Efficacy of Predators Attacking *Helicoverpa zea* (Boddie) (Lepidoptera: Noctuidae) Eggs on Grain Sorghum in the Field[1]

D. A. Jacobson[2] and T. J. Kring

Department of Entomology, AGRI 321, University of Arkansas
Fayetteville, AR 72701 USA

J. Entomol. Sci. 30(2): 251-257 (April 1995)

ABSTRACT Exclusion and insecticidal disruption studies were conducted to evaluate the efficacy of predators of corn earworm, *Helicoverpa zea* (Boddie), eggs on grain sorghum panicles in southwest and northeast Arkansas. Sets of three grain sorghum plants in a field were selected and one of three different treatments were applied to each plant in the trio. One panicle was fitted with an open cage with a large mesh that allowed colonization by most arthropod predators (particularly *Orius insidiosus* (Say)), but prevented feral *H. zea* moths from ovipositing on the panicles. The other two panicles in each trio were sprayed with mevinphos (Phosdrin) to erradicate predators, then one of these panicles was fitted with a cage of fine mesh that excluded all predators (total exclusion). The third panicle was covered with only a large mesh cage (insecticidal disruption). Ten *H. zea* eggs were placed on each of the panicles and the number that were shriveled or missing (indicative of predation) were recorded after 24 and 48 h. Predator densities also were evaluated on these and adjacent panicles. Tests were replicated in two locations over two years. When predator densities were highest, an average of 8.7 *O. insidiosus* (all stages) were found per panicle in open cages. Differences in the numbers of eggs shriveled or missing were significant in these treatments, with 62% missing from open cages, 27% from insecticidal checks, and only 15% from total exclusion cages. Because *O. insidiosus* represented 94% of the total predator population, the results indicated the importance of *O. insidiosus* as a predator of *H. zea* eggs on grain sorghum. The insecticidal disruption method appeared to be an effective technique for evaluating the efficacy of predators of *H. zea* eggs on grain sorghum panicles.

KEY WORDS *Orius insidiosus, Helicoverpa zea,* predation, grain sorghum.

The corn earworm, *Helicoverpa zea* (Boddie), is cosmopolitan and considered one of the most destructive pests of a number of crops, including cotton, tomato, and sweet corn (Davidson and Lyon 1979). Damage to crops is usually most severe when *H. zea* larvae feed on the reproductive parts of plants. *Helicoverpa zea* is an occasional pest of grain sorghum and chemicals are rarely applied for its control (Young and Teetes 1977). Chamberlin and All (1991) reported that survival of *H. zea* was higher on panicles of grain sorghum receiving an application of chlorpyrifos when plants were in the whorl stage, presumably resulting from a reduction in the number of beneficial arthropods.

[1] Accepted for publication 14 December 1994.

[2] Current Address: United States Sugar Corp., P. O. Drawer 1207, Clewiston, FL 33440.

Mueller et al. (1984) suggested that the development of damaging populations of *H. zea* in cotton can be delayed by early control of the pest in proximate weed hosts. It follows that control of *H. zea* in early season crops which serve as *H. zea* hosts, such as grain sorghum, may also effectively delay the onset of damaging populations in nearby cotton.

A diverse complex of predators and parasites are known to attack the eggs and small larvae of *H. zea*. These include coccinellids, predaceous Hemiptera, lacewings (Bell and Whitcomb 1964), and egg parasites (*Trichogramma* spp.) (Barber 1936). Perhaps the most important natural enemy of *H. zea* is the anthocorid *Orius insidiosus* (Say), a widely distributed predator that colonizes a variety of flowering plants, including a number of crops (Barber 1936, Fletcher and Thomas 1943, Lincoln and Williams 1952, Steward 1989). For example, *O. insidiosus* has been considered an important predator of *H. zea* on corn (Barber 1936, Winburn and Painter 1932), grain sorghum (Steward 1989), and cotton (Fletcher and Thomas 1943, Lincoln and Williams 1952). Barber (1936) found as many as 13 *O. insidiosus* on a single corn plant and estimated an average of 1.75 eggs were consumed/day by individual adults. Steward (1989) found a correlation between abundance of *O. insidiosus* and numbers of shriveled eggs and first instars in grain sorghum, and found as many as 18.2 *O. insidiosus* (nymphs and adults) per panicle. In cotton, Fletcher and Thomas (1943) estimated that 15.3 to 32.9% of *H. zea* eggs were attacked by predators, most of which were *O. insidiosus*.

