Trapping *Trogoderma variabile* (Coleoptera: Dermestidae): a comparison of traps and techniques for adult and larval monitoring

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Abstract

As part of a large Australian research program on the warehouse beetle, *Trogoderma variabile*, various trap designs and trapping methods were tested for larvae and adults of this species. Due to the cryptic habits of the larvae, detection is very difficult and an effective larval trap would be very useful as a monitoring tool. Three designs of larval traps were tested in a heavily-infested building. None of them performed well. Trapping of adult males using pheromone-baited sticky traps was far more successful. A comparative study of three brands of commercial pheromone lures was conducted, with one brand giving a higher catch than the others. For one brand the effect of ageing on the lure was examined and the results suggested that more frequent replacements were required than was recommended by the manufacturer. The importance of vertical positioning of traps on performance was studied on the outside of an infested grain storage structure where traps were placed between 0 and 4.2 m above ground. The highest numbers were caught less than 0.3 m above ground. Between 1.5 and 4.2 m, catch numbers were similar, suggesting that trap height has a minimal effect on catch within this range.

Introduction

Trogoderma variabile Ballion, the warehouse beetle, is a relatively new pest in Australia, having been present only since the late 1970s (Hartley and Greening 1983). It is a serious pest of storage environments, especially of packaged processed products that are not quickly consumed. It is an important pest for quarantine reasons in Australia because of its resemblance to *Trogoderma granarium*, a species that does not occur in Australia and against which there are many international quarantine barriers (Wright 1993).

A large research program has recently been completed on the biology and control of this species in Australia. To be able to monitor populations for ecological studies and to evaluate effectiveness of control treatments, it was necessary to have reliable methods for detection and estimation of populations of larvae and adults. Here we report on the testing of a number of trap designs and trapping methods.

The larvae of *T. variabile* are exceedingly cryptic, and when in diapause move relatively little and seldom from their refugia. The standard method of detecting larvae of *T. variabile* is by very thorough inspection, particularly in the very difficult and inaccessible locations within a structure. This is challenging and requires a significant amount of experience, so a reliable trap would be very useful. There are a various types of traps available that claim to capture larvae. We tested two of these, along with a very simple and inexpensive cardboard trap that has been used by Wright (1991) with much success for other species of stored-product insects.

The adults of *T. variabile* are known to be good fliers and the males respond to a sex pheromone, (Z)-14-methyl-8-hexadecenal, produced by the female (Cross et al. 1977). During the unsuccessful warehouse beetle eradication program in New South Wales in 1977–1981, an attempt was made to use pheromone lures in traps but no adult males were caught, probably because the main flight period had passed (Hartley and Greening 1983). The potential for use of pheromone-baited traps was so great that pheromone traps were tried again, this time with considerable success. Here we report on comparisons of three types of pheromone lures and a field trial to determine the optimum height above ground for setting the pheromone trap.

Experimental Methods and Results

Larval traps

The traps

1. Consep box trap (Consep Membranes, Inc., 213 Southwest Columbia, P.O. Box 6059, Bend, Oregon 97708, USA). This is a sticky trap designed to catch adults and larvae, primarily for use inside buildings. It uses a proprietary lure containing both sex pheromone and unspecified food attractants. This trap measures 15 × 8.5 × 5 cm, with flaps that fold inwards to provide the opening to the trap and ramps for the larvae to walk up. The interior is completely coated with a film of glue.
2. Khapra beetle trap (Barak 1989). This trap is designed to be attached to walls, and attracts adults using a pheromone lure, and larvae using wheat germ or sesame oil. The insects are captured by drowning in the reservoir of wheat germ oil, housed in a piece of corrugated cardboard which is enclosed in a cardboard jacket that is attached to a vertical surface.
3. Cardboard flour trap. This home-made cardboard trap (Wright 1991) contains a small amount of whole wheat flour as a food attractant for larvae. It acts as a harbourage for the insects and does not kill them. It is a single piece of corrugated cardboard (10 × 15 cm) that has been sealed along one long side with cellulose tape and filled with 0.4 g of whole wheat flour as a feeding attractant for the larvae.

