1991

SEASONAL ABUNDANCE OF MAIZE AND RICE WEEVILS (COLEOPTERA: CURCULIONIDAE) IN SOUTH CAROLINA

James E. Throne
USDA-ARS, Manhattan, KS, james.throne@ars.usda.gov

L. Daniel Cline
USDA-ARS

SEASONAL ABUNDANCE OF MAIZE AND RICE WEEVILS (COLEOPTERA: CURCULIONIDAE) IN SOUTH CAROLINA[1,2]

James E. Throne and L. Daniel Cline
Stored-Product Insects Research and Development Laboratory
Agricultural Research Service, U. S. Department of Agriculture
P. O. Box 22909, Savannah, Georgia 31403

ABSTRACT

Seasonal abundance of *Sitophilus zeamais* (SZ) and *S. oryzae* (SO) outside grain bins was monitored during 1986-88 with corn-filled bait packets at three grain storage sites in southern South Carolina. Corn was the predominant commodity stored at all sites. SZ were abundant and caught year-round at all sites, whereas SO were abundant and caught year-round only at the site at which wheat was stored regularly. Most weevils were caught during weeks when average temperatures were at or above 20°C. Catches generally peaked in fall, after newly-harvested grain was placed into storage. Catches fell during winter, began to rise in spring, peaked again during summer, and declined again in late summer. Results indicate that grain is susceptible to infestation by *Sitophilus* spp. year-round in South Carolina.

Key Words: Insecta, *Sitophilus zeamais*, *Sitophilus oryzae*, stored products, seasonal abundance, Coleoptera, Curculionidae.

J. Agric. Entomol. 8(2): 93-100 (April 1991)

The maize weevil (SZ), *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae), and rice weevil (SO), *S. oryzae* (L.), are cosmopolitan pests of stored products. The bionomics of these weevils has been studied intensively in the laboratory (Longstaff 1981); however, little is known about their bionomics in the field.

Seasonal flight activity of these weevils outside grain storage facilities has been investigated in South Carolina and in Kenya (Kirk 1965, Giles 1969, Throne and Cline 1989). Weevils generally fly when air temperatures exceed 20° to 23°C (Williams and Floyd 1970, Taylor 1971, Throne and Cline 1989). SZ and SO fly from late March to early November in southern South Carolina (Throne and Cline 1989).

During winter, weevils may emigrate from heavily-infested stored grain (Williams and Floyd 1970). However, we do not know if weevils migrate to or from less heavily-infested grain in winter or if weevils are generally active during winter. Studies on seasonal flight activity do not indicate whether weevils are active during periods of weather too cold for flight. Because bait packets may attract both flying and walking insects, they were used to determine the seasonal abundance of SZ and SO at three grain storage sites in southern South Carolina.

[1] Names of products are included for the benefit of the reader and do not imply endorsement or preferential treatment by USDA.

[2] Received for publication 9 April 1990; accepted 19 September 1990.

MATERIALS AND METHODS

Weevil abundance outside grain bins was monitored over a two-year period (1986-88), using corn-filled packets, at three grain storage sites in southern South Carolina. Throne and Cline (1989) described the storage sites, which were in Bamberg, Barnwell, and Hampton Counties (Fig. 1).

Packets were a galvanized hardware cloth (3.2 mm mesh) pouch (19.5 by 29.5 cm) closed with a 5-cm binder clip and were similar to those described by Strong (1970). Approximately 500 g of whole-kernel 'Pioneer 3320' corn, that was between 15 and 17% moisture content, were placed in each packet. Before being placed in packets, corn was frozen for at least two weeks to kill insects that may have previously infested it and was sieved over a U. S. standard no. 6 sieve (3.35 mm openings) to remove dockage. Despite the high moisture content of some samples, fungal growth was not a problem in this study.

Packets were placed in small plywood shelters to protect the contents from direct exposure to the weather. Each packet was placed on a platform (21.5 by 30.5 cm) supported about 8 cm above the ground by two 4-cm wide, wooden legs and tilted slightly. Preliminary tests showed that the platforms must be tilted so that water would not collect and ruin the samples. The wooden legs were driven about 10 cm into the ground to secure the shelter. A roof was placed 12.7 cm above the platform and overhung the platform by 1.3 cm on all sides. Weevils had to fly to packets or crawl up the legs of shelters to enter packets. However, weevils could easily fly over and around packets.

