Section 13: Pheromones

- Many forms of insect behavior are influenced by chemical signals - both intraspecific (within the same species) and interspecific (between different species) signals.
- Chemicals involved in signaling between organisms, and affecting behavior modification, are called semiochemicals. There are 2 major types:
  - Pheromones - mediate intraspecific interactions
  - Allelochemicals - mediate interspecific interactions
- Some pheromones are releaser pheromones, in which perceiving organisms immediately produce stereotypical behavior; some are primer pheromones, which set into motion physiological changes.

- Pheromones - intraspecific chemicals produced in exocrine glands and emitted. Common types:
  - Sex pheromone: substance produce to attract opposite sex, usually produced by female to attract male.
  - Aggregation pheromone: substance produced by one or both sexes that brings organisms together to feed or reproduce.
  - Alarm pheromone: substance produced by an insect, usually in response to being attacked, that alarms, alerts or repels others of the same species

- Allelochemicals
  - Allomone: an emitted chemical signal that benefits the producer but not the perceiving organism; e.g., a repellent.
  - Kairomone: an emitted chemical signal that benefits the perceiving organism but not the producer; e.g., feeding stimulant.
  - Synomone: an emitted chemical signal that benefits both the emitter and perceiver; e.g., chemical released by plant when attacked that attracts parasitoids

Pheromones in pest management

- Used for
  - Monitoring
  - Trapping-out
  - Attract-and-kill
  - Mating disruption/confusion
  - Alarm and oviposition deterrents

- Sex pheromones usually used.
- Sex pheromones usually very specific alcoholic esters
  - Specificity derived from the compound, the isomeric configuration, time and rate of release, and ratio of components.
  - Released from various sites.
  - Best known and most often used in moths, but most taxa have pheromones known.

Moth in flight tunnel (above) flying upwind to pheromone scent on glass slide. Such insect usually ignore visual stimuli, relying mostly on chemical stimuli, and so are easily caught in traps.

Adult female pickleworm moth (below) displaying hair pencils (tufts of scales that help disperse pheromone) at tip of abdomen.

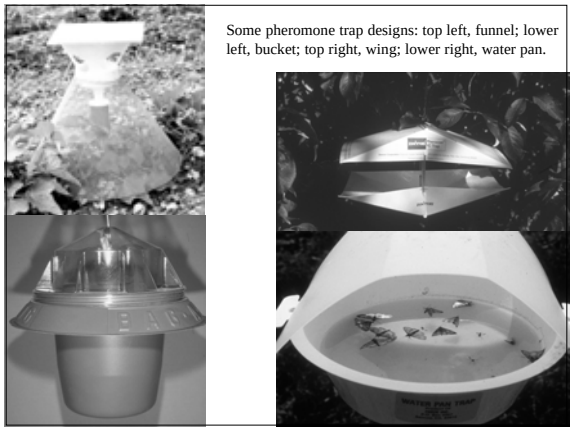
- Primary components of sex pheromones are most critical, but presence or absence of secondary components greatly affects response sequence. Sometimes pheromone complexes incompletely known or hard to synthesize/deliver.
- Long distance sex pheromones normally are those used for pest management, though short distance pheromones should be useful when used in conjunction.
- Pheromone delivery systems (technology) are also important elements of effective pheromone use.

Pheromones for monitoring

- Males often can be attracted by confining virgin females in cage.
- However, pheromone ID and synthesis is quite advanced, and most chemicals can be identified and synthesized.
- Synthetic lures often enclosed or impregnated in rubber or polyethylene, which provides gradual release.
- Trap is often a simple roof structure with sticky bottom to entrap insects, or roof over funnel with container for retaining insects that fall into funnel.

Pheromone-based monitoring

- Lots of variation in trap design.
- Sometimes hard to relate abundance of males in traps with number of ovipositing females, or damage.
- Most often, trap catches signal the onset of adult flight or reproduction and the time to increase monitoring effort by other means, or the time to commence control activities - usually chemical suppression.



Some pheromone trap designs: top left, funnel; lower left, bucket; top right, wing; lower right, water pan.

Pheromones for trapping out populations

- Ability to attract large number of insects has encouraged many attempts to reduce population densities with combination of sex pheromones and traps.
- Generally not very satisfactory, in part because often only males are attracted, leaving females to be impregnated by small but adequate number of males.
- Even where aggregation pheromones, or sex plus food-based lures used, population suppression often inadequate. Highly efficient traps needed.

