Detection or Estimation of Insect Populations in Bulk-stored Wheat with Probe Traps

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ABSTRACT Insect infestations of wheat stored on 20 Kansas farms were estimated with probe traps and 0.265-kg samples of wheat between September 1984 and June 1985. Traps in wheat bins for 2 d were 1.7-, 2.6-, 2.4-, and 2.6-fold more likely than wheat samples to detect infestations of *Cryptolestes ferrugineus* (Stephens), *Tribolium castaneum* (Herbst), *Oryzaephilus surinamensis* (L.), and *Rhyzopertha dominica* (F.), respectively. Sample-to-sample variation and percentage of samples with insects increased with insect density in a similar manner for both methods. The ratio of insects caught in trap to insects per wheat sample was quite variable and seemed to increase with insect density. Two methods for obtaining more quantitative estimates with traps are discussed.

KEY WORDS stored product, *Cryptolestes ferrugineus, Tribolium castaneum, Oryzaephilus surinamensis, Rhyzopertha dominica*

THE STANDARD METHOD of sampling grain bins for the detection or estimation of insect populations is to take wheat samples with a grain probe. This device is a hollow metal tube, which is inserted into the grain to a desired depth, opened and closed to collect the sample, and then removed from the grain and emptied. The sample is then sieved to separate the insects from the grain. This is a rather laborious method, especially if several locations are sampled to obtain a reliable measure of the numbers and species of insects present.

An alternative method of sampling insect populations is to use traps. Loschiavo & Atkinson (1967) developed a trap that is probed into the grain; this trap was modified by Loschiavo & Atkinson (1973) and Barak & Harein (1982). A new plastic version of the probe trap (Burkholder 1984) is a hollow 2.5-cm Lexan tube with 2.8-mm downward-sloped holes. Insects move through the grain, enter the perforations in the trap, and fall into a collecting vial at the bottom of the trap.

For stored grain, grain probes have generally been used to estimate the number of insects per kilogram of grain (Hagstrum et al. 1985), whereas traps have been used mainly for detection of the presence of insects (Barak & Harein 1982). The objectives of our study were 1) to compare probe traps and grain probes as sampling devices, 2) to develop a means to adjust catch data so that traps can be used to obtain the more absolute estimates of insect population density provided by grain probes, and 3) to establish criteria for determining how many traps to use.

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Materials and Methods

Grain samples were collected with a 0.265-kg deep-bin cup grain probe (Seedburo, 38 cm). The probe was pushed into the grain one-third the distance between the bin wall and center at eight equally spaced points corresponding to eight compass directions. Two additional samples were taken ca. 60 cm apart in the center of the bin. Samples were taken at a depth of 7.6–24.1 cm from the surface of the grain. Each of these 10 samples was placed in a plastic zip-lock bag, labeled by location, and taken to the laboratory, where adult insects were separated from the wheat with a grain sieve (Seedburo, 2 mm). The sievings were placed on a piece of plexiglass (5 cm^2) supported ca. 1 cm above the bottom of a petri dish with four compartments by partitions molded into the dish. Alcohol was placed in the dish to a depth of ca. 0.5 mm. The live adult insects left the material on the plexiglass and fell into the alcohol. The remaining material on the plate was sorted by hand for any remaining live adult insects, particularly for such slow-moving insects as lesser grain borer, *Rhyzopertha dominica* (F.). The total number of live adult insects of each species from each sample was recorded.

Traps (Burkholder 1984) were placed in the wheat at the same depth from which grain-probe samples were taken, but ca. 30 cm to the right. After 48 h, the collection vials were removed, labeled by location, and taken to the laboratory for sorting and counting of insects.

The number of farms visited varied from month to month. Between September 1984 and June 1985, 3, 4, 11, 10, 4, 7, 6, 3, and 3 farms were visited each month, respectively. Ten trap and 10 grain-

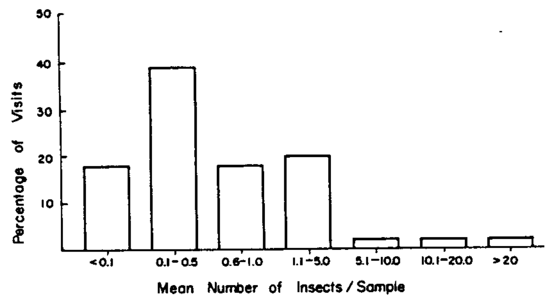

Fig. 1. Frequencies of *C. ferrugineus* infestation levels among 20 farms sampled between September and June.

