A Sex Attractant for the Pine Beauty Moth, *Panolis flammea*

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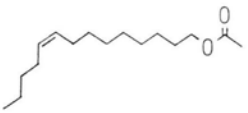
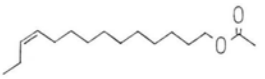
Electrophysiological recordings from antennal hair sensilla of male *P. flammea* revealed two types (A, B) of presumed pheromone receptor cells. The A receptors responded maximally to (Z)-9-tetradecenyl acetate and the B cells to (Z)-11-tetradecenyl acetate. In the field, a 100:5 mixture of the two compounds attracted 10 times more males than the (Z)-9 isomer alone.

The pine beauty moth, *Panolis flammea* Schiff. (Noctuidae: Hadeninae; Forleule, Kieferneule), is a most harmful pest of Scotch pine *(Pinus silvestris* L.) in Europe and Asia [1]. Along with the pine looper moth *(Bupalus piniarius* L.), the pine lappet moth *(Dendrolimus pini* L.), and the European pine sawfly *(Diprion pini* L.), estimation of population densities is currently based on soil sampling of hibernating stages. This time-consuming method is apparently unprecise in predicting population increase as shown by the recent outbreak of *P. flammea* in Northern Germany [2]. We are currently investigating the sex pheromones of these four pine pest species in order to improve early warning systems.

The field attraction studies on *P. flammea* reported here were prompted by results of electrophysiological recordings. Earlier electroantennogram (EAG) screening [3] of several hundreds of synthetic analogues of known lepidopteran pheromones led to (Z)-9-tetradecenyl acetate (Z9-14:Ac) as the most stimulatory structure. This chemical was therefore considered as a candidate for the primary sex pheromone of the species. Additional information resulted from nerve impulse responses of presumed pheromone receptor cells. These recordings, which were monitored via the ends of male sensilla trichodea with the tips cut off [4], revealed two types of receptor cells (Fig. 1) which according to their spike amplitude were designated cell A (large amplitude) and cell B (small a.). The A cells all responded maximally to Z9-14:Ac in consistence with the EAG response spectrum. The B cells were only weakly excited by this compound but responded maximally (out of about 100 test analogues) to a positional isomer, (Z)-11-tetradecenyl acetate (Z11-14:Ac).



Z9-14:Ac



Z11-14:Ac

Receptors for this latter compound were unexpected from the EAG response spectrum which apparently reflects only the A cells. Excised pheromone glands of virgin *P. flammea* females activated both types of receptors (Fig. 1) indicating that at least two components, either identical or structurally-related to the two model compounds, were produced by the female moth. In 29 (of a total of 36) sensillum recordings one A cell and one B cell were active simultaneously whereas in 7 recordings only a single A receptor was registered. In these experiments no evidence was obtained for any further type of receptor within the male olfactory hair sensilla.

Although chemical analysis of the female secretion could not be made at that time, we have started preliminary field attraction tests with the two candidate compounds. The chemicals used were at least 99.5% pure by gas chromatography on a 22 m × 0.3 mm Silar 10 C glass capillary column. Each contained not more than 0.05% of the (E) isomer and of tetradecyl acetate. The compounds were applied to rubber caps (Tellergummikappen No. 90142, Auer Bittmann & Soulié AG Zürich) from hexane solutions. Pherocon 1 C traps baited with the caps were attached to the trunks of pine trees at a level of 2 m. Each set of replicates consisted of 6 traps (1 with a blank cap and 5 with mixtures of chemicals) which were 3 – 5 m apart. Between replicates distances were 50 m or more. Posi-