Site and trapping details

The trapping trials were divided into two periods. During period 1 (14 August –17 October 1990) 8 khapra beetle traps, 11 box traps and 11 cardboard traps were set at various locations in an office in Griffith, New South Wales known to be infested with *T. variabile*. During period 2 (17 October 1990–4 October 1991), the number of box and cardboard traps was reduced to 3, but all 8 khapra beetle traps were retained.

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The box and cardboard traps were placed together in pairs to enable a direct comparison between the two types of traps that rested on horizontal surfaces. All traps were checked and the insects were removed and identified weekly. When an exuvium was found in a trap without any larvae, it was assumed that the larva had entered the trap for long enough to moult but had then escaped. The larval exuvium is sufficient for species identification, so the positive identification of a *T. variabile* exuvium was considered a larval detection.

Results

Very few insects were captured over the 14 months of the test, so no inferences about seasonal activity are possible. Totals only are presented (Table 1).

The box trap caught an average of 0.003 insects/trap day and retained no larvae at all, although 1 exuvium was found. Because the lure contained pheromone, it did catch a few adults, but overall, this trap was quite uninformative.

The cardboard trap caught only 4 larvae, giving a capture rate of 0.002 insects/trap day.

The khapra beetle trap caught both adults and larvae, with a capture rate of 0.01 insects/trap day. When considering larval catches only, the rate of capture was 0.005/trap day.

Discussion

None of the traps could be considered effective or useful. Over the time when very few larvae were caught by the traps, larvae were found often on the floors and furniture by office staff. Nevertheless, of the traps tested, the khapra beetle trap was best for detection of the presence of *T. variabile*, because it caught both adults and larvae. From the lack of catches of larvae by the box trap, we conclude that the food attractant in the lure used in this trap was ineffective. The cardboard trap was the best for larvae alone, although no larvae were trapped in the second, year-long period of the test. This trap was by far the least expensive of the three.

Pheromone traps for adults: comparison of commercial lures

Three commercial pheromone lures were tested, made by: Consep Membranes, Inc. (213 Southwest Columbia, P.O. Box 6059, Bend, Oregon 97708, USA); Trécé Incorporated (635 South Sanborn Road, Suite 17, P.O. Box 5267, Salinas, CA 93915, USA); and Agrisense-BCS Limited (Treforest Industrial Estate, Pontypridd, Mid Glamorgan, CF37 5SU, U.K.). The Consep lure was a round disk with an adhesive backing and an advertised life of 16 weeks. The Trécé lure was a rubber septum impregnated with pheromone, with a suggested replacement schedule of 3–4 weeks. The Agrisense lure was a thin plastic square about 1 × 1 cm, with an advertised lifespan of 3 months.

The first lures used in 1990 were from Consep, starting in August 1990. The lures from Trécé became available a few months later, and were tested against the Consep lures (experiment 1).

The Agrisense lure became available in Australia at a competitive price in late 1991, with a longer advertised lifespan than the Trécé. The Trécé and Agrisense lures were compared in experiment 2.

The trap used for the adult monitoring was a Delta-style trap. This is a home-made sticky trap constructed from 2-litre milk cartons (R.A. Vickers, unpublished data).

Experiment 1: Comparison of old and new Consep lures and new Trécé lures

Methods

The Consep lure had been in use for 12 weeks at the start of the trial. At the office site used for the larval traps study, three sets of three traps were placed in trees around the outside of the office. Within each set of traps there was 1 lure of each kind. Every four days, the catch was collected and the traps rotated one position within each set. This was repeated 6 times between 20 November and 26 December 1990. The lures were not changed during this trial.

Results

The aged Consep lure had definitely lost activity (Fig. 1) after 12 weeks in the field. There were differences in catches between the new Consep and Trécé lures for the first 2 weeks of the test. These data suggest that output of the Consep lure was different and more favourable than that of the Trécé lure at the start, but that it functioned very much like the Trécé lure

Table 1. Numbers of *Trogoderma variabile* caught in 3 larval traps in an infested office building in Griffith, New South Wales. Period 1 is 15 August–17 October 1990, Period 2 is 17 October 1990–4 October 1991. A=adults, L=larva, E=larval exuvium.

