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EVIDENCE OF A FEMALE-PRODUCED AGGREGATIVE PHEROMONE IN *LEPERISINUS CALIFORNICUS* SWAINE (COLEOPTERA: SCOLYTIDAE)

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Aggregation pheromones in most bark beetle species are produced by the gallery-initiating sex; they attract conspecifics of both sexes to the host and may elicit response from congeneric scolytids (reviewed by Lanier and Burkholder, 1974). Predators and parasites may also respond to these volatiles (reviewed by Borden, 1974). In *Dendroctonus,* initial host selection is followed by complex pairing behavior during which both sexes exhibit sonic and other interactions in the gallery (reviewed by Rudinsky and Ryker, 1977). Though it was first reported that the European ash bark beetle, *Leperisinus fraxini,* has an aggregative pheromone released by the male (Schönherr, 1970), a later study (Rudinsky and Vallo, 1979) shows that the host-selecting female produces the aggregation pheromone.

The literature on *Leperisinus* Reitter, little of which is recent, was extensively reviewed by Vernoff (1979). Wood (1977) proposed this genus be placed in synonymy under *Hylesinus* Fabricius. Sound production and pairing behavior of the Oregon ash beetle, *L. oregonus,* and the western ash beetle, *L. californicus,* are described by Vernoff and Rudinsky (in press). The present report on an aggregative pheromone in *L. californicus* is the first evidence of such a pheromone in any North American member of this genus.

Materials and Methods

Briefly, *L. californicus* was sexed by frons topography and scale size on the elytral declivity (Bright, 1976). *L. oregonus* was sexed using color pattern of scales on the elytral declivity (Blackman, 1943, detailed by Vernoff, 1979). Field work was done within ten miles of Corvallis, Oregon. Daily temperature data were provided by the National Weather Service at Oregon State University. All host material was Oregon ash, *Fraxinus latifolia* Benth.

Preliminary tests indicated that *Leperisinus* spp. could be attracted to ash by olfactory cues emanating from breeding galleries. To determine the origin of these cues, the following field test was performed. Sexually mature *L. californicus* were collected from the surface of winter-cut logs during beetle flight on 19–20 May 1978 (maximum daily temperatures 28–29°C). Since

Table 1. Field response of *Leperisinus californicus* to cages containing experimentally infested ash logs, Corvallis, Oregon, June 1978.

Treatment	Response	
	Total beetles	Ratio ♂:♀
27 CAL pairs	183	1:1.4*
27 CAL pairs	52	1:1.5
28 CAL females	167	1:1.3
28 CAL females	168	1:1.4*
24 CAL males	4	1:0.3
23 CAL males	2	1:0.0
107 ORE females	51	1:1.7
82 ORE males	1	0:1.0
Uninfested log	9	1:8.0*
Uninfested log	0	0:0.0
Totals	637	1:1.4*

Abbreviations: CAL: *L. californicus*; ORE: *L. oregonus*.
* Significantly different from 1:1 according to Chi-square test ($P = 0.05$).

pairs of this species were observed copulating at gallery entrances and even on cages used for field tests, it is likely that most collected adults had mated. Adults were sexed and stored at 4°C until needed. A small ash was felled and wrapped with white cotton cloth to prevent attack. After 7 days (when the leaves were wilted), it was cut into 60-cm long sections (8–13 cm diameter), and stored in a cooler (4°C) until needed. Six of these logs were placed separately in white cotton sacks; 23 or 24 male *L. californicus* were added to each of two logs; 28 females were added to each of two logs, and 27 beetles of each sex were added to each of the final two logs. The sacks were then sealed with masking tape and kept in the laboratory (23°C) for 56 hours to initiate the infestation. On 31 May 1978, each of the six test logs plus two uninfested control logs from the same tree were placed vertically inside eight fine-wire cages (56 × 61 × 86 cm) in an ash stand. Two additional cages were used to hold winter-cut logs with *L. oregonus* males or females respectively, which were introduced in the same way as with *L. californicus*. The ten cages were set 15 m apart, and *Leperisinus* landing on them were collected individually in gelatin capsules on 31 May through 5 June 1978 from 1 p.m. to 7 p.m.; previous experience had shown that morning flight is minimal.

On 6 June the six logs infested with *L. californicus* were placed in the freezer to kill the beetles, so that subsequent debarking would reveal gallery excavation as of field test termination.

