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COMPARISON OF TWO METHODS OF DETECTING INSECTS IN GRAIN

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ABSTRACT

Detecting insects in grain is fundamental in establishing the need for a fumigation, in post-fumigation assessment and in comparing the effectiveness of alternative treatments. Despite the importance of pest detection, there are few comparative studies of the various methods. This work compares the Berlese funnel method, commonly used by the Canadian Grain Commission (CGC), and the newly developed INSECTOMAT, a mechanised sieving mechanism capable of handling large samples of grain.

Samples of grain with a natural infestation of *Oryzaephilus surinamensis*, *Sitophilus granarius* and *Cryptolestes* spp. were used. The INSECTOMAT assessed 5-kg batches, and the funnels assessed 1-kg batches. Taking the sample sizes into account, the INSECTOMAT was generally better than the funnel at extracting all three species of insect. The INSECTOMAT allowed sample assessment to be completed in about 5 min as compared to more than 6 h for the Berlese funnel.

The size of the sample used by each system would appear to be the key to detection. The work indicates the potential dangers of using small samples taken from larger bulks in order to estimate insect populations and to determine the effectiveness of treatments.

INTRODUCTION

Insects are unacceptable in grain, both because of their potential to cause damage and because they are unhygienic contaminants. The grain industry devotes much effort to preventing infestation by use of good storage practice, but even their best efforts cannot prevent some infestation. Therefore, detection and control are also important aspects of storage, particularly when grain is being supplied to a market with a nil tolerance for pests.

Insects in grain destined for export are always regarded as a serious problem because of both quarantine restrictions and the potential for rapid population increases while the

grain is in transit. To combat this risk, governments in several countries, including the USA and Canada, set and enforce standards for levels of infestation in grain as it is loaded for export. In the case of Canada, this standard is zero, and inspectors of the Canadian Grain Commission, using Berlese funnels, test samples of all grain destined for export. This involves heating a 1-kg sample of grain for a minimum of 6 h to drive out any live, free-living adults or larvae. The method is widely recognised as being sensitive and effective, and Smith (1977) obtained recoveries of better than 80% for adult and large larval *Cryptolestes ferrugineus*. However, it is not easy to integrate this technique into the normal working of a commercial silo. During intake and outloading, silo staff must make decisions about the quality of grain in minutes, so the 6 h necessary for the Berlese funnel test is often impractical.

Research pioneered by scientists of Agriculture Canada has shown that using static traps is an excellent approach to pest detection in bulk grain (Loschiavo and Atkinson, 1967, 1973). Following these early developments, trapping is now an accepted approach to pest detection in commercial grain stores in many parts of the world. However, it is not a suitable method for assessing the quality of grain during transit. There also remain some concerns about the lack of data relating to how well the system works in deep silos with limited surface access and also about the exact commercial implications of the number of insects caught in traps.

The standard approach to detecting insects in grain during transit is to collect and examine samples. Unfortunately, the irregular distribution of insects in a bulk of grain adds to problems of pest detection via sampling and means that the chance of detection is directly related to the size of sample that is examined (Wilkin and Fleurat-Lessard, 1991).

Many new approaches to the detection of insects in samples of grain do not address the problem of looking at large amounts of grain. An exception is the inclined plane sieve developed by Ashman (1966) and refined by White (1983). Samplex Ltd. adapted the principle into their commercial prototype, the INSECTOMAT, which has the ability to remove insects from 10-kg samples in less than 2 min. Initial testing showed better than 90% recovery of two species of insects from 5- or 10-kg samples of wheat or barley (Wilkin, *et al*, 1994). The purpose of the investigation reported in this paper was to compare the efficacy of the INSECTOMAT with the standard Berlese funnel method in use by the CGC.

MATERIAL AND METHODS

Equipment and materials

The INSECTOMAT used in all tests was the latest production version with a 2.5-mm, round-hole sieve plate. The machine was operated at the standard reciprocation speed and sieve inclination which gave a throughput of 10 kg wheat in about 105 sec.

Berlese funnels, supplied by the CGC, were used in conjunction with locally manufactured screens (2.5 × 12 mm slots). Either 60-W, 240-V or 100-W, 240-V lamps were used to heat the wheat.

The test wheat (14% m.c.) was supplied as animal feed grain in 25-kg sacks by a local merchant.

