THE EVALUATION OF SOME FOOD ATTRACTANTS FOR THE DETECTION OF ORYZAEPHILUS SURINAMENSIS (L.) AND OTHER STORAGE PESTS

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Introduction

The presence of insect pests in stored food and in the environment of food storage, transport and processing frequently leads to economic losses. The standards which have been adopted in many countries have resulted in a very low tolerance level of insects and the discovery of even one live insect can lead to rejection of foodstuffs, costly control measures and consequent loss of revenue. The need for efficient pest detection techniques is well established in many fields of economic entomology (Beroza 1976, Lewis 1978) and the characteristics of storage environments and storage pests have demonstrated a need for development of insect detection and monitoring systems. Techniques based on physical trapping have been devised by Loschiavo (1975) and the use of attractant chemicals has been discussed by many authors including Haines (1976), Burkholder (1977) and Levinson (1979).

Bait bags containing foodstuffs have been used for insect detection and monitoring by the Ministry of Agriculture, Fisheries and Food in Great Britain for some years and are now commercially available (Pinniger and Wildey 1979). These bait bags have been successfully used by infestation advisers and researchers in other countries for insect detection and surveys (Loschiavo and Okumura 1979). The present paper describes studies on the effectiveness of bait bags and investigations into the attractive components of the food materials.

Bait bags

A bait bag is a 200 mm x 100 mm plastic mesh envelope containing approximately 80 g of equal parts of wheat, broken groundnuts and kibbled (crushed) carobs (locust beans). This mixture of foods was chosen because of its apparent superiority over other foods in limited trials in test rooms and storage premises. Bait bags are placed in strategic places in the environment being monitored and after a period of 2 to 7 days they are removed and shaken over a tray to remove trapped insects for identification and counting. The bags have proven very effective in practice and have been particularly useful for detection of infestations which had not been discovered by visual inspection or other trapping methods (Pinniger 1975). Pinniger and Wildey (1979) listed the 40 species which had been detected using bait bags and Jacobson and Pinniger (1982) give accounts of the use of bait bags for monitoring of Oryzaephilus surinamensis following treatment of farm grain stores. There are many complex factors which affect the performance of a trap and the relationship between the number of insects trapped and the size of pest populations. Although information of this sort is difficult to obtain from practical trials, an estimate of efficiency of trapping was obtained from trials in a 9.2 m x 3.6 m test room at the Slough Laboratory. The room was unlit and maintained at 25°C and 50% RH and 6 bait bags were placed on the floor wall junctions. 600 unsexed, 2-4 week old adult O. surinamensis were released in the centre of the floor and the number of insects caught in each bag was recorded at 7 day intervals. Insects trapped in the bags were removed and not released back into the room, the bait bags were then replaced in the same positions. The results are shown in Table 1.

Table 1

Recapture in bait bags over 4 weeks of 600 O. surinamensis released in a test room.

Week	Number in room at start of week	Estimated mortality during week	Number caught during week
1	600	17	263
2	320*	34	155
3	131*	37	46
4	48*	42	6

* Number of insects remaining corrected for estimated mortality.

The estimated mortality was obtained by placing 600 unsexed O. surinamensis in a large plastic container in the same room and recording mortality at 7 day intervals. It can be seen that during the first three weeks of the trial, the proportion of insects caught was between 35 and 48% and by the fourth week so few live insects remained in the room that the estimated mortality and therefore the estimated catch is probably unreliable. The reliability and effectiveness of bait bags at a range of insect densities has been demonstrated but controlled trials using low density releases have been fraught by difficulties of variation in mortality rates.

In order to investigate the performance of bait bag food components against different insect species, controlled release and recapture experiments have been carried out in a shallow 1 m x 1 m arena. Four smaller sized (90 x 90 mm) bait bags were placed in the arena, 200 insects were released and the number of insects in and under the bait bags was recorded after 24 hours in constant darkness at 20°C and 70% RH. Preliminary experiments showed that bait bags filled with an inert insulation material (Micafil) were almost as effective as those filled with the food mixture. It was thought that the crevice seeking nature of most storage species induced insects to remain in filled bait bags, food reinforces this arrestancy and volatile components attract insects to the bags. The test arena was therefore modified to determine the attractancy of the bait bags when alternative refuges were provided. A 20 mm deep layer of Micafil was placed over the arena floor to provide refuges and four bait bags were placed on the surface of the Micafil.