We evaluated the efficacy of *O. insidiosus* as a predator of *H. zea* on grain sorghum in the field using a combination of two well-known techniques. One of these techniques was a modification of the insecticidal check method (DeBach 1946) in which a plot is treated with an insecticide that is toxic to the natural enemies being evaluated but has much less impact on the pest. The pest density in this insecticidal disruption plot is then compared with that of an untreated plot. The other method used was an exclusion technique, comparing pest populations between caged and uncaged plants (Smith and DeBach 1942).

Materials and Methods

Experiments were conducted in fields of commercially grown grain sorghum, *Sorghum bicolor* L., Moench, near Foreman, AR during July of 1991 and 1992, and on grain sorghum grown at the Agricultural Experiment Station in Fayetteville, AR in August and September, 1991. The experimental procedures were the same in both locations. Tests were conducted when the plants were in the flowering stage (Vanderlip 1979).

Eggs of *H. zea* were acquired from moths collected at night from weed and crop hosts. Moths were placed in oviposition cages made of glass aquariums lined on every side with polyethylene wrap. The bottom of each cage was covered with 2 cm of vermiculite, and a piece of polyethylene was stretched across the top. The moths were provisioned with diet cups containing a mixture of honey and beer. Eggs oviposited overnight on the polyethylene were easily removed with a small paintbrush.

Sets of three grain sorghum plants of approximately the same size and growth stage before panicle emergence (boot) were selected in the field. A cage that covered an entire panicle was placed over each of the selected plants and covered with a sleeve of tulle netting (3 cells/cm) to prevent oviposition by wild moths. Cage

frames were designed to prevent the cage materials from rubbing on the panicle and dislodging the insects. Cages were constructed of two pieces of 1-cm-diam plastic tubing that were each formed into 19-cm-diam circles. The two circles of tubing were separated by about 25 cm using three pieces of wire that ran through transverse holes in the tubes. At the top of the cage the wires converged to a section of 4-cm-diam PVC pipe in the center of the top circle of tubing. These wires were attached to the section of PVC pipe by running them through holes drilled in the side of the pipe and bending the ends back. These free ends of the wire at the bottom of the cage were fastened around the peduncle of the plant with twist-ties. The mesh sleeve was placed over this framework and tied at the top and around the peduncle.

When the caged plants were in the flowering stage, cages were removed in the morning, and two randomly selected plants in each set of three were sprayed with mevinphos (Phosdrin, 0.56 kg/ha) to kill predators and other arthropods on the panicles. Mevinphos has a very short (<12-h) half-life, and is routinely used to clear plants of background arthropods prior to entomological tests (Young et al. 1987). The remaining plant in each set was sprayed with water as a control. In the afternoon of the same day, 10 eggs were placed at 10 sites on each panicle using a paintbrush dipped in a solution of four parts water to one part "Plant-guard" (Nordlund et al. 1974). The eggs were placed on developing grain approximately uniformly around the panicle, simulating the natural distribution of *H. zea* eggs within a panicle (Kring et al. 1989). The position of each egg was marked by making a spot on a grain or glume just above the egg with a black permanent ink marker. A cage of Lumite™ saran (21 cells/cm) was placed on one of the sprayed plants to exclude *O. insidiosus* and other small arthropods. The tulle netting cages for excluding moths were replaced on the other two plants in each set. Thus, there were three treatments in each set of plants. Those plants that had been sprayed with mevinphos and covered with fine mesh were termed "total exclusion" plants. It should be noted, however, that we did not expect absolute "total" exclusion of predators. Plants that had been sprayed with mevinphos but excluded only wild moths (large mesh) were termed "insecticidal check" plants, and those that were not sprayed with an insecticide and excluded only wild moths were termed "open cage" plants. The tulle netting cages did not appear to inhibit the movement of most common beneficial arthropods associated with grain sorghum panicles (Steward 1989). The only other common lepidopterous pest of grain sorghum panicles, *Celama sorghiella* (Riley), was not observed in either location during the study. Treatments were replicated 9 and 30 times at Foreman during 1991 and 1992, respectively, and 17 times for the 24-h time period and 10 times for the 48-h time period in Fayetteville during 1991.

