THE DETECTION OF INSECTS BY TRAPS IN GRAIN-FILLED BOXCARS DURING TRANSIT[1]

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ABSTRACT: A modified pitfall trap was designed for use in grain-carrying boxcars. Two traps were installed in the deck of each of 5 and 25 cars used in regular grain service during the summers of 1972 and 1973, respectively. The cars were traced from the point of loading at a country elevator to unloading at a terminal where the contents of the traps were removed. In the 1973 experiment an insertion-type trap was included in each car, and was fastened against the interior end wall. When the car was loaded this trap was surrounded by grain.

In the 1972 experiment adults or larvae of the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens) were found in 19% of the carloads, and a fungus beetle *Cryptophagus* sp. in 4% of the trips made by the 5 cars.

Of 148 carloads delivered in 1973, 20% and 63% contained rusty grain beetles and fungus beetles, respectively. The major species of fungus beetles were *Cartodere constricta* (Gyllenhal), *Corticaria pubescens* Gyllenhal, *Crytophagus varus* Woodroffe and Coombs, *Lathridius minutus* L., *Enicmus cordatus* Belon, and *Ahasverus advena* Waltl. About 35% of the carloads contained other fungus feeders consisting primarily of rove beetles, fungus gnats, and nitidulid beetles. Flour beetles, dermestids, and saw-toothed grain beetles were found in 5% of the carloads. Significantly higher infestations were found in floor traps than in insertion-type traps immersed in the grain bulk. Eight percent, 31%, and 15% of the trap samples contained rusty grain beetles, fungus beetles, and other fungus feeders, respectively. The mean number of insects per sample was 1.2. Nearly 28% of the 148 carloads and 61% of the 432 traps samples were uninfested, and 26% and 24% of carloads and samples, respectively contained from 1 to 2 insects.

It was shown statistically that insects found in a carload originated in that carload rather than in the grain residue from the previous load.

The method of insect detection in carloads of grain was superior to any other method used to sample boxcars.

INTRODUCTION: A primary objective of those involved in grain production and handling in Canada is to preserve the high quality of export and domestic grain. One of the determinants of quality is the absence of insects that feed on grain or occur in association

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[1]Contribution No. 636 of the Research Station

with deteriorating grain.

These insects can infest grain at all stages of storage and handling from the farm to the ocean-going vessel. One of the important links in this chain of grain movement is the boxcar that carries grain from the country elevator to the terminal elevators. Small samples are removed during the unloading operation and examined by grain inspectors for quality and the presence of infestation. The probability of detection by this method is not high, particularly in a lightly infested car. What was needed was an escape-proof device that could be left in grain for any desired length of time.

Several models of traps to detect and trap insects in stored grain have been described by Loschiavo and Atkinson [1], [2], [3], tested in laboratory and in field experiments [4], and shown to be reliable indicators of infestations in grain bulks in farm storages and country elevators.

The existing models of detection devices could not be used inside a boxcar because any protruding portions would be damaged during manual or automatic unloading of the grain. Therefore, a pitfall trap was designed for use in boxcars. A description of this trap and the results of its experimental use in boxcars is the subject of this paper.

MATERIALS AND METHODS: A prototype model of pitfall trap was constructed by soldering the metal lid from a 340-ml glass jar, 8 cm deep and 7.5 cm inner diameter to the bottom of a 22.7-l metal pail, 39 cm deep and 28.5 cm inner diameter. A hole, 6.5 cm in diameter was punched in the lid before soldering. A similar-sized hole was cut out of the bottom of the pail and covered with a piece of perforated brass sheeting of the kind used for the insertion-type trap [3]. The brass was soldered to the floor of the pail around the periphery of the hole. The jar could be screwed into the lid from below the pail.

Preliminary tests with known numbers of adults of the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens) placed on the surface of wheat-filled pails showed that more than 50% of the beetles dropped into the jar within 1 day and 99% in 15 days.