200 insects were then released: unsexed adult O. surinamensis 1-3 weeks old, Sitophilus granarius 1-3 weeks old and Tribolium castaneum 3-5 weeks old. Bait bags were filled with wheat, groundnuts, carobs, a 1:1:1 mixture of the three, or Micafil. The results of the 24 hour count are shown in Figure 1, the catch in the bags is a mean of 3 replicate tests for each species and bait bag type. The effect of the mica filled bait bags was much reduced and a very low catch obtained compared to that found in the Micafil-free arena. The effect of the food materials was clearly demonstrated and bait bags filled with food mixture produced the largest catch except with Sitophilus granarius where most were caught in the wheat filled bags. The success of wheat in attracting S. granarius is perhaps not surprising in view of the behaviour and the life history of this species. The apparent lack of attraction shown by the groundnut filled bags to T. castaneum was unexpected particularly in view of the apparent attractiveness of groundnuts to S. granarius and O. surinamensis. The effectiveness of bags containing only carobs reinforces the belief that this food material is very attractive to all three species and therefore studies have been continued to isolate and identify the attractive components in carobs.

Carob components

An investigation into the attractancy of vapour from extracts of carobs and triglycerides by O'Donnell et al (1983) had demonstrated that a soxhlet hexane extract of carobs was attractive to O. surinamensis and that this extract contained glyceride-based materials. O'Donnell et al also showed that the unsaturated triglyceride, 2-γ-linolenoyl-1,3-dipalmitin, produced the greatest attractant response of ten triglycerides tested. It was thought that degradation of the glycerides was probably responsible for their attractiveness to insects. When O'Donnell et al assayed a few potential degradation products of the triglycerides they found that glyceride acids, aldehydes and fatty acids produced responses ranging from attraction to repulsion. This may explain the range of apparent responses to the original triglycerides as different triglycerides will give rise to different mixtures of degradation products.

Glyceride and fatty acid components in foodstuffs have been shown to have an arrestant effect on T. confusum (Tamaki et al 1971) and on O. surinamensis (Freedman et al 1982 and Mikolajczak et al 1983). The attraction of O. surinamensis to a vapour source shown by O'Donnell et al (1983) was sufficiently promising to encourage investigation of the effect of vapour produced by carobs on stored product beetles.

