COMPARISONS OF TRAPS AND LURES FOR MONITORING GRASS GRUB, *COSTELYTRA ZEALANDICA*

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ABSTRACT

Phenol, the attractant pheromone of adult males of the native New Zealand grass grub, *Costelytra zealandica* (White), is produced in the beetles as the result of bacterial degradation of tyrosine. A lure consisting of a resin impregnated with phenol has been widely used to monitor male beetle flight activity. The present formulation is highly attractive for the first week in the field, but then loses activity rapidly. A number of phenol-containing formulations were tested to improve the lure. A new formulation gave lower catches that were more stable with time, producing data more suitable for population density estimation. Phenylacetaldehyde, a bacterial metabolite of phenylalanine, was tested as a possible synergist to phenol. Field results showed that this floral compound exhibited no behaviourally-active properties to grass grubs when tested together with phenol. Catches with water traps were compared with those in sticky delta and flat delta traps in two vineyards and in pasture. Water traps caught four times more beetles.

Keywords: grass grub, *Costelytra zealandica*, trap, monitoring, population density, phenol, resin lure.

INTRODUCTION

Larvae of the grass grub, *Costelytra zealandica* (White), can be devastating pests of permanent pasture in New Zealand and can cause severe damage in fodder and cereal crops (Chapman 1984). Damage also occurs when larvae feed on the roots of grapevines (Mundy et al. 2005). The adult grass grub beetle is a significant pest of various horticultural crops, such as grapes, blueberries and kiwifruit (East et al. 1983), where it consumes the newly emerged foliage and developing florets during spring. The sex attractant for the grass grub was identified almost 40 years ago as phenol (Henzell & Lowe 1970), but the practical use of this and other insect attractants in the New Zealand pastoral sector has been very limited. This situation contrasts with more intensively managed sectors such as horticulture, where pheromones for a number of pest species have been developed for decision support (Suckling et al. 2008). In the 1970s, Henzell and colleagues experimented with the use of phenol (e.g. phenol-baited water traps) to monitor and control adult grass grub populations in pasture (Henzell & Kain 1972; Henzell et al. 1979). During this work it was found that an acidic ion-exchange resin (i.e. Amberlite IR-120H, Aldrich, Australia) could be impregnated with phenol and used as a lure to attract grass grub males (Lauren 1979).

However, water traps are not likely to be practical for routine monitoring (except daily), because of evaporation. Sex attractant traps have recently been used on an *ad hoc* basis to monitor grass grub populations in high value vegetable cropping areas (R.J. Townsend, unpubl. data). These developments have led to a re-examination of the potential use of insect attractants for integrated pest management in the pastoral sector. The existing grass grub lures have a short and uncontrolled release of the active ingredient, which is a hazardous substance. It is envisaged that a low-cost and practical monitoring system could be used by farmers (or horticulturalists) for decision support, by guiding the need for treatment of grass grub at the paddock scale.

Addition of water to the resin was investigated because it was hypothesised that the resin was drying out, which lowered the release rate of the phenol and decreased attractiveness. The aim was to improve control over the release rate through the addition of water, thereby changing from an undefined resin surface to a fixed dispensing water surface area.

Leal (1998) reported that many scarab beetle pheromones are actually derivatives or metabolites of amino acids, and since phenol is produced by microbial catabolism of tyrosine (Hoyt et al. 1971), it was hypothesised that another amino acid, phenylalanine, could be cleaved to a compound very common in flower odour, phenylacetaldehyde (Helinck et al. 2004), and potentially be a minor component of the New Zealand grass grub pheromone.

This paper reports on three trials aimed at improving the longevity, predictability and safety of phenol-based grass grub sex attractant lures.

MATERIALS AND METHODS

The standard phenol resin lure was prepared by immersing 50 g of the resin (Amberlite IR-120H ion-exchange resin, Aldrich, Australia) in 500 ml of water and adding 5 g of phenol. After stirring for 1 h, the excess water was filtered off by vacuum suction and the impregnated resin was stored in an airtight container. The phenol resin in water lure was prepared by agitating 1 g of the impregnated resin in 25 ml of water. Individual doses of a phenol resin suspension lure were prepared by dissolving 100 mg of phenol in 25 ml of water in a 70 ml plastic jar. Then 1 g of resin was added and the mixture was thoroughly agitated and stored in airtight containers. Lures were either used fresh or aged under field conditions during late October-early November, and stored until needed in airtight containers. All experiments were conducted at Lincoln.

