Sex Attractants in Frass from Bark Beetles

Shortly after Kangas *et al.* (*1*) reported that α-terpineol was the major component of a primary host attractant for *Blastophagus piniperda* L., Silverstein, Rodin, and Wood (*2*) revealed the identity of three other terpene alcohols that play a role in the orientation of bark beetles. However, Silverstein *et al.* concluded, from laboratory bioassay, that a mixture of the three terpene alcohols they had isolated and identified from the frass produced by male *Ips confusus* (LeC.) represents "the sex attractant that is responsible for the mass attack following initial boring activity." This terminology and conclusion largely ignore present knowledge in the behavior of bark beetles and should be held in doubt, since reactions of walking insects in laboratory bioassay do not necessarily reflect the behavior of flying populations (*3*). In fact, frequently, materials that elicit response in laboratory bioassay are found inactive under field conditions. Furthermore, the term "sex attractant" would appear not to fit material that is active at different combinations of various host- and insect-produced components, does not stimulate mating in any obvious way, and attracts both sexes and probably other insects as well.

Instead, it has been determined by field biossay that the attractant principle responsible for population aggregations of *Ips confusus* originates in the hindgut of the male when the beetle feeds in new host material, as well as in the phloem tissue of nonhost species; it has also been shown, under field conditons, that hindguts and fecal matter deriving from mature and fed males are the ultimate source of the attractant (*4*). None of these findings, which are now accepted, remained unchallenged, for controversial evidence is easily obtained from laboratory observations (*5*). The complex nature of the phenomenon of population aggregation of bark beetles (*6*), with its various activities, such as directed flight and landing and arrest in search of suitable breeding places, must involve a whole chain of reactions, among them reactions to various olfactory stimuli. In order to derive legitimate conclusions concerning the attractant principle that causes directed flight, the behavioral elements in population aggregation that allow meaningful bioassay of candidate substances must first be known. Frass that contains a multitude of host- and insect-produced fractions of potential olfactory activity appears to be a confusing base for the selection of test compounds, in comparison to pure fecal matter or dissected hindguts (*7*). The limitation of suspect compounds, in turn, would be of special concern where synergistic effects are expected.

Only experiments performed under field conditions can prove whether the conclusions presented by Silverstein *et al.* are actually valid and do not fall prey to deficiencies in laboratory bioassay.

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We reply to Dr. Vité's comments seriatim:

1) We agree that walking responses in the laboratory may not precisely reflect the behavior of flying populations. However, the laboratory bioassay (*1*) was developed from critical field evaluation of flight response (*2*) and actually utilizes present knowledge of bark beetle behavior. We outlined a protocol for isolation and identification of insect pheromones at the annual meeting of the Entomological Society of Canada (Banff, September 1966). In this protocol, we emphasized the need for field assessment in all such studies. A laboratory bioassay, however, is an indispensable tool for following the isolation of minute amounts of active components. Dr. Vité and his colleagues also recognize this need in their isolation studies (*3–5*). The correlation of laboratory and field data is routine in biological research and they are complementary.

2) Bark beetle attractants have been variously termed, that is, assembling scent, aggregating pheromone, sex attractant, secondary attractant, mass attractant, beetle-associated attractant, ovipositional attractant, male attractant, and "the pheromone." Each of these terms is open to criticism, but as long as the phenomenon is described thoroughly, communication can occur. Further refinement of terminology at our present level of knowledge would merely be an exercise in semantics.

3) The attractants have been found to be associated with the fecal pellets present in male frass (*3, 5, 6*) which was shown earlier to be attractive to walking populations in the laboratory (*1*) and to flying populations in the field (*7*). Frass, therefore, seemed to be the logical starting material for the isolation (*6*) and subsequent identification (*8*) of attractant compounds. The activity found by Pitman, Kliefoth, and Vité (*5*) in the hindgut of feeding beetles could simply result from the presence of fecal material. Claims to the discovery of secretory areas in the hindgut have been retracted (*5*). Collection of "pure fecal matter or dissected hindguts" seems to be an extraordinarily laborious and unnecessary performance. We await the identification of attractant compounds from the hindgut alone. Earlier claims (*9*) to "independent identification" were apparently premature.

4) Results of our experiments for the evaluation, under field conditions, of the compounds we isolated were reported at the Banff meeting and published in the abstracts of that meeting (*10*). Dr. Vité was in attendance.

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