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LABORATORY BIOLOGY OF *CHETOGENA SCUTELLARIS* (DIPTERA: TACHINIDAE), A PARASITOID OF NOCTUIDAE, REARED ON FALL ARMYWORM AND CABBAGE LOOPER

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ABSTRACT

The tachinid parasitoid *Chetogena scutellaris* (Wulp) was reared from southern armyworm, *Spodoptera eridania* (Cramer), a new host record. When reared in cabbage looper, *Trichoplusia ni* (Hübner), (a new host) and in fall armyworm, *Spodoptera frugiperda* (J. E. Smith), in the laboratory, *C. scutellaris* developed successfully ca. 30% of the time. Success of parasitism depended on the numbers of eggs laid per host, host age, and host species. Parasitoid development was not synchronized with host development. *C. scutellaris* developed mostly as a solitary parasitoid. Female flies preferred fifth instar hosts for oviposition. Cabbage looper was a better host than fall armyworm for mass rearing of this parasitoid.

Key Words: biological control, parasitoid development, southern armyworm, *Spodoptera frugiperda*, *Spodoptera eridania*, Tachinidae, *Trichoplusia ni*

RESUMEN

El parasitoide taquínido *Chetogena scutellaris* (Wulp) fué criado de *Spodoptera eridania* (Cramer), un nuevo registro de hospedero. Cuando fué criado en el gusano medidor de repollo, *Trichoplusia ni* (Hübner), (un nuevo registro de hospedero) y en el gusano cogollero, *Spodoptera frugiperda* (J. E. Smith), en el laboratorio, *C. scutellaris* se desarrolló exitosamente ca. 30% del tiempo. El éxito de parasitismo dependió del número de los huevos puestos en cada hospedero, la edad del hospedero, y la especie del hospedero. El desarrollo del parasitoide no fué sincronizado con el desarrollo del hospedero. *C. scutellaris* se desarrolló principalmente como un parasitoide solitario. Las moscas hembras prefirieron ovipositar en el quinto estadío larval de los hospederos. El gusano medidor de repollo fué un mejor hospedero para criar el parasitoide en masa que el gusano cogollero.

The tachinid fly *Chetogena scutellaris* (Wulp) is largely known by its synonym *Euphorocera floridensis* Townsend (Aldrich & Webber 1924). Two families of Coleoptera (Cerambycidae and Coccinellidae) and 11 families of Lepidoptera (Arctiidae, Citheroniidae, Ctenuchidae, Geometridae, Hesperiidae, Noctuidae, Notodontidae, Sphingidae, Zygaenidae, Pierdae, and Saturniidae) are listed as hosts for this species (Arnaud 1978). *C. scutellaris* was recorded from seven noctuid species that are crop pests: velvetbean caterpillar, *Anticarsia gemmatalis* Hübner; in Georgia, cotton leafworm, *Alabama argillacea* (Hübner), true armyworm, *Pseudoletia unipuncta* (Hawitson.), and corn earworm, *Helicoverpa zea* (Boddie); in North Carolina, green cloverworm, *Plathypena scabra* (F.); in S. Carolina, Florida and Maryland, fall armyworm, *Spodoptera frugiperda* (J. E. Smith); in Mississippi, soybean looper, *Pseudoplusia includens* (Walker). It is also known from Costa Rica and Peru (Arnaud 1978).

In June, 2000, we collected ca. 100 late-instar larvae of southern armyworm, *Spodoptera eridania* (Cramer), from lambsquarters, *Chenopodium album* (L.), in a corn field near Bunnell, Florida. Approximately 25% of late instar larvae had one or more tachinid eggs on their surface, and laboratory colony was established from the resulting *C. scutellaris* adults. Two major noctuid pests were used as hosts: cabbage looper, *Trichoplusia ni* (Hübner), and fall armyworm. This study was conducted to assess the biology of *C. scutellaris* in the laboratory and evaluate its potential for mass rearing.

MATERIALS AND METHODS

Host third-fifth instar larvae were maintained on a pinto bean diet (Guy et al. 1985) and offered in groups of 20-30 larvae to *C. scutellaris* maintained inside 20-cm^3 cages with netting sides. *C. scutellaris* tend to parasitize larger larvae, thus to obtain parasitism in younger larvae they had to be offered separately from the old ones. The time that larvae were exposed to flies varied, though usually flies attack larvae right away, so within an hour larvae were removed and checked for eggs.

Initially, flies were maintained in groups on honey and water, and then some were randomly chosen for the experiments (freshly emerged copulating pairs were carefully removed from the communal cage into solitary ones, insuring that the female is young, mated and that it has a male partner with it for further matings). Parasitized larvae were identified by observing the eggs that were laid on them. Host larvae with one or more tachinid eggs were transferred into individual 200-ml waxed paper cups with plastic lids, supplied with a diet cube, and checked daily for parasitoid emergence. Thus, the development rates from egg to pupa, and from pupa to adult were recorded. The study was repeated three times, using flies and hosts of three consecutive generations. Overall, 705 parasitized larvae were reared individually.

To estimate host age preference, 20 fall armyworm larvae (10 fourth and 10 fifth instar) were exposed for a period of five minutes to several 10-d-old female flies in a similar cage. Larvae were then checked for parasitoid eggs, easily noticeable on the larval surface, to compare egg numbers laid on hosts of different stages. This experiment was repeated 12 times and was analyzed using ANOVA and t-tests ("JMP", SAS Institute 1995). Standard error values are provided for all means.

