N O T E

Relative Attractiveness of Developmental Stages of Sorghum Panicles to Predator, *Orius insidiosus* (Say), and Prey, *Helicoverpa zea* (Boddie)[1]

P. Glynn Tillman[2]

USDA-ARS, Crop Protection and Management Research Laboratory, PO Box 748,
Tifton, Georgia 31793 USA

J. Entomol. Sci. 41(3): 248-252 (July 2006)

Key Words *Helicoverpa zea*, *Orius insidiosus*, sorghum, panicle attractiveness

Habitat manipulation for control of insect pests is an ecologically-based strategy aimed at enhancing the impact of natural enemies on pest populations (Landis et al. 2000, Annu. Rev. Entomol. 45: 175-201). Colonization rates of insect pests and predators are important in highly disturbed annual crop habitats (Ehler and Miller 1978, Entomophaga 23: 207-212), and these rates of colonization depend upon the proximity of the source of colonizers and the crop's attractiveness during the critical period of dispersal (Huffaker et al. 1977, Biological Control by Augmentation of Natural Enemies, pp. 3-28). Habitats can be manipulated to ensure that colonization of natural enemies and their prey occur quickly and at the same time and place by providing a highly attractive plant species to both these insects in close proximity to the source of these insects at this critical period of emigration of insects from their source.

In corn-cotton farmscapes, the corn earworm, *Helicoverpa zea* (Boddie), exhibits a spring population build-up on corn, *Zea mays* L., and a midsummer dispersal into cotton, as corn dries out and becomes an unsuitable host (Quaintance and Brues 1905, USDA Bureau Entomol. Bull. 50: 1-155). Grain sorghum, *Sorghum bicolor* (L.) Moench, planted along the interface, or common boundary, of corn and cotton fields can trap corn earworms in these corn-cotton farmscapes (Tillman and Mullinix 2004, Environ. Entomol. 33: 1371-1380). The objective of this paper was to examine the relative attractiveness of developmental stages of sorghum panicles to *H. zea* females and *Orius insidiosus* (Say) adults, and thus the possible role attractiveness of these panicles can have in the success of a habitat management strategy in these farmscapes.

Sorghum (variety DeKalb E57 Plus) was planted at a rate of 25,500 seeds/ha using a 2-row John Deere (Deere & Co., Moline, IL) planter. Sorghum was planted on 30 April in 2001, 13 May in 2002, and 12 May in 2003. Three 46 m × 3.7 m strips of sorghum were planted along the interface, or common boundary, of a corn and cotton

---

[1] Received 23 January 2006; accepted for publication 12 February 2006.

[2] Address inquiries (e-mail: pgt@tifton.usda.gov).

field. This was done in 3, 4, and 3 corn-cotton farmscapes in 2001, 2002, and 2003, respectively.

Vanderlip's (1972, Kansas Agric. Exp. Sta. Dept. Agronomy 1203) description of sorghum panicle development was modified by including preflowering, flowering, and postflowering stages. Furthermore, flowering was placed in one stage based upon Kring et al. (1989, Environ. Entomol. 18: 150-156) who previously determined that *H. zea* did not show a preference for any level (⅓, ⅔, or full bloom) of flowering of sorghum.

Helicoverpa zea eggs were monitored every 3 d from preflowering through hard dough sorghum panicle developmental stages. For insect sampling, 3 random sorghum panicles per 15.2-m section of row were cut for each of 4 rows of sorghum per corn-cotton farmscape (108 panicles per sampling date per farmscape). Individual panicles were placed in paper bags which were then stapled closed. In the laboratory, the developmental stage of each sorghum panicle was recorded. Then heliothine eggs and *O. insidiosus* adults were removed from sorghum panicles as described by Tillman and Mullinix (2004). Heliothine eggs were identified to species following Neunzig's (1969, North Carolina State Univ. Agric. Exp. Sta. Tech. Bull. 196) description. Voucher specimens of all insects are held in the USDA-ARS, Crop Protection & Management Research Laboratory (Tifton, GA).

Larval development and timing of pupation of *H. zea* were monitored in corn adjacent to the sorghum plots to obtain an estimate of timing of emigration of adults from corn. Wire cone pheromone traps were placed in each of the sorghum plots to monitor occurrence of immigration of *H. zea* in these plots. Each trap was baited every week with a fresh strip of Luretape™ (Health-Chem Corporation, South Plainfield, NJ) containing 2.5 mg of zealure, the synthetic male sex attractant for *H. zea*.

