in 9.2 d regardless of sex (range = 8-11, SE = 0.24, t = 0.65). Thus the average time from oviposition to adult emergence was 29.2 d (range = 25.5-32.5).

The adult moth has been adequately described elsewhere (Meyrick 1928, Heinrich 1943). Not surprisingly, females were again larger and heavier than males and also survived longer (Table 3). If the midpoint of the adult female stadium (4 d) were assumed to be the ovipositional midpoint, then the average generation time would be 33 d. Given 11 to 120 d from planting to harvest, there could be sufficient time for the completion of three generations per soybean crop.

TABLE 1. MEASUREMENTS OF *C. FABIVORA* LARVAL SIZE AND DEVELOPMENT TIME.

		INSTAR				
		1	2	3	4	5
HEAD	mean	0.34	0.74	1.05	1.4	1.9
CAPSULE	min.	0.30	0.50	0.95	1.2	1.8
WIDTH	max.	0.44	0.90	1.10	1.6	2.0
(mm)	se	0.009	0.02	0.07	0.03	0.13
LARVAL	mean	1.7	5.9	8.8	13.1	17.8
LENGTH	min.	1.5	5.0	7.0	11.0	15.0
(mm)	max.	1.9	6.8	10.0	14.5	20.0
	se	0.29	0.14	0.2	0.20	0.27
LARVAL	mean	1.0	3.1	10.7	50.4	80.8
WEIGHT	min.	0.8	2.5	12.5	44.0	63.0
(mg)	max.	1.2	3.5	8.5	60.0	94.5
	se	0.02	0.054	0.22	0.98	1.95
DEVELOPMENT	mean	3.9	2.2	2.8	2.4	4.1
TIME	min.	3.3	2	2	2	3.5
(d)	max.	4.5	3	3	3	4.5
	se	0.09	0.07	0.06	0.07	0.06

Oviposition Behavior

Oviposition began after ca 48 h. Sixteen percent of the eggs were laid on stems of plants at all three growth stages. In pre-flowering soybean, the remaining eggs were laid predominantly on the undersides of leaves (55%), with leaf uppersides (16%) and petioles (12%) accounting for the rest (Table 3). The same pattern occurred on flowering plants except that flowers received 20% of the eggs at the expense of leaves. At pod-fill, all 84% of eggs not on stems were found on pods. Thus, the preferred oviposition site shifted from leaves to reproductive structures over the course of plant development.

TABLE 2. COMPARISONS BETWEEN *C. FABIVORA* MALE AND FEMALE PUPAE AND ADULTS.

	MEAN		MAX.		MIN.		T[a]	P<
PUPA	♂	♀	♂	♀	♂	♀		
Length (mm)	9.3	10.1	10.5	11.0	6.9	8.9	5.1	0.001
Width (mm)	2.5	2.7	3.0	2.8	1.9	2.5	4.9	0.001
Weight (mg)	40.0	47.5	31.5	33.6	41.5	60.7	5.9	0.001
ADULT								
Length (mm)	7.6	8.8	7	8	8	10	10.1	0.001
Wingspread (mm)	15.8	17.8	17	19	15	19	10.8	0.001
Survivorship (d)	5.2	8.0	7	9	4	7	15.4	0.001

[a]Students T-test used to determine statisitical significance.

TABLE 3. OVIPOSITION BY CAGED *C. FABIVORA* ON SOYBEAN PLANTS OF THREE DIFFERENT AGES.

STAGE	EGGS	LEAF SURFACE UPPER	LEAF SURFACE LOWER	PETIOLE	STEM	FLOWER	POD
PRE-FLOWERING	112	16%	55%	13%	16%	—	—
FOWERING	93	12%	38%	13%	16%	22%	—
POD FILL	104	—	—	—	16%	—	84%

Field Observations

First instar larvae attacking plants in vegetative stages began perforating the stem soon after eclosion, often at the axil of the petiole, causing desiccation of the trifoliate.

TABLE 4. CHARACTERISTICS OF *C. FABIVORA* COMPARED WITH 3 OTHER OLETHREUTINE LEGUME PESTS (AFTER PERRIN & EZUEH, 1978).

