(*Z*)-3-Tetradecenyl Acetate as a Sex-Attractant Component in Gelechiinae and Anomologinae (Lepidoptera: Gelechiidae)

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The title compound, unreported as an insect pheromone component, effectively attracted certain male Gelechiidae (genera *Chionodes, Monochroa, Argolamprotes*) as a single chemical. Trap captures with this chemical decreased on addition of either (*E*)-3-dodecenyl acetate, (*E*)-3-tetradecenyl acetate or (*Z*)-3-tetradecen-1-ol, the sexual attractants of other, closely related species. Results on an *Aproaerema* test species showing a synergistic attraction response to combinations of (*Z*)-3-tetradecenyl acetate with its homologue (*Z*)-3-dodecenyl acetate are included.

Long-chain alkenyl acetates are the most common structural type among identified sex pheromone and attractant components in the Lepidoptera [1]. The title compound, (*Z*)-3-tetradecenyl acetate = *Z*3-14:Ac, recently joined this group of semiochemicals when Willemse *et al.* [2] reported its attractiveness towards male *Chionodes electella* (Zell.) and *Monochroa tenebrella* (Hb.), members of the Gelechiidae subfamilies Gelechiinae and Anomologinae. Their report prompts a brief presentation of my own results obtained on this same and some structurally related compounds. The results define more closely the sex-attractant systems for the two species, demonstrate the attractiveness of *Z*3-14:Ac for further spp. of the same subfamilies, and provide evidence for involvement of this compound in synergistic attractant systems.

The response of certain male Gelechiidae to sources of *Z*3-14:Ac was discovered by simply including this compound in field screening tests, as in the study by Willemse *et al.* Sticky traps baited with 100 μg of *Z*3-14:Ac, set out in woodlands near Seewiesen (southwest of Munich, southern Germany) during June/July, caught large numbers of *C. electella, M. tenebrella* and another Anomologinae species, *Argolamprotes micella* (Den. & Schiff.). The three species feed on *Picea, Rumex* and *Rubus*, respectively, and their relative trap captures greatly varied between test sites, depending on host abundance; which may explain why one species *(A. micella)* was missing from the test by Willemse *et al.*

The outstanding effectiveness of the *Z*3-14:Ac for males of these gelechiid species was supported by electroantennogram measurements. These were made from males newly taken in *Z*3-14:Ac baited traps (with antennae not yet glued to the adhesive), using technical procedures as in other Microlepidoptera [3, 4]. In the series of (*Z*)- and (*E*)-alkenyl acetates, varied for chain length and double bond position, the *Z*3-14:Ac, at the test amount of 1 μg, elicited the greatest EAG response. This was followed by the geometric isomer (*E*3-14:Ac), the corresponding alcohol analogue (*Z*3-14:OH) and some positional isomers and shorter-chain homologues (*Z*2-14:Ac, *Z*4-14:Ac, *E*4-14:Ac, *Z*5-14:Ac, *Z*3-13:Ac, *Z*3-12:Ac). Evaluation of equipotent stimulus amounts [3, 4] showed that these compounds were between 10- to 300-fold less stimulating than the *Z*3-14:Ac, in all three species. EAG effectiveness decreased by > 1,000-fold when the double bond was beyond position 5 or chain length was altered by more than 2 carbons. These data supported the view that *Z*3-14:Ac may be the primary female pheromone in all three species.

Further field tests were designed to assess modifying effects of second compounds. Thus, 100 μg of *Z*3-14:Ac and a varying amount of another compound [5] were applied to the same rubber cap dispenser. Trap types and operating procedures were as in field studies on other Microlepidoptera [4, 6]. For the three gelechiids, no attraction synergism over *Z*3-14:Ac alone was found but some compounds strongly reduced the response. Results of a pilot study using 100 μg additions of other compounds are presented in Table I. They show strong inhibitory effects for *E*3-14:Ac and *Z*3-14:OH in all three species and for *E*3-12:Ac in *C. electella,* whereas the five other additives (*Z*3-10:Ac, *Z*3-12:Ac, *Z*5-14:Ac, *E*5-14:Ac, *Z*5-16:Ac) did not markedly alter capture rates.

