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## $\alpha$ -Farnesene, a Natural Attractant for Codling Moth Larvae

THE skin of the apple cultivar 'Sturmer Pippin' contains one or more chloroform-soluble volatile substances which are highly attractive to newly hatched codling moth (*Laspeyresia pomonella*) larvae<sup>1</sup>. There is now evidence that the factor inducing this olfactory response is the acyclic sesquiterpene  $\alpha$ -farnesene (Fig. 1), a compound present in the natural coating of 'Sturmer' as well as several other apple and pear varieties<sup>2-4</sup>. This hydrocarbon has also been isolated from the Dufour's gland of at least two<sup>5,6</sup> and possibly more<sup>7</sup> species of ant and Blum<sup>8</sup> has speculated that it may have a role as a pheromone in these insects.

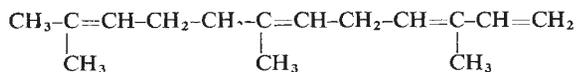


Fig. 1 Structure of  $\alpha$ -farnesene.

A small (2 × 1 cm) rectangle of filter paper was treated with 0.025 ml. of test material in chloroform and was placed vertically against one side of a 5.2 cm diameter Petri dish after the solvent had evaporated. A second paper treated with the same quantity of pure solvent was placed on the opposite side of the dish. Ten vigorous larvae, less than 12 h old, were released in the centre of the dish and the lid was replaced. The number of larvae present on the filter papers at the end of a 5-min test period was recorded. Each test was repeated five times and was conducted in dim diffuse light<sup>1</sup>.

In preliminary tests we found that the ethopotent factor was present only in the hydrocarbon fraction of the initial chloroform extract and that the behaviour of the insects in the odour gradient was manifest as a klinotaxis. Larvae did not respond to esters, waxy alcohols or waxy acids. The active hydrocarbon fraction was obtained and its components separated and tested in the following manner. Six small apples were washed in chloroform (3 × 300 ml.) and the combined extracts evaporated under reduced pressure at less than 40° C. The residue was redissolved in light petroleum ether and subsequent chromatography on Florisil yielded a highly active hydrocarbon fraction (Table 1, A). All samples were diluted to a final concentration of 6 apple-equivalents in 50 ml. of solvent prior to testing. The saturated and unsaturated hydrocarbons were separated by re-chromatography of the active fraction on silicic acid impregnated with 20% AgNO<sub>3</sub>. The larval response to each was evaluated. The bioassay indicated (Table 1, B-D) that the unsaturated hydrocarbons were responsible for the potency of the original material and further separation of the unsaturated fraction was undertaken, again on silicic acid impregnated with 20% AgNO<sub>3</sub>. No mono-unsaturated hydrocarbons were obtained, but when the di, tri and polyunsaturated hydrocarbons were tested, all activity was in the polyunsaturated fraction (Table 1, E-H). Subsequent column chromatography yielded a fraction (obtained with 25% ether in benzene) to which larvae again responded strongly (Table 1, I). Gas-liquid chromatography

**Table 1** Attraction of Newly Hatched Codling Moth Larvae to Hydrocarbons in the Natural Coating of Apples

Test material	No. of larvae present after 5 min*	
	Test paper	Control paper
Hydrocarbons		
A. Combined	34	0
B. Saturated	9	5
C. Unsaturated	33	4
D. Residue	11	7
Unsaturated hydrocarbons		
E. 1 double bond (not present)	—	—
F. 2 double bonds	6	7
G. 3 double bonds	11	9
H. > 3 double bonds	36	1
> 3 double bonds		
I. $\alpha$ -Farnesene	31	1
J. > 4 double bonds	5	7
K. $\alpha$ -Farnesene (pure)	34	1

\* Fifty larvae were exposed to each test material in 5 groups of 10.

of this fraction showed one major peak with a retention time identical to that of pure  $\alpha$ -farnesene, and the peak of the extracted fraction coincided with that of pure material when the two were chromatographed together.

$\alpha$ -Farnesene is not the only polyunsaturated hydrocarbon present in the natural coating of apples. Gas-liquid chromatography of the active polyunsaturated fraction revealed the presence of a small group of highly unsaturated compounds. This group was isolated and tested, with negative result (Table 1, J), from which we conclude that the sesquiterpene  $\alpha$ -farnesene was the olfactory attractant in our extract of 'Sturmer Pippin' apples.

$\alpha$ -Farnesene was confirmed as an olfactory stimulant for these insects when the pure material was tested at a concentration equivalent to that in the apples<sup>3</sup>. The strongly positive response of the test larvae (Table 1, K) left no doubt that this compound is a potent attractant for neonate codling moth larvae.

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## An Upper Cretaceous Symmetrodont from Alberta, Canada

THE Order Symmetrodonta consists of small Mesozoic therian mammals with tricuspid molars of pretribosphenic type. The order includes species probably ancestral to Jurassic eupantotheres<sup>1</sup> and hence to marsupials (Metatheria) and placentals (Eutheria), and it includes less central lineages that have left no known descendants. Symmetrodont fossils are uncommon,