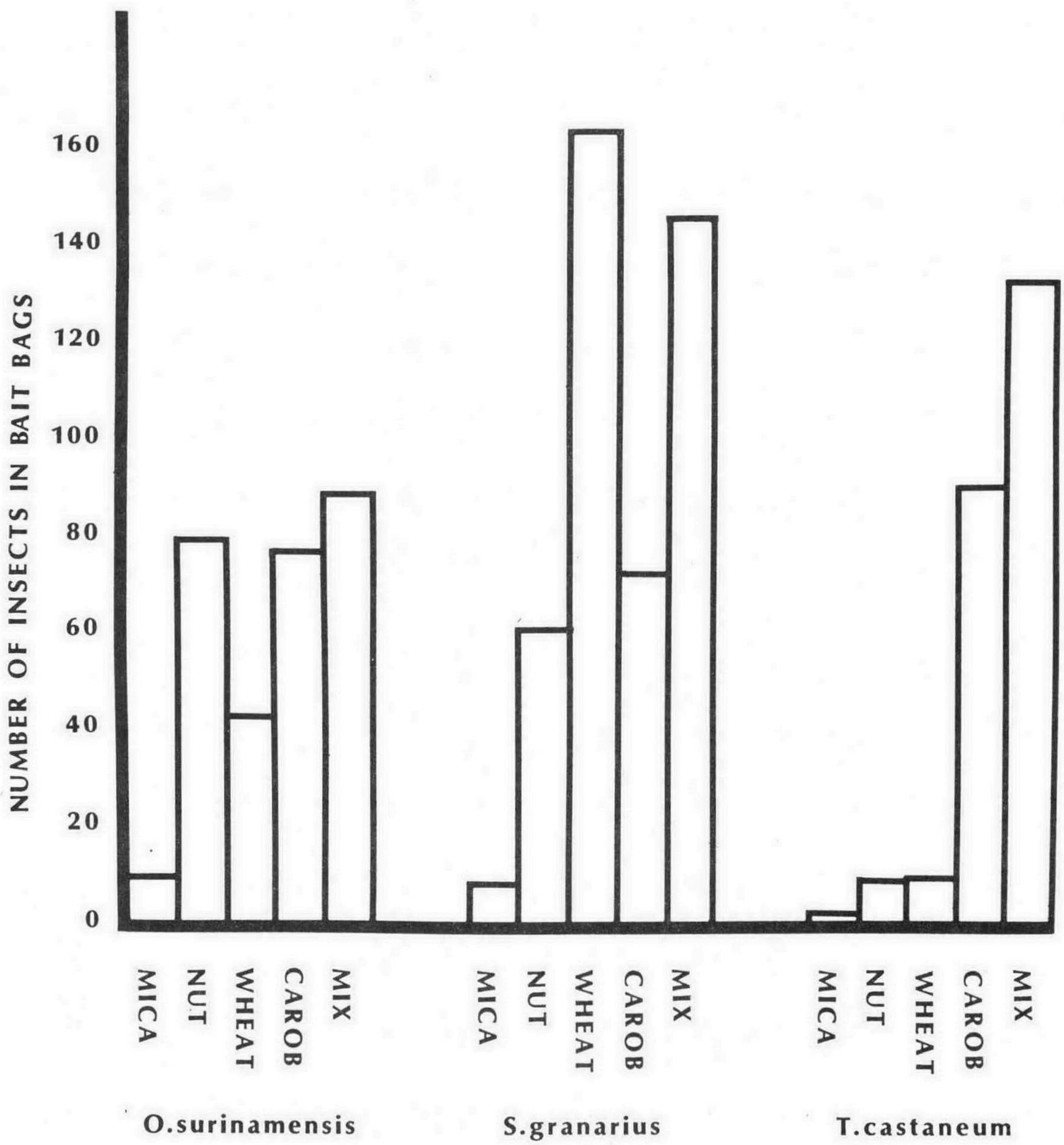

Fig 1. Numbers of O. surinamensis, S. granarius and T. castaneum caught in bait bags filled with various foods or Micafil

Volatiles from powdered carobs were isolated by vacuum distillation (Stubbs et al, In press) and the resulting distillate was tested for attractancy in an insert activity detector based on the design described by Pinniger and Collins (1976) and O'Donnell et al (1983). This apparatus consists of a base-plate containing eight light dependent resistors (LDRs), an overhead light source and counting equipment which recorded the number of times an insect crossed an LDR. An arena was set up over each LDR with the LDR at the centre. Each arena comprised a 15 cm x 15 cm ground glass base-plate with a 10 cm diameter metal ring coated with 'Fluon' to contain the insects in the arena. A 12.5 cm diameter crystallising dish was inverted over each arena and a porous polyethylene wick was suspended on fine steel wire through a hole in the centre of the dish. The 10 mm x 1 mm wick was arranged to hang directly over the LDR about 10 mm from the arena floor. A diagram of the apparatus and arena is given by Stubbs and Griffin (1983).

When insects are introduced into the arena they cross under the wick by random movements and trigger the LDR. The frequency of crossings depends on the size of the arena, the number of insects, their rate of movement and general behaviour. If insects are attracted to the wick then the number of crossings of the LDR should be greater than those produced by random movement. The degree of attractancy should be related to the frequency of crossings. An increase in number of crossings could also have been produced by other stimuli but observations during the tests confirmed that the response to the chemical was directed and therefore that it was attractancy which was being measured (Kennedy 1978).

