MONITORING BEETLE PESTS MOVEMENT IN AERATED GRAIN BINS BY THE USE OF PITFALL CUP AND PROBE TRAPS

P. M. COGAN, M. E. Wakefield, D. M. Armitage and D. R. Wilkin

M.A.F.F. Central Science Laboratory, London Road, Slough, Berkshire SL3 7HJ. U.K.

ABSTRACT

Pitfall and insect probe traps have been used successfully to monitor insects in grain during ambient aeration of bins filled with 20 tonnes of wheat at an initial temperature of approximately 30°C. The major beetle pests of grain in temperate regions; *Oryzaephilus surinamensis*, *Sitophilus granarius* and *Cryptolestes ferrugineus* were added to the grain at 1, 1 and 0.5/kg prior to aeration. The traps, located both on the surface and within the grain bulk, indicated by trap capture that *O.surinamensis* and *C.ferrugineus* migrated in numbers to the surface, whilst *S.granarius* remained within the bulk. After 7 months of storage using ambient aeration, no live insects were detected either in the traps or by using conventional sampling methods.

INTRODUCTION

Grain in temperate climates is often stored in large bulks for several years. To ensure safe storage, newly harvested grain has to be dried to reduce its moisture content to avoid fungal spoilage and then cooled to prevent moisture migration within the bulk and to prevent insect development. Climatic conditions in northern Europe, including the U.K. permit the use of ambient aeration to cool stored grain to 12°C, which is the temperature at which storage beetle pests cease to breed (Howe 1965). Continuation of cooling with ambient air to maintain low temperatures in grain has been shown to kill many storage beetles (Armitage and Llewellin 1987).

The detection of insects within grain bulks has until recently been by sieving samples of grain obtained from the surface, or within the bulk by the use of gravity spears or vacuum samplers. These methods have been shown to be both inefficient and ineffective compared with the combined use of beaker pitfall and insect probe traps (Cogan *et al* 1985 and Cogan and Wakefield 1987). Studies utilising these traps for the determination of beetle behaviour in aerated grain have been undertaken as part of work on integrated control of insect pests in stored bulk cereals funded by The Home Grown Cereals Authority.

MATERIALS AND METHODS

The experiment was conducted using six 20 tonne metal bins (3x3x3.5m) consisting of 3 adjoining bins either side of a common central wall housed inside a large store. Each bin had a single perforated metal aeration duct connected to a centrifugal fan which provided an airflow rate of about 10cu m/tonne/hour. Differential thermostats were used to control the fans so that 3 bins were aerated when the ambient air was 2°C, or lower than the grain temperature (in the bin centre at 1m depth). A differential of 4°C was used for the other 3 bins. Each bin was filled with approximately 20 tonnes of wheat with a moisture content ranging from 12.5% to 16.5%, and temperatures ranging between 27°C and 35°C. This was considered to be the worst post-harvest conditions likely to be encountered at the start of storage in the U.K. and favoured rapid insect development.

All bins were seeded with *Oryzaephilus surinamensis*, *Cryptolestes ferrugineus* and *Sitophilus granarius* at a rate of 1.0, 1.0 and 0.5/kg respectively, (a total of 50000 insects per bin). Insects were introduced into the grain by inserting a 22mm diameter plastic pipe to the bottom of the bin using a vacuum sampler and then pouring a mixture of insects and grain down the pipe as it was withdrawn. Grain was used to fill the final 20cm of each pipe, so that insects were not introduced into the surface layer. This procedure was repeated 13 times throughout each bin to provide as even distribution as possible.

The insects were monitored in each bin by the use of 16 pitfall traps (Cogan and Wakefield, 1987) placed in a 4 x 4 grid on the surface and 27 insect probe traps (Burkholder, 1984) in grids 3 x 3 in the surface layer, 1m, and 2m depth. The traps were approximately 1m apart and 0.5m from the sides of the bins. Both trap types were placed into the bins one week after the insects were added (one week before aeration commenced) and then checked at weekly intervals for 6 weeks, after 2 further weeks and finally at monthly intervals for 9 months. Insects leaving the bins were monitored by the use of bait bags (Pinniger, 1975) which were placed at approximately 1 metre intervals around the block of bins.