In 1972, this modified version was used in 5 grain-carrying boxcars owned by Canadian National Railways, to test the feasibility of detecting insects in grain during transit. Each car was fitted with 2 traps, located about 15 cm left of each door and 15 cm from the wall (Fig. 1) The glass container was screwed into the metal lid from below the car and secured with an elastic band to a spike nailed to the underside of the deck. The soldered brass-lid assembly was lowered into the hole from above the deck, countersunk so that it was flush with the deck, and fastened with nails. The portion external to the container was sealed with patching plaster. The 5 cars were put into regular grain service in mid-July, and their movements monitored through the railway's computer tracing service. A loaded car's arrival at its destination was telexed to appropriate officers of the Canadian Grain Commission

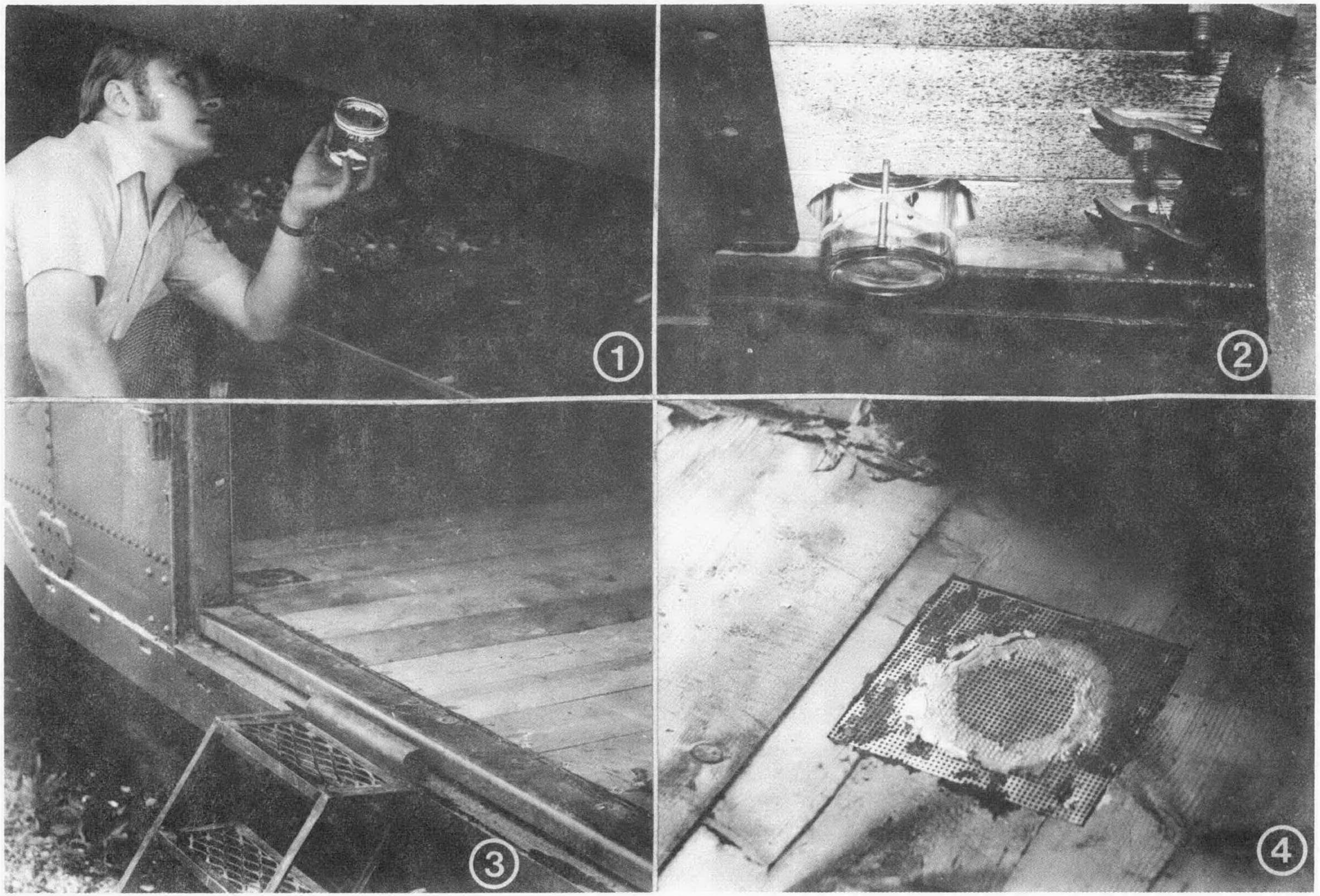

FIGURE 1. Details of detection trap construction and installation in 1972. 1. Placing of glass container from below deck; 2. View from below, of container in position. Note spike and elastic band; 3. View from above, of location of trap; 4. Close-up view of surface of trap showing perforated brass soldered to lid of container.