For laboratory testing ten female *L. californicus* were introduced 20 cm apart in an ash log and left to feed for one day at 28°C. Three of the females

Table 2. Examined contents of ash logs experimentally infested with *L. californicus*.

Treatment	No. beetles excised	Galleries			(abandoned)		
		No.	No. w/ eggs	Length (cm)	No.	No. w/ eggs	Length (cm)
Pairs I	24 CAL pairs + 3 CAL ♀♀	27	27	65.7	9	0	3.1
Pairs II	25 CAL pairs + 2 CAL ♀♀ + 3 CAL ♂♂ + 2 ORE pairs	29	26	68.6	7	0	2.1
Females I	26 CAL ♀♀	26	19	39.0	30	1	13.4
Females II	26 CAL ♀♀ + 1 ORE ♂	26	17	40.4	22	0	8.7
Males I	12 CAL ♂♂	11	0	4.6	20	0	6.3
Males II	6 CAL ♂♂ + 1 ORE pair	5	0	2.2	22	0	5.7

were then removed from under the bark and the excision damage was repaired. Twenty males were tested individually over each of the three entry holes ($n = 60$). Likewise twenty other males were tested over each of three entry holes where the female had not been excised. Finally, three holes were bored into the bark and tested with 20 males in the same way to determine response to host substances alone. Glass slides laid parallel 8 mm apart on the log made a simulated walkway leading to the entry hole, which was plugged by a number 0 insect pin to prevent male entry. The males were gently placed with a brush at the end of the glass walkway and allowed to walk to the gallery entrance. The criterion of arrestment was a full stop over the entry and excited turning of the head during attempts to enter the gallery. Passing over the entry hole was categorized as nonarrestment or no response. Beetles used in these tests were collected earlier in the field and stored in gelatine capsules in the refrigerator.

Results and Discussion

Both sexes of *L. californicus* were attracted to cages containing the logs experimentally infested with females or pairs of this species (Table 1). The logs with female *L. oregonus* were also attractive to *L. californicus*, though less so than conspecific females. Since flight of *L. oregonus* had occurred earlier in May, the alternate cross attraction of this species to *L. californicus* could not be determined. Logs containing males of either species or uninfested logs were not attractive. Sex ratios of responding beetles differed from 1:1. Significantly more females were caught at three of the ten cages and on two of the six days (1 and 4 June); the total number was also significantly higher (Table 1).

Table 2 shows results of debarking the logs experimentally infested with

L. californicus for the above field tests. The beetles had excavated a total of 8.5 days, over 2 in the laboratory and nearly 6.5 in the field. Single males bored very little, made short galleries, and abandoned most of them. This indicates that they do not normally excavate galleries. Most single females and mating pairs made biramous galleries of which one arm was usually longer than the other, with no consistent preference for right or left. The entrance usually led upward rather than downward. Individual gallery length differed significantly ($P < .0005$, analysis of variance) among *L. californicus* pairs (1.3–3.5 cm, $\bar{x} = 2.54$ cm, SE = .076 cm, n = 49), single females (.3–2.6 cm, $\bar{x} = 1.53$ cm, SE = .077 cm, n = 52) and single males (.3–.7 cm, $\bar{x} = 0.43$ cm, SE = .031 cm, n = 16). Pairs excavated farther than single females, which in turn excavated farther than single males (Student-Newman-Keuls multiple comparison test). The individuals of *L. oregonus* observed in these logs are assumed to have been present in bark crevices for maturation feeding before the tree was felled.

Results of the laboratory olfactory tests support the field tests. The galleries with feeding females arrested 53 out of 60 males, and the female galleries containing frass from which the females had been excised arrested 54 out of 60 tested males. Thus the arrestment response appears to be evoked by olfactory stimulus. Host substances emanating from fresh holes in the bark elicited response in only 3 out of 60 males.

These data support current belief that the host-selecting sex releases the first pheromone components in Scolytidae.

Acknowledgments

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BOOK REVIEW

Arthropod Phylogeny. A. P. Gupta, editor. 1979. Van Nostrand Reinhold Company, New York, xx + 762 pages, 228 text figures, taxonomic and subject indexes. $32.50, cloth.

Since 1958, S. M. Manton has argued that arthropods share only a grade of organization, not immediate ancestry. The bases for her view, developed