The inhibitory effects of the *E*3-14:Ac and *Z*3-14:OH were further studied in subsequent tests. Results obtained for *C. electella* and *A. micella* in two test series using 3, 10, 30 and 100 μg additions of these compounds are presented (Table II). The data show that a 30% addition of *E*3-14:Ac and a 3% one

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Table I. Captures of male *Chionodes electella*, *Monochroa tenebrella* and *Argolamprotes micella* in tetratraps baited with 100 μg *Z*3-14:Ac alone or in combination with eight different additives. Seewiesen/Starnberg, June 19 to July 27, 1982; three replicates.

Additive [100 μg]	$\overline{X}$ males/trap of *C. electella*	*M. tenebrella*	*A. micella*
none	71.0	17.7	26.7
*Z*3-10:Ac	61.3	22.7	22.0
*Z*3-12:Ac	80.3	14.0	34.0
*E*3-12:Ac	0	9.3	23.3
*E*3-14:Ac	0	0	0
*Z*5-14:Ac	49.7	23.0	22.0
*E*5-14:Ac	53.3	11.7	19.7
*Z*5-16:Ac	45.7	17.0	16.7
*Z*3-14:OH	0	0	0

Table II. Effect of varying amounts of *E*3-14:Ac or *Z*3-14:OH on captures of male *Chionodes electella* and *Argolamprotes micella* with 100 μg *Z*3-14:Ac. Seewiesen/Starnberg, July 3 to 29, 1983 (series A) and June 25 to July 24, 1984 (series B); tetratraps, four replicates per series.

Additive, μg		$\overline{X}$ males/trap of *C. electella*		*A. micella*	
		A	B	A	B
none		92.75	55.0	17.5	28.5
*E*3-14:Ac,	3	53.0	18.0	9.25	9.0
	10	18.5	9.25	2.0	0
	30	0.25	0	0	0
	100	0	–	0.25	–
*Z*3-14:OH,	3	0	0	0	1.75
	10	0.5	0	0	0
	30	0	–	0	–
	100	0	–	0	–

of *Z*3-14:OH were sufficient to suppress captures, in both species. In these tests the main flight of *M. tenebrella* had already passed when traps were set. A separate test conducted on this species (Table III) revealed inhibitory effects of the two compounds comparable to the two other species.

The abolition of captures by adding to the *Z*3-14:Ac source only 3% of the alcohol analogue *Z*3-14:OH was an unexpected discovery, as the *Z*3-14:Ac samples used contained almost 1% of this parent alcohol [7]. This suggests that *Z*3-14:Ac sources free of alcohol might be even more attractive for these gelechiids. Related alcohols, such as *Z*3-12:OH or *E*3-14:OH, showed only weak inhibitory effects.

Table III. Effect of varying amounts of *E*3-14:Ac or *Z*3-14:OH on captures of male *Monochroa tenebrella* with 100 μg *Z*3-14:Ac. Seewiesen/Starnberg, June 10 to July 12, 1985; tetratraps, three replicates.

Additive, μg		$\overline{X}$ males/trap
none		37.7
*E*3-14:Ac,	3	10.7
	10	3.3
	30	0.3
	100	0
*Z*3-14:OH,	3	2.0
	10, 30, 100	0

On extending these tests further to various other structural analogues, *E*3-13:Ac was established as another strong inhibitor for *C. electella* (but not the two other species). Both *E*3-12:Ac and *E*3-13:Ac are identified sex pheromone or attractant components for some other Gelechiinae and Anomologinae [8–11]. No further strong inhibitor was found for the three test species. Particularly noteworthy is the failure of various chain length homologues (from *Z*3-10:Ac to *Z*3-18:Ac) to modify captures by *Z*3-14:Ac. Two of these homologues, *Z*3-13:Ac and *Z*3-12:Ac, even caught small numbers of *C. electella* and *M. tenebrella* (but not *A. micella*) when offered as single chemicals. A similar pattern of attraction specificity as for *C. electella* was obtained for two other *Chionodes* spp. responsive to *Z*3-14:Ac, *C. luctuella* (Hb.) and *C. nebulosella* (Hein.), at other central European test sites.