at terminal elevators in Thunder Bay, Ontario; Churchill, Manitoba; and Vancouver, British Columbia.

In 1973, this experiment with minor modifications was repeated on a larger scale with 25 consecutively numbered boxcars. The traps were located about 60 cm to the left of the door to ensure that they would not be covered by overlapping paper liners used around the doors of loaded cars. Plastic containers were used instead of glass. Special markings on the car, and fluorescent paint on the inner door posts were used to help identify and locate the cars on track. Stencilled instructions on the interior wall above the trap requested that before loading, the elevator agent unscrew the jar, sweep out all grain debris from the car, replace the jar, and include a label showing the date and place of loading and kind of grain (Fig. 2). The request to remove the jars while the car was being cleaned was to ensure that they were not filled with dust and debris from a previous cargo. The 25 cars were thoroughly cleaned with compressed air hoses during installation of the traps. In the 1973 experiment, an insertion-type trap was fastened to the end wall about 150 cm above the deck (Fig. 2).

As in 1972, Canadian National Railway's car tracing service and the Canadian Grain Commission's telex service were utilized to help locate cars. Upon arrival of a loaded car at a terminal point, a grain sanitation officer or grain inspector removed the contents of the traps, and forwarded them in sealed polyethylene bags together with pertinent information to the author for examination. The kinds and numbers of insects in each trap, origin and destination of carloads, kind of grain and moisture content, time in transit, distribution of cars in each grain-growing province, and number of trips per car were compiled and programmed for computer analysis.

RESULTS AND DISCUSSION: In the 1972 experiment, adults or larvae of the rusty grain beetle were found in the traps 5 times, and a fungus beetle, *Cryptophagus* sp. once, in the 42 carloads carried by the 5 cars during a 5-month period beginning in mid-July. Eight carloads were missed at the unloading terminal, and 7 were rejected because no data were available. Thus, based on 27 carloads 22% were infested with insects. Although mites were observed occasionally they were not recorded. The 6 infestations detected by the pitfall trap were not detected by any other method of sampling.

It is unlikely, for the following reasons, that the insects found in the boxcar traps came from a residual infestation in the car prior to loading:

1. The detection of insects in the initial trip of 2 of the 5 completely refitted cars indicates that the source of infestation was the grain loaded into the cars.

2. In 2 of the cars no insects were found until at least the 3rd trip, and in 3 of the cars no insects were found after the 1st occurrence. Had residual populations been present they should have been detected more frequently.

