[redacted]

Predators of Velvetbean Caterpillar Eggs in Florida Soybeans[1]

L. L. BUSCHMAN,[2] W. H. WHITCOMB,[2] R. C. HEMENWAY,[2] D. L. MAYS,[3] NGUYEN RU,[2] N. C. LEPPLA,[4] AND B. J. SMITTLE[5]

ABSTRACT

The following 20 species were recorded as egg predators of the velvetbean caterpillar, *Anticarsia gemmatalis* Hübner, in Florida soybeans: Orthoptera, *Pictonemobius ambitiosus* (Scudder); Dermaptera, *Labidura riparia* (Pallas), *Doru taeniatum*, (Dohrn); Hemiptera, *Orius insidiosus* (Say), *Nabis deceptivus* Harris, *Nabis capsiformis* Germar, *Nabis roseipennis* Reuter, *Pachybrachius bilobatus* (Say), *Spanogonicus albofasciatus* (Reuter), *Halticus bractatus* (Say); Coleoptera, undetermined coccinellid larva; Neuroptera, *Chrysopa rufilabris* Burmeister, *Chrysopa* sp., Formicidae, *Pheidole dentata* Mayr, *Conomyrma flavopecta* (M. R. Smith), *Solenopsis geminata* (Fabr.), *Solenopsis invicta* Buren, *Cardiocondyla nuda minutior* Forel, *Monomorium viridum* Brown; Arachnida, *Chiracanthium inclusum* (Hentz).

Egg predators were identified during continuous diurnal observation of eggs placed in the field and by recovering radioactive predators after placing ^{32}P labeled eggs in the field. Ants and earwigs were recorded as egg predators most frequently during continuous observations. Nabids, chrysopids, and spiders were recorded as egg predators most frequently while using the radioactive tracer. The mean rate of predation on the *A. gemmatalis* eggs placed in the field for 24 h was 26%. Twelve species of predators were observed attacking 1st instars of *A. gemmatalis*.

Whitcomb (1974) estimated that over 1000 species of arthropod predators could be found in Florida soybeans. To study the role of these predators in suppressing pest populations it is necessary to first identify the predators that attack the important pest insects. Predators of specific target insects are usually identified by accumulating incidental field observations or by conducting laboratory feeding tests with suspected predators. Such data are often incomplete and misleading, since many important predators go unnoticed and quantitative data are missing. Greater effort and more specific and quantitative techniques are needed to gain more complete information on predators that attack specific insect pests.

Whitcomb and Bell (1964) and Whitcomb (1967) recorded 28 species of predators of bollworm eggs, *Heliothis zea* (Boddie), during continuous observations of eggs in Arkansas cotton. Other investigators have recorded predators by placing radioactive prey in the field and recovering radioactive predators (Baldwin et al. 1955, Delucchi et al. 1975, Frank 1967). In this study, both continuous observations and radioactive tracers were used to identify the predators of eggs of the velvetbean caterpillar (VBC), *Anticarsia gemmatalis* Hübner.

[1] This publication was supported in part by the National Science Foundation and the Environmental Protection Agency, through a grant (NSFGB-34718 later known as BMS 75-04223), to the University of California. The findings, opinions, and recommendations expressed herein are those of the authors and not necessarily of the University of California, NSF, or EPA. Received for publication Nov. 30, 1976.

[2] Dept. of Entomology and Nematology, University of Florida, Gainesville 32611. Florida Agricultural Experiment Station Journal Series No. 305.

[3] 3110 N.E. 13th Street, Gainesville, FL 32601.

[4] USDA-ARS Insect Attractants, Behavior and Basic Biology Res. Lab., Gainesville, FL 32604.

[5] USDA-ARS Insects Affecting Man and Animals Res. Lab., Gainesville, FL 32604.

Methods

In 1973, we observed and recorded egg predators of VBC eggs in 3 insecticide-free 0.4-ha plots, in a 4.8-ha field of "Hutton" soybeans. In 1974, we worked in an insecticide-free 0.2-ha field of "Bragg" soybeans. Both fields were in Alachua County, FL.

