SEX ATTRACTANT FOR THE GORSE BIOCONTROL AGENT *AGONOPTERIX ULICETELLA* (OECOPHORIDAE)

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ABSTRACT

No easy and reliable method of detecting the establishment of the recently-released gorse soft shoot moth (*Agonopterix ulicetella*) was available, so we undertook to identify an attractant. Pheromone sticky traps were baited with a wide range of lures based on sex attractants known from other species in the genus and trapping was conducted in Hawaii. Several blends with compounds in common were successful at catching moths. The most attractive blends were then used to determine whether the release of this biocontrol agent had been successful in New Zealand. Ten moths were caught at a site in Canterbury in September 1999 with Z5-decenyl acetate and Z7-dodecenyl alcohol (1:1). This is the first time that sex attractants have been used to demonstrate the successful establishment of a biological control agent within a country. Further tests in Hawaii have confirmed the above blend as highly attractive. It is now available and suitable for monitoring the establishment and spread of this biocontrol agent elsewhere in New Zealand.

Keywords: pheromone, biocontrol, gorse, *Agonopterix*, establishment.

INTRODUCTION

Widespread and aggressive weeds are causing New Zealand significant direct and indirect control costs through the use of herbicides and other management tactics, lost production of pastoral land and environmental impacts in sensitive areas (Hackwell and Bertram 1999). In an attempt to reduce these costs, there has been a sustained programme to introduce biological control agents against gorse (*Ulex europaeus* L.) in New Zealand (Harman *et al.* 1996). The most recent introduction from this programme is the gorse soft shoot moth (*Agonopterix ulicetella* Stainton (Lepidoptera: Oecophoridae)). Larvae of this species were released by Landcare Research staff at a site in central Canterbury in 1997 but establishment remained unconfirmed. No practical method of detecting the insect, which was presumed to be at very low density or extinct at the release site, was available.

A pheromone developed for the gorse pod moth (*Cydia succedana* D. & S.) has proven extremely effective for determining the presence of moths at a site, even when small releases have been made (Suckling *et al.* 1999). The provision of a cost-effective monitoring system based on the attractant has the potential to offer several benefits. These include identifying phenological synchrony between host and herbivore, identifying the minimum density for establishment of the biocontrol agent, assessing its rate of spread within a region and helping to characterise the impact of the new herbivore on the host weed.

Pheromones have been identified for other species of *Agonopterix* (Ando *et al.* 1981; Szöcs *et al.* 1981; Priesner 1988; Tóth *et al.* 1992), so it was considered likely that a sex attractant for the gorse soft shoot moth could be found. Moth sex pheromones are typically identified by gland or efluvia extraction and chemical analysis, followed by confirmatory electrophysiological, behavioural and finally trapping experiments (Suckling and Karg 2000). The limited budget and the lack of certainty that the insect was established in New Zealand meant that international cooperators were sought to provide a wide range of lures and to conduct initial trapping offshore. This paper reports the successful identification of a sex attractant for a weed biological control agent, including the use of the sex attractant to confirm the successful establishment of the insect following its release.

MATERIALS AND METHODS

Experiment 1: lure comparison in Hawaii

A total of 36 lures were prepared and baited sticky traps (Suckling and Shaw 1990) were operated in the field in Hawaii from February 1999 until May 1999, with two replicates of each lure. Lures were designed to cover the range of compounds known from the genus (Ando *et al.* 1981; Szöcs *et al.* 1981; Priesner 1988;Tóth *et al.* 1992). Trap positions were re-randomised weekly. The site was a gorse patch on Mana Road at about 2020 m elevation near Pua Akala Ranch at Humuula on the south slope of Mauna Kea (Lat. N 19 deg 46 min, Long. E 155 deg 22 min). Gorse is the dominant shrub layer with kikuyu grass *Pennisetum clandestinum* Chiov. understory and widely scattered *Acacia koa* Gray trees. Lures were prepared in Hungary as 1:1 ratios of 100 µg loadings of a range of unsaturated acetates (Ac), alcohols (OH) and aldehydes (Ald) (Table 1) applied to pieces of red rubber tubing (Taurus, Budapest, Hungary, MSZ 9691/6).