Lures used in all experiments are shown in Table 1. Lures were placed in water traps (2 litre ice-cream containers 17 × 17 cm × 9 cm deep), which were covered with 2.5 cm square wire mesh to prevent birds taking the trapped beetles. Treatments were in place for at least 30 min prior to the expected start of the flight period, to enable the male beetles to orientate toward an attractant source. Experiment 3 also included delta traps.

Experiment 1

The grass grub has a short and unpredictable flight season of adults and the aim of this trial was to improve stability and longevity of the lures used for monitoring of population densities. The phenol resin lures either were prepared fresh (0 days) or had been aged (7 or 21 days) prior to the experiment. The trial was laid out in a randomised block design across the prevailing wind direction, to minimise interactions between adjacent treatments (5 m gap between traps within replicates, 50 m between replicates). Three replicates were operated for 1 night, 15 November 2007, and a second set of three replicates was operated on 19 November 2007.

Experiment 2

The aims of this experiment were to test modified lures that would streamline lure preparation and investigate phenylacetaldehyde as a synergist to phenol. The lure modifications consisted of (1) comparing a simple suspension of phenol and the resin against the phenol-impregnated resin, and (2) testing whether polyethylene bags could be used to contain and dispense the phenol. Phenol resin lures and phenol suspensions were prepared as above (aged 0 or 21 days). The polyethylene bag (5 cm × 3 cm; 150 μm thick) dispenser used for lures 4-7 (see Table 1) contained a 4 cm × 2.5 cm piece of felt, impregnated with 0.5 mmol phenol in 200 μl of water. In addition, 0.5 mmol of phenylacetaldehyde was prepared as above in polyethylene bags and included in lures

6 and 7 (Table 1, N.B. separate dispensers for phenol and phenylacetaldehyde). Three replicates were operated for 1 night on 15 November 2007, and a second set of three replicates was operated on 19 November 2007, as for Experiment 1.

Experiment 3

The aim of this trial was to improve the practicality of the system, by comparing catch in a delta trap with that in the water trap standard, since the former is easier to operate for decision support. A flattened version of the delta trap was also tested, to avoid potential windage problems. The delta traps used the standard phenol resin lure (Table 1) but required a change in size of lure dispenser, as the standard lure was too large. The new dispensers were made from 5 ml polycarbonate vials (Labserv, Biolab Scientific, New Zealand). Phenol-impregnated resin (1 g) was added to the vial, and steel mesh (5 μm) fitted to the top of the vial to prevent the contents from spilling. This was then placed horizontally on the sticky base inside the delta trap. Traps were operated for 7 days (23–30 November 2007) (10 replicates) at the Lincoln pasture site. The water trap and delta trap comparison was repeated at two vineyard sites in Marlborough over 4 weeks from 30 October to 29 November 2007.

TABLE 1: Lures and traps used in three experiments for adult *Costelytra zealandica* at Lincoln in 2007.

Treatment	Lure	Lure age/Trap[1]	Dispenser
Experiment 1			
A	1 g of phenol resin	<4 h	70 ml jar
B	1 g of phenol resin	Aged 7 days	70 ml jar
C	1 g of phenol resin	Aged 21 days	70 ml jar
D	Control (no lure)		70 ml jar
E	1 g phenol resin in 25 ml water	<4 h	70 ml jar
F	1 g phenol resin in 25 ml water	Aged 7 days	70 ml jar
G	1 g phenol resin in 25 ml water	Aged 21 days	70 ml jar
Experiment 2			
1	1 g of phenol resin	<4 h	70 ml jar
2	1 g of phenol resin	Aged 21 days	70 ml jar
3	Phenol resin suspension lure	Aged 21 days	70 ml jar
4	Phenol in polyethylene bag	<4 h	1 bag
5	Phenol in polyethylene bag	Aged 21 days	1 bag
6	Phenol+phenylacetaldehyde in sep. bags	Fresh	2 bags
7	Phenol+phenylacetaldehyde in sep. bags	Aged 21 days	2 bags
8	Control (no lure)		
Experiment 3			
1	1 g phenol resin	Water trap	70 ml jar
2	1 g phenol resin	Sticky delta trap	5 ml vial
3	1 g phenol resin	Sticky flattened delta trap	5 ml vial

[1]Lure age for Experiments 1 and 2 and type of trap for Experiment 3.