	Horizontal traps				Vertical traps		
	Box trap		Cardboard trap			Khapra beetle trap	
Trap location	Period 1	Period 2	Period 1	Period 2	Trap location	Period 1	Period
1	0	–	0	–	1	2L	3A, 1L
2	0	–	0	–	2	1A	2A 5L 1E
3	0	–	0	–	3	0	4A
4	0	–	0	–	4	1L	6A
5	0	–	1L	–	5	1L	4A, 1L
6	0	2A	1L	0	6	0	3A
7	0	1A	0	0	7	0	3A
8	0	–	1L	–	8	0	2A
9	1A	–	1L	–			
10	0	1A, 1E	0	0			
11	0	–	0	–			
Totals	1A	4A, 1E	4L	0		1A, 4L	27A, 7L, 1E

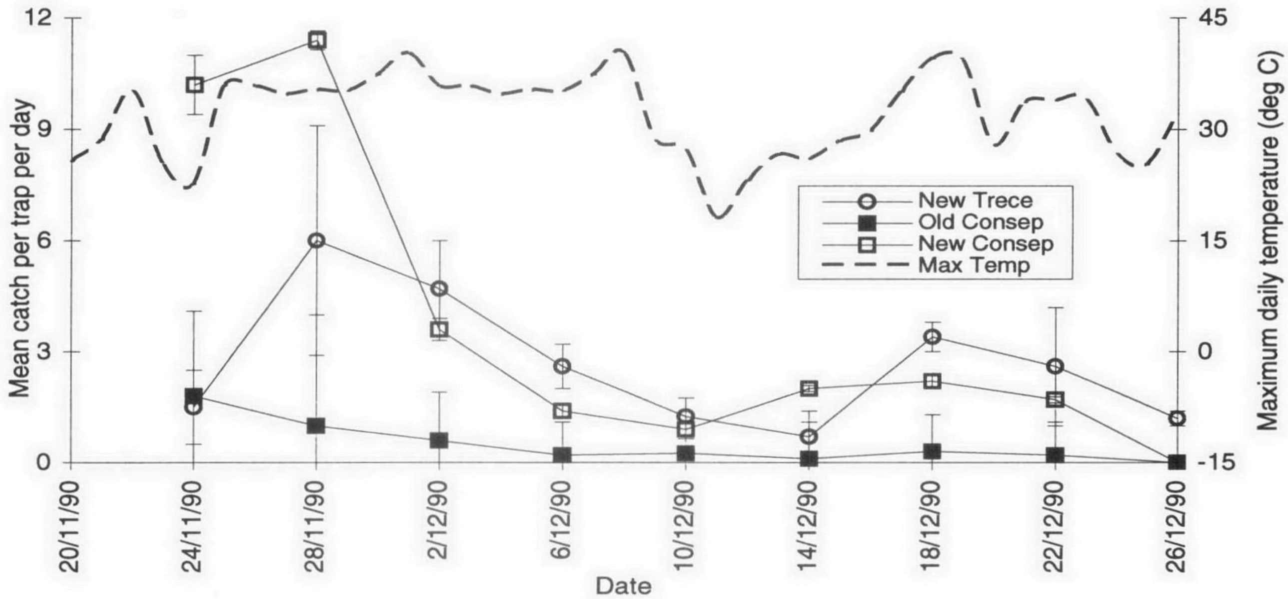

Fig. 1. The trap catches of the aged and new Consep lures and new Trécé lures for *Trogoderma variabile*, with the maximum daily temperatures. Error bars represent ±1 standard error, n = 3.

after 2 weeks. Because the same catch pattern is reflected by all baits, it suggests that the trap catches were indicative of the population through the period of the trial. The daily maximum temperatures (Fig. 1) throughout the period were suitable for flight of *T. variabile* (unpublished data) so the decline of catches represents the real decline of the adult population at this time of the year.

Discussion

The Consep lure was advertised to last for 16 weeks at a constant 25°C. During the 12 weeks it had been out in the field, the average maximum daily temperature was only 21.4°C. Thus it appears that the effective lifespan of the lure in Australia was much less than expected, given the temperatures to which it was exposed. The difference in catch rate of the new lures emphasises the inherent differences in release rates of different types. The difference in lures is more than just the amount released, but also the pattern of release.

Experiment 2: Comparison of Trécé lure vs Agrisense lure

Methods

This trial compared the Trécé lure with the Agrisense lure. The procedure was similar to the preceding test, except that 6 pairs of traps were used around the office site. The catch was collected and the trap positions changed every 4 days between 9 March–21 April 1992, for a total of 10 trapping periods. Lures were replaced on 16 April at trap positions 1, 2 and 4.