Cages in half the sets were removed the evening following egg placement. A small plastic bag was carefully placed over each of these panicles and tied at the peduncle. The panicles were clipped and taken to the laboratory for observations under a dissecting scope. The same procedure was executed on the remaining half of the plants 48 h after treatment. Branches on which an egg had been placed were clipped off with small scissors while the panicle was kept inside the bag. Eggs were classified as normal, shriveled, or missing. After determination of egg status, each panicle was twirled in a white plastic bucket, dislodging the insects, to estimate the number of predators per panicle (Steward et al. 1991).

Data were analyzed separately for each location and year. A *t*-test (Ott 1988) was used for each treatment to determine differences in the mean number of eggs shriveled or missing between the 24 and 48 h time periods. Differences among treatments for the mean number of eggs shriveled or missing were determined by analysis of variance (Proc ANOVA, SAS Institute, Inc. 1988). When significant, means were separated using least significant difference (LSD) procedures (Ott 1988).

Results and Discussion

Orius insidiosus was the most abundant predator on the panicles in all locations during both years, as previously reported in the region (Steward et al. 1991). Other than the placed *H. zea* eggs, no potential prey of *O. insidiosus* were regularly observed on any test panicles. There was no significant difference in the number of shriveled or missing eggs between the two observation periods (24 and 48 h) ($P < 0.05$) in any of the tests; therefore, the data for the two periods were pooled.

Foreman 1991. There were no significant differences among the treatments in the tests run near Foreman during 1991. Mean numbers of eggs shriveled or missing were 3.44, 2.83, and 2.39 for the open cage, insecticidal check, and total exclusion treatments, respectively. The low number of eggs shriveled or missing and the lack of significant differences among treatments in this location may have resulted from the low population of *O. insidiosus* on grain sorghum panicles. The mean number of *O. insidiosus* in all stages per panicle was only 1.89 in the open cages. This represented 69% of the predator fauna in this location in 1991 and was the lowest of any test, and lower than in previous studies (Steward 1989). The other predators encountered on the panicles included immature and adult *Geocoris punctipes,* nabids, coccinellids, lacewings, and spiders (oxyopids, salticids, and thomisids). None of these individual groups represented more than 10% of the total predator fauna for any test.

Fayetteville 1991. The number of *O. insidiosus* per panicle was also low at Fayetteville in 1991 with a mean of 1.78/panicle in open cages (Table 1). However, *O. insidiosus* comprised 81% of the total predator fauna. The mean number of eggs shriveled or missing was significantly higher in the open cages (48.2% shriveled or missing) than in the other two treatments (21.9-31.1%), with nearly half of the eggs introduced being destroyed or removed. Not all of the loss of eggs can be attributed to predation, however, as 22% were shriveled or missing in the total exclusion cages. These eggs were likely not properly affixed to the panicles and were accidentally dislodged. The apparent increase in predation on eggs in fields in Fayetteville, despite a low mean number of *O. insidiosus* in these fields, may be due to a change in the structure of populations of arthropods or in feeding habits of *O. insidiosus* late in the season (late August/September in Fayetteville, versus July in Foreman), or may simply be attributable to experimental variation.