Statistical analysis

Catches were square-root transformed and subjected to analysis of variance. Least significant difference values were used to separate treatment means. Regression analysis was used to correlate catch numbers among the trap types in Experiment 3.

RESULTS

Experiment 1

In the absence of water, the trap catches of the phenol-impregnated resin were much lower (ca three-fold) for aged than fresh lures (Fig. 1) (P<0.05). The addition of water lowered the initial catch, but improved catch consistency for lures aged over 3 weeks. For lures aged for 3 weeks, catches to phenol-impregnated resin with water were similar to catches obtained with the resin alone (P>0.05). Overall, fewer beetles were caught to lures with added water (P<0.05). In this experiment a total of 8,796 beetles was caught without water in the lure and 4,170 with water added.

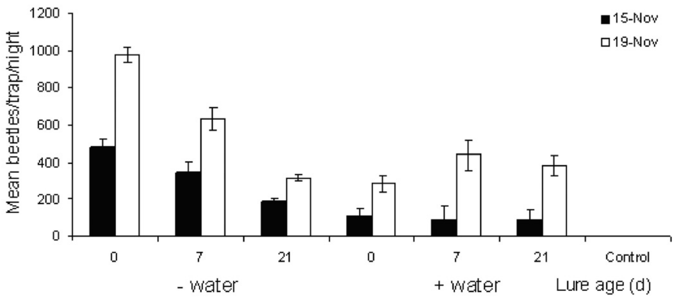

FIGURE 1: Mean catch per trap per night of *Costelytra zealandica* to aged or fresh phenol resin lures with or without added water. Bars show one standard error.

Experiment 2

The fresh phenol-impregnated resin was again the best lure for catching grass grubs (Trt 1, Fig. 2). Lures aged for 3 weeks (Trt 2) again caught significantly fewer beetles than the fresh resin (P<0.05). The suspension of phenol and resin in water (Trt 3) was as effective as the resin of the same age (3 weeks). Catches of beetles to fresh and aged phenol presented in polyethylene bags (Trts 4 and 5) were lower than with fresh resin, but were not different between the two ages. The phenylacetaldehyde (Trts 6 and 7) had no significant effect on catch (P>0.05). A total of 8,123 beetles was caught in this experiment.

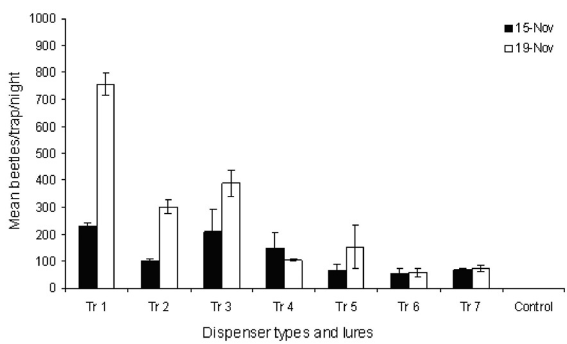

FIGURE 2: Mean catch per trap per night of *Costelytra zealandica* using fresh, aged, and suspended phenol resin lures compared with phenol-containing polyethylene bags (without or in combination with phenylacetaldehyde bags) as baits (see Table 1, Experiment 2 for the list of treatments). Bars show one standard error.

Experiment 3

Water traps caught significantly more beetles than either of the delta traps (Fig. 3) (P<0.001), which had the same efficacy. Trap catch was correlated between water and delta traps ($r^2 = 0.87$; P<0.01). A total of 5,112 beetles was caught in this experiment. The results from the Marlborough vineyard sites were very similar, also indicating that the water traps were four times as effective as the delta traps (data not shown).