The responses of adult O. surinamensis, S. granarius and T. castaneum to carob distillate (CD) and carob distillate diluted with distilled water to a concentration of 0.01 (1/100 CD) were determined using a similar experimental procedure to that described by Stubbs and Griffin (1983). Groups of 10 unsexed insects were conditioned at 25°C, 50 % rh for 24 hours and then placed in arenas. 16 replicates were carried out for each test. One hour after the insects were introduced into arenas, dry wicks were removed and replaced by either new dry wicks or wicks treated with 5 µl of water or the material being assayed. The aqueous nature of carob distillate meant that control assays were carried out using dry wicks and wicks treated with distilled water. Stubbs and Griffin (1983) had shown that water produced a considerable attractant response in O. surinamensis and that the response was related to the humidity at which the insects were preconditioned. Most of the attraction to the wicks treated with water occurred in the first 10 minutes after application and the number of crossings under the wick fell to a low level after 30 mins when a humidity equilibrium had been reached in the arena.

Table 2 Mean number of crossings (± s.e.) in 2 hrs under a dry wick or one treated with 5µl of water, carob distillate (CD) or carob distillate diluted to 1/100 with water (1/100 CD).

Wick Treatment	O. surinamensis	S. granarius	T. castaneum
Dry	4.31 (0.81)	12.06 (0.81)	33.00 (4.00)
Water	67.00 (8.06)	39.25 (3.60)	101.56 (7.29)
1/100 CD	137.56 (17.77)	46.06 (4.43)	103.56 (7.22)
CD	116.31 (11.70)	62.25 (7.91)	96.81 (5.82)

The results of the total activity over a period of 2 hours shown in Table 2, demonstrate that all three species show a significant response to water vapour and that the carob distillate produced a greater response in O. surinamensis and S. granarius. The effect of concentration is obviously important, 1/100 CD produced a greater response than CD in O. surinamensis but a lesser response than CD in S. granarius and so it is possible that high concentrations may be initially repellent to some species. For example, the distillate did not appear to be more attractive than water to T. castaneum despite the fact that the presence of carobs in bait bags greatly increased their attraction to this species. The attraction of O. surinamensis to water and carob distillate was further investigated in a series of tests carried out in a similar manner but activity records were taken after 30, 60, 90 and 120 minutes. Figure 2, shows that after 30 minutes the distillate produced 40% more crossings than water. Although the response decreased slowly over the following 90 minutes it was considerably greater than the response to water alone and the carob distillate still produced an attractant effect 2 hours after it was introduced into the arena.

The carob distillate has been subjected to a series of extractions to isolate attractive materials and a detailed description of this work is currently being prepared for publication (Stubbs et al, in press). An acidic fraction of the distillate was found to be attractive to O. surinamensis and the components of this fraction have been identified as acetic, isobutyric, n-butyric, 2-methylbutyric and hexanoic acids. These acids were assayed using similar concentrations to those found in the distillate and hexanoic acid was found to produce the greatest response of O. surinamensis. Fig. 3. shows the response of O. surinamensis to hexanoic acid and the distillate over the test period. It can be seen that although the response to hexanoic acid is less than to the distillate over the first 30 minutes, the subsequent response over the following 90 minutes is very similar. The hexanoic acid found in carob distillate is sufficient to account for its attractancy to O. surinamensis and it may be significant that hexanoic acid is likely to be the most abundant volatile degradation product of the triglyceride 2- γ-linolenyl-1,3-di-palmitin mentioned earlier.