3. Much of the wooden lining in the 5 cars had been

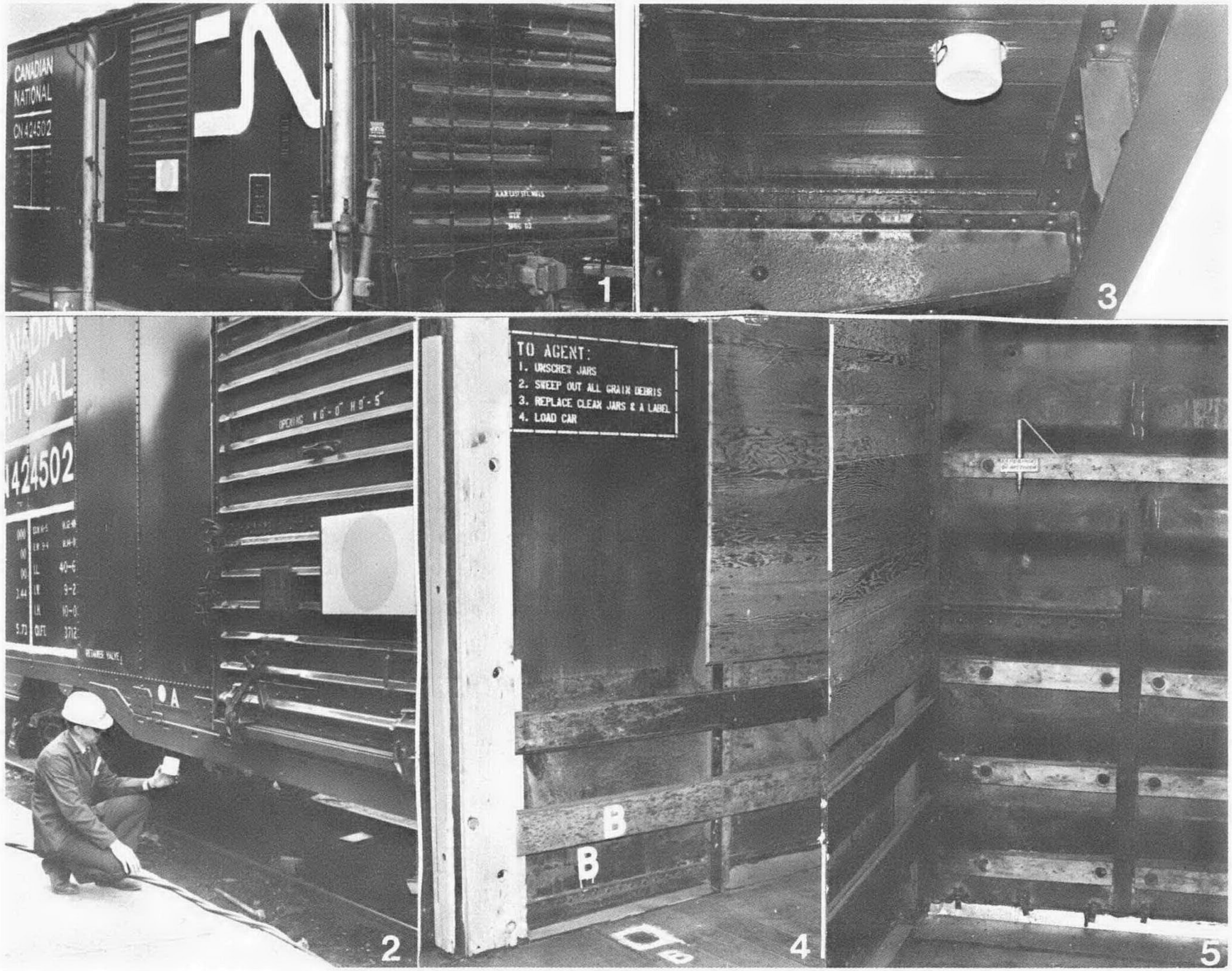

FIGURE 2. Details of car markings and detection trap in 1973. 1. View of car. Note circle painted on placard board; 2. Placing of plastic container from below dec; 3. View from below, of container in position; 4. View from above, of location of trap. Note stencilled instructions to agent and absence of wooden liner near floors; 5. View of insertion-type trap fastened to interior wall at brake end of car.

removed, thus eliminating areas where undisturbed grain could accumulate and become reservoirs of infestation.

4. With I exception, no insects were found in traps after mid-September, presumably because the bulk of shipments consisted of newly harvested 1972 crop which was unlikely to be infested. If the cars contained infested residual grain from previous cargoes, insects should have been detected with the same frequency throughout the shipping season, or until grain temperatures had decreased to the point that insects ceased to be mobile. The exception was a car carrying tough No. 3 wheat. One of the traps from this car contained larvae of the rusty grain beetle, suggesting a breeding population. It is unlikely that this population originated in the car because no insects were detected in the previous 2 trips.

