Rusty Grain Beetle (Coleoptera: Cucujidae) Oviposition in Cracked and Whole Corn[1,2]

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J. Entomol. Sci. 26(1): 183-187 (January 1991)

ABSTRACT Number of eggs laid by individual female rusty grain beetles, *Cryptolestes ferrugineus* (Stephens), during a 72-h period was determined on cracked and whole corn at 75% RH and 30°C. More eggs were laid on finely cracked corn (11.2 eggs/female/72 h) = medium cracked corn (9.6) > coarsely cracked corn (3.9) > whole, slit kernels (1.2) = whole, undamaged kernels (0.4). The results indicate that the greater number of progeny produced on cracked corn, as compared to whole corn, reported in an earlier study must have been, at least partly, due to the greater number of eggs laid on cracked corn.

KEY WORDS Insecta, *Cryptolestes ferrugineus,* rusty grain beetle, bionomics, oviposition, stored products, corn.

The rusty grain beetle (RGB), *Cryptolestes ferrugineus* (Stephens), is a cosmopolitan pest of stored products, particularly stored grains (Throne 1987). Number of RGB progeny produced on cracked corn, *Zea mays* L., is greater than on whole corn (Throne and Culik 1989). Throne and Culik (1989) suggested that the observed differences in progeny production may be due to differences in rates of oviposition on cracked and whole corn.

Results of previous studies support the hypothesis that rate of oviposition is greater on cracked grain than on whole grain. *Cryptolestes* eggs normally are laid in cracks in wheat kernels, or loosely in the food if no cracks are present (Bishop 1959). A few eggs may be laid in wheat kernels with undamaged seed coats, but oviposition is more prevalent on kernels with damaged seed coats (Mathlein 1971). RGB lay more eggs in wheat flour than on whole kernels (Smith 1962, 1966). However, oviposition on various particle sizes of grain was not examined in previous studies. At 75% relative humidity, Throne and Culik (1989, test 2) reported that number of progeny produced on coarsely cracked corn was twice as great as on medium cracked corn and almost five times as great as on finely cracked corn. The present study was conducted to determine whether differences in number of progeny produced in the earlier study could be attributed to differences in rates of oviposition on various particle sizes of cracked corn and on damaged and undamaged whole corn.

[1] Accepted for publication 10 December 1990.

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

Materials and Methods

Corn was 1987 crop cultivar 'Pioneer 3320' that had been frozen for at least 2 weeks to kill any insects that may have infested the corn naturally. Kernels with no breaks or abrasions in the seed coat (visible to the naked eye) were used. A portion of the corn was cracked in a blender (Waring CB-6) and sieved to obtain a certain particle size. A separate portion of the corn was cracked to obtain each particle size. Treatments were as in Throne and Culik (1989), test 2: 1) whole, undamaged kernels; 2) whole kernels that were slit longitudinally through the germ with a razor blade (<1 mm deep); 3) coarsely cracked corn (passed through a sieve with 6.3-mm openings, but retained on a U.S. standard no. 6 sieve with 3.35-mm openings); 4) medium cracked corn (passed through a U.S. standard no. 6 sieve, but retained on a U.S. standard no. 20 sieve with 0.85-mm openings); and 5) finely cracked corn (passed through a U.S. standard no. 20 sieve, but retained on a U.S. standard no. 40 sieve with 0.425-mm openings). Corn not passing through the top sieve was recracked until it would pass through the top sieve.

Three kernel equivalents (0.96 g) of each treatment level of corn were placed in individual cylindrical acrylic tubes (18 mm i.d. by 13 mm high) covered with nylon screen (64 μ openings) on the bottom and open on top. A cage was formed by inverting an empty acrylic tube, also covered with screen on one end, on the tube containing corn and securing the two tubes with a rubber band. Ten cages of each treatment level of corn were randomly placed in a plastic box (26.5 by 37 by 15 cm high) containing a saturated sodium chloride (NaCl) solution beneath a perforated false floor, resulting in an equilibrium relative humidity of 75% (Greenspan 1977). A 300-g sample of whole corn was placed in the humidity box to monitor moisture content of the corn weekly with a Motomco® model 919® automatic grain moisture tester (Dickey-John Corp., Auburn, IL). The whole corn sample should be indicative of moisture content in cracked, as well as whole corn, because cracking does not affect equilibrium moisture content (Throne, unpublished data). The experiment was conducted at 30°C and 12:12 L:D.

The corn was equilibrated for at least 6 weeks before introduction of RGB. RGB used in the study were from cultures that were started with beetles from grain storage sites in South Carolina. One 3 - 4 wk old, second laboratory generation female that had been reared at 30°C and presumably was mated was placed in each cage to oviposit. Females were removed after 72 h, and their species and sex confirmed (Banks 1979). The corn samples were placed in a refrigerator (ca. 2°C) to retard egg hatch.