About 30 pairs of VBC moths, reared according to the methods of Green et al. (1976) at the Insect Attractants, Behavior, and Basic Biology Research Laboratory, Gainesville, FL, were maintained in a 50×45×45-cm plexiglass oviposition cage. Each day, 3–4 potted greenhouse or field-grown soybean plants were placed in the oviposition cage. The plants had been washed. The moths oviposited 50–400 eggs on each plant during the night. In the morning the egg-laden plants were used for field experiments.

Once each week, mid-July–early-Oct., 3 egg-laden plants were placed in the field for continuous observations. The pots were buried 30 cm apart in a row of soybeans. The eggs and a few 1st instars on these plants were observed in 2-h shifts by observers for predator activity 0600–1800 h (EDT). The predators that attacked eggs or larvae were collected for identification after they had finished feeding.

The rate of predation on the VBC eggs was measured once each week by placing 3 egg-laden plants, with 50 or 100 marked eggs in the field. In 1973, one plant was placed in each of the 3 plots, but in 1974, plants were placed in 3 locations in the field. After 24 h, the plants were returned to the laboratory and the condition of each egg was recorded as healthy, collapsed, chewed, or missing. When possible this procedure was repeated on a 2nd day so that a total of 6 egg-laden plants was exposed for 24 h each week. The Kruskal-Wallis test and the Wilcoxon Two-Sample test (Sokal and Rohlf 1969) were used to locate significant differences among weekly predation rates.

Predator populations were monitored in 1973 by making weekly midday shake-cloth surveys as described by Boyer and Dumas (1963). Each week, 9.0 m (30 ft) of row were sampled in each of the 3 plots by this method.

The number of *Labidura riparia* (Pallas) present on soybean foliage at different times of the day was determined in the following manner. A 0.9×0.9-m cloth kept flat by diagonal braces was placed next to the plants in a row of soybeans. The soybean foliage was shaken over the cloth and the dislodged earwigs were counted. A total of 9.0 m (30 ft) of a row selected at random in each of 3 plots was sampled at 11 predetermined times on 3 occasions (Sept. 26, Oct. 3 and 11).

Each week in 1974 ca. 25, 5-day-old VBC moths were placed in a 4-liter paper container. The container was covered with organdy and the moths were allowed to feed ad lib. on 50 ml of sugar solution containing 0.2 millicuries of $H_3{}^{32}PO_4$. To prevent surface contamination of the moths the solution was presented in a plastic cup, 2 cm deep and 6 cm diam, covered with a carefully fitted and perforated styrofoam float. The radioactive moths were transferred to an oviposition cage and allowed to oviposit on 3–6 potted soybean plants. Moths were transferred daily to a clean oviposition cage containing a new set of plants to avoid infesting the plants with radioactive 1st instars hatching from eggs laid on the cage walls. Each day the plants were removed from the oviposition cage, the eggs on each plant were counted and a sample was checked for radioactivity. When 90% of the eggs were radioactive and there were 20–300 eggs/plant (4 or 5 days after ^{32}P feeding), the plants were used for field experiments. The daily mean radioactivity of individual eggs ranged from 555–3817 cpm (0.0025–0.017 microcuries) and was measured in an end-window GM counter.

The radioactive-egg-laden plants were placed in 2–3 locations in the field. The pots were buried and the foliage was incorporated into the canopy of the field soybeans. When it rained, the plants were removed to avoid contaminating the field. After 24 h of field exposure, the plants were returned to the laboratory and the remaining eggs were counted. The Kruskal-Wallis test and the Wilcoxon Two-Sample test were used to locate significant differences among weekly rates of predation.