A shelter and packet were placed 0.5 m from the edge of bins in each of the four major compass directions at each site (i.e., four sampling locations at each of three sites). The corn in the packets was transferred to 0.95-liter canning jars with copper screen/filter paper lids and fresh corn was added to the packets weekly from 20 August 1986 to 2 September 1987 (hereafter referred to as the first year) at the Bamberg and Barnwell Co. sites. Weevils were sieved from the samples in the laboratory using a U.S. standard no. 6 sieve within 36 h after collection, and then sexed and identified based on genitalic characters (Halstead 1964). We did not begin sampling at the Hampton Co. site until 22 October 1986. Beginning 30 September 1987 and continuing to 5 October 1988 (hereafter referred to as the second year), corn was placed in the packets every 4 wk and left in the packets for 1 wk. That is, we sampled insects for 1 wk each month during the second year of the study.

Corn and a mixture of corn and wheat were stored at the Bamberg Co. site during parts of the first year of the study; and corn, soybeans, wheat, and mixtures of corn and wheat and corn and sorghum were stored during parts of the second year of the study. Corn and wheat were stored at the Barnwell Co. site throughout the first year of the study; and corn, wheat, and rye were stored during parts of the second year of the study. Corn, soybeans, and sunflower seeds were stored at the Hampton Co. site during parts of both years of the study. Commodities were generally placed into storage during September. Cooperators generally followed storage practices recommended by the state extension service. Temperature data were from National Oceanic and Atmospheric Administration records for Bamberg (Bamberg Co.), Blackville (Barnwell Co.), and Hampton (Hampton Co.) (NOAA 1986-88).

