ADULT *CALOSOMA SAYI* (COLEOPTERA: CARABIDAE) AS A PREDATOR ON FALL ARMYWORM PUPAE

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ABSTRACT

Pupae of the fall armyworm, *Spodoptera frugiperda* (J. E. Smith), placed on the soil surface or partially buried under laboratory conditions, were readily consumed by adult *Calosoma sayi* DeJean. Predation did not occur when pupation in the soil occurred naturally or when pupae were artificially buried in the soil at various depths.

Key Words: *Spodoptera frugiperda,* ground beetles, predator avoidance.

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INTRODUCTION

The fall armyworm (FAW) *[Spodoptera frugiperda* (J. E. Smith)] is an economic pest of major importance in the United States that migrates northward each year from overwintering sites along the Gulf Coast or further south (Snow and Copeland 1969). This species can overwinter in the pupal stage, and as many as 10 generations per year may occur in southern areas (Luginbill 1928; Vickery 1929). The frequent temporal occurrence and abundance of FAW pupae in these areas, combined with a pupal developmental period of 6 - 45 days (Luginbill 1928), may make pupae of the FAW susceptible to biological control agents.

Biological mortality factors affecting the pupal stage of the FAW are poorly understood. Although FAW egg and larval stages have numerous predators, parasitoids, and pathogens (Luginbill 1928; Ashley 1979; Gardner and Fuxa 1980), until recently pupae have been considered relatively free from direct attack by such organisms. Pair and Gross (1984) have provided indirect evidence of substantial levels of predation (28 - 96%) on several populations of FAW pupae under experimental field conditions, but were unable to assign any portion of that predation to a particular species. One species that may be functioning as a FAW pupal predator is *Calosoma sayi* DeJean, a large (22 - 30 mm), abundant, and widely distributed inhabitant of agroecosystems in the eastern and southern United States (Gidaspow 1959). Species of *Calosoma* are known to be predators of FAW larvae and are believed to strongly influence FAW populations, particularly in the late summer (Luginbill 1928; Hofmaster and Greenwood 1949). *Calosoma sayi* adults can consume noctuid pupae in soybean canopy (Price and Shepard 1978a). Laboratory experiments also have demonstrated that *C. sayi* adults can consume both live and dead FAW pupae on a non-soil surface (Young, unpublished data). It is not known, however, whether *C. sayi* can detect and obtain FAW pupae located below the soil surface.

To be an effective predator on FAW pupae, *C. sayi* adults should be able to: 1) detect pupae below the soil surface and burrow down to capture them, and

2) detect and obtain FAW pupae on or above the soil surface. Typically, FAW larvae burrow into soil at the end of the 5th instar, molt into the 6th prepupal instar, form a pupal chamber, and molt into the pupal stage. The depth of the pupa below the soil surface has been reported to be from 0.5 to 7.5 cm (Chittenden 1901; Luginbill 1928; Wood et al. 1979). Pupae also may occur in the ear, tassel, or whorl of corn (Burkhardt 1952), or at the base of plants or partially covered by dirt clods and rocks (Luginbill 1928). The purpose of this report is to present experimental results defining the ability of *C. sayi* to obtain FAW pupae in the laboratory

METHODS AND MATERIALS

Adults of *C. sayi* were obtained from a walk-in UV-light trap located 6 km NW of Tifton, Tift. Co., GA, during the night of 28 - 29 June 1981. In the laboratory, each beetle was placed in a clear plastic container (17 × 12 × 6 cm) with a tight-fitting lid and moist paper toweling covering the bottom. Beetles were maintained at ambient conditions (ca. 25°C and 75% RH) and exposed to the local photoperiod. Two live laboratory-reared 5th instar (25 - 35 mm) FAW larvae and water mist were added to each container at 2 - 3 day intervals. At the end of a 14 day acclimation period, 20 beetles (10 ♂, 10 ♀) were each placed in separate containers with 3 cm of moistened soil packed in the bottom and left without food for 48 hours. Containers were then grouped into 5 sets of 4 adults each (2 ♂, 2 ♀) and one live FAW pupa from a laboratory colony was placed in each container at the following strata: set A, on soil surface; set B, partially buried horizontally with upper surface visible; set C, completely buried horizontally one cm below soil surface; set D, 2 cm below soil surface; set E, 3 cm below soil surface. Each container was examined after 48 hours for FAW pupal survival and the beetle moved to another container with fresh moistened soil and one live 5th instar FAW larva. After forty-eight hours, containers were grouped into 4 sets of 5 adults each and live 5th-instar FAW larvae were placed in each container in the following densities: set F, one larva; set G, 2; set H, 4; set I, 8. Each container was examined for larval and pupal survival 96 hours after exposure to the beetle.