Foreman 1992. Population densities of *O. insidiosus* were much greater than in previous experiments, with a mean of 8.69/panicle in open cages (Table 1). *Orius insidiosus* represented about 94% of all arthropod predators in these fields. These overall densities relative to other predators are similar to those observed in previous studies (Steward et al. 1991). The mean number of shriveled or missing

Table 1. Mean number of shriveled or missing *H. zea* eggs and density of *O. insidiosus* in Fayetteville during 1991 and near Foreman during 1992.*

Location	Treatment	n	No. Eggs** shriveled or missing ($\bar{x} \pm$ SE)	*O. insidiosus* per panicle ($\bar{x} \pm$ SE)
Fayetteville	Open cage	27	4.82 ± 0.38 a	1.78 ± 0.30 a
	Insecticidal check	27	3.11 ± 0.35 b	0.67 ± 0.20 b
	Total exclusion	27	2.19 ± 0.27 b	0.22 ± 0.08 c
Foreman	Open cage	60	6.15 ± 0.24 a	8.69 ± 1.23 a
	Insecticidal check	60	2.72 ± 0.19 b	0.38 ± 0.11 b
	Total exclusion	60	1.50 ± 0.14 c	0.07 ± 0.04 c

* Means within a column, for each location, followed by the same letter are not significantly different (LSD, $P < 0.05$).
** Mean based on an initial density of 10 eggs/panicle.

eggs was significantly different (LSD, $P < 0.05$) among the three treatments (Table 1). The greatest attrition of eggs was observed in open cages (61.5%), followed by that in the insecticidal check (27.2%) and exclusion cages (15.0%).

In partial life tables constructed over three years near Foreman, Steward (1989) determined that approximately 61% of *H. zea* eggs on grain sorghum panicles during the month of July died from predation and/or infertility and unknown causes combined. Similar attrition of *H. zea* eggs has been observed in life table studies on grain sorghum in Texas (Teetes et al. 1992). Interestingly, these levels of egg loss are in close agreement with the 61.5% of the eggs shriveled or missing in open cages near Foreman in July, 1992, where *O. insidiosus* comprised 94% of the predator complex, averaging 8.7/panicle. In the same fields, only 15% of the eggs were shriveled or missing on panicles from which *O. insidiosus* were excluded (exclusion was not complete, as 0.07 *O. insidiosus*/panicle were found in these cages). These results provide strong evidence that *O. insidiosus* is the major predator of *H. zea* eggs in grains sorghum, supporting previous greenhouse studies (Jacobson and Kring 1994).

Upon disturbance by insecticide application, *O. insidiosus* recolonized grain sorghum panicles slowly, as indicated by the slightly higher egg loss and number of *O. insidiosus* per panicle in the insecticidal checks relative to the exclusion treatment. The modified insecticidal check method of evaluating the efficacy of predators of *H. zea* eggs on grain sorghum panicles was moderately effective in this study. Numbers of predators in panicles sprayed with insecticide remained significantly lower than that in panicles that were not sprayed, even after 48 h. These results suggest that it would be possible to utilize an insecticidal check method on a field-wide basis to evaluate the efficacy of *O. insidiosus* or other predators on grain sorghum. Because mobile life stages are not generally considered amenable to exclusion studies as a result of cage confinement (DeBach and Huffaker 1971), the insecticidal check method might be used to assess predation of the mobile larval stages of *H. zea.*

Acknowledgments

We acknowledge Gordon and Worth Matteson III of Matteson Farms, Foreman, AR, for providing the land and crop for the studies. We thank J. R. Ruberson for technical assistance and A. J. Mueller and S. Y. Young for reviews of earlier drafts of the manuscript. This project was supported in part by USDA-CSRS Special Grant 89-34195-4378. Published with the approval of the Director of the Arkansas Agricultural Experiment Station (Manuscript # 94133).

References Cited

Barber, G. W. 1936. *Orius insidiosus* (Say), an important natural enemy of the corn earworm. USDA Tech. Bull. 504: 1-24.

Bell, K. O. and W. H. Whitcomb. 1964. Field studies on egg predators of the bollworm, *Heliothis zea* (Boddie). Florida Entomol. 47: 171-180.

