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JOURNAL OF THE KANSAS ENTOMOLOGICAL SOCIETY
63(4), 1990, pp. 486–489

Variables Affecting Capture of Stored-Grain Insects in Probe Traps

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ABSTRACT: Many variables affect probe trap catch of stored-product insects in bulk grain. Often these variables affect trap catch because of their influence on behavior and mobility of insects. Five of the most important variables affecting trap catch are insect species, trapping duration, grain temperature, grain type and condition, and trap placement. The number of *Cryptolestes ferrugineus* (Stephens), *Rhyzopertha dominica* F., *Tribolium castaneum* (Herbst) and *Sitophilus oryzae* (L.) captured per trap increased by 0.77, 0.26, 0.36 and 0.47 insect, respectively, per day of trapping. Temperature significantly affected only the number of *C. ferrugineus* caught and captures per trap increased by 0.35 insect per degree between 10 and 32°C. Captures of *Cryptolestes pusillus* (Schonherr) in millet were 2–3 times greater than in wheat or corn. Aggregated distributions of insects make trap catch very sensitive to trap placement. Estimates of insect populations in stored grain using probe traps are likely to be inaccurate without careful consideration of these factors.

Sampling is a critical component of any management program for stored-product insects. The use of traps to sample stored-grain beetles has been studied extensively during the past 2–3 decades (Loschiavo and Atkinson, 1967, 1973; Lippert and Hagstrum, 1987; Fargo et al., 1989; Subramanyam and Harein, 1990). Insect traps are effective and sensitive tools for detection of adult insects (Loschiavo, 1974, 1975; Barak and Harein, 1982; Lippert and Hagstrum, 1987). They capture more insects than a grain sample taken using a standard grain sampling probe because the traps are left in the grain and capture insects over a period of time. The ratio of mean numbers of adult *Rhyzopertha dominica* F., *Tribolium castaneum* (Herbst), *Oryzaephilius surinamensis* (L.), and *Cryptolestes ferrugineus* (Stephens) trapped to the mean numbers in grain samples varied from 2.87:1 to 6.75:1 after 5 days of trapping in shelled corn (Barak and Harein, 1982) and 1.7:1.0 to 2.6:1.0 after 2 days of trapping in wheat (Lippert and Hagstrum, 1987). These studies suggest that traps may be useful in estimating densities of stored-grain insect populations.

All insect traps depend on insect movement. Any factor that influences insect movement will also affect trap capture. The magnitude of this effect depends primarily on insect species, temperature, grain type and grain condition. For relative population estimates, these factors can be incorporated into action threshold tables to assist stored-grain managers in interpreting trap catch and to make economically sound decisions (Higgins and Lippert, 1988; Cuperus et al., 1989). When samples are taken without monitoring these factors, there will be no way to remove the variability in trap catch, and estimates are likely to be inaccurate (Wright and Mills, 1984; Lippert and Hagstrum, 1987; Fargo et al., 1989; Subramanyam and Harein, 1990). These studies of probe traps are used here to illustrate

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Accepted for publication 15 July 1990.

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the importance of insect species, trap placement, grain temperature, trapping duration, grain type and grain condition in interpreting trap catch.

BEHAVIOR OF SPECIES IN RELATION TO TRAP PLACEMENT: *T. castaneum* and *C. ferrugineus* both are very active insects, whereas *R. dominica* does not move as much as other species and therefore is not as likely to be trapped (Subramanyam and Harein, 1989). This also results in differences in the distribution of insects within the grain mass and thus influences trap catch.