Potential radioactive predators were collected (1) in 3 pitfall traps (buried pint and quart jars) installed 30 cm from the base of each radioactive-egg-laden plant for the 24 hr the radioactive eggs were in the field, (2) by extensive vacuum sampling of the surrounding soybeans with a D-vac® in the afternoon and at dusk the day the radioactive-egg-laden plants were removed, and (3) during 5–8 inspections of the radioactive-egg-laden plants made during the afternoon, evening, and morning hours. The arthropods in the pitfall traps were examined for radioactivity with a portable Geiger counter. The insects in the vacuum samples were immediately anesthetized with CO_2 and frozen to prevent secondary predation. The radioactive insects were then sorted from the samples with the aid of a portable Geiger counter. Arthropods encountered on the egg-laden plants were observed to verify egg predation. They were then collected in individual vials and their radioactivity determined without killing them so that they could be reared to adulthood for positive taxonomic identification. The end-window GM counter was used to determine counts/min for all radioactive arthropods. The maximum number of eggs taken by the radioactive predators was estimated by dividing the predator cpm by the mean egg cpm; the minimum was estimated by dividing the predator cpm by the upper 95% confidence limit of the egg cpm.

Results and Discussion

During the continuous diurnal observations, 3 species of predators of VBC eggs were recorded during 144 h of observation (12 weekly observations) in 1973, and 10 species of predators were recorded during 120 h (10 weekly observations) in 1974 (Table 1). Two additional species of ants were observed removing VBC eggs from egg-laden plants left in the field for 24 h. Thus, a total of 14 species (33 predators) was recorded.

The following 12 species of predators took VBC 1st instars during the continuous observations (number of larvae taken in parenthesis): *Labidura riparia* (Pallas) (16 larvae), *Geocoris punctipes* (Say) (1 larva), *Calleida decora* (Fabr.) (1 larva), *Hippodamia convergens* Gúerin-Méneville (1 larva), *Pheidole dentata* Mayr (2 larvae), *Conomyrma flavopecta* (M. R. Smith) (2 larvae), *Solenopsis geminata* (Fabr.) (2 larvae), *Solenopsis invicta* Buren (1 larva), *Oxyopes salticus* (Hentz) (2 larvae), and *Hentzia palmarum* (Hentz) (1 larva). A *Trichogramma* sp. was observed ovipositing on 2 VBC eggs, and a *Meteorus autographae* Muesebeck parasitized a 1st instar.

The 24-h rate of egg predation on the egg-laden plants averaged 2.7% collapsed, 1.5% chewed, and 22.1% missing, in 1973. The rate of predation before Aug. 20 was significantly lower than during several weeks after that date ($p=0.05$). In 1974, the 24-h rate of predation averaged 1.1% collapsed, 2.0% chewed, and 22.9% missing. The weekly predation data that year was extremely variable and there were no significant differences ($p=0.05$). However, the predation on the radioactive eggs averaged 39.2% and the rate during the 1st 2 wk in Aug. was significantly lower than during several weeks after that date ($p=0.05$). These data indicate that considerable predation occurred on the experimental plants, but this predation occurred on plants having up to 400 VBC eggs/plant.

The population estimates of 2 predators with suck-

Table 1.—Predators of velvetbean caterpillar eggs recorded during diurnal observations in Florida soybeans.

Predator species	1973 Predators observed	1973 Total eggs taken	1974 Predators observed	1974 Total eggs taken
Dermaptera				
Labidura riparia (Pallas), nymph	9	ca. 40	0	0
Doru taeniatum (Dohrn), nymph	0	0	1	67
Hemiptera				
Orius insidiosus (Say), adult	1	1	1	1
Nabis deceptivus Harris, adult	0	0	3	14
Spanogonicus albofasciatus (Reuter), adult	1	2	0	0
Coleoptera				
Lady beetle larva	0	0	1	3
Neuroptera				
Chrysopa sp., larva[a]	0	0	2	38
Chrysopa rufilabris Burmeister, larva	0	0	1	3
Formicidae				
Pheidole dentata Mayr, worker	0	0	3	3
Conomyrma flavopecta (M. R. Smith), worker	0	0	1	1
Solenopsis geminata (Fabr.), worker	0	0	2	2
Solenopsis invicta Buren, worker	0	0	4	4
Cardiocondyla nuda minutior Forel, worker	0	0	1	1
Monomorium viridum Brown, worker	0	0	2	2
TOTALS	11	ca. 43	22	139

[a] This trash-bearing larva is probably *Chrysopa cubana* Hagen, but there is taxonomic confusion in this species group.

ing mouth parts showed a significant linear correlation with the percentage of collapsed eggs ($p=0.05$): *Geocoris punctipes* adults ($r=0.60$), and nymphs ($r=0.82$), and *Nabis* spp. adults ($r=0.69$). *Geocoris* spp. were not vertified as egg predators in these studies. Collapsed eggs represented only 8.6% of the total egg damage. There was no significant linear correlation between the percentage of chewed plus missing eggs and the population estimates of predators that remove eggs or leave egg fragments including *Labidura riparia, Notoxus* spp., *Scymnus* spp., and salticids.