Experiment 2: confirmation of *A. ulicitella* presence in New Zealand

The experiment was conducted on a gorse-covered hillside where about 50,000 larvae on cut shoots had been released by Landcare in November 1997 at Jimmy's Knob (Lat. S 43 deg 25 min, Long. E 17 deg 22 min), near Darfield, central Canterbury. Blends revealed as attractant from Hawaii were prepared at Lincoln and used to bait sticky traps tested at this site, for the period of 26 August to 9 September 1999, with weekly checks and re-randomisation (four replicates). Rubber septa were loaded with 100 µg of Z5-10:Ac alone, or with 1:1 ratios of Z5-10:Ac with Z7-14:Ac, Z9-14:Ac, Z11-14:Ac, Z7-10:Ac, Z3-10:Ac, Z7-12:Ald, Z7-12:OH or a blank. Chemicals (>99% purity) were obtained from Pherobank (Wageningen).

Experiment 3: second blend comparison in Hawaii

A blend confirmation experiment was conducted from 7 February to 21 February 2000 at the Hawaiian site described in Experiment 1, with the above blends from Experiment 2 (five replicates). Traps were checked approximately weekly and re-randomised.

Experiment 4: dose response in Hawaii

A range of loadings of lures were prepared and the following treatments were compared at the Hawaiian site. The lures were prepared as 1:1 ratios of Z5-10:Ac with Z7-12:OH in loadings of 0, 20, 60, 200, 600 or 2000 µg. Five replicates of each loading were used to bait traps, which were placed in the field at 5 m spacings from 10 March 2000. Traps were checked and re-randomised on 21 March and trapping continued until 29 March.

Statistical Analysis

Analysis of variance was performed on log-transformed counts using Minitab.

RESULTS

Experiment 1: lure comparison in Hawaii

A total of 1426 moths were trapped at the Hawaiian site during Experiment 1 to a range of blends (Table 1). Analysis of variance on log-transformed counts indicated that several of the thirty-six lure combinations were successful at trapping significant numbers of *Agonopterix ulicetella* ($P<0.05$). The highest catches occurred to lures that contained Z5-10:Ac. The range of lures that caught moths indicated the presence of a high male moth population.

TABLE 1: Numbers of *Agonopterix ulicetella* caught in Hawaii to a range of sex attractant blends in Experiment 1. Total number of moths for the two replicates.

	Z7-14Ac	Z9-14Ac	Z11-14Ac	Z7-12Ac	Z7-10Ac	Z3-10Ac	Z5-10Ac	Z7-12OH
Z9-14Ac	0							
Z11-14Ac	6	3						
Z7-12Ac	0	3	0					
Z7-10Ac	0	5	6	2				
Z3-10Ac	3	3	5	0	3			
Z5-10Ac	204	212	9[1]	12	165	116		
Z7-12OH	4	5	8	3	0	11	299	
Z7-12Ald	8	2	3	0	6	6	311	3

[1]Data from replicate 2 only as the trap for replicate 1 was missing.

Experiment 2: confirmation of establishment in New Zealand

Ten male *A. ulicitella* were caught in August-September 1999 at Jimmy's Knob, all with one lure combination (Z5-10:Ac and Z7-12:OH). This result demonstrated for the first time that the insect was present in the field in New Zealand following its release. No other lure combinations caught any moths, presumably indicating a low density compared to Hawaii.

Experiment 3: second blend comparison in Hawaii

A total of 370 insects were caught over two weeks. There were significant differences between the blends (Fig. 1) with the largest catch in traps that were baited with a blend of Z5-10:Ac and Z7-12:OH (P<0.0001). Higher than expected catches were made to unbaited controls, probably indicating the high population present at this site, as noted in Experiment 1. After re-analysis without the catch data for the most attractant blend, control traps caught significantly more moths (P<0.001), suggesting the potential for repellency in the remaining non-attractive but baited treatments.

