Camponotus a. floridanus is common in slash pine plantations of all ages in Florida where it has been observed to prey on newly-emerged pine sawfly adults (unpubl.), but almost nothing is known about its relation to other slash pine pests. It is recommended that the role of the Florida carpenter ant be investigated to determine if it has potential for management as a control agent.

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EFFECTS OF *HELIOTHIS VIRESCENS*[1] LARVAL SIZE ON PREDATION BY *GEOCORIS PUNCTIPES*[2,3]

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ABSTRACT

The ability of nymphal and adult *Geocoris punctipes* (Say) to successfully attack and kill *Heliothis virescens* (F.) larvae of different sizes was evaluated. Successful predation or prey consumption decreased as larval size

[1]Lepidoptera: Noctuidae.
[2]Hemiptera: Lygaeidae.
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increased, while consumption increased with predator age. First-, 2nd- and 3rd-instar predator nymphs fed on newly hatched, mid, and late 1st-instar *H. virescens* larvae, respectively; 4th- and 5th-instar nymphs and adult predators were able to feed on 1st- to late 2nd-instar larvae. The defensive actions of the larger larvae in response to predator attack were sufficient to prevent predator feeding in some encounters.

A lygaeid bug, *Geocoris punctipes* (Say), is considered to be one of the most important predators of the cotton bollworm, *Heliothis zea* (Boddie) and the tobacco budworm, *H. virescens* (F.). Whitcomb and Bell (1964) regarded *G. punctipes* as a successful predator of *Heliothis* spp. eggs in cotton fields in Arkansas; in small containers in the laboratory this predator consumed substantially large numbers of eggs and/or larvae of *Heliothis* (Whitcomb and Bell 1964, Butler 1966, Lingren et al. 1968, Ridgway and Lingren 1972). The comparative efficiency of *G. punctipes* and several other predators was examined by Lingren et al. (1968) and Lopez et al. (1976).

In Mississippi, *G. punctipes* is abundant in cotton fields during the early growing season (Laster and Brazzel 1968, Dinkins et al. 1970, Smith et al. 1976, Pitre et al. 1978). The ability of this hemipterous predator to successfully attack and kill *H. virescens* larvae is under intensive investigation in our laboratory to obtain information on feeding effectiveness. Mukerji and LeRoux (1969) determined in their work with *Podisus maculiventris* (Say) that prey size can be an important component of the predatory process. Recently, Lawrence and Watson (1979) reported on predator-prey relationships between *G. punctipes* and *H. virescens* which described the 1st-instar nymphs primarily as egg predators and later instars as egg and larval predators. The present study was initiated to obtain additional information on predator feeding and to ascertain the ability of *G. punctipes* nymphs and adults to successfully attack and feed on *H. virescens* larvae of different sizes.

Methods and Materials

The *G. punctipes* used in this study were collected originally on crimson clover, cotton, and soybean in northeastern Mississippi and maintained (or reared) on 1st- to 5th-instar tobacco budworm larvae at 27°C, 16L:8D photoperiod in 3.8-liter cartons. The first 2 instars were offered alive to the predators; 4th- and 5th-instars were killed in boiling water immediately before being placed into the rearing cartons. Green bean sections served as a source of water for the predators (York 1944). Other predator rearing procedures were similar to that described by Champlain and Sholdt (1966). Tobacco budworm larvae were used as prey and as a food source for the stock colony of *G. punctipes*. The prey were maintained on artificial diet (BioMix #FCJ1-724A, Bio Serv, Inc.; New Jersey) in the laboratory.

Each *G. punctipes* nymph or adult was confined alone in a 9 cm plastic petri dish sealed with a piece of transparent polyethylene (Glad Wrap®). Twenty individuals (= 20 replications) were tested for each predator stage. The test was established as a factorial experiment in a randomized block design. Each predator was tested on day 3 after molting from the previous developmental stage. First-, 2nd- and 5th-instar nymphs were ca. 1/3 to 1/2 developed, whereas 3rd- and 4th-instars were ca. 3/4 developed according to Champlain and Sholdt (1967).

Larval size was the basic prey measurement of comparison in this feeding study. *Heliothis virescens* larvae were measured as they were extended while crawling over a mm scale and the larvae of desired length were placed in the dishes before the predators were released. The number of larvae confined in each dish varied based on their size; this number (1 to 15) decreased as larval size increased. Because all predator and prey stages were not available for testing at one time, the study was conducted over a period of several weeks. All 20 replications for any one predator-prey combination were included in one test segment (24 h). First-instar nymphs were tested on larvae of various sizes. The procedure was repeated for 2nd-, 3rd-, 4th- and 5th-instars, and adult male and female *G. punctipes*. The dishes were examined at various intervals to insure that prey were available at all times. The small numbers of larger larvae provided less chance of cannibalism, but adequate food for the predator. Cannibalism was not an obvious factor in this study, although prey mortality in the control dishes without predators was used to correct for natural and/or handling mortality. Dishes were placed in a growth chamber at 25°C with a 16L:8D photoperiod. Larval mortality was recorded 24 h after the predators were released in the dishes.