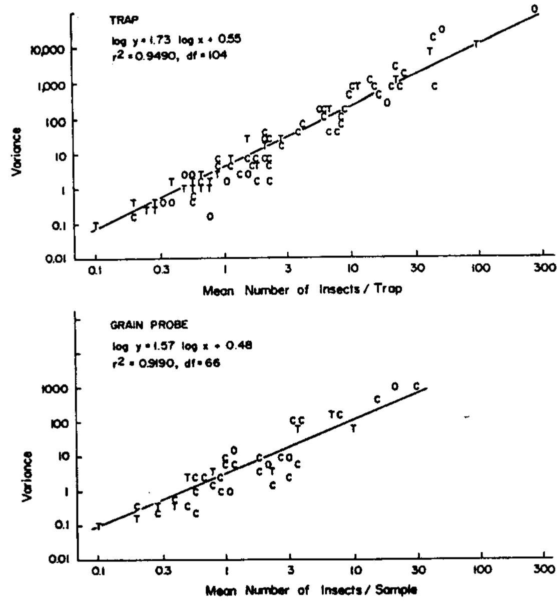

Fig. 2. Regression of log of variance (y) against log of mean (x) numbers of insects in the 10 grain probe samples or 10 catches in traps on different bin visits. The letters on graphs are the first letter of the genus name for the three most common species.

probe samples were taken during each bin visit; the same bin was sampled each time. The wheat was newly harvested in July 1984 (14 out of 20 bins) and ranged from 123 to 273 *t* (2,000–10,000 bu) per bin. To calculate the percentages of traps and grain probes detecting insects, we included only the samples from farms on which a given species was known to be present.

We used programs from the SAS Institute (1982) to calculate means, do *F* tests, fit regression equations, and plot data. Regression models were compared using the model comparison procedures of Draper & Smith (1981).

Results

For the four most common species, traps were 1.7- to 2.6-fold more likely to detect an infestation than grain probes (Table 1). The average numbers of insects per probe sample were 1.3, 2.0, 2.2, and 5.7 for *R. dominica*; the red flour beetle, *Tribolium castaneum* (Herbst); the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens); and the saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.), respectively. However, *T. castaneum* and *C. ferrugineus* were found on a higher percentage of farms than were the other two species. The frequency distribution of bin means for the most common species, *C. ferrugineus*, is shown in Fig. 1. The variance/mean regression lines were not significantly different for the three most abundant species for either grain probe (F = 0.230; df = 62,66; $P > 0.25$) or trap (F = 0.922, df = 100,104; $P > 0.25$), so data for these species were combined (Fig. 2). For the combined data, the rate of increase in the variance of catches as mean insect density increased was significantly greater ($F = 3.176$; df = 170,172; $P < 0.001$) than that for grain-probe samples. The increase with mean density in both the percentage of grain-probe samples and traps containing insects (Fig. 3) fit the same model that fit the data of Hagstrum et al. (1985).

For *C. ferrugineus* and *T. castaneum*, the ratio of the number of insects per trap to the number of insects per grain-probe sample was quite variable and may actually have increased with insect density up to a density of 17 insects per trap (Fig.

Table 1. Determination of insect infestations in farm-stored wheat with probe trap and grain probe

Species[a]	% of farms[b]	No. samples	% catches with insects	% grain-probe samples with insects	Ratio trap/grain probe	No. insects/0.265 kg[c]			
						No. bin means	$\bar{x}$	SEM	Range
C. ferrugineus	95	522	56.7	32.4	1.7	43	2.2	5.3	0.1–32
T. castaneum	90	507	21.7	8.3	2.6	12	2.0	3.0	0.1–9
O. surinamensis	80	472	17.6	7.4	2.4	5	5.7	9.1	0.1–22
R. dominica	55	373	11.3	4.3	2.6	4	1.3	1.7	0.1–4

[a] The four species belong to the order Coleoptera and, in the order listed, to the families Cucujidae, Tenebrionidae, Cucujidae, and Bostrichidae, respectively.
[b] Represents the percentage of 20 farms on which a species was detected on at least 1 of 3–11 visits.
[c] Determined by grain probe; includes only data from bins in which a given species was detected with grain probe or trap.

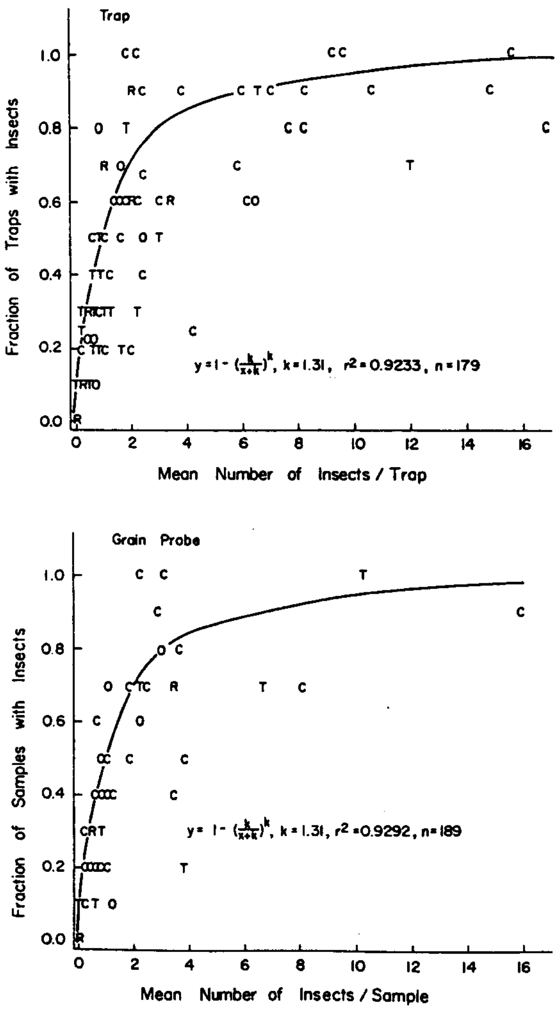

Fig. 3. Increase in fraction of grain-probe samples or trap catches with insects (y) as a function of the mean number of insects per sample or catch (x). The letters on graphs are the first letter of the genus name for each species, and each point represents the mean of the 10 samples or 10 catches in traps on a single visit to a bin.