Distribution of the insects within the grain bulk was also checked after the experiment had been running for 7 months by sieving and examining 200gm samples of grain obtained by gravity spear taken from each bin at the surface, 1m and 2m. At the end of the experiment the grain was further checked for insects as it was moved from bin to lorry. Samples of 1kg/15 minutes was examined from the auger outlet whilst each lorry load was examined for insects by removing samples with a vacuum sampler in accordance with BS4510.

The grain temperature in each bin was monitored by using thermocouples in the centre and at an outer corner, recording from 0.5m, at 0.5m depth intervals, to 2m. The trapping results for the 2°C and 4°C differential aerations were similar and for the purposes of this paper the 2°C bins were chosen as representative.

RESULTS

Table I. Mean pitfall and probe catch per trap of *Oryzaephilus surinamensis* (+/- S.E.) at surface, 1 and 2 metres depth.

Weeks post aeration	Mean trap catch per trap			
		Probe Traps		
	Pitfall (n=48)	Surface (n=71)	1Metre (n=71)	2Metres (n=71)
0	0.2 (0.1)	1.7 (0.7)	6.4 (2.9)	0.3 (0.2)
1	0.9 (0.2)	247.6 (73.2)	2.1 (0.6)	1.6 (0.7)
2	34.3 (4.0)	14.7 (2.2)	1.6 (0.4)	1.0 (0.9)
3	2.7 (0.5)	5.3 (1.7)	0.6 (0.2)	0.6 (0.2)
4	4.5 (0.7)	2.3 (0.7)	1.2 (0.4)	1.0 (0.3)
5	1.6 (0.3)	2.2 (0.5)	0.6 (0.1)	0.7 (0.2)
6	1.3 (0.2)	1.4 (0.4)	0.4 (0.1)	0.2 (0.1)
8	2.2 (0.3)	0.04 (0.04)	0.04 (0.04)	0.3 (0.04)
12	0.6 (0.1)	0.3 (0.04)	0	0.2 (0.2)
16	0.2 (0.1)	0.1 (0.1)	0	0
20	0	0.1 (0.1)	0	0.04 (0.04)

N.B. Nil *O.surinamensis* were trapped during weeks 24-40, except one in surface probes on week 36.

Table I shows the effect of ambient aeration on the movement of *O.surinamensis* as determined by trap catch. *C.ferrugineus* is likewise presented in table II. Figure 1 illustrates the differences in peak catch and number caught per trap, between pitfall and surface probe traps, most clearly demonstrated in *O.surinamensis*.

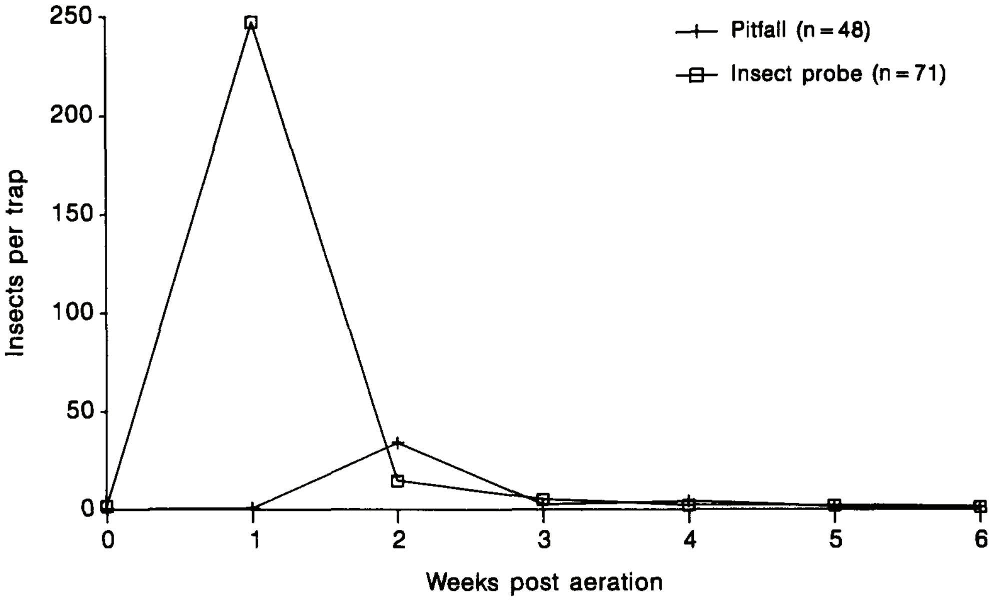

Figure 1.