RESULTS AND DISCUSSION

Calosoma sayi adults were able to kill and consume those FAW pupae that occurred on the soil surface or were partially buried (Table 1, sets A and B). The experimental location of these pupae is typical of natural situations after land preparation or cultivation, as well as representative of naturally-occurring exposed pupation sites. *Calosoma sayi* adults did not feed upon or burrow to FAW pupae buried at various depths (Table 1, sets C - E). This statistically significant (non-overlapping 95% confidence intervals, binomial distribution) failure of *C. sayi* adults to feed on experimentally-buried FAW pupae may have been due to poor burrowing capabilities, a lack of hunger, and/or an inability to detect buried pupae. Buried pupae appear to be undetectable, since *C. sayi* adults are active burrowers under these experimental conditions (Young 1985), and sufficiently hungry after 48 hours without food to consume FAW pupae (Young, unpublished data).

Table 1. Exposure of fall armyworm pupae to *Calosoma sayi* adults.

Set*	Location of pupae	Number of pupae	No. killed after 48 hrs	Combination of pupal locations	No. of pupae	% killed	95% Confidence Interval†
A	Soil surface	4	4	above soil surface	8	100	63.1 - 100
B	Partially buried	4	4				
C	Buried 1 cm	4	0	below soil surface	12	0	0 - 26.5
D	Buried 2 cm	4	0				
E	Buried 3 cm	4	0				

* Four containers per set, one beetle and one pupa per container, beetle unfed for previous 48 hours.

† Obtained from Binomial Distribution Tables.

Artificial burial of pupae may have eliminated potential detection cues that may have been produced if the 5th instar FAW larvae had been allowed to burrow into the soil and fill the resultant tunnel. However, rainfall and cultivation are two commonly occurring environmental factors that may also substantially alter or eliminate potential cues of a chemical or mechanical nature. These experimentally-buried pupae may thus be representative of situations occurring in agro-ecosystems.

When various densities of late 5th instar FAW larvae were placed into a container with an adult *C. sayi* and soil, some larvae at the higher densities were able to escape predation by burrowing the soil and pupating (Table 2). All larvae either burrowed or were killed within the first 24 hours, and of the 21 larvae successfully burrowing below the soil surface and pupating, no evidence was found in the 96 hour observation period of pupal predation (95% Confidence Interval, binominal distribution, for 0% predation, n = 21, is 0 - 16.1). Thus naturally-buried (Table 2) as well as artificially-buried (Table 1) FAW pupae apparently cannot be detected by *C. sayi* under these laboratory conditions.

Table 2. Exposure of fall armyworm larvae to *Calosoma sayi* adults.

Set	No. cages*	No. FAW larvae/cage	No. pupae produced/set	% pupation†	% predation of pupae
F	5	1	0	0	–
G	5	2	0	0	–
H	5	4	4	20	0
I	5	8	17	43	0

* One beetle per container with soil, beetles without food for previous 48 hours.
† Experiment terminated after 96 hours.

Calosoma sayi adults have been demonstrated to be voracious predators of noctuid larvae or pupae in plant canopies and on the soil surface in southern agroecosystems (e.g., Burgess and Collins 1917; Price and Shepard 1978b; House and All 1981). Pupation in the soil thus may be an effective tactic for these pests to avoid predation by adult *C. sayi.*

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