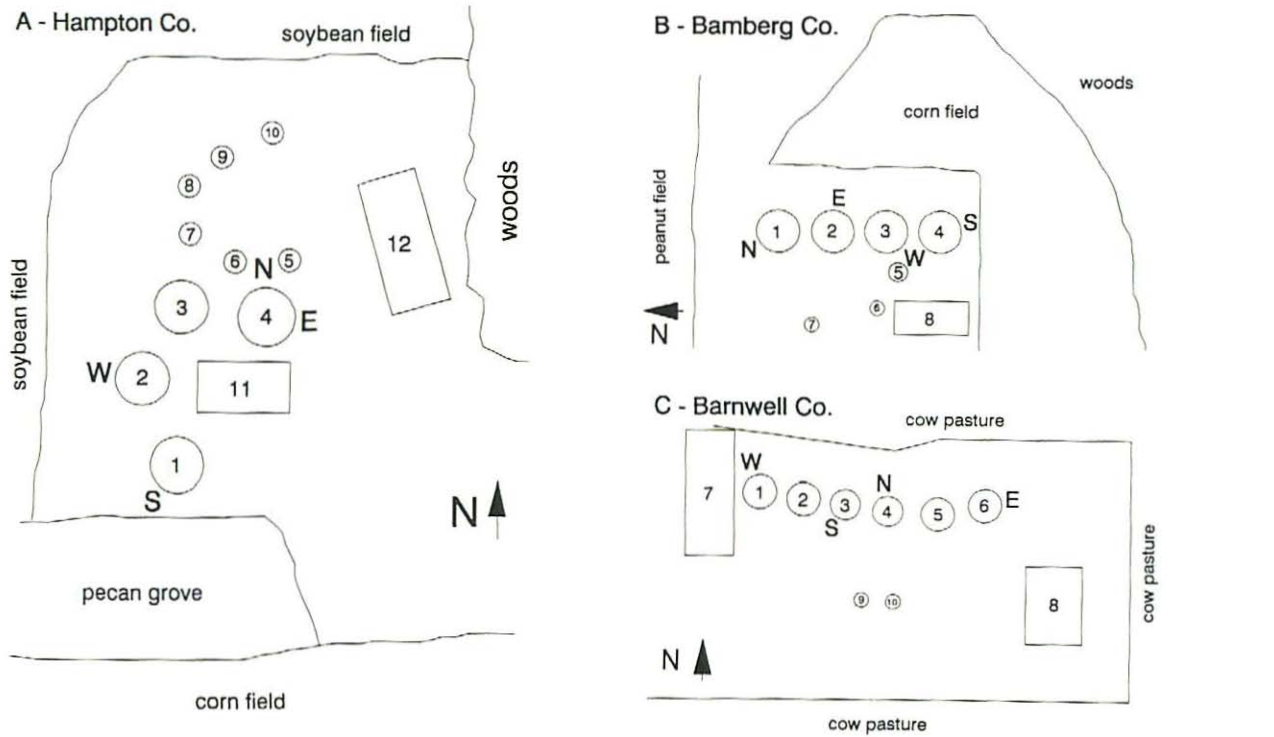

Fig. 1. Location of bait traps at: A, Hampton Co.; B, Bamberg Co.; and C, Barnwell Co. (not drawn exactly to scale). Location of bait traps is indicated by a location designation. For example, N indicates the location of the north trap and E indicates the location of the east trap. A: 1-4 - Grain bins; 5-10 - small, empty storage bins; 11 - concrete loading slab; 12 - equipment shed. B: 1-4 - Grain bins; 5-7 - small bins containing hog feed supplement or oats; 8 - equipment building. C: 1-6 - Grain bins; 7 - office and barn; 8 - barn; 9-10 - fertilizer and pesticide storage.

RESULTS

The total number of SZ caught at each site and SO caught at the Barnwell Co. site were similar; however, few SO were caught at the Hampton and Bamberg Co. sites (Fig. 2). SZ were active year-round at all sites and SO were active year-round at the Barnwell Co. site, although lower numbers of both species were caught during winter at all sites (Fig. 2). Most weevils were caught during weeks when average temperatures were at or above 20°C (Table 1).

There were two peaks of weevil activity each year (Fig. 2). One peak was in fall, after which catches generally decreased during winter. Catches increased again in spring and peaked during summer, before dropping again in late summer. There was a trend toward more females than males being caught (Table 2); however, the sex ratio was close to 1:1 for each species at every site.

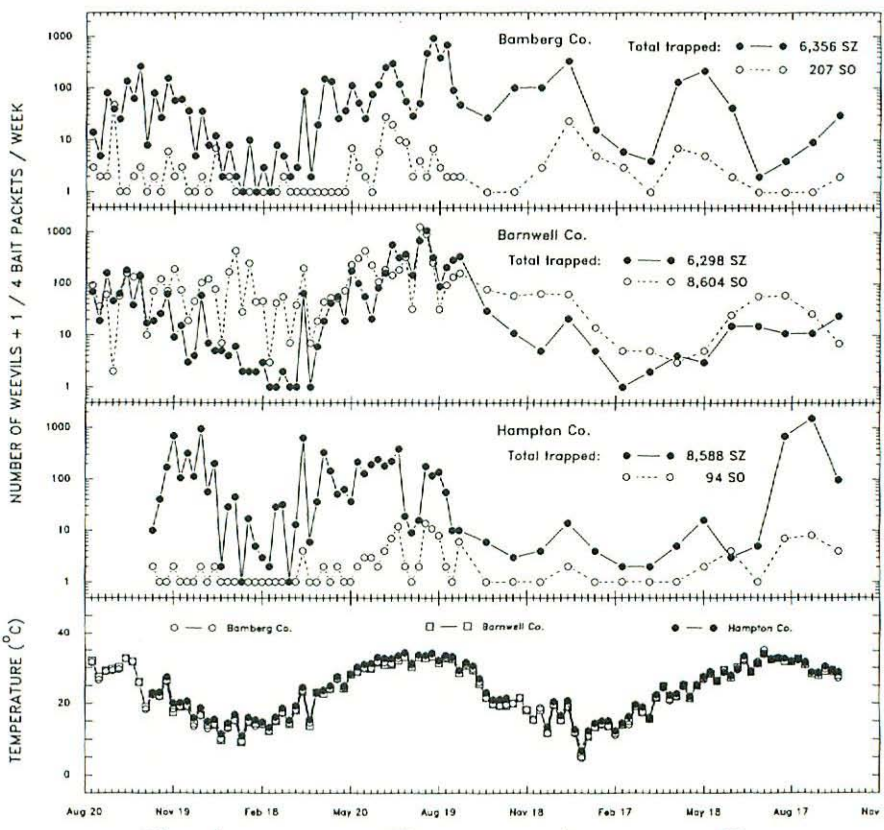

Fig. 2. Number of *S. zeamais* (SZ) and *S. oryzae* (SO) caught in bait packets and weekly average temperatures at grain storage sites in three counties in South Carolina, 1986-88.