Results

The traps with the Agrisense lure caught more *T. variabile* than did those with the Trécé lure on 8 of 10 trapping periods (Table 2). Also, within pairs, the Agrisense traps caught the same or more *T. variabile* than the Trécé trap in 48 of 59 pairs (1 trap lost one trapping period). Changing the lure in half of the trap positions did not obviously affect trap catch in the

Table 2. Trap catches of *Trogoderma variabile* for the comparison between the Agrisense (A) and Trécé (T) lures, using paired traps at 6 locations outside an infested office building in Griffith, NSW, 9 March–21 April 1992

Collection date	Trap locations												Totals	
	1		2		3		4		5		6			
	A	T	A	T	A	T	A	T	A	T	A	T	A	T
13/3/92	6	3	5	2	7	2	1	0	8	1	3	0	30	8
17/3/92	15	3	0	2	4	2	7	12	3	0	2	4	31	23
22/3/92	6	6	0	0	1	0	5	0	0	1	1	0	13	7
26/3/92	6	1	0	0	0	0	2	1	2	1	0	0	10	3
31/3/92	0	0	0	1	0	0	1	1	0	1	0	1	1	4
4/4/92	5	4	0	1	1	0	–	1	1	0	1	0	8	6
8/4/92	5	1	1	1	1	0	7	0	2	5	0	0	16	7
12/4/92	2	6	0	0	0	1	3	1	2	2	0	0	7	10
16/4/92	1	1	0	0	0	1	1	0	0	0	0	0	2	2
21/4/92	10	3	1	0	0	0	0	0	0	0	0	0	11	3
Totals	56	28	7	7	14	6	27	16	18	11	7	5	129	73

next trapping period, in part because there were few beetles flying so late in the season.

Discussion

The Agrisense lure was shown to be the more effective one, especially in the first 4 trapping periods. It would be the lure of choice for a program where detection of low numbers of insects was required.

Height of trap

Methods

The trap used in this trial was the Delta-style trap used previously, with the Trécé lure, which was replaced every 4 weeks.

Two trap locations were chosen at a grain storage facility at Emery, New South Wales at either end of a large grain shed, where there was a suitable vertical post from which to hang traps. Initially traps were hung at 0.3, 1.5, 2.4, 3.3 and 4.2 m above ground on 16 December 1992. The insects were removed from the traps weekly, except on the first occasion when they were removed after 2 weeks. After 4 trapping periods, an additional trap was set just above the ground at each location. The trapping continued for 13 more weeks until the end of the flight season.

Results

The numbers caught were converted to the proportion of insects caught at that location in each trap, for each trapping period. These data were then averaged to give the mean proportion caught at each height (Fig. 2). As virtually no insects were caught in the last 4 trapping periods (23 March–21 April 1992) because the flight season had ended, these data were omitted from the analysis. It was clear from the first trapping periods that there was a much higher catch at the 0.3 m height (Fig. 2a), prompting the additional trap set just at ground level. The trend continued (Fig. 2b), with an average of 70% of the insects caught at or below 0.3 m. The exact height above the ground, up to 1.5 m had a very large effect on the catch.

Discussion

It is clear that maximum trap catch is obtained with the trap very close to the ground. If detection of very low populations is desired, then traps should be placed close to the ground.

In certain kinds of ecological studies, it more important to have catches comparable between locations than to catch the maximum number of insects. During seasonal flight activity studies, traps at different sites were placed between 1.5 and 2.5 m above ground level, for operational reasons. The results of this height trial show that the catch is fairly constant within this range, which means that the data for these different trap sites are comparable, at least in terms of height effects.

Conclusions

None of the larval traps tested was of any use and there appears to be no substitute for the experienced inspector for detecting larval infestations.

