Seasonal Feeding by *Phyllophaga crinita* and *Anomala* spp. (Coleoptera: Scarabaeidae) Larvae in Northeastern Mexico[1]

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ABSTRACT Larval feeding by *Phyllophaga crinita* (Burmeister) and *Anomala* spp. (mixed populations of *A. flavipennis* Burmeister and *A. foraminosa* Bates) was studied under simulated field conditions in northern Tamaulipas, Mexico. Each month from July 1994 to February 1995, 50 field-collected larvae of *P. crinita* and *Anomala* spp. were placed individually in plastic pots with soil and corn seeds, and damage was evaluated 10 d after seedling emergence. Second-instar *P. crinita* caused 41% root loss in July, whereas third instars caused most damage (66-88% root loss) during July-September. Feeding by *P. crinita* decreased gradually from October to December, and ceased in January-February. In contrast, feeding by *Anomala* spp. peaked in July and again in November (73 and 53% root loss, respectively), a result of the bivoltine life cycle of these species in this region. The relationship of these findings to similar studies is discussed.

KEY WORDS Seasonality, white grub, root damage, corn.

The white grubs of *Phyllophaga crinita* (Burmeister), *Anomala flavipennis* Burmeister, and *A. forminosa* Bates, are important pests of field corn, *Zea mays,* L., and grain sorghum, *Sorghum bicolor* (L.) Moench, in Tamaulipas, Mexico (Rodriguez-del-Bosque et al. 1995). In addition, *P. crinita* causes economic damage to several field crops and turfgrass in Texas (Reinhard 1940, Teetes 1973, Fuchs et al. 1974, Merchant and Crocker 1995). The life cycle of *P. crinita* has been studied under both laboratory and field conditions (Reinhard 1940, Teetes et al. 1976, Huffman and Harding 1980, Rodriguez-del-Bosque 1988). In northern Tamaulipas, *P. crinita* is univoltine, with reproductive flights peaking from late April to early June, whereas, *A. flavipennis* and *A. foraminosa* are bivoltine, with adults emerging in spring and fall (Rodriguez-del-Bosque et al. 1995). There is little information, however, on the feeding of white grubs in this region. Such information is a prerequisite for developing integrated pest management strategies for white grubs in northeastern Mexico.

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Materials and Methods

This study was conducted at the Campo Experimental (Experiment Station), near Rio Bravo, Tamaulipas. During the third week of each month from July 1994 to February 1995, at least 60 third instars each of *P. crinita* and *Anomala* spp. (mixed populations of *A. flavipennis* and *A. foraminosa*) were dug from infested fields. Larvae were placed individually in 30-mm plastic cups with soil, and transported to a laboratory; 24 h later, 50 healthy larvae (i.e., not parasitized, diseased, or bruised due to collection and handling) of each *P. crinita* and *Anomala* spp. were placed singly in plastic pots (10 cm diam and 12 cm deep) at 4 cm from the bottom. Three germinated corn seeds ('VS-409') were then placed in the middle of each pot, 4 cm above the larvae. Pots were filled with a sandy clay loam soil (50% sand, 32% clay, 18% silt) to a level of 2 cm below the top edge, and watered. Seeds had been previously soaked (2-3 d) in water and placed in a growth chamber at 30°C for germination. Ten pots with seeds (three per pot) but no larvae were used as checks. Feeding of second-instar *P. crinita* was tested during July 1994, when they were available in the field.

Pots were placed outdoors on tables, in shade at ambient temperatures, to simulate field conditions, and watered every 2-3 d. Larval survival and feeding damage to plants were evaluated 10 d after seedling emergence. Seedlings were trimmed to soil level, after which roots were washed, air-dried, and weighed. Larvae were observed for fecal materials in the gut (easily detected through their translucent abdomen), and classified as either full- or empty-gut. Feeding was estimated for each pot by calculating % root loss = [(average root weight of check seedlings) - (root weight of infested seedling) ÷ average root weight of check seedlings] × 100. Pots in which the larva died were eliminated from these calculations. The average % root loss was calculated for each species during each month, and compared using multiple t-tests ($P < 0.05$), after percentages were transformed to arcsine function (SAS Institute 1988). Comparisons of percentage of larvae with full gut among months were made for each species using χ^2 ($P < 0.05$) with expected values calculated based on overall mean; comparisons were made on raw data before percentages were calculated (SAS Institute 1988). Correlation between monthly % root loss and the percentage of larvae with full gut was estimated for each *P. crinita* and *Anomala* spp. (SAS Institute 1988). Minimum and maximum daily temperatures were utilized to estimate the average temperature for each period of study.