The majority of stored-grain insects have aggregated distributions within the grain mass. Thus, the variability in insect numbers between two grain samples from the same location is as great as between different quadrants of a grain bin, or between grain bins (Hagstrum et al., 1985). Subramanyam and Harein (1990) obtained similar results with traps. Surtees (1965) suggests that stored-grain insects move randomly until a suitable location is found and that a population never becomes totally inactive. Variation in temperature and moisture within a grain mass (Hagstrum, 1987) results in some areas being more favorable for insects than others. *C. ferrugineus* movement is affected by moisture, temperature and gravity (Loschiavo, 1983; Watters, 1969). Legg et al. (1987) indicated that the aggregation of maize weevil, *Sitophilus zeamais* Motschulsky, was directly related to initial population density. The behavior of the insects colonizing the surface of grain and dispersing into the grain mass also contributes to the aggregated distributions (Hagstrum, 1989). These aggregated distributions make trap catch very sensitive to trap placement. Species-specific distribution has received relatively little attention and is a critical issue that must be addressed if effective sampling programs are to be developed and implemented. Without knowledge of how different insect species distribute themselves in grain, a high sampling intensity is needed to compensate for aggregated distributions.

GRAIN TEMPERATURE: Several authors have found that trap catch was significantly greater at higher grain temperatures (Loschiavo and Smith, 1986; White and Loschiavo, 1986; Fargo et al., 1989). In these studies, capture rate of *Cryptolestes* spp. increased significantly at higher temperatures. However, between 10 and 32°C, other species including *R. dominica, T. castaneum,* and *S. oryzae* were not captured in greater numbers at higher temperatures (Table 1).

TRAPPING DURATION: Fargo et al. (1989) showed that the number of insects of a given species trapped increased significantly ($P \leq 0.05$) with trapping duration (Table 1). These slopes indicate that the response to trapping duration varies with species, and thus should be considered when interpreting trap catch. Choice of trapping duration can be complicated by the fact that trapping efficiency changes due to insects already trapped emitting an aggregation or sex pheromone thus increasing trap attractiveness over time (Loschiavo, 1974; Barak and Harein, 1982). However, data from Fargo et al. (1989) do not support this hypothesis.

GRAIN TYPE AND CONDITION: Grain type has been shown to have an impact on trap catch for known densities of insects. Wright and Mills (1984) showed that catches of *Cryptolestes pusillus* (Schonherr) in millet were 2–3 times greater than in wheat or corn. The amount of cracked grain and fine material also influences insect movement. McGregor (1964) reported that *T. castaneum* were attracted to areas in the grain that contained higher concentrations of fine material. Watters (1969) showed that moisture and fungi can also affect locomotor activity of insects. The condition of the grain may also have an impact on the random movement of the insects and thus affect the number of insects trapped.

Table 1. Regression models for effect of temperature or trapping duration (x) on mean trap catch (y) for four species of stored-grain insects.[a]

Species	N[b]	Slope[c]	SE	Intercept[c]	SE	r^2
			Temperature			
C. ferrugineus	12	0.3491**	0.0596	−1.2792	1.3685	0.77
R. dominica	12	0.0067	0.0106	0.1742	0.2438	0.04
T. castaneum	14	0.0225	0.0432	1.1678	0.9805	0.02
S. oryzae	14	0.0563	0.0528	0.7268	1.1991	0.09
			Duration			
C. ferrugineus	8	0.7746**	0.1469	0.7738	0.6144	0.82
R. dominica	8	0.2643*	0.1065	0.0500	0.4458	0.51
T. castaneum	8	0.3551*	0.1247	1.3611	0.5218	0.57
S. oryzae	8	0.4714**	0.1169	0.2000	0.4892	0.73

[a] Reanalyzed data from Fargo et al. (1989). These studies were done with 40 adults in 1 bu lots of wheat.

[b] Means based on catches from five to seven traps.

[c] Slopes or intercepts are significantly different from zero at the 1% or 5% level if followed by ** or *, respectively.

SUMMARY: Insect species, trap placement, grain temperature, trapping duration, grain type and grain condition greatly influence trap catch. Estimates of absolute insect populations from trap catch will be inaccurate unless adjustments are made for these factors. With adequate understanding of variables that affect trap catch, multiple regression analysis can be used to estimate absolute populations (Lippert and Hagstrum, 1987; Southwood, 1978). Regression equations in Table 1 for capture rate as a function of trapping duration and temperature should be extremely useful for adjusting trap catches obtained with different trapping durations or from bins with differing temperatures. To improve reliability and utility, further research is needed on the number of traps required, placement of traps, the role of attractants and interpretation of the importance of various factors relative to trap catch.

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