4). However, these ratios did not vary significantly with the month that the samples were taken for *C. ferrugineus* (F = 1.41; df = 8,35; P = 0.2) or *T. castaneum* (F = 1.33; df = 5,7; P = 0.3). For *R. dominica*, the ratios were 11, 0.5, and 0.5 at densities of 0.1, 0.8, and 3.8 insects per 0.265 kg of wheat, respectively. For *O. surinamensis*, the ratios were 24, 5.9, 136, 6.5, and 2.4 for densities of 0.1, 1.1, 2.2, 3.1, and 22 insects per 0.265 kg of wheat, respectively.

Discussion

Over a 48-h period, a trap was, on average, twice as likely as the grain probe to detect an infestation. Although the increase with insect density in variation among grain-probe samples and catches in traps, and the increase with insect density in the percentage of samples and catches containing insects were similar for the two devices, the ratio of insects per trap to insects per grain-probe sample was quite variable. This is perhaps explained by the observation of Hagstrum et al. (1985) that one grain sample does not predict very well the insect density in another grain sample taken at a distance of 30 cm.

If traps are twice as likely as grain-probe samples to contain an insect, then traps should also have twice as many insects as grain-probe samples. In fact, traps tended to have more than twice as many insects as the probe samples, and the ratio tended to increase with density, indicating that traps collected insects from a volume of wheat >0.265 kg. Either an increase in insect activity with density or an increase with density in the levels of pheromone (Barak & Harein 1982) or moisture pro-

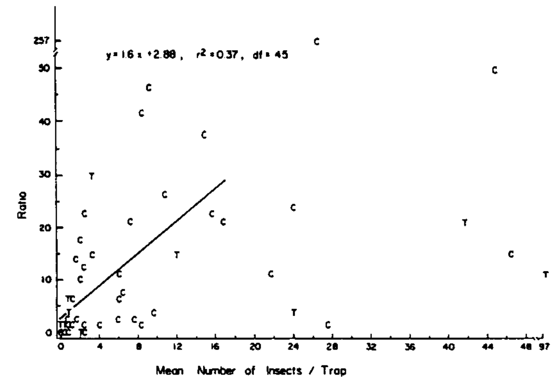

Fig. 4. Regression of the ratio of the average trap catch divided by the average number of insects per 0.265 kg of wheat (y) against the average number of insects per trap (x). The letters on the graph represent the first letter of the genus name for the two most abundant species.

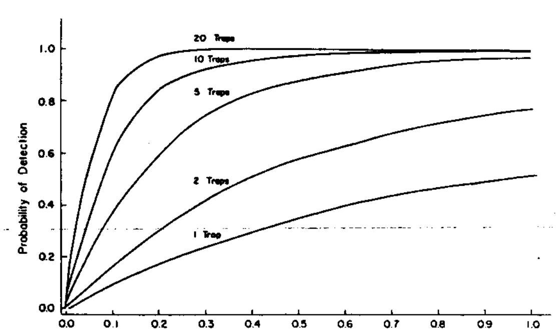

Fig. 5. Increase in probability of detection (y) with increasing infestation levels (x) for 1, 2, 5, 10, or 20 traps per bin, based on Hagstrum et al. (1985), because the data in the present study fit the same model used in the earlier study.

duced by insects in the traps could explain this tendency. Loschiavo et al. (1986) demonstrated that pheromone in traps will attract other insects and increase catch.

The equation in Fig. 4 provides the best ratio for adjusting catch in traps to give a better absolute estimate of insect density. Alternatively, the graphs in Fig. 3 could be used to estimate mean density from the percentage of traps capturing insects. Although either way of adjusting the catch will improve the estimate, neither way is as direct as making an estimate with a grain probe, and, thus, neither would be expected to provide estimates as accurate as those obtained with a grain probe.

The probability of detection can be improved by using more traps (Fig. 5). One trap should detect half of the 26% of the *C. ferrugineus* infestations exceeding one insect per trap (Fig. 1), or 13%. With 2, 5, 10, and 20 traps, the farmer would have on the average probabilities of 0.77, 0.96, 1, and 1 of detection and would, thus, detect 20, 25, 26, and 26% of infestations, respectively. Based on the estimates in Fig. 5, the improvement achieved by using a second trap is much greater than the improvement achieved by further increasing the number of traps; nothing is gained by using >10 traps. However, if a farmer hopes to detect infestations at lower densities to ensure that he will not be docked when delivering wheat to the elevator, the benefits of increasing the number of traps above five could be substantial. The location of traps in the bin may also become more important as the number of traps is decreased.

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