Whole kernels (damaged and undamaged) and coarsely cracked kernels were examined individually under a microscope for eggs, including the slit in the damaged whole kernels. An individual corn sample was then placed in a 75 ml flask with ca. 35 ml water and shaken vigorously for ca. 5 sec. The rinse water was poured into a U.S. standard no. 100 sieve (150 μ openings) placed over a nylon screen funnel (64 μ openings) supported by a plastic funnel and collected in a beaker placed below the funnel. The sample was rinsed twice more, and then poured onto the no. 100 sieve and vigorously rinsed with water. The cages were also vigorously rinsed over the no. 100 sieve. The sample was then discarded. The material on the no. 100 sieve was rinsed into the nylon funnel, and the collected rinse water was poured through the nylon funnel again. The material retained on the nylon funnel was then rinsed onto a black cotton cloth placed over several layers of paper towels to absorb water, and examined under a microscope for eggs. Finely cracked and medium cracked kernels were processed as for whole kernels, except the corn was not examined under the microscope before rinsing. In preliminary tests, few eggs were found during microscopic examination of finely cracked and medium cracked corn samples. Rate of recovery of eggs placed in the no. 100 sieve without corn, or placed in fine corn and then processed, was at least 90% in five trials using 10 or 20 eggs.

The experiment was replicated three times (three replications with 10 samples of each treatment per replication). Data from one sample on whole kernels were not included in the analyses because the female was inadvertently left in the cage to oviposit for more than 72 hours. Data were analyzed using the general linear models (GLM) procedure of SAS (SAS Institute 1987). Egg counts were transformed before analysis, using the Box-Cox transformation with $\lambda = 0.39$ (Box and Cox 1964), to stabilize variances. Means and standard errors in the table are for untransformed data. Probabilities less than or equal to 0.05 were considered statistically significant.

Results and Discussion

Few eggs were laid on whole, slit or whole, undamaged kernels (Table 1). Significantly more eggs were laid on coarsely cracked corn. The greatest number of eggs was laid on finely cracked and medium cracked corn. The replication * treatment interaction mean square was not significantly different from residual error ($F = 1.54$; df = 8, 134; $P(F > 1.54) = 0.15$); therefore, the interaction sum of squares was combined with the residual sum of squares before testing for differences between treatments. Differences in number of eggs laid on the various particle sizes of corn were statistically significant ($F = 63.3$; df = 4,142; $P(F > 63.3) = 0.00$). Moisture content of the corn, measured when beetles were placed in the cages at the beginning of the 72-h oviposition period, was 14.7, 14.4, and 14.7% in the three replications.

Table 1. Number of eggs laid by rusty grain beetles during a 72-hour period on cracked and whole corn at 30°C and 75% RH.

	Number of eggs laid*		
Condition of Corn	$\bar{X}$	SEM	n
Finely cracked	11.2 a	1.23	30
Medium cracked	9.6 a	0.89	30
Coarsely cracked	3.9 b	0.61	30
Whole, slit	1.2 c	0.28	30
Whole, undamaged	0.4 c	0.13	29

* $\bar{X}$ = mean, SEM = standard error, and n = number of observations. Means followed by a common letter are not significantly different (LSD) at the $\alpha = 0.05$ level.

The small number of progeny produced on whole kernels in previous studies (Throne and Culik 1989, Throne 1990) was probably, at least in part, due to the small number of eggs laid on whole kernels. Damaging the kernels by slitting through the germ did not significantly increase the number of eggs laid. Only four eggs were found in slits in kernels. Most eggs laid on whole kernels were under the chaff that remains attached to the tip cap.

Surprisingly, more eggs were laid on finely cracked and medium cracked corn than in coarsely cracked corn. In a previous study (Throne and Culik 1989), more progeny were produced on coarsely cracked corn than on finely cracked or medium cracked corn. This indicates that under the conditions tested, mortality of immature RGB increases as particle size of corn decreases. This increased mortality may be due to the more finely cracked corn being a less suitable food source or to density effects.

Immature and adult RGB often crawl inside pieces of grain to feed, and may remain in the grain for extended periods of time. The grain probably provides protection from mechanical damage and cannibalism (Sheppard 1936). More finely cracked corn would not provide this shelter. The greater number of eggs laid on finely cracked corn and lack of sheltered feeding sites may result in increased mortality due to cannibalism or mechanical damage. Optimum densities for rearing RGB on various particle sizes of corn remain to be determined. Results of this study show that oviposition is greatest on more finely cracked corn, but the results of Throne and Culik (1989) indicate that other factors may be more influential in determining population densities supported by corn varying in particle size.

Acknowledgments

I thank M. Culik and P. Lang for technical assistance, V. Chew for advice on the statistical analysis, and M. Mullen and P. Weston for reviewing an earlier version of the manuscript.

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