Table 1. Percentage of total *S. oryzae* (SO) or *S. zeamais* (SZ) caught in bait packets during a 2-yr period at three average weekly temperature ranges at grain storage sites in three counties in South Carolina.*

	Average weekly temperature range (°C)		
County	0-10	10-20	20-30
	S. oryzae		
Bamberg	7	17	76
Barnwell	9	21	70
Hampton	0	10	90
	S. zeamais		
Bamberg	1	22	77
Barnwell	0	6	94
Hampton	0	42	57

* Average weekly temperatures at Bamberg and Barnwell Counties were 0° - 10°C for 14 weeks, 10° - 20°C for 22 weeks, and 20° - 30°C for 33 weeks. Average weekly temperatures at Hampton Co. were 0° - 10°C for 8 weeks, 10° - 20°C for 24 weeks, and 20° - 30°C for 27 weeks.

Table 2. Proportion males of *S. oryzae* and *S. zeamais* in bait packets at grain storage sites in three counties in South Carolina, 1986-88.*

	Proportion of males			
County	$\bar{X}$	SEM	*n*	95% confidence interval
		S. oryzae		
Bamberg	0.39	0.050	64	0.29 - 0.49
Barnwell	0.45	0.016	212	0.42 - 0.49
Hampton	0.54	0.073	40	0.39 - 0.69
		S. zeamais		
Bamberg	0.44	0.019	205	0.41 - 0.48
Barnwell	0.42	0.023	184	0.38 - 0.47
Hampton	0.43	0.022	160	0.39 - 0.47

* $\bar{X}$ = mean proportion males per bait packet per week; SEM = standard error of the mean; n = number of observations.

At the Hampton Co. site, several bushels of corn were spilled near the east packet during the first year and near the south packet during the second year. Seventy-seven percent of SZ and 75% of SO caught at the Hampton Co. site were in the east packet the first year and 46% of SZ and 67% of SO were in the south packet during the second year.

DISCUSSION

Although SZ and SO do not fly during winter in South Carolina (Throne and Cline 1989), both species are active and infest corn throughout winter. We do not know the source of weevils in bait packets during winter. However, the grain in the bins at these sites was in good condition during winter (based on monthly visual and odor inspections), and it seems unlikely that weevils would leave these bins and migrate to a relatively small and exposed packet of grain outside the bin. More likely, weevils in the bait packets in winter came from populations that normally feed on seeds of uncultivated plants (Linsley 1944, Mills 1989) or on grain residues around the storage facilities. Temperatures are usually well above freezing through most of winter in southern South Carolina, and weevils probably wander in search of food on warm days and take shelter on cold days. Bins of grain may attract weevils from around the storage site. Once near the bins, weevils probably are attracted to the odor of the food baits or may be attracted by aggregation pheromones, produced by males already in the food packets, that are believed to signal presence of a suitable food or oviposition site (Walgenbach et al. 1983).

Probably few SO were caught during winter at the Hampton and Bamberg Co. sites because there were few SO at these sites during most of the year. SO were probably more abundant at the Barnwell Co. site because that was the only site at which wheat was stored regularly throughout the study. In field infestations, SO generally infest wheat and SZ infest corn (Coombs and Porter 1986). Corn was the predominant commodity stored at the other two sites, and this probably explains the predominance of SZ at these sites.

The seasonal activity trend was similar to that for SZ and SO on sticky traps (Throne and Cline 1989) and for four species of stored-product insects, including the rice weevil, in grain residues on farms (Sinclair 1982). There was a peak of trap activity in fall, after grain was placed into storage. This peak may have consisted of weevils brought into the storage area with the grain; however, most of the corn stored at these sites had low insect population levels when placed into storage (R. T. Arbogast and J. E. Throne, unpublished data). More likely, this fall peak was a result of rapid population increase in abundant grain residues and natural food sources during summer and subsequent migration to newly-harvested grain in bins, which probably was a long-range attractant to weevils feeding around the storage site. Catches dropped in winter, presumably due to temperatures too low for flight or for rapid population increase. Catches rose in spring as temperatures warmed, weevils feeding outside bins became more active, and alternative food sources became scarce. Based on our observations, grain is usually in poor condition in summer and weevil populations are increasing in size rapidly. Hence, by midsummer there were probably many weevils in the grain and many weevils were emigrating to find alternative food sources. Ripening corn in the field may also lure weevils from the bins in summer (Kirk 1965, Dix and All 1985). Decreased catches in late summer may be due to poor reproduction during midsummer because of high temperatures (Hwang et al. 1983), because grain (a potential long-range attractant) had been removed from storage, or because alternative food sources were abundant.