When testing binary combinations between *Z*3-14:Ac and another (*Z*)-3-alkenyl acetate, numerous male *Aproaerema anthyllidella* (Hb.) (Gelechiinae) were caught by the 100/100 mixture of *Z*3-14:Ac / *Z*3-12:Ac. The species was absent from neighbouring traps containing the single chemicals alone, indicating a synergistic attraction response. In subsequent tests of different mixtures of the two compounds, maximum attraction occurred with *Z*3-14:Ac / *Z*3-12:Ac ratios ranging from 100/10 to 100/100; the 10/100 mixture produced only poor captures and the single chemicals alone again were non-attractive (Table IV). Male *A. anthyllidella* were also caught by 100/100 combinations of *Z*3-14:Ac with either *Z*3-13:Ac or *E*3-12:Ac (data not shown), though at far lower numbers than with the 100/100 *Z*3-14:Ac / *Z*3-12:Ac combination. Third components were tested on this species as 100 μg amounts

Table IV. Captures of male *Aproaerema anthyllidella* in tetratraps baited with varying amounts of *Z*3-14:Ac and *Z*3-12:Ac. Seewiesen/Starnberg, July 15 to August 21, 1985; three replicates.

Amount [μg/trap] of *Z*3-14:Ac	*Z*3-12:Ac	$\overline{X}$ males/trap
100	0	0
100	3	6.7
100	10	25.7
100	30	18.3
100	100	23.7
30	100	9.0
10	100	1.3
3	100	0
0	100	0

added to this binary mixture. Only the alcohol *Z*3-14:OH reduced but did not fully suppress captures; various other third components tested (including *Z*3-10:Ac, *E*3-10:Ac, *E*3-12:Ac, *Z*5-12:Ac, *Z*3-13:Ac, *E*3-13:Ac, *E*3-14:Ac, *Z*5-14:Ac, *Z*3-16:Ac, *Z*5-16:Ac and *Z*3-12:OH) did not markedly modify capture rates. In this species, using a synergistic attractant system, attraction-inhibition thus appears to be less pronounced, compared to the other gelechiids treated above.

Potent inhibitors discovered in lepidopterous sex-attractant systems have often turned out to be essential attractant components in other, taxonomically related species. The *E*3-13:Ac and *E*3-12:Ac, highly inhibitory to male *C. electella*, are indeed the reported pheromones or attractants of certain other gelechiids ([8–11]; see also above). To further test potential attractive or synergistic properties for these two compounds, and also for *E*3-14:Ac and *Z*3-14:OH, traps containing 100 μg amounts of these chemicals either alone or in different combinations with 100 μg *Z*3-14:Ac were set out at various central European test sites for some years. A number of further Gelechiinae and Anomologinae spp. (representing the genera *Apodia, Athrips, Bryotropha, Caryocolum, Chionodes, Metzneria, Monochroa, Recurvaria, Scrobipalpa* and *Scrobipalpopsis*), all unresponsive to pure *Z*3-14:Ac, were effectively captured by some of these baits. For example, male *Chionodes holosericella* (H. Sch.) responded specifically to *E*3-12:Ac and male *C. perpetuella* (H. Sch.) to *E*3-14:Ac, with *Z*3-14:Ac (the *C. electella* attractant) acting inhibitorily on these species. Such data indicated a role for the various inhibitors in reproductive species isolation. Results obtained on species from the two gelechiid subfamilies responsive to Δ3-alkenyl attractants other than *Z*3-14:Ac will be presented elsewhere.

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