A total of 32 radioactive predators, belonging to 11 species were recovered (Table 2). Chrysopids, nabids, coccinellid larva, *Orius insidiosus* (Say), *Doru taeniatum* (Dohrn)[6], and *Chiracanthium inclusum* (Hentz) were observed feeding on VBC eggs. The highest levels of radioactivity were observed in chrysopids, nabids, and spiders. Three species of radioactive arthropods were considered egg predators even though they could have been contaminated with radioactive excrement deposited on the plants by the radioactive moths. The radioactivity of 2 of the 4 specimens of *Pachybrachius bilobatus* (Say) was considerably less than that of a radioactive egg, but the radioactivity of the other 2 specimens was equivalent to 1–2 radioactive eggs. Since this insect has been observed feeding on lepidopteran eggs in a light trap, it was probable that at least 2 of the 4 specimens fed on the radioactive VBC eggs. The radioactivity of the flea hopper, *Halticus bractatus* (Say), was about equal to that of a single radioactive egg. Since another flea hopper, *Spanogonicus albofasciatus* (Reuter), was a documented egg predator (Neal et al. 1972), it was likely that *H. bractatus* became radioactive by feeding on a VBC egg. The radioactivity of the cricket, *Pictonemobius ambitiosus* (Scudder), was about equal to that of a single radioactive egg. This cricket probably also became radioactive by feeding on a VBC egg, since several other gryllids and tettigoniids have been recorded as egg predators (Whitcomb and Bell 1964).

Table 2.—Radioactive arthropods recovered after ^{32}P labeled VBC eggs were placed in Florida soybean, 1974.

Radioactive arthropods	No. recovered	Total estimated prey taken (eggs)
Orthoptera		
Pictonemobius ambitiosus (Scudder), adult	1	1
Dermaptera		
Doru taeniatum (Dohrn), nymph	1	3–4
Hemiptera		
Orius insidiosus (Say), adult	2	2–3
Nabis deceptivus Harris, nymph	1	2–4
Nabis sp., nymphs[a]	3	34–54
Nabis capsiformis Germar, large nymph	1	6–11
Nabis roseipennis Reuter, large nymph	1	9–14
Nabis sp., nymphs[b]	4	7–13
Pachybrachius bilobatus (Say), adults	4	2–6
Halticus bractatus (Say), adult	1	0–1
Coleoptera		
Undetermined cocconellid larva	1	3–5
Neuroptera		
Chrysopa sp., larvae[c]	8	16–26
Arachnida		
Chiracanthium inclusum (Hentz), immatures	2	31–52
Undetermined immature spiders	2	3–5

[a] These immature nabids are probably *Nabis deceptivus*.
[b] These immature nabids could not be determined to species.
[c] These trash-bearing larvae are probably *Chrysopa cubana* Hagen, but there is taxonomic confusion in this species group.

[6] This earwig was formerly known as *Doru lineare* (Eschscholtz) (Gurney 1972).

The possibility that some predators became radioactive by feeding on other radioactive predators cannot be ruled out; however, it did not appear to be a significant factor in these experiments. There seldom was more than one predator on the egg-laden plants at one time so the chance of 2 predators meeting was small. Among the radioactive predators recovered in these experiments the nabids and spiders were the most likely to be secondary predators. Their status as egg predators would be questioned except that these insects were observed feeding on VBC eggs.

During this 2-yr investigation we recorded a total of 20 species of VBC egg predators in Florida soybeans. Ants and earwigs were recorded most frequently during diurnal observations; chrysopids, nabids and spiders were recorded most frequently when the radioactive tracer was used. These 5 groups of predators were apparently responsible for most egg predation occurring in these soybean fields.