In a previous study using sticky traps (Throne and Cline 1989), there was no consistent pattern among sites as to which sex was more likely to be trapped. The sex ratio of both species in culture is generally close to 1:1 (e.g., Ungsunantwiwat and Mills 1979). Therefore, the sex ratio of weevils in bait packets probably reflects the sex ratio of the weevil population.

Results of this study indicate that small quantities of grain located near a storage site attract weevils. Large catches in bait packets near grain spills indicate that grain spills may attract weevils or serve as a breeding site. Therefore, even a small quantity of grain spilled at a storage site should be removed. Although weevils only fly from March to November in southern South Carolina, weevils infest grain year-round. Growers should not assume that cooler weather will alleviate the need to dispose of spilled grain.

ACKNOWLEDGMENT

We thank Mark Culik and Pat Lang for technical assistance; James Baker, Paul Flinn, Rudy Hillman, and Lincoln Smith for reviewing an earlier draft of the manuscript; and Messrs. Bates, Peeples, and Rentz for allowing us to conduct this study on their farms.

REFERENCES CITED

Coombs, C. W., and J. E. Porter. 1986. Some factors affecting the infestation of wheat and maize by *Sitophilus oryzae* (L.) and *Sitophilus zeamais* Mots. (Coleoptera: Curculionidae). J. Stored Prod. Res. 22: 33-41.

Dix, D. E., and J. N. All. 1985. Invasion patterns and sex-ratio dynamics of the maize weevil (Coleoptera: Curculionidae) infesting field corn. J. Econ. Entomol. 78: 1072-1075.

Giles, P. H. 1969. Observations in Kenya on the flight activity of stored products insects, particularly *Sitophilus zeamais* Motsch. J. Stored Prod. Res. 4: 317-329.

Halstead, D. G. H. 1964. The separation of *Sitophilus oryzae* (L.) and *S. zeamais* Motschulsky (Col., Curculionidae), with a summary of their distribution. Entomol. Mon. Mag. 99: 72-74.

Hwang, J. S., F. K. Hsieh, and K. S. Kung. 1983. Influences of temperature and relative humidity on the development and reproduction of the maize weevil, *Sitophilus zeamais* Motschulsky [in Chinese, English summary]. Plant Prot. Bull. (Taiwan) 25: 41-52.

Kirk, V. M. 1965. Some flight habits of the rice weevil. J. Econ. Entomol. 58: 155-156.

Linsley, E. G. 1944. Natural sources, habitats, and reservoirs of insects associated with stored food products. Hilgardia 16: 187-224.

Longstaff, B. C. 1981. Biology of the grain pest species of the genus *Sitophilus* (Coleoptera: Curculionidae): A critical review. Prot. Ecol. 2: 83-130.

Mills, R. B. 1989. *Sitophilus zeamais* Motschulsky breeding in acorns. J. Kansas Entomol. Soc. 62: 416-418.

NOAA. 1986-88. Climatological data South Carolina, vols. 89-91. National Oceanic and Atmospheric Administration.

Sinclair, E. R. 1982. Population estimates of insect pests of stored products on farms on the Darling Downs, Queensland. Aust. J. Exp. Agric. Anim. Husb. 22: 127-132.

Strong, R. G. 1970. Distribution and relative abundance of stored-product insects in California: A method of obtaining sample populations. J. Econ. Entomol. 63: 591-596.

Taylor, T. A. 1971. On the flight activity of *Sitophilus zeamais* Motsch. (Coleoptera, Curculionidae) and some other grain-infesting beetles in the field and a store. J. Stored Prod. Res. 6: 295-306.

Throne, J. E., and L. D. Cline. 1989. Seasonal flight activity of the maize weevil, *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae), and the rice weevil, *S. oryzae* (L.), in South Carolina. J. Agric. Entomol. 6: 183-192.

Ungsunantwiwat, A., and R. B. Mills. 1979. Influence of medium and physical disturbances during rearing on development and numbers of *Sitophilus* progeny. J. Stored Prod. Res. 15: 37-42.

Walgenbach, C. A., J. K. Phillips, D. L. Faustini, and W. E. Burkholder. 1983. Male-produced aggregation pheromone of the maize weevil, *Sitophilus zeamais,* and interspecific attraction between three *Sitophilus* species. J. Chem. Ecol. 9: 831-841.

Williams, R. N., and E. H. Floyd. 1970. Flight habits of the maize weevil, *Sitophilus zeamais.* J. Econ. Entomol. 63: 1585-1588.