Results and Discussion

Successful predation on *H. virescens* larvae by *G. punctipes* increased as the predator's age increased (i.e., as the predator developed from early instar nymph through adulthood) and, conversely, *H. virescens* mortality decreased as the size of the prey increased (Table 1). First-instar predators attacked and killed early 1st-instar larvae, but did not kill mid and late 1st-instar larvae. Second-instar predators killed more early than mid 1st-instar larvae, but did not kill late 1st-instar larvae. The 3rd-instar predators killed significantly more early 1st-instar larvae than mid and late 1st-instar larvae, but did not kill early 2nd-instar larvae. A higher percentage of early and mid 1st-instar larvae were killed consistently by 3rd-instar nymphs than by 2nd-instar nymphs, even though the difference was not significant. Fourth- and 5th-instar nymphs, and adult females and males successfully attacked and killed 1st- and 2nd-instar larvae, but did not kill early 3rd-instar larvae. The defensive actions of the larger larvae in response to predator attack were sufficient to prevent predator feeding in some encounters. Lopez et al. (1976) also reported that 3rd-instar nymphs, and adult female and male *G. punctipes* are unable to successfully attack 3rd-instar *Heliothis* larvae. Fourth- and 5th-instars of this predator survived on 3rd-instar *H. virescens* larvae, but with very low ($< 7\%$) survival rates (Lawrence and Watson 1979). These authors reported that percent survival of all nymphal instars of *G. punctipes* declined as the size of the prey increased. They did not separate the different sizes within larval instars, as in the present study.

Adult females killed more 1st- and 2nd-instar larvae than did adult males. The greater consumption by adult females than by adult males may be associated with the greater size of females and their metabolic demands during egg production (Crocker et al. 1975). Fifth-instar nymphs were generally less effective (n.s.) than adult females in killing 1st-instar larvae,

TABLE 1. PERCENT ($\bar{X}$ ± SE) *Heliothis virescens* LARVAE KILLED BY *Geocoris punctipes* NYMPHS AND ADULTS IN 24 H IN THE LABORATORY.

Predator stage*	Larval instar** First			Second		Third
	2†	3	4	5	7	9
Nymphal instar						
First	2.0± .7 a A††	0.0 a B				
Second	5.5±1.2 a A	1.5± .8 a B	0.0 a B			
Third	14.0±2.7 a A	5.5±1.7 a BC	3.1±1.2 a C	0.0 a C		
Fourth	43.1±4.1 b A	42.0±5.8 b A	30.0±3.8 bc B	16.0±3.7 b C	7.5±4.1 a CD	0 a D
Fifth	54.5±6.8 bc A	56.5±4.3 c A	40.1±4.5 cd B	27.1±4.4 bc C	10.0±3.8 ab D	0 a D
Adult						
♀	62.4±6.4 c AB	70.0±6.2 d A	49.5±7.0 d B	33.0±5.9 c C	22.5±5.7 b C	0 a D
♂	41.1±5.7 b AB	51.0±6.3 bc A	21.9±4.9 b CD	32.0±6.2 c BC	10.0±3.8 ab DE	0 a E

*20 replications/predator stage (1 predator/dish).
**Number of larvae (prey) per dish/size of larvae (mm): 15/2 mm, 10/3 mm, 8/4 mm, 5/5 mm, 2/7 mm, 1/9 mm.
†Length of prey within each instar.
††Means (± SE) in column (a, b series) and row (A, B series) followed by the same letter do not differ significantly at P = 0.05 according to Duncan's new multiple range test.

but were more effective than adult males. Adults and 5th-instar nymphs were similar in their ability to kill 2nd-instar larvae.

Geocoris punctipes is apparently limited to feeding on 1st- and 2nd-instars of *Heliothis*. However, based on host suitability studies with the potato tubermoth, *Phthorimaea operculella* (Zeller), Dunbar and Bacon (1972) suggested that *G. punctipes* is basically an egg predator. They reported that eggs were preferred over live insects, and that inactive prey were more suitable than active prey. This is consistent with our observations of limited predation on larger larvae due to the defensive actions of the prey.

Nabis roseipennis Reuter and *P. maculiventris*, 2 relatively large predators, feed on early larval instars of *Heliothis*, but also kill larger, more damaging instars (Lopez et al. 1976, Nadgauda and Pitre 1978). Predators that are limited to feeding on egg and early instar *Heliothis* larvae or similar lepidopterous pests would obviously be most beneficial in the field when large numbers of eggs and small larvae are present. Since prey defense and predator age affect the functional response of predators (Morris 1963), knowledge of the ability of specific predators, e.g., *G. punctipes*, to successfully attack and kill larval prey of various sizes is essential to aid in adjusting predator/prey ratios for making decisions in pest management at the farm level. Additionally, this information should be useful in developing equations of potential predation effectiveness in some dynamic models of *Heliothis* biology.

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RESPONSE OF THE FALL ARMYWORM[1] AND OTHER LEPIDOPTEROUS PESTS OF BOLIVIA TO SYNTHETIC PHEROMONES[2]

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ABSTRACT

Pheromones for the fall armyworm, *Spodoptera frugiperda* (J. E. Smith), and 4 other lepidopterous pest species were field tested for attractancy in Bolivia in February 1978. The fall armyworm in Bolivia responded to the pheromone [(*Z*)-9-dodecen-1-ol acetate] identified for this species in the United States. Positive responses for respective species were recorded also for gossyplure [1:1 mixture of (*Z,Z*)- and (*Z,E*)-7,11-hexadecadien-1-ol acetate], the pheromone for the pink bollworm, *Pectinophora gossypiella* (Saunders); (*Z*)-7-dodecen-1-ol acetate, the pheromone for the cabbage looper, *Trichoplusia ni* (Hübner), and soybean looper, *Pseudoplusia includens* (Walker); and an attractant for the tomato pinworm, *Keiferia lycopersicella* (Walsingham).

The fall armyworm, *Spodoptera frugiperda* (J. E. Smith), female produces a sex pheromone, (*Z*)-9-dodecen-1-ol acetate (Z-9-DDA), (Sekul and Sparks 1976) which is highly attractive to fall armyworm males in the

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[2]This paper reports the results of research only. Mention of a commercial or proprietary product in this paper does not constitute a recommendation or an endorsement of that product by the USDA. Accepted for publication 26 September 1979.

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