Mean pitfall and surface insect probe trap catch of Oryzaephilus surinamensis.

Few *S.granarius* were trapped compared with the other 2 species and mean trap catch above 1 was only recorded in the 1 and 2 metre, 4.9 +/- 1.2 S.E. during week 0 (post aeration). Surface probe trap catch rose from 0.2 +/- 0.1 at week 0, to 0.4 +/- 0.2 at week 1 then fell to 0.2 +/- 0.1 for the next 3 weeks. The highest mean pitfall trap catch (0.4 +/- 0.1) was 2 weeks post aeration. After week 6 only 1 *S.granarius* was trapped at week 12, and at week 16. No further *S.granarius* were trapped after week 16.

Temperatures prior to aeration (week 0, 18.9.1987) were in the range 20-30^{o}C. One week after the start of aeration temperatures were below 15^{o}C at the centre of each bin and 2 weeks later no temperatures were recorded above 15^{o}C. After a further 7 weeks temperatures fell to below 10^{o}C and in the following 2 weeks (10.12.1987) were approximately 5^{o}C. Temperature maxima in the grain remained at 5°C +/- 4° until after week 24 (31.3.1988). Temperature maxima rose above 10°C throughout the grain following week 32 and finally above 11.5°C by the end of the experiment (7.7.1988). By the end of the experiment the temperature maxima at the base of the bins had reached 16°C.

Table II. Mean pitfall and probe catch per trap of *Cryptolestes ferrugineus* (+/- S.E.) at surface, 1 and 2 metres depth.

	Mean trap catch per trap			
Weeks post aeration	Pitfall (n=48)	Probe Traps Surface (n=71)	Probe Traps 1Metre (n=71)	Probe Traps 2Metres (n=71)
0	0	0.8 (0.7)	1.4 (0.8)	0.04 (0.04)
1	0	22.5 (8.9)	0.3 (0.2)	0.2 (0.1)
2	2.3 (0.5)	2.0 (0.7)	0.3 (0.1)	0.1 (0.1)
3	0.9 (0.2)	1.1 (0.3)	0.04 (0.04)	0.1 (0.1)
4	1.5 (0.2)	0.9 (0.3)	0.1 (0.1)	0.1 (0.1)
5	0.6 (0.1)	1.2 (0.3)	0.1 (0.1)	0.04 (0.04)
6	0.8 (0.2)	0.6 (0.2)	0.2 (0.1)	0.04 (0.04)
8	0.4 (0.03)	0	0	0
12	0.8 (0.04)	0	0	0

N.B. No further *C.ferrugineus* were trapped after week 12 except one in a 1 metre probe trap at week 20 (3.3.1989).

No live insects were detected in the gravity spear samples taken at week 28 and no larvae were detected at any time in the grain. A total of 1282 *O.surinamensis* (approximately 1% of this species added to the bins at the start) were trapped in the baitbags surrounding the experimental bins. None were trapped during the last 3 weeks and only one in the last 6 weeks of the experiment. Nil *C.ferrugineus* and only one *S.granarius* were found in the baitbags throughout the experiment.

In the samples examined when the grain was outloaded, all insects recovered were dead. Estimates of *S.granarius* and *O.surinamensis* obtained from these samples were 1 (standard deviation 0.5) and

(Loschiavo,1974), although it is known that pitfall traps are relatively inefficient at trapping this species (Cogan *et al*, 1985),so that low numbers may have been present but were not trapped.