To determine the length of time in days that sorghum was attractive to *H. zea* females and *O. insidiosus* adults, individual sorghum plants were tagged and monitored around every 2-4 d for panicle developmental stage. In 2002, individual panicle development over time was determined and recorded for 60 plants per corn-cotton farmscape. In 2003, the same was accomplished for 120 plants in two farmscapes and for 34 plants in one farmscape. Development for individual plants over time was not determined in 2001.

For each date a developmental stage was observed in the field, the mean number of *H. zea* eggs and *O. insidiosus* adults per panicle was weighted by the frequency of occurrence of the developmental stage. To determine the expected contribution of a developmental stage over all dates, the sum of the weighted means was divided by the sum of the frequencies of occurrence of the developmental stage for each date. Differences in these adjusted means for number of *H. zea* eggs and *O. insidiosus* adults per panicle between panicle developmental stages were tested using mixed model analysis techniques (PROC MIXED, SAS Institute 2003, version 9.1, SAS Institute, Cary, NC) with Satterthwaite option. Developmental stage was considered a fixed effect, whereas random effects were farmscape (year) and residual error. Least squares means were separated by least significant difference (LSD) (SAS Institute 2003) where appropriate. For individually tagged sorghum plants, means and standard errors associated with these means were determined for the number of days sorghum panicles were attractive (preflowering or flowering) to *H. zea* females and *O. insidiosus* adults over all farmscapes in 2002 and 2003 using PROC MEANS (SAS Institute 2003). Means for the time (d) that individual sorghum panicles were in the attractive stages of development were compared between years using Student's *t*-tests.

Adult *H. zea* males were found in pheromone traps during the period of sorghum panicle development, and healthy ovipositing females were observed in all plots during this same time frame. Moth flights of this pest began at the expected time of emigration of adults from corn. In addition, for one field in 2002, rubidium-marking studies revealed that the generation of females from corn oviposited eggs on sorghum over the period of panicle development (Tillman et al., unpubl. data). Therefore, it was concluded that all of the female moths ovipositing in sorghum were from the same cohort—from the generation of *H. zea* larvae that had developed on corn.

Young sorghum panicles were very attractive to both *H. zea* females and *O. insidiosus* adults preying on the eggs laid by females of this pest. Factorial analysis revealed that there was a significant developmental stage effect for number of *H. zea* eggs ($F = 13.39$; df = 4, 28.9; $P = 0.0001$) and *O. insidiosus* adults ($F = 18.56$; df = 4, 25.7; $P = 0.0001$) per sorghum panicle. The significant differences observed for stage were above any variance associated with field or year due to the Satterthwaite option. The number of *H. zea* eggs and *O. insidiosus* adults per sorghum panicle was significantly higher on flowering panicles compared with all other stages of panicle development and on preflowering panicles compared with more mature panicles (Table 1). Even though a statistical difference was not detected in number of *H. zea* eggs per panicle between soft and hard dough stages of development, numerically there were fewer eggs in hard dough panicles compared with soft dough ones. A possible explanation for the presence of any eggs on hard dough panicles is that females may have been forced to oviposit on older panicles due to the absence of younger ones. The number of *O. insidiosus* adults was significantly lower for hard dough panicles compared with soft dough panicles.

Presence of preflowering/flowering panicles was used as an indication of the attractiveness of the sorghum trap crop to *H. zea* females and *O. insidiosus* adults. In 2002 and 2003, the mean (± SE) time that individual sorghum panicles were in the attractive stages of development was 10.95 (±1.58) and 6.65 (±1.26) d, respectively. These means were significantly different ($t = 2.13$, df = 5, $P < 0.05$). Higher rainfall in

Table 1. Least squares means (±SE) for number of *Helicoverpa zea* eggs and *Orius insidiosus* adults per panicle for each stage of sorghum panicle development

Panicle developmental stage	No. *H. zea* eggs		No. *O. insidiosus* adults	
	Mean*	Range	Mean*	Range
Pre-flowering	1.2205 ± 0.3231 b	0-37	1.0468 ± 0.3234 b	0-15
Flowering	2.2657 ± 0.3231 a	0-33	1.8336 ± 0.3234 a	0-15
Post-flowering	0.3197 ± 0.3395 c	0-5	0.4407 ± 0.3351 cd	0-11
Soft dough	0.1663 ± 0.4106 c	0-3	0.5747 ± 0.3852 c	0-7
Harddough	0.0899 ± 0.4106 c	0-1	0.3902 ± 0.3852 d	0-1

Least squares means within a column followed by the same letter are not significantly different (PROC MIXED; LSD; $P > 0.05$), $n = 10$ farmscapes.