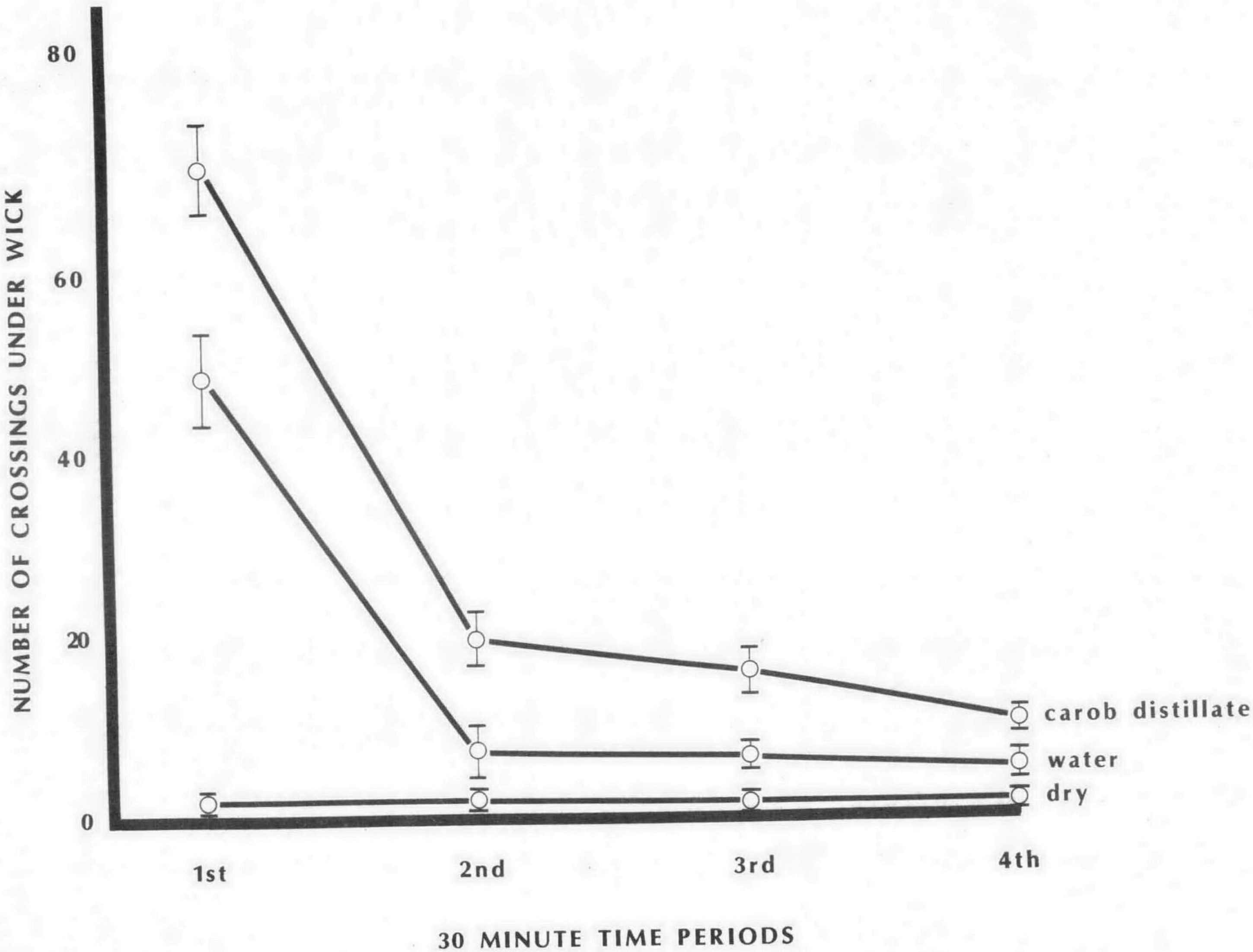

Fig. 2. Response over 2 hr of O. surinamensis to wicks treated with water or carob distillate.