Chamberlin J. R. and J. N. All. 1991. Grain sorghum response to fall armyworm and corn earworm infestations. J. Econ. Entomol. 84: 619-624.

Davidson, R. H. and W. F. Lyon. 1979. Insect pests of farm, garden, and orchard. Seventh edition.Wiley, New York.

DeBach, P. 1946. An insecticidal check method for measuring the efficacy of entomophagous insects. J. Econ. Entomol. 39: 695-697.

DeBach, P. and C. B. Huffaker. 1971. Experimental techniques for evaluation of the effectiveness of natural enemies. *In:* Biological control. C. B. Huffaker [ed.]. Plenum Press, New York. 511 pp.

Fletcher, R. K. and F. L. Thomas. 1943. Natural control of eggs and first instar larvae of *Heliothis armigera*. J. Econ. Entomol. 36: 557-560.

Jacobson, D. A. and T. J. Kring. 1994. Predation of corn earworm (Lepidoptera: Noctuidae) eggs and young larvae by *Orius insidiosus* (Say) (Heteroptera: Anthocoridae) on grain sorghum in a greenhouse. J. Entomol. Sci. 29: 10-17.

Kring, T. J., W. C. Yearian and V. B. Steward. 1989. Within-field and within-panicle distribution of *Heliothis zea* (Lepidoptera: Noctuidae) and *Celama sorghiella* (Lepidoptera: Noctuidae) eggs in grain sorghum. Environ. Entomol. 18: 150-156.

Lincoln, C. and F. Williams. 1952. Control of cotton bollworm and boll weevil in 1951. Ark. Agr. Expt. Sta. Tech. Bull. 33, Fayetteville.

Mueller, T. F., V. E. Harris and J. R. Phillips. 1984. Theory of *Heliothis* (Lepidoptera: Noctuidae) management through reduction of the first spring generation: a critique. Environ. Entomol. 13: 625-634.

Nordlund, D. A., W. J. Lewis, H. R. Gross, Jr. and E. A. Harrell. 1974. Description and evaluation of a method for field application of *Heliothis zea* eggs and kairomones for *Trichogramma*. Environ. Entomol. 3: 981-984.

Ott, L. 1988. An introduction to statistical methods and data analysis. Third edition. PWS-Kent, Boston.

SAS Institute, Inc. 1988. SAS user's guide: statistics. SAS Institute, Cary, NC.

Smith, H. S. and P. DeBach. 1942. The measurement of the effect of entomophagous insects on population densities of their hosts. J. Econ. Entomol. 35: 845-849.

Steward, V. B. 1989. Arthropods infesting grain sorghum panicles: parasitism, partial life tables, and sampling. Ph.D. dissertation, Univ. of Arkansas, Fayetteville.

Steward, V. B., W. C. Yearian and T. J. Kring. 1991. Sampling of *Heliothis zea* (Lepidoptera: Noctuidae) and *Orius insidiosus* (Hemiptera: Anthocoridae) in grain sorghum panicles by a modification of the beat-bucket method. J. Econ. Entomol. 84: 1095-1099.

Teetes, G. L., M. J. Scully and G. C. Peterson. 1992. Partial life tables for corn earworm (Lepidoptera: Noctuidae) on compact- and loose-panicle sorghum hybrids. J. Econ. Entomol. 85: 1393-1401.

Vanderlip, R. L. 1979. How a sorghum plant develops. Kansas Agricultural Experiment Station Extension Contribution 1203, Manhattan.

Winburn, T. F. and R. H. Painter. 1932. Insect enemies of the corn earworm (*Heliothis obsoleta* F.). J. Kans. Entomol. Soc. 5: 1-29.

Young, S. Y., J. R. Lack and W. C. Yearian. 1987. Transmission of a nuclear polyhedrosis virus in *Anticarsia gemmatalis* (Lepidoptera: Noctuidae) larval populations on caged soybeans. Environ. Entomol. 16: 691-698.

Young, W. R. and G. L. Teetes. 1977. Sorghum entomology. Ann. Rev. Entomol. 22: 193-218.