Z-11-TETRADECENYL ACETATE: SEX ATTRACTANT OF *AGAPETA ZOEGANA* (LEPIDOPTERA: TORTRICIDAE), A POTENTIAL SPECIES FOR THE BIOLOGICAL CONTROL OF KNAPWEED

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In Canada, 78 of the most important weed species are introductions from Eurasia (Frankton and Mulligan 1970). Classical biological control aims to reduce the density of alien weeds below the economic threshold through introduction of specific herbivores from the native distribution area (Peschken 1979). During extended field surveys in central and southeastern Europe, the Commonwealth Institute of Biological Control established the root-mining tortricid *Agapeta zoegana* Haw. as a promising control agent for *Centaurea diffusa* Lam. and *C. maculosa* Lam., 2 important ranch weeds in southwestern Canada (Harris and Myers 1984) and the northwestern United States (Maddox 1982). Due to the limited host range and suitable climatic conditions this moth was chosen for introduction into North America (Müller *et al.* 1982; Müller 1984). We wish to report an attractant that may be used to monitor the establishment of this beneficial species in its new habitat.

Larvae of *A. zoegana* were collected from roots of knapweed in western Hungary and eastern Austria, transported to Delémont, and reared on host roots. The sexes were separated at the pupal stage and ca. 20 females and 5 males were sent to Wädenswil where they emerged in a 16L:8D cycle at 24°C, 56% RH, and 3000–6000 lx in the photophase and 18°C, 85% RH, and 1 lx in the scotophase. Extracts of the female sex glands (2–5 days old) were made in the first half of the scotophase. Following anesthesis, the ovipositor tip was everted, removed with forceps, and extracted for some minutes in hexane (ca. 2 μL/gland).

Gas chromatography with electroantennographic detection (GC-EAD) (Arn *et al.* 1975) using the male *A. zoegana* antenna as detector (20 m Silar 10c high-resolution gas chromatography column, 2 min at 40°C, 10°C/min to 60°C, and 4°C/min to 180°C, EAD/FID split ratio of 1/1) provided evidence for a biologically active main component of the extract at the retention time of Z11–14:Ac (for abbreviations, see Table 1). Gas chromatography – mass spectrometry analysis (EI, Finnigan 4015 instrument equipped with a 50 m SP 1000 column, 3 min at 50°C, 20°C/min to 100°C, and 5°C/min to 240°C) confirmed the presence of Z11–14:Ac as the main component accompanied by a tetradecenyl alcohol at the retention time of Z11–14:OH and the *n*-alkane series, heneicosane to nonacosane, with the odd-numbered members predominating. A specific search for acetates

Table 1. Pheromone-related components found in *A. zoegana* female sex gland extract

Component	Short form	Amount per female (ng)
Dodecyl acetate	12:Ac	0.08
Tetradecyl acetate	14:Ac	0.5
E-11-Tetradecenyl acetate	*E*11–14:Ac	0.08
Z-11-Tetradecenyl acetate	*Z*11–14:Ac	8
Z-11-Tetradecen-1-ol	*Z*11–14:OH	1.2
Eicosyl acetate	20:Ac	0.5
Docosyl acetate	22:Ac	0.5

(m/z 61, $CH_3COOH_2^+$) revealed the presence of lower amounts of an additional tetradecenyl acetate at the retention time of *E*11–14:Ac, and the saturated acetates dodecyl, tetradecyl, eicosyl, and docosyl (Table 1).

The geometry of the tetradecenyl acetates was confirmed by GC-EAD employing male antennae of *Zeiraphera diniana* for *E*11–14:Ac and *Pandemis heparana* for *Z*11–14:Ac as compound-specific detectors (Guerin *et al.* 1985).

Field tests were conducted in a knapweed-containing field near Julia Major Experimental Station, Budapest, in 1983, using tetra traps with flaps and rubber caps as dispensers (Arn *et al.* 1979). Those baited with *Z*11–14:Ac (≤0.03% *E* isomer) attracted significant numbers of *A. zoegana* males (Table 2). None of the secondary compounds found in the female gland augmented trap catches when added to the main component; both *Z*11–14:OH and *E*11–14:Ac were strongly inhibitory at levels found in the female and above. In an additional test, catches in 4 replicates were 3 with 10 μg *Z*11–14:Ac, 7 with 100 μg, and 39 with 1000 μg. Though *Z*11–14:Ac alone also attracted *Agapeta hamana* L., treatments containing *Z*11–14:OH at 0.5–2% or 12:Ac at 2% proved superior. As in *A. zoegana*, *E*11–14:Ac, 14:Ac, and higher doses of *Z*11–14:OH were inhibitory.

Table 2. Catches of *A. zoegana* males

Blend composition (μg per cap)					Total catch*	
12:Ac	14:Ac	*E*11–14:Ac	*Z*11–14:Ac	*Z*11–14:OH	*A. zoegana*	*A. hamana*
Test 1. 10 replicates, 18 July to August 8						
			100		35 a	9 b
		0.5	100		2 b	0 b
		2	100		1 b	1 b
		10	100		0 b	0 b
			100	2	36 a	23 a
			100	10	2 b	7 b
			100	50	0 b	3 b
		2	100	10	6 b	0 b
Test 2. 5 replicates, 12 August to 13 September						
			100		36 abc	13 c
		0.05	100		31 abc	23 c
			100	0.5	55 a	81 a
	10		100		26 bcd	3 c
2			100		35 abc	56 b
2	10	0.05	100	0.5	39 ab	69 a

*Catches followed by the same letter are not significantly different at $P = 0.05$ as indicated by log $(x + 1)$ transformation, 2-way analysis of variance, and Duncan's multiple range test.

In test 2, considerable numbers of *Aphelia paleana* Hbn. were caught in traps containing Z11–14:Ac with 10% *E* isomer, as observed by Booij and Voerman (1984).

Z11–14:Ac is widespread as a pheromone component in the Tortricidae family, and catches of other species can be expected in monitoring of *A. zoegana*. Selectivity might be achieved on site with secondary components. Meanwhile, a formulation containing 1000 μg Z11–14:Ac of high isomeric purity appears to be useful for attraction of *A. zoegana*.

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