Methods

Preliminary tests. A series of initial tests were undertaken to confirm that the INSECTOMAT would remove insects from grain. Between two and five adult *Sitophilus granarius* or *C. ferrugineus* were added to 10-kg batches of wheat which were then passed through the INSECTOMAT. An illuminated magnifying lens (10× magnification) was used to examine the sievings collected in the undertray for insects.

During the course of the initial tests it became apparent that the grain had a natural infestation of *S. granarius*, *Oryzaephilus surinamensis* and *Cryptolestes* spp. Therefore this grain without the addition of other insects was used for most of the subsequent tests.

Comparison between the INSECTOMAT and the Berlese funnel. Tests were done by dividing 10 kg of the naturally infested wheat into two equal parts using a mechanical sample divider. One lot of about 5 kg was passed through the INSECTOMAT and the insects were removed, counted and identified. This grain was then put through the INSECTOMAT a second time to check for the extraction of more insects. The second 5-kg sample was further divided to give 1-kg sub-samples, and three of these were set up in Berlese funnels while the remaining 2 kg was discarded. Each funnel was heated for 6 h and any insects driven out were collected in water traps beneath the funnels. The temperature of the grain at the centre of the funnel at the start and end of the heating process was measured with a thermistor probe.

Four 10-kg batches were tested. The tests were then repeated with the lamps changed from 60 to 100 W to increase the amount of heat applied to the samples in the Berlese funnels. Exceptionally, after the division of one of the 10-kg batches, five *C. ferrugineus* larvae were added to each of the two resulting 5-kg lots. One of these was passed through the INSECTOMAT and the other was further divided to give 1-kg samples that were assessed in the funnels.

After heating in the funnels, the three 1-kg samples from each test were re-combined and passed through the INSECTOMAT to check for the recovery of any further insects.

Recovery of C. ferrugineus larvae from grain by the INSECTOMAT. A series of tests was done to assess both the efficacy of the INSECTOMAT in extracting *C. ferrugineus* larvae and the ease with which they could be sighted amongst the sieved material. Two adult and two larval *C. ferrugineus* were added to each of six 5-kg batches of insect-free wheat which were then passed through the INSECTOMAT. The screenings were inspected and the number of adults and larvae found were recorded.

A second, similar test was done with a further three 5-kg batches of grain, except that five larvae and no adults were added to each batch before assessment. The grain was passed through the INSECTOMAT and the time taken to find the first larva was noted.

RESULTS

Preliminary tests

The initial tests showed that all insects added to the 10-kg samples of grain were recovered by a single pass through the INSECTOMAT. These tests also showed that the wheat was naturally infested with *S. granarius*, *O. surinamensis* and *Cryptolestes* spp. at a density of 1–4 adults per kg.

Comparison between the INSECTOMAT and the Berlese funnels

Table 1 compares the number of insects extracted from samples by the Berlese funnels heated with 60-W lamps and by the INSECTOMAT. The results obtained when 100-W lamps were used are given in Table 2. During the 6-h exposure, the temperature of the grain at the centre of the sample rose from about 15°C to about 28°C with the 60-W lamps and about 36°C with the 100-W lamps.

Various species of mites, psocids and lepidopterous larvae were also seen in the screenings produced by the INSECTOMAT, but these were not recorded. All second passes through the INSECTOMAT were negative for insect findings. However, when the samples previously extracted using the funnel were passed through the INSECTOMAT, in some cases a few further live insects were recovered.

TABLE 1
Numbers and species of insects removed from grain sample by the INSECTOMAT and the Berlese funnel (heated with 60-W lamps)

Test	Method	*S. granarius*	*O. surinamensis*	*C. ferrugineus*
A	INSECTOMAT	6	0	0
	Funnel A1	2	0	0
	Funnel A2	1	0	1
	Funnel A3	0	0	0
B	INSECTOMAT	7	5	0
	Funnel B1	1	0	0
	Funnel B2	2	0	0
	Funnel B3	0	0	0
C	INSECTOMAT	18	3	1
	Funnel C1	4	0	0
	Funnel C2	3	0	0
	Funnel C3	1	0	0
D	INSECTOMAT	23	6	7
	Funnel D1	5	0	0[1]
	Funnel D2	2	0	0
	Funnel D3	1	0	0

All insects were adults unless otherwise stated. [1]One small, unidentified larva.

