An Aggregation Pheromone of *Sitona lineatus*

Identification and Initial Field Studies

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The pea and bean weevil, *Sitona lineatus* (L.) (Coleoptera: Curculionidae) is a pest of leguminous crops in Britain, central Europe and the north-western region of the USA [1]. We report here a male-produced aggregation attractant, the first demonstration of pheromonal communication by this weevil.

Field studies [2] with lures consisting of *S. lineatus* on broad bean plants demonstrated that both sexes are attracted to male weevils feeding on beans. Pentane extracts of volatiles produced by broad bean shoots and by weevils feeding on bean shoots were obtained by an air entrainment technique [3]. Gas chromatographic (GC) and coupled gas chromatographic-electroantennogram (GC-EAG) analyses [4] on a 25 m × 0.3 mm i.d. SE-30 fused silica column revealed the presence of a number of electrophysiologically active compounds, one of which was associated only with male weevils. The plant-derived compounds were identified by coupled gas chromatography-mass spectrometry (GC-MS) on a 25 m × 0.2 mm i.d. OV-101 fused silica column and by GC coinjection with authentic samples as (*Z*)-3-hexen-1-ol, (*Z*)-3-hexen-1-yl acetate and linalool; standard samples of these compounds elicited EAG responses from the antenna of *S. lineatus*.

The mass spectrum of the compound produced by male weevils [142(M^+, 4%), 113(10), 86(30), 57(100), 55(16), 44(12), 41(8), 29(74), 27(25)] suggested it was 4-methyl-3,5-heptanedione. An authentic sample was prepared by methylation of 3,5-heptanedione using the method of Morgan and Taylor [5], except that sodium hydride in ether/dimethylformamide replaced sodium in ether. Purification of the 4-methyl-3,5-heptanedione was achieved by recrystallisation of the copper complex [6] and the structure was confirmed by GC-MS and proton nuclear magnetic resonance spectrometry. GC-MS, GC and GC-EAG data for the authentic sample were identical with those of the weevil-produced compound.

The field response of *S. lineatus* to synthetic samples of the weevil and bean metabolites was studied in a factorial experiment performed during April 1984, on two separate fallow fields which had contained field beans in 1983. Yellow traps, similar in design and size to an *Anthonomus grandis* cone trap [7], were placed 9 m apart on the soil. The weevil and bean metabolites were tested at two concentrations (Table 1). The experiment was set out as two randomised blocks, with 9 replications within each block. The results (Table 1) showed that the blank treatment caught few weevils (1.8% of the total catch) and treatments 2 and 3 consisting of bean volatiles alone were no more attractive than the blank. A factorial analysis of variance of the untransformed data revealed that all treatments containing the weevil metabolite caught significant numbers of weevils ($P<0.001$), but more weevils were trapped ($P<0.01$) by treatments containing the higher, rather than the lower concentration of this substance. There was also an indication ($P=0.05$) that the addition of bean volatiles to the higher concentration of 4-methyl-3,5-heptanedione synergised the attraction. However, this effect was seen predominantly in one block and thus requires further investigation.

The results show clearly that 4-methyl-3,5-heptanedione attracts both sexes, although substantially more males than females were trapped. The reason for this is not yet clear. In addition, the analysis revealed significant differences between the sex ratios of individual treatments but too few weevils were caught by treatments 1, 2 and 3 to enable any firm conclusions to be drawn.

There is one previous report of an aliphatic β-diketone acting as an insect attractant [8], and a closely related compound, (4*R*,5*S*)-4-methyl-5-hydroxy-3-heptanone has recently been identified as the major component of the aggregation pheromones of the rice weevil, *Sitophilus oryzae*, and the maize weevil, *S. zeamais* [9].

Table 1. Field response of *S. lineatus* to baits releasing the weevil metabolite, 4-methyl-3,5-heptanedione and/or the bean volatiles, (*Z*)-3-hexen-1-ol, (*Z*)-3-hexen-1-yl acetate and linalool. The substances were released from separate polythene vials. Weevil (1) and weevil (2) were respectively 5 mg and 21 mg of 4-methyl-3,5-heptanedione. Bean (1) consisted of 7 mg (*Z*)-3-hexen-1-ol, 5 mg (*Z*)-3-hexen-1-yl acetate and 34 mg linalool. Bean (2) was 34 mg (*Z*)-3-hexen-1-ol, 21 mg (*Z*)-3-hexen-1-yl acetate and 3 × 50 mg linalool. The data were derived from 2 blocks, with 9 replications per block. Total number of weevils caught was 4796

Treatment	Mean number of weevils caught per replicate	Sex ratio ♂:♀
1. Blank (empty trap)	4.9	1.7:1
2. Bean (1)	6.6	1.2:1
3. Bean (2)	3.9	1.6:1
4. Weevil (1)	39.1	1.9:1
5. Weevil (2)	38.9	2.0:1
6. Weevil (1) + Bean (1)	32.1	2.1:1
7. Weevil (1) + Bean (2)	41.5	1.8:1
8. Weevil (2) + Bean (1)	47.7	2.2:1
9. Weevil (2) + Bean (2)	54.8	2.5:1

The work described here will be reported in more detail elsewhere. Further investigations on these and other behaviour-controlling chemicals which might be used to monitor, mass trap or time insecticide applications to control *S. lineatus* are in progress.

We thank J. McEwen and R. Moffitt for their help and cooperation with field trials; T. Dixon for statistical analyses; J. Steinmann and L. Scudder for technical assistance and E. Macaulay for discussions on trap design.

Received June 22, 1984

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