In 1973 we observed an avg of 26% predation on the VBC eggs exposed for 24 h in the field, but observed very few acts of predation during the diurnal observations. Late in the season we observed *Labidura riparia* take eggs in the early morning and late evening hours. These observations suggested that this earwig might be removing eggs at night. Since extensive nocturnal observations were not possible, we conducted additional earwig surveys to determine when the earwigs were present on the soybeans. The number of earwigs on soybean foliage at different times of the day is presented in Fig. 1. *L. riparia* was present on the foliage in larger numbers at night than during the day. Pitfall trap studies by Walker and Newman (1976) also indicate the nocturnal activity of this predator. We believe *L. riparia* was responsible for most of the predation observed in 1973.

There were several interesting new records of egg predation. *Chiracanthium inclusum*, a well known predator in row crops (Peck and Whitcomb 1970) was not previously known as an egg predator. The only spiders previously recorded as predators of lepidopteran eggs were several salticids (Whitcomb and Bell 1964) and *Peucetia viridans* (Hentz) (Madden and Chamberlin 1945). The observed predation by *Pachybrachius bilobatus* was notable since Sweet (1960) reported that most of the lygaeids, except *Geocoris* spp., were seed feeders. *Doru taeniatum, Pictonemobius ambitiosus,* and *Halticas bractatus* were not previously recorded as egg predators under field conditions.

The most effective method of recovering radioactive predators was by repeated visual inspection of the egg-laden plants. Of the 32 radioactive predators recovered, 30 were recovered during inspection and 2 were encountered in the vacuum samples.

Acknowledgment

We thank the following for taxonomic determinations: F. W. Mead and R. I. Woodruff, Fla. Dept. Ag., Division of Plant Industry, Gainesville; Cath-