Nevertheless, boxcars in regular grain service, particularly those with liners, and floors full of cracks and crevices can become infested. Liscombe (1965, unpublished), and Rudd (1968, unpublished) have found insects in 12% to 28% of samples of grain residues from empty boxcars. Smallman (1942, unpublished) found that of 38 cars examined after unloading, 27 showed insects in the grain residue, the most common being the rust-red grain beetle (rusty grain beetle). Cogburn [5] found 29 species of stored products insects in about 90% of boxcars in Gulf Coast ports in the U.S.A. during summer. He noted that about 75% of the cars contained enough farinaceous debris to support insects, and 80% of 175 cars were infested.

Whether the source of infestations in a boxcar is the grain residue in the car from previous trips, or from the current cargo is a spurious argument. Usually, grain insects are pests of grain, not of boxcars. Undeniably, a boxcar is not infested when it is first released for grain service. The presence of insects in grain residues from boxcars indicates the need for thorough cleaning of cars before each loading.

Table I shows that 72% of 148 carloads of grain delivered in 25 boxcars during a 6-month period in 1973 was infested with I or more kinds of insects. During this period 20% and 63% of the loads contained rusty grain beetles and fungus beetles, respectively. The predominant species of fungus beetles were *Cartodere constricta* (Gyllenhal), *Corticaria pubescens* Gyllenhal, *Cryptophagus varus* Woodroffe and Coombs, *Lathridius minutus* L., *Enicmus cordatus* Belon, and *Ahasverus advena* Waltl. Other fungus feeders, primarily rove beetles, fungus gnats, and nitidulids made up 35% of the infestations. The presence of fungus beetles and other fungus feeders indicates that the grain was damp or was stored in a facility where moisture could enter and microorganisms could flourish. Other grain insects, for example, flour beetles, dermestids, and saw-toothed grain beetles occurred in 5% of the carloads. Incidental insects such as leafhoppers, flies, mosquitoes, and small ground beetles were found in 7% of the loads.

There was no significant difference in infested carloads or samples between A and B deck traps (χ^2 = 1.14, χ^2_1, 0.01 =

Table I. Percentage of carloads of grain infested with insects from the prairie provinces during a 6-month period in 1973.

Kind of insect	Trap	May	June	July	Aug	Sept	Oct	Total period
		Month						
All species	A	54	68	55	55	60	32	55
	B	50	58	52	55	43	21	47
	Insertion	23	19	6	18	3	16	14
	All traps	73	87	71	73	73	47	72
Rusty grain beetles	A	0	3	13	36	7	0	7
	B	4	13	10	27	17	5	11
	Insertion	12	6	3	0	0	0	4
	All traps	12	23	23	45	20	5	20
Fungus beetles	A	50	55	42	18	47	16	42
	B	42	52	42	27	33	21	39
	Insertion	12	19	3	18	3	16	11
	All traps	69	77	58	45	67	42	63
Other fungus feeders	A	19	16	23	18	27	21	21
	B	19	13	23	36	33	5	21
	Insertion	0	0	6	9	0	0	2
	All traps	31	23	42	45	47	26	35
Other grain insects	A	0	3	0	0	3	5	2
	B	4	3	3	0	7	0	3
	Insertion	0	0	0	0	0	0	0
	All traps	4	6	3	0	7	5	5
Other insects	A	12	0	0	0	3	0	3
	B	8	0	3	0	7	11	5
	Insertion	0	3	0	0	0	0	1
	All traps	15	3	3	0	10	11	7

6.63) but a highly significant one between either of these and the insertion-trap ($\chi^2 = 60.97$, $\chi^2{}_{2,\ 0.01} = 9.21$). The larger number of insects found in deck traps may be due to 1 or more of the following factors:

1. Rocking of the car during transit may have a sifting action.
2. Sliding of grain along the floor during automatic or manual unloading increases the probability of trapping.
3. Some insects are positively geotactic and move downwards in a bulk of grain.

Table II shows that 40% of the trap samples from the carloads of grain was infested with 1 or more kinds of insects. Eight percent, 31% and 15% of the samples were infested with rusty grain beetles, fungus beetles, or other fungus feeders, respectively. Other grain insects and incidental insects were found in 2 and 3%

Table II. Percentage of infested trap samples from carloads of grain from the prairie provinces during a 6-month period in 1973.