Results and Discussion

Substantial variation was observed among individual *C. scutellaris* females in their parasitism (emergence of maggot(s)) in hosts of different stages and species (Table 1). Higher percentage of successful parasitism was observed when fifth-instar versus fourth-instar cabbage loopers were attacked (46.5 ± 5% vs. 22.7 ± 4%, $P < 0.05$ (Means ± SD)). In fall armyworm, differences in parasitism were not statistically significant among larval stages. The decline in success of parasitism towards the end of the fourth instar probably should be attributed to moulting prior to hatching of parasitoid eggs. Parasitized third-instar hosts produced no parasitoids in either host species. Thus, majority (close to 70%) of attacked larvae escaped parasitism and developed into healthy adult moths.

In 10 trials of 12, flies parasitized older larvae at a higher rate (fifth instars, 6.6 ± 0.4%; fourth instars, 5.0 ± 0.5%, $P < 0.05$), which suggests that older larvae are preferred for oviposition. The total number of eggs laid also was higher in older larvae (fifth instars, 11.5 ± 1.1 eggs; fourth instars, 6.5 ± 0.7 eggs, $P < 0.05$). The probability of successful parasitism increased from 29 ± 8.2% to 53.1 ± 4.1% ($P < 0.05$), when number of eggs oviposited was more than one per host (Fig. 1). A single maggot emerged from 81% (N = 228) of the hosts, though two-thirds of these hosts had multiple parasitoid eggs laid on them. In 16% of the hosts, two parasitoids per host emerged and, only in 3% of the hosts did three or more (maximum of six) parasitoids emerge. The latter parasitoids were smaller (e.g., the dry weight of an average fly was 10.7 mg, exceeding eight times the weight of a fly that developed gregariously in a group of six (1.3 mg)). When five or six parasitoids came from a single host, half of the flies never emerged from their puparium. Our data concerning influence of host age and number of eggs laid on success of parasitoid development correspond with similar studies on other species of Tachinidae (Konotie & Paolo 1992).

The host stage from which the parasitoid emerged depended on the stage at which it was parasitized. When fourth-instar host larvae were attacked, 85% of maggots emerged from larvae and 15% emerged from pupae (N = 65). In contrast, when hosts were attacked as fifth instars, 13% of maggots emerged from larva while 87% emerged from pupae (N = 139). Thus, this parasitoid's development does not appear to be synchronized with development of its host. *C. scutellaris*' development time from egg to pupa at 21°C was 12.3 ± 0.2 days (N = 145) with no significant difference ($P > 0.05$) found between different hosts. Flies emerged from pupae in 13.3 ± 0.6 days.

C. scutellaris reproduce easily in the laboratory on hosts fed artificial diet. Cabbage looper, a species that has not been previously recorded as a host of *C. scutellaris*, would probably be attacked

Table 1. Successful parasitism of cabbage looper and fall armyworm larvae by *Chetogena scutellaris*.

	Successful parasitism (% ± SE)			
Stage Attacked	Cabbage looper	N	Fall armyworm	N
Early 4th	24.0 ± 5.0	23	49.0 ± 8.4	92
Mid-4th	30.5 ± 4.5	38	—	0
Late 4th	13.5 ± 8.5	30	2.9 ± 1.5	68
Early 5th	48.3 ± 16.3	56	50.0 ± 0.0	16
Mid-5th	47.3 ± 3.9	89	15.0 ± 8.0	93
Late 5th	44.0 ± 12.5	164	31.0 ± 11.6	36
Mean	34.5 ± 8.5	400	29.5 ± 5.9	305

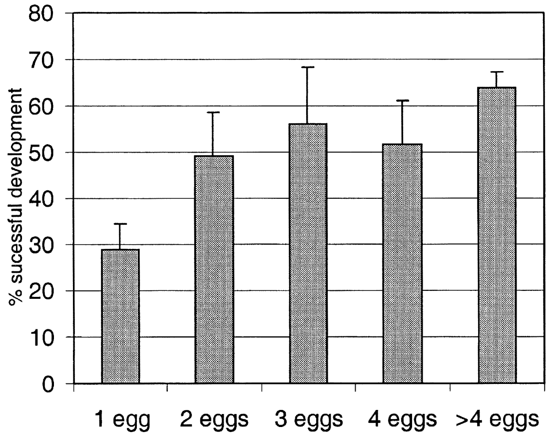

Fig. 1. Success of development of one or more *Chetogena scutellaris* flies in relation to the number of eggs oviposited on a host larva. Increase was significant ($P < 0.05$) when one ($29 \pm 8.2\%$) and more than one ($53.1 \pm 4.1\%$) egg per host was laid.

in the field should both the host and the parasitoid occur synchronously (cabbage looper is mostly a winter pest in the southeastern United States). Field trials are needed to evaluate potential of this species as a biological control agent of noctuid pests. Cabbage looper also proved to be a more convenient host for mass rearing *C. scutellaris.* Cabbage looper larvae make cocoons on top of the cage, while maggots pupate on the bottom where they can be easily collected. In contrast, southern and fall armyworms pupate inside the diet cakes in the laboratory, as in nature they pupate in soil. When these hosts were used, collecting pupae of *C. scutellaris* was labor intensive because they had to be extracted from the diet.

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