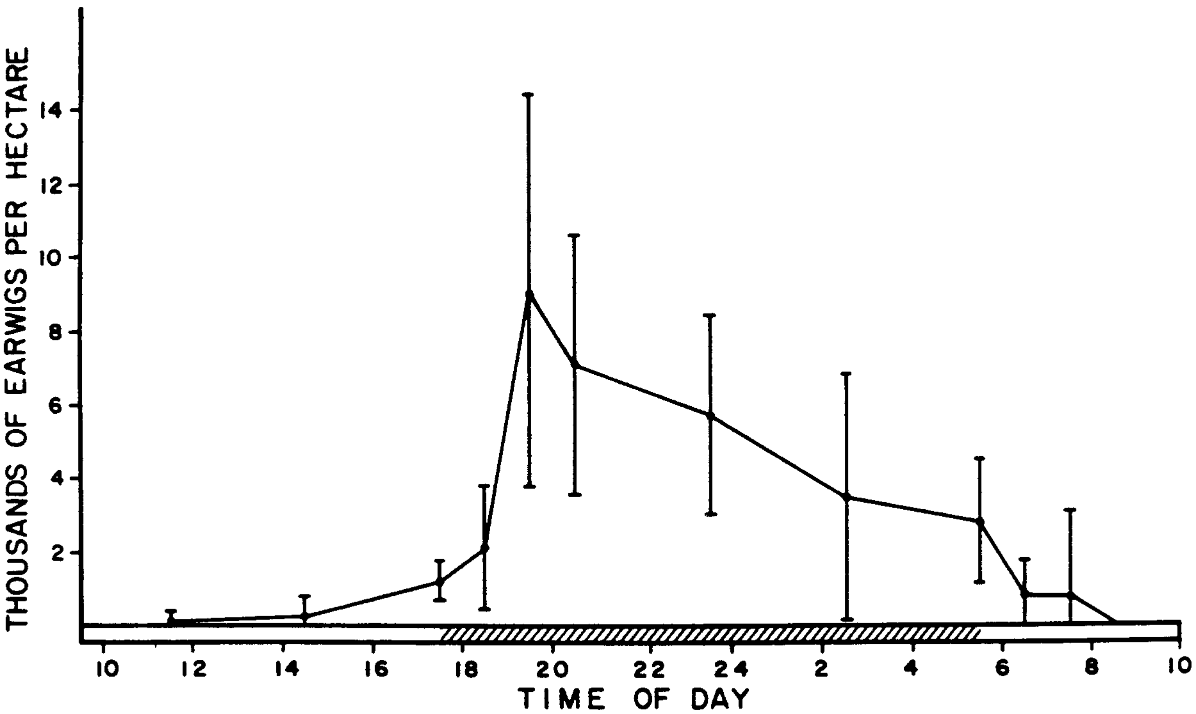

FIG. 7.—Number of *Labidura riparia* (Pallas) on soybean foliage at different times of the day. Data are presented as the mean number of earwigs per ha ± the 95% confidence limits.

erine Tauber, Dept. Entomol., Cornell Univ.; and Wm. F. Buren, Dept. Entomol., Univ. of Florida. We thank Harvey Cromroy for technical assistance.

REFERENCES CITED

Baldwin, W. F., H. G. James, and W. H. Welch. 1955. A study of predators of mosquito larvae and pupae with a radio-active tracer. Can. Entomol. 87: 350–6.

Boyer, W. P., and W. A. Dumas. 1963. Soybean insect survey as used in Arkansas. U.S. Dept. Agric. Coop. Econ. Insect Report. 13: 91–2.

Delucchi, V., J. P. Aeschlimann, and E. Graf. 1975. The regulating action of egg predators on the populations of *Zeiraphera diniana* Guenee (Lepidoptera: Tortricidae). Bull. Soc. Entomol. Suisse. 48: 37–45.

Frank, J. H. 1967. The insect predators of the pupal stages of the winter moth, *Operophtera brumata* (L.) (Lepidoptera: Hydriomenidae). J. Anim. Ecol. 36: 375–89.

Greene, G. L., N. C. Leppla, and W. A. Dickerson. 1976. Velvetbean caterpillar: a rearing procedure and artificial medium. J. Econ. Entomol. 69: 487–8.

Gurney, Ashley B. 1972. Important recent name changes among earwigs of the genus *Dorù* (Dermaptera, Forficulidae). U.S. Dept. Agric. Coop. Econ. Insect Report. 22 (13): 182–5.

Madden, A. H., and F. S. Chamberlin. 1945. Biology of the tobacco hornworm in the southern cigar-tobacco district. U.S. Dept. Agric. Tech. Bull. 896. 51 pp.

Neal, T. M., G. L. Greene, F. W. Mead, and W. H. Whitcomb. 1972. *Spanogonicus albofasciatus* (Hemiptera: Miridae): a predator in Florida soybeans. Fla. Entomol. 55: 247–50.

Peck, William B., and W. H. Whitcomb. 1970. Studies on the biology of a spider, *Chiracanthium inclusum* (Hentz). Arkansas Agric. Exp. Stn. Bull. 753. 76 pp.

Sokal, Robert R., and F. James Rohlf. 1969. Biometry: The principles and practices of statistics in biological research. W. H. Freeman and Co., San Francisco. 387–95.

Sweet, Merrill H. 1969. The seed bugs: a contribution to the feeding habits of the Lygaeidae (Hemiptera Heteroptera). Ann. Entomol. Soc. Am. 53: 317–21.

Walker, J. T., and Gary G. Newman. 1976. Seasonal abundance, diel periodicity and habitat preference of the striped earwig *Labidura riparia* in the Coastal Plain of South Carolina. Ibid 69(4): 571–3.

Whitcomb, W. H. 1967. Bollworm predators in northeast Arkansas. Arkansas Farm Research. 61: 1.

1974. Natural populations of entomophagous arthropods and their effect on the agroecosystem. Pages 150–69 *in* F. G. Maxwell and F. A. Harris, eds. Proceedings of the summer institute on biological control of plant insects and disease. Univ. Press, Jackson, MS.

Whitcomb, W. H., and K. Bell. 1964. Predaceous insects, spiders, and mites of Arkansas cotton fields. Arkansas Agric. Exp. Stn. Bull. 690. 83 pp.

Reprinted from the
ENVIRONMENTAL ENTOMOLOGY