Kind of insect	Trap	May	June	July	Aug	Sept	Oct	Total period
		Month						
All insects	A	54	68	57	55	64	33	57
	B	50	58	52	55	45	21	48
	Insertion	23	20	7	18	4	19	14
	All traps	42	49	38	42	38	25	40
Rusty grain beetles	A	0	3	13	36	7	0	8
	B	4	13	10	27	17	5	12
	Insertion	12	7	3	0	0	0	4
	All traps	5	8	9	21	8	2	8
Fungus beetles	A	50	55	43	18	50	17	43
	B	42	52	42	27	34	21	39
	Insertion	12	20	3	18	4	19	11
	All traps	35	42	30	21	29	19	31
Other fungus feeders	A	19	16	23	18	29	22	22
	B	19	13	23	36	34	5	21
	Insertion	0	0	7	9	0	0	2
	All traps	13	10	18	21	21	9	15
Other grain insects	A	0	3	0	0	4	6	2
	B	4	3	3	0	7	0	3
	Insertion	0	0	0	0	0	0	0
	All traps	1	2	1	0	4	2	2
Other insects	A	12	0	0	0	4	0	3
	B	8	0	3	0	7	11	5
	Insertion	0	3	0	0	0	0	1
	All traps	6	1	1	0	4	4	3

of the samples, respectively. More rusty grain beetles were found in August and more fungus beetles in June than in other months but the differences were not significant.

Table III shows that the mean number of insects per sample for the 6-month period was 1.2. The mean numbers of rusty grain beetles, fungus beetles, and other fungus feeders were 0.2, 0.7, and 0.4, respectively. The frequency of insect infestation excluding incidental insects was as follows:

Table III. Mean number of insects per infested sample from carloads of grain during a 6-month period in 1973.

Kind of insect	Trap	Month May	June	July	Aug	Sept	Oct	Total period
All species	A	1.9	1.3	1.7	2.5	1.7	0.9	1.6
	B	1.2	1.3	1.8	2.2	3.4	1.1	1.8
	Insertion	0.2	0.3	0.2	0.4	0.0	0.3	0.2
	All traps	1.1	1.0	1.3	1.7	1.7	0.8	1.2
Rusty grain beetles	A	0.0	0.0	0.2	1.6	0.3	0.0	0.2
	B	0.0	0.2	0.1	0.8	0.3	0.1	0.2
	Insertion	0.1	0.1	0.0	0.0	0.0	0.0	0.0
	All traps	0.1	0.1	0.1	0.8	0.2	0.2	0.2
Fungus beetles	A	1.2	1.0	1.1	0.2	0.7	0.2	0.8
	B	0.7	1.0	1.2	0.8	1.3	0.6	1.0
	Insertion	0.1	0.2	0.0	0.3	0.0	0.3	0.1
	All traps	0.7	0.7	0.8	0.4	0.7	0.4	0.7
Other fungus feeders	A	0.6	0.2	0.4	0.7	0.6	0.6	0.5
	B	0.2	0.1	0.4	0.6	1.5	0.3	0.5
	Insertion	0.0	0.0	0.1	0.1	0.0	0.0	0.0
	All traps	0.3	0.1	0.3	0.5	0.7	0.3	0.4
Other grain insects	A	0.0	0.0	0.0	0.0	0.0	0.1	0.0
	B	0.1	0.0	0.1	0.0	0.2	0.0	0.1
	Insertion	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	All traps	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Other insects	A	0.1	0.0	0.0	0.0	0.0	0.0	0.0
	B	0.1	0.0	0.0	0.0	0.1	0.2	0.1
	Insertion	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	All traps	0.1	0.0	0.0	0.0	0.1	0.1	0.0

No. of insects	No. of carloads	No. of samples
0	41	262
1	22	59
2	17	43
3	13	24
4	16	12
5	6	10
6	4	4
> 6	29	18

Nearly 28% of the 148 carloads and 61% of the 432 samples were uninfested. About 26% and 24% of the carloads and samples, respectively, contained from 1 to 2 insects. About 20% of the carloads and 4% of the samples contained 6 or more insects. These results and those reported in Table III show that the numbers of insects recovered from traps were small and indicate the sensitivity of the traps and their ability to detect low levels of infestation. However, a carload or sample containing even 1 insect was rated as infested (Table I and II). These high percentage infestations show that large quantities of infested grain are transported from country elevators to terminals but are not readily detected by the present sampling system. Apparently the cleaning, drying, treatment, and movement of grain in the terminal elevators help to reduce or eliminate insect infestations in our export and domestic grain.