	C. nigricana	*C. phychora*	*Leguminovora glycinivorella*	*C. fabivora*
DISTRIBUTION:	Europe N. America	Sub-sahara India	N.E. Asia	Cen. & S. America
HOST RANGE:	peas	common bean lima bean pigeon pea	soybean lupin	common bean lima bean soybean
PART ATTACKED	seed	seed	seed	stem and seed
EGG				
length (mm)	0.75	0.45	0.48	0.89
width (mm)	0.53	0.35	0.35	0.66
incubation (d)	6-8	2-4	7-9	4-5
LARVAL INSTARS[a]:				
length (1) (mm)	1.2	0.7-0.9	0.8-1.1	1.73
length (5) (mm)	12-15	8.5-10.4	6-9.5	15-20
head (5) capsule width (mm)	1.27	0.90	1.07	1.9
duration (d)	19-30	11-14	18-25	13-18
PUPA:				
length (mm)	7-8	6	6-7	8-11
width (mm)	1.6-1.9	1.5	1.8	2-2.9
duration (d)	10-15	5-7	10-13	8-11
ADULT:				
length (mm)	7-8	4-6	7	7-9
wingspan (mm)	11-13	14-16	13-15	15-19
survival (d)	10-12	4-7	10-13	4-9

[a]Numbers in parentheses indicate instar.

Otherwise, the neonate larva penetrated the stem directly, leaving a short encircling mine. The larva spun a silken support and remained in the same stem until development was completed. Boring of the main stem killed small plants.

Attacked pods could be identified by short brownish mines where the first instar larva had passed on its journey to the seed. Silken support webs were also spun in pods, and one or two seeds were consumed during larval development, depending on seed maturity. Some larvae were still feeding at harvest time. Pupae were normally found in thin cocoons at the site of larval development in both stems and pods.

Hymenopteran parasitoids reared from *C. fabivora* included *Trichogramma* sp. (Trichogammatidae) from eggs and *Bracon* sp., *Apanteles* sp., and *Orgilus* sp. (Braconidae) from larvae.

Comparison with Related Species Attacking Legumes

C. fabivora is compared in Table 4 with three other olethreutine species that attack grain legumes (Perrin and Ezueh, 1978). *C. fabivora* stands out by its relatively large size and ability to use both stalks and pods. By feeding on either stems or seeds it could complete three generations per crop cycle and potentially build up large populations that would be difficult to control chemically because of the larva's cryptic habitat. Crop rotation, or at least fallow periods between crops, and uniform planting dates to reduce possible immigration from mature stands to new plantings, would probably provide more effective and economical control.

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POPULATION SUPPRESSION OF MAHOGANY WEBWORM, *MACALLA THYRSISALIS* (LEPIDOPTERA: PYRALIDAE), WITH NATURAL PRODUCTS

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ABSTRACT

In laboratory tests, both Margosan-O, diluted to 20 ppm azadirachtin in water, and Dipel 2X, which contains the entomopathogenic bacterium, *Bacillus thuringiensis* var. *kurstaki* Berliner, at 9,600,000 international units (i.u.)/liter H_2O, applied to foliage of West Indies mahogany, *Swietenia mahagoni* Jacquin, inhibited feeding by young mahogany webworms, *Macalla thyrsisalis* Walker, as measured by differences in growth and in the production of fecal pellets ($P < 0.05$). No clear effect was observed on older larvae. In a field test, the mean number of larvae per tree was reduced 10-fold ($P < 0.05$) ten days after treatments with either 20 ppm azadirachtin in H_2O or *B. t* at 19,200,000 i.u./liter H_2O applied to the foliage of West Indies mahogany. One or more treatments with either of these materials during the spring when mahogany webworms are active on foliage is a suitable method of controlling this pest.

RESUMEN

En pruebas de laboratorio, Margosan-O, diluído a 20 ppm azadirachtin en agua, y Dipel 2X, lo cual contiene el bacterium entomopatogénico, *Bacillus thuringiensis* var. *kurstaki* Berliner, a 9,600,000 unidades internacionales (u.i.)/litro H_2O, aplicado al follaje de caoba antillana, *Swietenia mahagoni* Jacquin, inhibieron la alimentación de larvas de primeros estadíos de *Macalla thyrsisalis* Walker, medida por diferencias en crecimiento y en la producción de pelotillas fecales ($P < 0.05$). No se observó un efecto claro sobre las larvas más crecidas. En un ensayo de campo, el promedio de larvas por árbol fue reducido diez veces ($P < 0.05$) diez días después de tratamientos con azadirachtin a 20 ppm/litro H_2O, o *B. t.* a 19,200,000 u.i./litro H_2O aplicado al follage de caoba antillana. Uno o más tratamientos con cualquier de estos materiales durante la primavera cuando *M. thyrsisalis* es activo sobre el follaje es un método satisfactorio para controlar esta plaga.