All of the pheromone lures were effective at attracting adult male *T. variabile* although there were some minor differences. The catches in traps baited with Consep and Trécé pheromone lures were similar, except that catches for Consep lures were much higher than for Trécé lures for the first 2 weeks. A comparison of new Trécé and Agrisense lures showed that almost twice as many insects were caught with the Agrisense lure, and this lure would be a better choice when detection of very low populations was important. The effective life of a lure depends on many factors, including temperature, wind and exposure to ultraviolet light. The effective life of the lure indicated by the manufacturer is generally based on constant and moderate conditions. If it is intended to use the lure under extreme conditions, it is important to test the effective life under those conditions. Even so, in one of the trials reported here, when daily temperatures were far from extreme, the effective life of the Consep lure was shown to be much less than the advertised 16 weeks. As a result of these trials, the lures were changed every 4 weeks in ecological studies on *T. variabile* to ensure as much consistency as possible between locations and seasons.

Maximum catches of adult males were achieved by pheromone traps very close to the ground, so during detection programs for, for example, quarantine, they should be set as low as possible. However, when comparable data between trapping locations is needed for ecological work and it is not possible to set traps on the ground, catches from traps set between 1.5 and 2.5 meters high are sufficiently high and uniform to be useful.

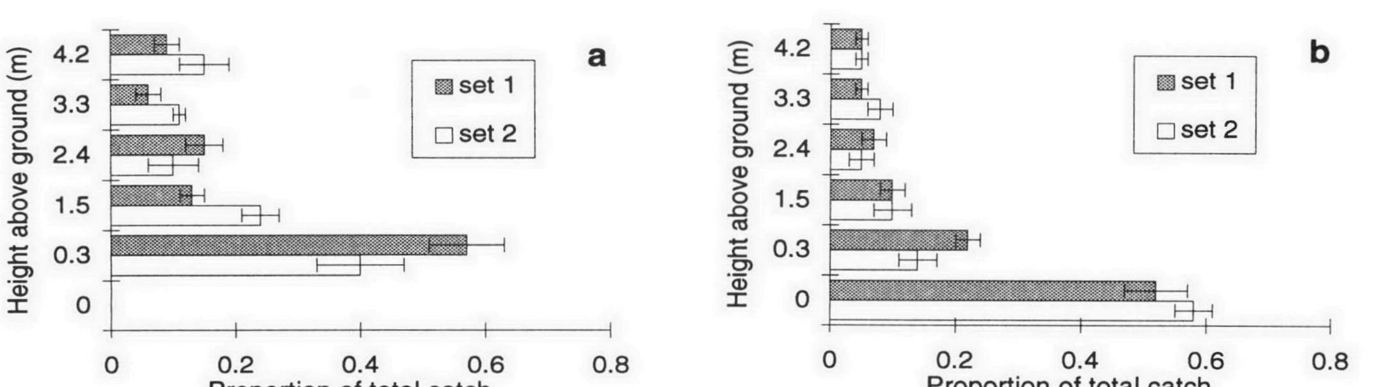

Fig. 2. The results of the experiment investigating the effect of height on pheromone trap catch, Emery, New South Wales. a, Results for trapping period 16 December 1991–21 January 1993 with no trap at ground level. b, Results for trapping period 21 January–23 March 1992 including a trap at ground level. Error bars represent ±1 standard error.

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References

Barak, A.V. 1989. Development of a new trap to detect and monitor Khapra beetle (Coleoptera: Dermestidae). Journal of Economic Entomology, 82, 1470–1477.

Cross, J.H., Byler, R.C., Silverstein, R.M., Greenblatt, R.E., Gorman, J.E. and Burkholder, W.E. 1977. Sex pheromone components and calling behavior of the female dermestid beetle, *Trogoderma variabile* Ballion (Coleoptera: Dermestidae). Journal of Chemical Ecology, 3, 115–125.

Hartley, D.J. and Greening, H.G. 1983. Review of warehouse beetle control programme. A report to the Standing Committee on Agriculture. Department of Agriculture New South Wales. vi+43 p.

Wright, E.J. 1991. A trapping method to evaluate efficacy of a structural treatment in empty silos. In: Lessard, F. and Ducom, P., ed., Proceedings of the Fifth International Working Conference on Stored-product Protection, Bordeaux, France, September 1990, 3, 1455–1462.

Wright, E.J. 1993. *Trogoderma variabile* (Coleoptera: Dermestidae) in Australia. In: Corey, S.A., Dall, D.J. and Milne, W.M., ed., Pest control and sustainable agriculture. Melbourne, CSIRO Publications, 373–375.