

Genetic Basis of Semiochemically Mediated Bark Beetle-Predator Coevolution: Implications for Developing Mass-Trapping Technologies¹

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Background

The pheromone chemistry of *Ips pini* (Coleoptera: Scolytidae) has been extensively studied in recent years. In eastern North America, *I. pini* populations respond most strongly to ipsdienol with an enantiomeric composition of about 40 percent to 75 percent-(S)-(+). (Herms and others 1991, Lanier and others 1980, Raffa and Klepzig 1989, Teale 1990). In western populations, *I. pini* typically responds maximally to ipsdienol with an enantiomeric composition of 93 percent to 100 percent-(R)-(-) (Lanier and others 1980, Miller and others 1989, Seybold and others 1992d).

In eastern populations of *I. pini*, both isomers of ipsdienol function as attractants (Teale 1990), whereas in most western populations the (-)-isomer serves as an attractant and the (+)-isomer functions as an interruptant (Birch and others 1980, Seybold and others 1992d). Recently, lanierone was demonstrated to be an important component of the aggregation pheromone of eastern populations of *I. pini* (Teale and others 1991), but it was not found in western populations (Seybold and others 1992c).

Teale (1990) demonstrated in *I. pini* that the chirality of male-produced ipsdienol was heritable. In addition, Teale and others (personal communication) have shown a strong, positive correlation between male response to and production of enantiomeric blends of ipsdienol. If positive assortive mating were common among individuals with similar ipsdienol preference/production, then genetic substructuring of *I. pini* populations could easily occur. Moreover, if movement by *Ips* adults were limited between habitat patches (e.g., isolated pine woodlots), then further genetic divergence could result on a spatial scale.

Thanasimus dubius (Coleoptera: Cleridae) is a specialist predator of *Ips* and other bark beetles, and can cause significant bark-beetle mortality (Riley and Goyer 1986, and references therein). *Thanasimus dubius* uses the pheromone of *I. pini* as a kairomone in prey location, and like *I. pini*, demonstrates preferences among different blends of ipsdienol (Herms and others

1991, Raffa and Klepzig 1989). Such variation in the kairomone response of *Thanasimus* could lead to differential mortality of *Ips* adults that respond/produce different enantiomeric blends of ipsdienol. *Ips* that respond/produce low-risk ipsdienol blends theoretically could escape intense predation and increase in numbers. This change in *Ips* pheromone production would, eventually exert a reciprocal selective force on its predators, resulting in a coevolutionary feedback system.

Similar to the selective pressures described above for *Thanasimus*, mass-trapping with a single enantiomeric blend of ipsdienol may also cause differential mortality of *Ips* populations and lead to an increase in *Ips* that respond/produce blends of ipsdienol that differ from the pheromone bait being used. In other words, there is potential for *Ips* populations to evolve resistance to mass-trapping programs that utilize a single blend of ipsdienol.

Current Research Objectives

We are interested in developing mass-trapping technology for managing *I. pini* populations in midwestern pine woodlots. This will require an understanding of the relative genetic and environmental components to variation in the pheromone responses of *I. pini* and its specialist predators (Herms and others 1991). Heritable variation in beetle responses to different enantiomeric blends of the aggregation pheromone ipsdienol implies the potential for *Ips* populations to evolve resistance to mass-trapping programs that use individual blends of ipsdienol. This risk is especially great if *Ips* populations are genetically substructured on the basis of pheromone preferences or if gene flow between pine woodlots is rare. The risks are complicated by secondary impacts on predators that exploit ipsdienol as a kairomone for prey location. Mass-trapping has potential as an economically viable, ecologically sound control measure, but its sustained effectiveness may be compromised by disregarding the above risks. We will develop models to predict evolutionary responses of *Ips* and their predators to different mass-trapping scenarios. The expected product is an economical resistance management program, probably based on sequential or simultaneous use of different ipsdienol blends, and including considerations of predator-prey dynamics.

Current Research Question

To what extent are populations of *I. pini* and *T. dubius* genetically substructured within and between habitat patches (pine woodlots)?

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Experiments in Progress

1. Electrophoretic studies to test for genetic differentiation within and among populations of *I. pini* (and its clerid predator, *T. dubius*) based on ipsdienol-blend preferences.

2. Mark-recapture studies to test pheromone-response specificity of *I. pini*.

3. Comparison of pheromone-response profiles of *I. pini* populations from several isolated red-pine stands in Michigan. Assuming a genetic component exists to the observed intrapopulation variation, then genetic drift or differential selection pressures could result in stand-to-stand differences on a local scale.

Future Research Plans

We plan to initiate replicated mass-trapping studies in several isolated red pine woodlots in Michigan in 1992. If there is a genetic component to the observed variation in pheromone response, we should be able to manipulate pheromone response profiles by exerting selection through mass-trapping. Directional selection (e.g., using one pheromone blend) should change the response profile, whereas stabilizing selection (e.g., using several blends) should maintain it. If the genetic component to pheromone response is weak relative to environmental influences, or if there is substantial gene flow within and among woodlots, then mass-trapping should have little effect on response profiles of local *I. pini* populations.