TABLE 2
Numbers and species of insects removed from grain sample by the INSECTOMAT and the Berlese funnel (heated by 100-W lamps)

Test	Method	*S. granarius*	*O. surinamensis*	*C. ferrugineus*
A	INSECTOMAT	8	1	2
	Funnel A1	1	1	0
	Funnel A2	1	1	1
	Funnel A3	2	0	0
B	INSECTOMAT	11	5	0
	Funnel B1	0	1	0
	Funnel B2	2	0	0 (1 larva)
	Funnel B3	3	0	0 (1 larva)
C	INSECTOMAT	8	0	0
	Funnel C1	0	0	0
	Funnel C2	2	0	0 (1 larva)
	Funnel C3	0	1	0
D[1]	INSECTOMAT	5	1	0 (4 larvae)
	Funnel D1	2	0	1 (1 larva)
	Funnel D2	1	0	0 (1 larva)
	Funnel D3	2	0	1 (1 larva)

All insects were adults unless otherwise stated.
[1]Larvae added to this replicate.

Recovery of *C. ferrugineus* larvae from grain

The results of passing seeded samples through the INSECTOMAT are given in Table 3. Small larvae were not easy to locate in the screenings, but the first larvae were always found within 75 sec of the start of the extraction process.

In the second assessment of the recovery of larvae, in which five larvae were added to 5 kg of wheat, the total number of larvae recovered from each replicate was: four (replicate 1), three (replicate 2) and four (replicate 3). The time taken to detect the first larva was as shown above.

DISCUSSION AND CONCLUSIONS

The INSECTOMAT proved to be simple to operate, and it was able to process the samples of grain rapidly. All adult insects appeared to be removed by a single pass through the machine. There was no evidence of any insects "hanging up" within the machine and then escaping to contaminate later samples.

The key objective of this work was to complete a practical comparison between the INSECTOMAT and the Berlese funnel method. Therefore, the results obtained by the

TABLE 3
Number of adult and larval *C. ferrugineus* removed by the INSECTOMAT from 5-kg samples of wheat spiked with two adults, two larvae and additional screenings

	C. ferrugineus	
Replicate No.	Adults	Larvae
1	3	2[1]
2	2[1]	0[2]
3	3	1
4	2	2
5	2	2
6	2	2[1]

[1]1 dead, [2]1 recovered on second pass through INSECTOMAT.

INSECTOMAT should be compared to those obtained from a single funnel extraction rather than to the mean of all three replicates as, in practise, only 1 kg of grain was examined. Viewed in this light, the INSECTOMAT was somewhat more successful in detecting insects than the Berlese funnel. In one case (Test B) a single *Cryptolestes* sp. was found in one funnel sample when none were found by the INSECTOMAT. Conversely, insects were found by the INSECTOMAT on five occasions when none were found by the funnel method.

The larvae added to the grain used in the second test were recovered as effectively by the INSECTOMAT as by the Berlese funnel, although those removed by the funnel method were much easier to see. Careful searching was necessary to ensure that an occasional larva was not missed in the INSECTOMAT screenings. By contrast, live adults were detected readily in the screenings.

The results show that the INSECTOMAT will reliably remove insects from samples of wheat and that it is then easy to detect the live adult insects that are removed. It will also remove free-living larvae from wheat, but these are more difficult to detect in the screenings. The efficacy of the method in detecting early instar larvae is dependent upon the skill of the operator. During these tests, adults and larvae extracted by the Berlese funnel were easy to spot as there were no visual distractions. Smith (1977), however, showed that the funnel was not effective in the removal of early instar larvae. Therefore, it may be that both the INSECTOMAT and the Berlese funnel lack sufficient sensitivity for the detection of smaller, early instar larvae. In addition, neither method is suitable for detecting insects which are developing within the grains.

The effects of sample size on the detection of insect populations at densities below 3/kg was apparent during the experiments. On occasion no insects were found in 1-kg samples used with the funnel, whereas several were found in corresponding 5-kg samples passed through the INSECTOMAT. This difference would probably have been more

pronounced if the recommended sample size of 10 kg had been used with the INSECTOMAT.

The ability of the INSECTOMAT to detect free-living insects in grain was at least as good as that of the Berlese funnel and appeared to be better for free-living adults. Therefore, it could, in some circumstances, be used as an alternative or supplement to the Berlese funnel method. It is hoped that a further series of comparative tests will be carried out under practical conditions at a Canadian grain elevator.

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