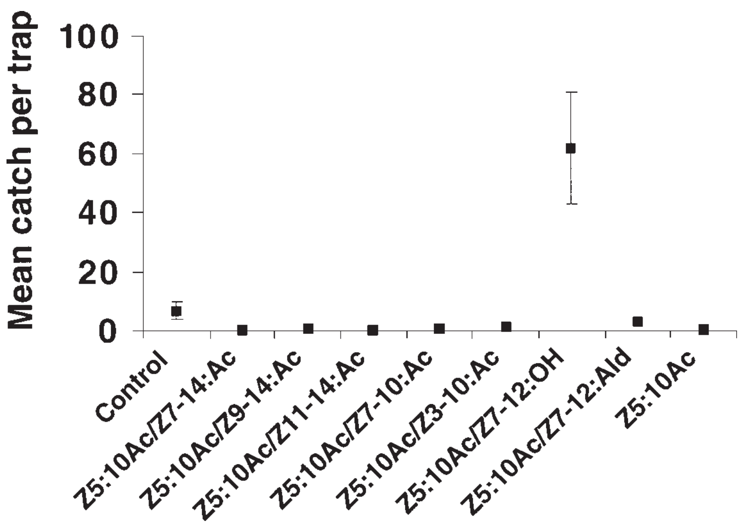

FIGURE 1: Mean catch of *Agonopterix ulicetella* to a range of sex attractant blends in Experiment 3 in Hawaii. Mean number of moths per trap for the five replicates.

Experiment 4: dose response in Hawaii

A total of 2081 moths were caught in 19 days, indicating the continued presence of a high population of males. There was a significant difference in catch between treatments (P<0.0001), however there was no difference between the traps baited with different loadings when they were considered without the control traps (P>0.05). There was a slight but non-significant trend for more moths to be caught in the middle three attractant loadings (Table 2).

TABLE 2: Mean catch for the five replicates of *Agonopterix ulicetella* to a range of 1:1 ratios of Z5-10:Ac with Z7-12:OH in Experiment 4 in Hawaii.

Loading (µg)	0	20	60	200	600	2000
Mean catch per trap	7	68.6	91.6	92.8	98	64.4
SEM	2.05	7.8	18.7	15.8	12.3	12.3

DISCUSSION

These experiments demonstrate that *A. ulicetella* is highly attracted to lures releasing Z5-10:Ac and Z7-12:OH, and that this species has established after release in New Zealand. It is possible that the 1:1 ratio of these compounds is not exactly the blend released by female moths. Since we have not studied the full blend used by females, we have conservatively used the term "sex attractant", rather than "sex pheromone". Our use of binary blends in 1:1 ratios does not rule out the potential for other components or blend ratios to enhance catches. However, catches with relatively low loadings of attractants on rubber septa lures have been achieved in this study and further refinement may not be warranted. One difference between the first and third experiments was the initial high catch to the blend with Z5-10:Ac and Z7-12:Ald (311 moths). This blend failed to catch significant numbers of moths in the other tests.

The compound Z5-10:Ac is present in the pheromone of *A. yeatiana* F. (Preisner 1988), but has not been recorded in other members of the genus which have been studied. Similarly, Z7-12:OH is known as part of the attractant blend for *A. encentra* Meyrick (Ando *et al.* 1981) and *A. liturella* (Tóth *et al.* 1992).

The low catch at Jimmy's Nob in August-September 1999 was probably due to a low population density, although it could also be related to the phenology of the insect in New Zealand, which is still unclear. These data suggest that adult flights can occur over the August-September period, although this may vary with latitude. Further trapping should provide insights into the phenology of *A. ulicetella* in New Zealand. In Hawaii peak adult flights occur from February to March and the insect is considered to be univoltine. The high numbers trapped (up to 116 moths per trap in the first 8 days) suggests that trap saturation may explain the lack of a dose response. Trap saturation was also considered likely in another gorse biocontrol agent *C. succedana* (Suckling *et al.* 1999). The high catches at the lowest trap loading suggest that an effective lure can be based around 20 µg of attractant.

Sex attractant traps have already played a useful role in determining the establishment success and biology of one control agent for gorse (Suckling *et al.* 1999). There is now a tool available to help support the deployment of another weed biological control agent. The prospects for using such traps for monitoring populations of other weed biological control agents are excellent, especially for Lepidoptera. The traps can provide information on the seasonal pattern of the insect life cycle in relation to plant phenology, their rate of spread from release sites and help to determine the establishment success of releases of insects as a function of habitat, region of release, founding population size and other factors of interest.

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