No significant differences in infestations of rusty grain beetles and fungus beetles were detected between province (χ^2 = 1.24, χ^2_2, 0.01 = 9.21) or between months (χ^2 = 9.39, χ^2_5, 0.01 = 15.08). These species were found in about equal proportions in carloads from country elevators in Manitoba, Saskatchewan, and Alberta during the 6-month period. A general decline in numbers of insects from trap samples began in September, probably because most of the grain being delivered at that time was freshly harvested 1973 crop.

Tests to determine whether infestations of rusty grain beetles, fungus beetles, or other fungus feeders originated in a previous carload were not significant. Thus, infestations found in any given carload most likely originated in that load. This result provides further evidence that the car is not the source of an infestation. Nevertheless, cars should be thoroughly cleaned between loads to ensure that infestations do not become established in boxcars.

About 39% and 4% of the 432 trap samples contained dead and live insects, respectively. Most of those that were alive upon arrival of the sample were rusty grain beetles. The high incidence of dead insects, particularly fungus beetles, is not surprising since many of these species cannot long survive where there is insufficient food and moisture. These insects spent from 2 to 30 days in the cars, the average being 10 days. Therefore, those that fell into the trap were unlikely to survive because of the long exposure to dry conditions.

CONCLUSIONS: A device designed to detect insects in carloads of grain during transit was successful when tested in cars in regular grain service. If feasible, treatment of infested grain in the car is desirable because it practically eliminates the risk of introducing insects into the unloading equipment of the elevator.

The device was a more effective means of detection than the existing procedures used with official unload samples.

The boxcars were not the source of infestations.

The high percentage of fungus beetles and other fungus-feeding insects found in carloads of grain suggests that some of the storage facilities and practices at the farm and primary elevator level are inadequate. These insects feed on microorganisms which in turn flourish under conditions of high moisture. A greater awareness of grain insect infestations, the use of improved storage facilities, and the application of sound sanitation procedures at the farm or primary elevator, or both, would reduce insect populations and spoilage organisms in the transportation system and large-bulk storage facilities.

If this device is installed in all boxcars used for grain service, including the newer hopper cars, it would help grain inspectors maintain the high quality of Canadian export grain. Assurance of high quality is especially important today because many grain-importing countries are becoming increasingly exacting in their sanitation requirements and are developing improved and more rigorous standards of inspection of imported food products.

ACKNOWLEDGEMENTS: The author is indebted to many people without whose cooperation this experiment could not have been conducted. He is grateful to the following officers of Canadian National Railways, Winnipeg for permission to use company boxcars and the railway tracing service.

R. G. Messenger, A. E. Deegan, J. J. Harris, B. Gasior, J. Y. Roy, L. Worobey. Thanks are due to M. M. Ainslie, C. W. Hammond, A. G. Rudd, D. G. Plews, J. R. Elvidge of the Canadian Grain Commission for their cooperation in the retrieval of traps at terminal elevators. The author is pleased to acknowledge the cooperation of the following grain company officers: H. E. Ripley, Alberta Wheat Pool; W. W. Hays, J. J. Mallon, and J. K. Wilson, Manitoba Pool Elevators; W. G. Bradley and J. Pineau, Saskatchewan Wheat Pool; W. M. Nielson, National Grain; B. A. Domes and H. R. Moore, N. M. Paterson and Sons; J. Stangeland, Pioneer Grain; J. H. Simpson, Richardson Terminals; D. Campbell and J. F. Mants, United Grain Growers. Thanks are due to M. Bickis of the Research Station for preparing a computer program to analyze the data, to B. Salamon for his valued technical assistance, and to R. J. Cheale for taking the photographs.

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