* For all years combined.

2003 compared with 2002 may have been responsible for the faster panicle development observed in 2003 compared with the previous year.

These tests were conducted on-farm, and thus reliable in terms of what would occur with natural populations of *H. zea* and *O. insidiosus* in sorghum fields on producers' farms. Of course in any field test, there are many variables involved, but in these tests the variables were not significant or minimized where possible. For example, the significant differences observed for stage were above any variance associated with field or year. Drought can produce great differences in timing of panicle development, but all these plots were either irrigated or received ample rain before panicles were present. Rain can wash *H. zea* eggs from flowering sorghum panicles, however, it did not rain in any of the sorghum plots whereas panicles were in this stage of development. Insecticides which can disrupt insect populations were not applied in these plots. Finally, mechanical disturbance of plants which can cause flowers to fall off of panicles was avoided during panicle development.

Based on abundance of insects in these panicles, both *H. zea* females and *O. insidiosus* adults were more attracted to preflowering and flowering sorghum panicles than to the more mature panicles. Other researchers have observed that almost all oviposition by *H. zea* and *Helicoverpa armigera* (Hübner) on grain sorghum panicles occurred just before and during flowering (Roome 1975, Bull. Entomol. Res. 65: 523-530; Wilson 1976, Exp. Agric. 12: 257-265; Teetes et al. 1992, J. Econ. Entomol. 85: 1393-1401). McMillian and Wiseman (1972, J. Georgia Entomol. Soc. 6: 237-242) determined that *H. zea* larvae were present in large numbers during the early stages of plant maturity, and so it can be assumed that corn earworm females oviposited eggs on young sorghum panicles in their study also. Presumably, *H. zea* females oviposit their eggs on young sorghum panicles in response to an attraction to these developmental stages of the plant. Because plant volatiles are important in attracting herbivores (Visser 1986, Annu. Rev. Entomol. 31: 121-144), they may be involved in attracting *H. zea* females to young sorghum panicles.

Previously, in a study on seasonal abundance of *O. insidiosus*, Elkassabany et al. (1996, J. Entomol. Sci. 31: 76-88) determined that populations of this predator peaked during flowering in sorghum. In this current study, the presence of greater numbers of *O. insidiosus* adults in preflowering and flowering panicles compared with the more mature panicles was probably due to a combination of factors. Adults of the predator readily moved into sorghum panicles as soon as panicles extended through flag-leaf sheaths. Presence of *O. insidiosus* adults, however, did not always coincide with prey availability. Adults of the predator occurred in preflowering panicles with and without *H. zea* eggs, and even though *O. insidiosus* adults were observed feeding on thrips in sorghum panicles in this field study, these prey were more abundant in panicles with pollen than in preflowering panicles (Tillman, unpubl. data). Therefore, the presence of *O. insidiosus* adults in preflowering panicles was not always due to a response to prey density which indicates that adults of this predator may be attracted to plant volatiles from sorghum panicles. Such an attraction of *O. insidiosus* to plant volatiles has been documented for corn. A synomone present in hexane extracts of corn silks was found to attract *O. insidiosus* (Reid and Lampman 1989, J. Chem. Ecol. 15: 1109-1115). A portion of prey-searching behavior of this predator apparently relies on olfactory perception when corn is the host plant of the prey, *H. zea*. Future laboratory bioassays will be conducted to determine the effect of plant volatiles on attractiveness of sorghum panicles to this predator.

The consequence of adults of both the pest and predator being attracted to young sorghum panicles is that the appearance of *O. insidiosus* closely coincides with the presence of eggs of its prey, *H. zea*. Similarly, both *H. zea* females and *O. insidiosus* adults are more attracted to corn when silking than at any other time in the development of this plant, and thus both species are abundant at the same time (Barber 1936). In conclusion, the attractiveness of a specific developmental stage of a plant species to *H. zea* and *O. insidiosus* can play a role in the success of a habitat management strategy for this pest by ensuring that colonization of the pest and the predator occur at the same time and place during the critical period of dispersal.

Acknowledgments

Thanks to the Georgia Cotton Commission and Cotton Incorporated for financial support of this research, Kristie Graham for technical support, and Benjamin G. Mullinix, Jr., for assistance with statistical analyses.