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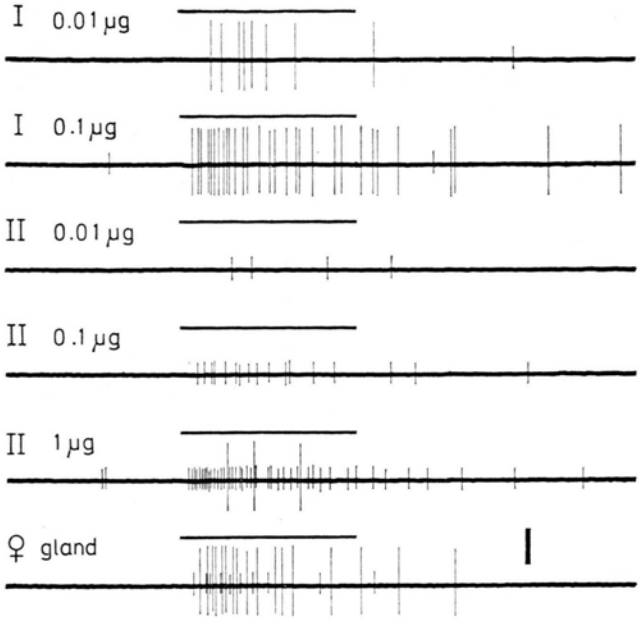

Fig. 1. Nerve impulse responses of two pheromone receptor cells of male *Panolis flammea* to indicated amounts of *Z*9-14:Ac (I) and *Z*11-14:Ac (II) and to a female gland. Bars indicate 1.0 sec of stimulation. Calibration is 0.5 mV.

tions of traps were systematically changed for every replicate. The field tests were conducted from April 10 to June 5, 1978, near Speyer and Karlsruhe (Oberrheintal) and Celle (Lüneburger Heide) in forests of *P. silvestris* of different stages of *P. flammea* infestation.

Table I lists trap catches for two successive periods and three replicates at a location of higher population density. Except for the 100 : 100 ratio, all formulations were attractive. In both periods with each replicate the highest catch was consistently obtained with the 100 : 5 ratio, the difference to the other treatments being significant at the 99% level.

In comparative tests in areas of very low moth activity (Karlsruhe and Speyer, April to May 1978), 1 or 2 males per trap were attracted to the 100 : 1 to 100 : 25 mixtures but none to pure *Z*9-14:Ac.

Although formulations with *Z*11-14:Ac as the major constituent have not been investigated, attractivity is unlikely considering the total lack of catch with the 100 : 100 combination. Based on the present results, *Z*11-14:Ac can be considered a candidate structure of a secondary [5] component of the pine beauty moth pheromone which is not attractive by itself but synergizes the response to a primary component.

Among the various binary sex attractants reported for Noctuidae spp., the combination of *Z*9-14:Ac plus *Z*11-14:Ac has to our knowledge

Table I. Numbers of *Panolis flammea* males attracted to combinations of *Z*9−14:Ac and *Z*11−14:Ac in 3 replicates at Celle, May 10 to 26, 1978.

Amount of chemical per cap [µg]		Period I, May 10−18					Period II, May 19−26					Total *
		replicate no.			Σ	(%)	replicate no.			Σ	(%)	
*Z*9-14:Ac	*Z*11-14:Ac	1	2	3			1	2	3			
0	0	1	0	0	1	(0.7)	0	0	0	0		1 d
100	0	3	7	4	14	(9.3)	3	5	0	8	(6.2)	22 c
100	1	11	5	10	26	(17.3)	4	4	4	11	(8.5)	37 bc
100	5	31	30	16	77	(51.3)	37	38	10	85	(65.9)	162 a
100	25	4	19	7	30	(20.0)	10	7	8	25	(19.4)	55 b
100	100	1	1	0	2	(1.3)	0	0	0	0		2 d

* Numbers followed by the same letter are not significantly different at the 99% probability level as indicated by two-way analysis of variance followed by Duncan's multiple range test.

not been reported before. The two compounds constitute the synergistic pheromone blends of a number of Tortricidae spp. including the summerfruit tortrix, *Adoxophyes orana* [6] and the smaller tea tortrix, *A. fasciata* [7]. In contrast to *P. flammea*, pure *Z*9-14:Ac is essentially unattractive to these tortricids which respond maximally to combinations of *Z*9-14:Ac with *Z*11-14:Ac at ratios of 8 : 2 to 9 : 1 [6 – 8].

Further studies will be needed to determine the actual composition of the female pheromonal secretion and to define a standard formulation for monitoring *P. flammea* populations by sex attractant traps.

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