Traps are marketed to homeowners despite their fundamental flaws. The market continues because homeowners trust advertising, and see apparently impressive results.

Above, Japanese beetle trap; left, gypsy moth trap.

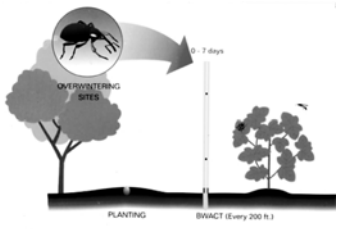
Some traps, such as this boll weevil trap, are used mostly for monitoring. However, some suppression is also accomplished, especially at low densities. This is likely due to the fact that it is baited with “grandlure,” an aggregation pheromone that attracts both sexes.

Attract and kill systems

- Pheromone or pheromone-like chemical used to bring insect into contact with insecticide
- Treatment sprayed into crop, reduced area of crop, or non-crop area.
- Example: methyl eugenol for Oriental fruit fly

Grape root borer is easily attracted by a sex pheromone. By mixing the pheromone with insecticide, adults are attracted to a lethal dose of toxicant. Below (left) is the grape root borer moth, and (right) an applicator being used to apply this mixture to grape vines.

Another attract and kill system is the boll weevil tube. The hollow yellow tube emits grandlure aggregation pheromone from the holes. A feeding stimulant and insecticide coat the interior. Weevils emerging from overwintering sites are attracted by the color and pheromone, and contact enough insecticide to be killed. It is particularly effective at low weevil densities.



Mating disruption/confusion

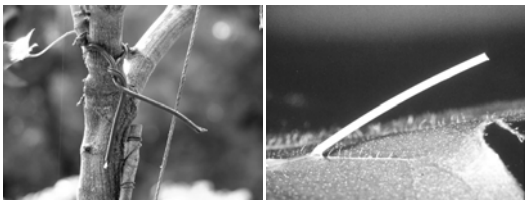
- The basic concept is to saturate an area with pheromone, preventing males from finding females. Exact mechanism not known, perhaps:
  - Camouflage of natural by synthetic pheromones
  - Synthetic pheromone out-competes natural
  - Synthetic pheromone acts as antagonist
  - Breakdown of sensory neurons
  - Insects habituate to chemical, no longer respond

Effectiveness of mating disruption

- Shown to be effective in numerous cropping systems. Examples include pink bollworm, lesser peachtree borer, grape berry moth, artichoke plume moth, codling moth, gypsy moth.
- Cost is a consideration, so tends to be used where:
  - Effective, low-cost insecticides lacking
  - Insecticide resistance is an issue
  - Use of insecticides would disrupt biological control
  - Environmentally sensitive area

Pheromone distribution for confusion

- Distributed as encapsulated droplets sprayed on crop, hollow fibers sprayed on crop, or twisting releasers onto crop plants.



Pheromone releasers: twist-tie (left) and hollow fiber (right).

Pheromones other than sex pheromones

- Oviposition deterrent or oviposition marking pheromones are fairly common, and have been shown experimentally to be effective at reducing damage by reducing egg-laying.
- Alarm pheromones occur in several orders, but best known in aphids - (E) beta-farnesene, released from cornicles, causes other aphids to disperse. Can be used to increase likelihood of contacting insecticide.

Other considerations

- Natural enemies and pheromones/kairomones - some natural enemies locate hosts by their pheromones. A possible way to concentrate natural enemies? Raise the level of activity of natural enemies with kairomone stimulants.
- Pheromone resistance - slight variation among pheromones among insects. Would extensive use in a lethal manner lead to development of resistant (insensitive) strains.

Questions

- Can you distinguish between semiochemicals, pheromones, and allelochemicals?
- Can you name 3 types of pheromones? Of allelochemicals?
- Describe the major approaches to using pheromones in pest management. Which are used commercially? What is the major (most frequent use?
- What are some of the current and potential constraints on use of pheromones for pest management?

Questions from supplementary readings

- Reading 17, Black cutworm traps
  - How did trap design affect moth capture rate? What is the postulated behavioral basis for the difference in capture rates between trap designs?
  - Was there a relationship between adult captures and larval infestation?
- Reading 19, Corn rootworm area-wide
  - How did area-wide affect resistance to susceptibility to carbaryl; responsiveness to cucurbitacin baits?
  - Was the resistance physiological or behavioral?
  - What suggestions do the authors have with respect to resistance management?