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SPECIALIA

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Attraction of *Scolytus scolytus* (F.) to the components of Multilure, the aggregation pheromone of *S. multistriatus* (Marshall) (Coleoptera: Scolytidae)¹

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Summary. The attraction of *S. scolytus* to the components of Multilure is described. 4-Methyl-3-heptanol is an attractant which is synergised by α -cubebene. Multistriatin appears to be an inhibitor. A combination of 4-methyl-3-heptanol and cubeb oil is more effective as a bait for *S. scolytus* than Multilure.

In the United Kingdom a major vector of *Ceratocystis ulmi* (Buism.) C. Moreau, the causal fungus of Dutch elm disease, is the larger European elm bark beetle, *Scolytus scolytus*. When unmated beetles bore into English elm, *Ulmus procera* Salis., the volatiles produced include threo and erythro 4-methyl-3-heptanol **I**, α -multistriatin **II** and α -cubebene **III**^{3,4}. (-)-Threo-**I**, (-)-**II** and (-)-**III** have been identified as components of the aggregation pheromone of *S. multistriatus*⁵⁻⁷. In both species **I** and **II** are beetle-associated whilst **III** is a host metabolite.

In *S. scolytus* the male produces the secondary attractant⁸. There is also a differential production of **I** and **II** between the sexes. α -Multistriatin is produced mainly by females whilst males produce 4-methyl-3-heptanol⁴. This is in contrast to *S. multistriatus* where the components, **I** and **II**, of the aggregation pheromone are produced by the female⁵. A mixture, Multilure, of synthetic isomers of 4-methyl-3-heptanol and multistriatin, and distilled cubeb oil (70% α -cubebene) is effective in trapping large numbers of *S. multistriatus* in the USA⁹, but does not appear to attract large

numbers of *S. scolytus* in Europe¹⁰. We report on field tests designed to indicate the relative attraction of the Multilure components to *S. scolytus*.

Materials and methods. Field tests were carried out on Sussex farmland between 13 and 29 July 1977. Traps consisting of a 45 cm × 20 cm cylinder of 8-mm metal mesh coated with 'Stikem Special' (Michel and Pelton, Manufacturing Chemists, Emeryville, California) were placed on 1.8 m high 2.5-cm dowels set at least 25 m apart close to hedgerows containing diseased and healthy *U. procera*.

The Multilure materials used in the trial were: A) 99% 4-methyl-3-heptanol (three:erythro, 2:1), B) multistriatin mixed isomers (34.7% α -isomer), and C) distilled cubeb oil (51.6% α -cubebene). Traps were baited with 1 mg each of A and B and 2 mg of C. Dispensers of the vial within a vial type were used to release the materials. Each component, in 5 ml of pentane, was placed in a separate 4-dram glass vial with a hole (1.7-mm diameter) drilled in the cap. The vials were placed in inverted aluminium containers 11.5 cm × 6 cm with 9 holes (6-mm diameter) bored through the lid. The dispensers were positioned at mid-trap height.

The experimental design was a randomised block replicated 3 times (table). To reduce the positional effect of traps the treatments were randomised within blocks a total of 5 times during the experiment. Prior to each randomisation beetles were picked off the traps, immersed in xylene to remove the Stikem and sexed in the laboratory. Data were transformed to $\sqrt{x+0.5}$ and subjected to analysis of variance.

Results and discussion. The release rates of the materials from the dispensers were not constant. Laboratory tests showed that after evaporation of the solvent (i.e. after 5–6 days in the field) the release rates were approximately 300 μ g/day for each of the components and thereafter declined exponentially. The ratio of I to II released (approximately 3:1) was relatively constant although the ratio of I to III and II to III was not.

The low catches obtained in these tests (table) were influenced by several factors. The weather conditions, mainly

windy and unseasonably cold, were unfavourable to beetle flight. Additionally there was probably competition between the *U. procera* hedgerows and the adjacent traps. Another disadvantage of placing traps close to hedgerows is that trap silhouette is obscured. Lanier et al.⁹ have shown that trap placement influences the catch in *S. multistriatus* and that visually obscured traps may fail to catch beetles attracted to the immediate vicinity.

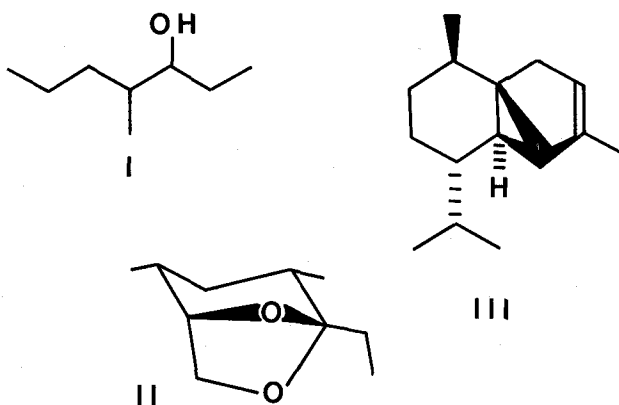
Despite the limitations in the experimental design significant data on the attraction of *S. scolytus* to the Multilure components was obtained. Of the materials tested only 4-methyl-3-heptanol showed any attraction in the field ($p=0.001$). Since I is only produced in appreciable quantities by male beetles the results suggest that 4-methyl-3-heptanol forms part of the male-produced aggregation pheromone in *S. scolytus*.

The attraction to 4-methyl-3-heptanol is enhanced by the addition of cubeb oil ($p=0.05$). α -Cubebene was the only major component of the cubeb oil mixture to elicit an increased response when tested in a laboratory bioassay with 4-methyl-3-heptanol⁴. Thus the enhancement of trap catch associated with cubeb oil is probably derived from α -cubebene, which acts as a host-produced synergist for both *S. scolytus* and *S. multistriatus*.

The situation regarding multistriatin is more complex. In laboratory bioassays the response to the mixed isomers used in the field trials is not greatly different from that elicited by α -multistriatin alone. δ -Multistriatin, the major component is inactive⁴. Thus the inhibition shown in the field by the mixed isomers ($p=0.01$) is probably mediated largely by α -multistriatin.

In a separate experiment using traps baited with *S. scolytus* infested logs Borden and King⁸ obtained significant catches with males, whereas logs baited with females or equal numbers of males and females elicited low responses. This effect could be due to the cessation of production of the aggregation pheromone by the males or to an inhibitor produced by the females. Our results favour the latter explanation since in *S. scolytus* the production of α -multistriatin is mainly associated with females boring into *U. procera*.

Further work is in progress to determine the role of the geometric and optical isomers of I, II and III in the chemically mediated behaviour of *S. scolytus*.



Response of *S. scolytus* to the Multilure components

Treatment	Total no. of <i>S. scolytus</i> caught		
	Male	Female	Total
4-methyl-3-heptanol A	43	36	79
Multistriatin B	13	3	16
Cubeb oil C	9	6	15
A + C	60	43	103
A + B	13	15	28
B + C	5	5	10
A + B + C	30	18	48
Control	24	14	38

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