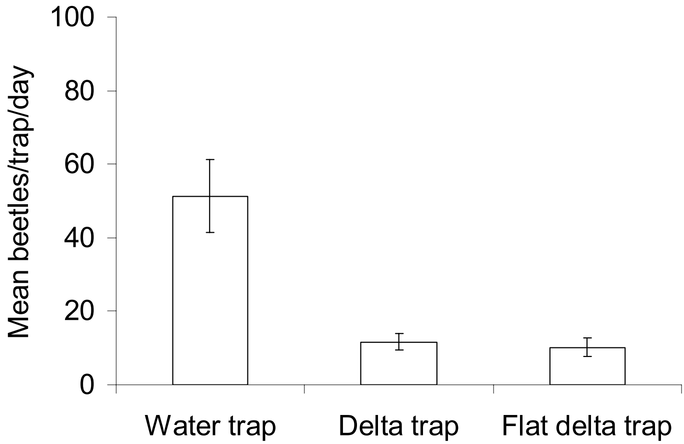

FIGURE 3: Mean catch per trap per day of *Costelytra zealandica* to phenol resin lures in three trap types at Lincoln. Bars show one standard error.

DISCUSSION

These results confirmed the long-held suspicion that the standard resin lure for grass grub rapidly loses attraction in the field. This changing trap attractiveness makes it difficult to use the resin to estimate grass grub populations based on trap catches, without frequently replacing lures. The additional trouble necessitated by frequent lure replacement could be a significant cost in materials and farmer interest in adoption. The addition of water stabilised the release dynamics, and a more even catch resulted. However, the catch to lures with water added was much lower than with the standard resin lure.

While trap sensitivity (i.e. ability to detect low populations) may only be important in some circumstances, this reduction in catch is probably undesirable. It would be preferable to have traps that are capable of operating with constant efficiency over a range of population sizes, for the entire flight. This apparent trade-off of lowered sensitivity for higher consistency is important, and any analysis needs to factor in the sometimes erratic flight dynamics of grass grubs, which could involve a delay to the initiation of flight of up to 1 week (R.J. Townsend, pers. obs.). Reliability and consistency of performance may be more important for pastoral farmers, who want to determine relative population size as the basis for a treatment decision. Greater sensitivity may be more important to other users, such as farmers or horticulturalists with high value crops, who may want early warning to mitigate risk of a sudden attack of defoliation.

The addition of water to the phenol potentially renders the lure more dangerous for users, because it increases the risk of spillage, although it is easier to prepare. A safer, more "user-friendly" lure would be desirable, although this is a challenge given the hazardous properties of phenol itself. Polyethylene bags are easy to handle and could be used as an alternative to the water-based lures, but they continue to release the material, and still require the use of gloves for handling (as do all phenol-based lures). Although the risk of human exposure would be reduced using polyethylene bags to contain the substance, this type of dispensing method reduced the total catch compared to phenol resin in a jar. However, the catches to lures in polyethylene bags were stable over time. The hypothesis that phenylacetaldehyde could be a synergist to the pheromone arose from a tiny peak seen on the base-line of the GCMS track from extracts of grass grub females (A.M. El-Sayed, unpubl. data). The peak was too small for positive identification but in conjunction with the possibility that other side-chains than phenol could be cleaved from amino acids and used in the pheromone mix by microbial catabolism (as has been shown by Helinck et al. 2004), it was thought that this chemical was worth including in the experiment. However, analyses of trap catches showed no effect from phenylacetaldehyde.

The fact that water traps caught four times more beetles than the delta traps means that the water traps have a wider active space and/or have a higher catch efficiency than the delta traps. It should be noted that different dispensers were used in the delta and water traps and that the efficacy of the delta traps may be improved by use of another dispenser. Even if that is not possible, there was a correlation in catch between trap types, so that the more "user-friendly" delta traps supposedly could be used in the same semi-quantitative way in a decision support system for farmers, despite their lower efficacy.

Knowledge of the trap active space or catchment area (e.g. Byers et al. 1999) would be very useful if trapping is to be used for decision support. Experimental tests of the effective attraction radius of difference doses of phenol could be useful as a first step in estimating the effective area of attraction. Catchment areas for both types of traps are of course very dependent on prevailing wind conditions. Work is underway to clarify whether there are any correlations between average trap catches in the spring and autumn larval populations before investigating trap catchment area effects.

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