Results and Discussion

Root weight of check seedlings ranged from an average of 4.5 g (July) to 7.5 g (November) per pot, as a result of variable temperatures during the period of study (Table 1). Regardless of species or month, larval survival at the end of each test was > 95%. Emergence of seedlings was not affected by either species in any month, indicating that neither seeds nor coleoptiles were used as food sources by white grubs, similar to findings of Teetes (1973) for *P. crinita* attacking grain sorghum and wheat, *Triticum aestivum* L., in northwestern Texas.

Root loss caused by second-instar *P. crinita* was moderate (41%) in July, the only time they were detected in the field. Third instars, caused most damage from July through September (66-88% root loss), after which feeding decreased gradually from October to December, and ceased feeding in January and February (Table 1). Percent root loss associated with feeding by *P. crinita* third instar was positively correlated with the percentage of larvae with full guts ($r^2 = 0.79$; $P < 0.01$; $df = 6$). These results agree with those reported in south Texas by Huffman and Harding (1980), who observed cessation of feeding by third-instar *P. crinita* at the end of October, and by January, most larvae possessed empty guts and had constructed earthen cells. Most scarabaeids cease feeding and migrate deeper into the soil during the winter, particularly in temperate zones (Ritcher 1958). However, this is not always the case in the tropics; for instance, the sugarcane white grub, *Ligyrus subtropicus* Blatchley, feeds even during the winter in Florida (Cherry 1991).

Anomala spp. had a seasonal feeding different from *P. crinita* as a result of their bivoltine life cycle (Rodriguez-del-Bosque et al. 1995, Rodriguez-del-Bosque 1996). Feeding peaked in July with 72.5% root loss, and decreased sharply in August, when most larvae were ready to pupate. Second-generation larvae (fall) fed most actively in November (53.3% root loss). Feeding subsequently decreased gradually from December to February (Table 1). Percent root loss by *Anomala* spp. also was significantly correlated with percentage of larvae with full guts ($r^2 = 0.84$; $P < 0.01$; $df = 4$).

In contrast, *A. flavipennis* is univoltine in Kansas, and its larval feeding cycle resembles that reported here for *P. crinita* in northeastern Mexico (Hayes and McColloch 1924). The differences in life cycle shown by *A. flavipennis* in Kansas and Mexico most likely are due to differential rates of accumulation of heat units throughout the year. Similarly, a proportion of the *P. crinita* population has a two-year life cycle in northern Texas (Teetes et al. 1976), where heat units accumulate slower than in south Texas and northeastern Mexico.

These results suggest that crops in northeastern Mexico could escape damage by both *P. crinita* and *Anomala* spp. larvae during the "spring" or first growing season, which commonly is planted in January-March. Although heavy populations of white grubs may be present during June and July, damage is not significant because spring crops by this time are senescent (Loera-Gallardo 1980). In contrast, white grub damage may be severe for crops planted in July-August, the "fall' or second growing season in this region, as shown by feeding activity of both *P. crinita* and *Amanala* spp. in this study. This has been demonstrated in commercial field studies where losses might be total if control measures are not implemented (Rodriguez-del-Bosque 1988). The feeding of *Anomala* spp. in November-December observed in this study suggests winter crops (e.g., wheat), considered as new crop alternatives for this region, might suffer from considerable losses by this species during the initial plant stages.

Table 1. Feeding activity of field-collected *P. crinita* and *Anomala* spp. larvae on corn seedling in northern Tamaulipas, Mexico (July 1994-February 1995).

Month	Average temperature (°C)*	Root weight of check seedlings (g ± SEM)**	% Root loss†			% Larvae with full gut‡	
			P. crinita. (2nd instar)	*P. crinita* (3rd instar)	*Anomala* spp. (3rd instar)	*P. crinita* (3rd instar)	*Anomala* spp. (3rd instar)
Jul	31.5	4.5 ± 0.3	41.3	66.1 b	72.5 a	100 a	81 a
Aug	31.3	4.9 ± 0.3	§	88.4 a	14.5 c	100 a	8 d
Sep	26.9	5.1 ± 0.2	§	67.5 b	§	100 a	§
Oct	27.8	6.6 ± 0.3	§	33.0 c	§	93 a	§
Nov	24.8	7.5 ± 0.4	§	9.8 d	53.3 b	51 b	63 ab
Dec	15.3	7.0 ± 0.5	§	4.9 de	16.5 c	0 d	46 b
Jan	16.9	6.2 ± 0.2	§	0.0 e	6.4 d	0 d	21 c
Feb	21.9	5.1 ± 0.2	§	0.0 e	0.0 e	12 c	12 cd

* During the period of study (10 consecutive days after seedling emergence).
** Average of 10 replications with three seedlings each.
† Percentages within a column followed by the same letter are not significantly different ($P < 0.05$; t-test).
‡ Percentages within a column followed by the same letter are not significantly different ($P < 0.05$; χ^2 test).
§ No test (larvae were not available in the field).

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