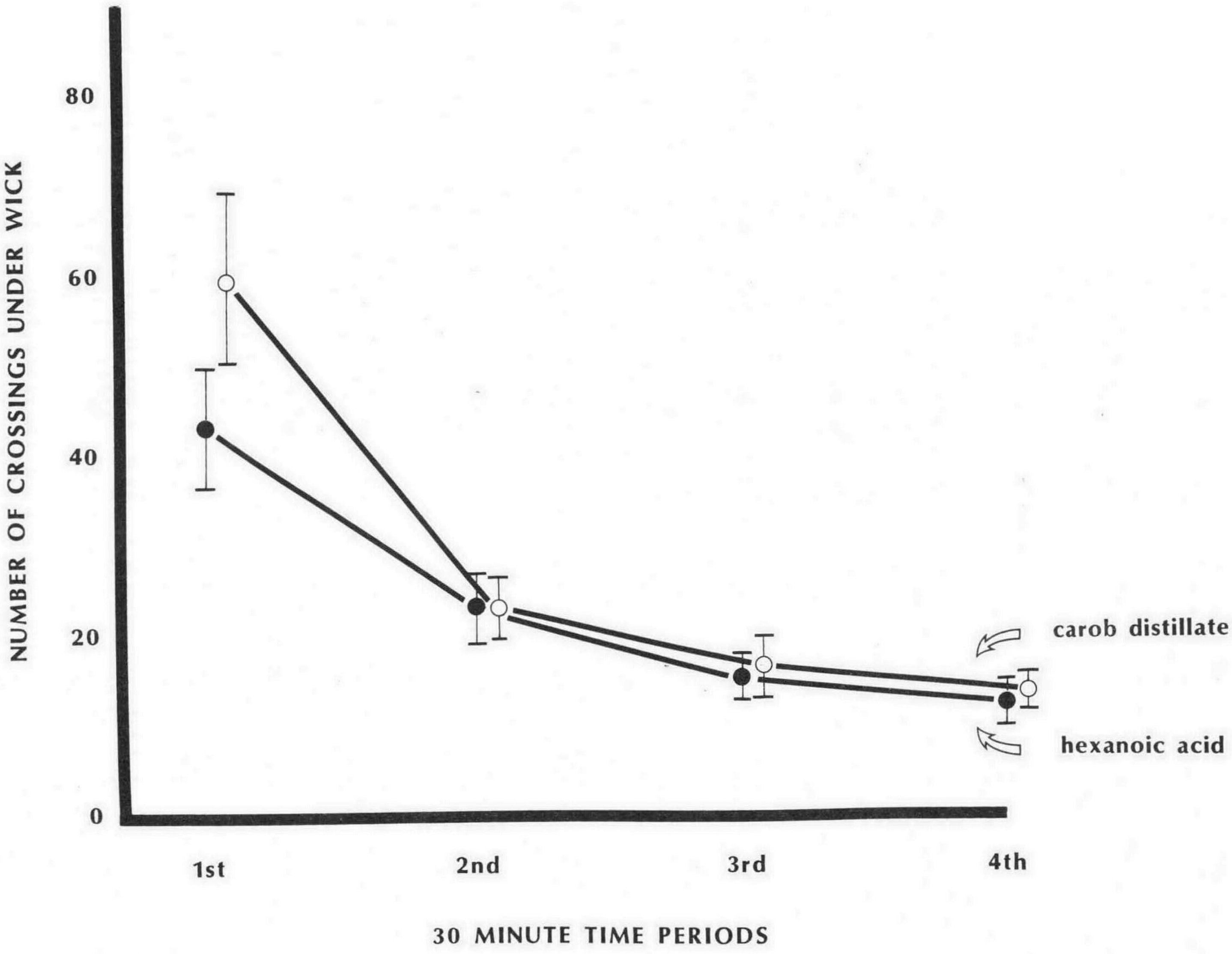

Fig. 3. Response over 2 hr of O. surinamensis to wicks treated with carob distillate or hexanoic acid.

Conclusions

It is clear that food or pheromone-based attractant materials have an increasingly important role to play in the detection of stored product pests in the near future (Burkholder 1979). Pheromone-based traps have been shown to be very successful for some pest species but because of their sex and species-specificity have some disadvantages. In storage environments a range of genera and species are frequently encountered and successful use of pheromone traps implies foreknowledge of target species. Traps utilising food materials can be multispecific and bait bags have been successfully used for monitoring stored product beetle populations where their particular value has been their ability to trap a range of species in widely differing environments.

Carobs, which are one of the bait bag food components, have been shown to be attractive to O. surinamensis and O'Donnell et al (1983) and Stubbs et al (in press) have demonstrated that materials isolated by solvent extraction and vacuum distillation produce attractant responses. Hexanoic acid appears to be the most active material derived from carobs which has yet been tested. A small number of other researchers have investigated a range of food materials and used different assay techniques. Tamaki et al (1971), Yamamoto et al (1974) and Mikolajczak et al (1983) have investigated triglycerides and acids derived from oats, wheat, rice, and yeast. It seems that tests carried out which measure contact of insects with a treated substrate and determine aggregant effects demonstrate that the unsaturated triglycerides produce the highest levels of response. However, assays which primarily measure the response of insects to vapour demonstrate the ability of volatile acids and particularly hexanoic acid, to attract insects.

The present investigation is incomplete, and work is currently in progress to evaluate carob distillate as an attractive component in insect traps.

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