The appearance of a peak in the pitfall trap catches, for all three species (albeit slight with *S.granarius*), one week after the peak in the surface probe traps (see Figure 1) may have been due to the surface layer of the grain being at its highest temperature after the first cooling front had passed through the grain. Thus the probe traps located in the grain just below the surface where the pitfall traps were positioned may have been in cooler grain. The large number of *O.surinamensis* trapped compared with the other 2 species may have been due in part to an increase in its activity as temperatures decreased from 25^{o}C to below 20^{o}C as found by Surtees (1963). Thus numbers trapped of this species would be expected to increase as the aeration produced (initially) lower grain temperatures. As the grain cooled further, due to aeration, numbers of all 3 species trapped in the probe and pitfall traps decreased correlating with the decrease in temperature maxima. This was undoubtedly due to a decrease in insect activity. Following the initial aeration, from 19th November (7 weeks after aeration started) until the beginning of May the bulk of the grain remained cool (below 10^{o}C) and few insects were trapped (mainly *O.surinamensis*). From the beginning of April no further *C.ferrugineus* or *S.granarius* were trapped and only a single *O.surinamensis*, even though temperature maxima in the surface layers rose above 15^{o}C during May. As this temperature would have allowed insect activity and hence trapping to occur ,death or escape of the insects must have occurred. Death of the insects seems most likely as only one percent of the *O.surinamensis* released into the bins were recovered in the baitbags whilst only one *S.granarius* and nil *C.ferrugineus* were trapped with no insects recovered during the period when the temperature rose above 15^{o}C. Moreover the samples taken at outloading, contained only dead insects. These results endorse those found by Armitage and Stables (1984) where 2% of the estimated population of *O.surinamensis* (the major species they detected in baitbags surrounding the bins) were recovered in the baitbags after aeration.

The observation that *O.surinamensis* and *C.ferrugineus* migrating to the surface in response to the cooling of the grain makes possible selective insecticide treatments of the surface to kill these insects before any leave the bins and thus prevent them from infesting other nearby grain stores. The trapping results for *S.granarius* did not show this trend. The possibility that the traps were not trapping this species seems most unlikely as Cogan *et al* (1985) showed that pitfall traps were effective traps for this species. A more likely explanation is that this species appears less able to move through the intergranular spaces as readily as the others and failed to respond to the cooling fronts produced by the aeration and then apparently succumbed to the long period at low grain temperature (Armitage and Llewellin, 1987).The low numbers of all 3 species trapped by the probe traps at 1 and 2 metres compared with the surface probe and pitfall traps indicates that there is no benefit to be gained by storekeepers placing traps at 1 and 2 metre depths in bins. Before such a recommendation is made however, it must be remembered that the insects were seeded into these bins and did not infest the grain naturally. Traps at depth may well be useful for early detection of hot spots but the use of temperature probes coupled with using surface traps would probably be as effective and certainly would be easier to use. The use of traps in this experiment successfully demonstrated that ambient aeration can be used to prevent the 3 major U.K. grain beetle pests from becoming established within 20 tonne grain bulks as no larvae were found throughout the trial and at the end of the experiment no live insects could be detected.

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LE CONTROLE DU DEPLACEMENT DES COLEOPTERES RAVAGEURS DANS LES CELLULES DE GRAIN VENTILEES GRACE A L'EMPLOI DE PIEGES A ENTONNOIR ET DE SONDES PERFOREES.

P.M. COGAN, M.E. WAKEFIELD, D.M. ARMITAGE, D.R. WILKIN et K.P. THOMAS.

Adas Central Science Laboratory, London Road, Slough, Berks SL3 7HJ, England.

RESUME

Oryzaephilus surinamensis, *Cryptolestes ferrugineus* et *Sitophilus granarius* ont été ajoutés à raison de 1/kg, puis surveillés dans six cellules de 20 tonnes de froment au moyen de pièges à entonnoir placés à la surface du grain et de sondes perforées placées à trois niveaux différents des cellules, (en haut, au milieu et à la base) dans le grain. Les déplacements de ces déprédateurs ont été surveillés pendant la ventilation des cellules qui a duré trois mois.

Les données fournies par les pièges ont été étudiées par rapport à la ventilation et la température. Les résultats ont montré non seulement l'utilité des pièges statiques pour surveiller les populations de ravageurs mais ils ont aussi démontré l'efficacité du contrôle différentiel automatique de la ventilation à l'air ambiant pour réduire les dégâts occasionnés au grain par ces coléoptères.