Sex pheromone offers promise for control of artichoke plume moth

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Virgin female artichoke plume moth on a globe artichoke. Once mated, this female could lay over 200 eggs.

The artichoke plume moth, *Platyptilia carduidactyla* (Riley), has been a pest of globe artichokes, *Cynara scolymus* L., in California since the 1920s. Its native host plants are thistles, but the moth became the principal pest of the related artichokes after they were introduced to the state. In some harvests, as many as 90 percent of the buds have been infested by plume moth larvae, and recent annual losses have frequently averaged 25 to 50 percent of the bud crop.

The crop suffered about $13 million damage in the Castroville area in 1975-1976 (*California Agriculture,* February 1978). To combat losses, artichoke growers apply a large number of insecticide sprays throughout the year (at a cost of about $300 per acre), with the result that some degree of pesticide resistance has developed in the insect and normal biological controls have been completely disrupted.

Recently, integrated pest management has been initiated: Use of insecticides is reduced and diversified, and such cultural practices as removal of host plant material are employed to disrupt the cycle of plume moth generations. To time insecticide applications, field traps containing virgin female moths have been used to monitor moth flight. Virgin females emit a sex pheromone that attracts male moths, which are then captured. Because the use of virgin females in population monitoring is tedious and capricious, we initiated a program to isolate and identify the female sex pheromone of this species.

Female moths reach a peak of attractiveness to males when they are three days old, and they remain attractive up to 10 days. Males stimulated by the female pheromone become sexually excited, raising antennae and vibrating their wings, before flying upwind toward the females. Males normally respond to females some time after sunset, the time of this response being influenced by temperature. On cold nights, males are maximally attracted within two hours of sunset, but on warm nights their activity may be somewhat later.

To demonstrate the occurrence of a sex pheromone, we reared adult artichoke plume moths from infested artichokes brought into the laboratory and kept at 10°C. When mature larvae crawled out of the artichokes, they were allowed to pupate and were then separated by sex. If screen cages containing adult virgin females were hung upwind in a wind tunnel, males released downwind showed the typical responses of flight upwind to the female followed by attempted copulation. Virgin females and excised female abdominal tips or ovipositors (which include the sex pheromone gland) elicited the same response from the males.

The pheromone was identified by washing in heptane the excised ovipositors of three-day-old females. Analysis of the combined washes from a number of females by gas chromatography and mass spectrometry at Beltsville revealed a single component: (*Z*)-11-hexadecenal. This compound alone evoked the whole range of male responses in the wind tunnel. Thus, although many moth pheromones are now known to have two or more components, the complete range of long-distance mating orientation behavior can be stimulated in this moth by a single compound.

In field tests, Pherocon 1C traps containing 100 micrograms of synthetic pheromone caught significantly more male moths than did traps containing four three-day-old virgin female moths. Mean catches from 44 traps of each treatment over five nights were 13.0 and 8.4, respectively ($p<0.05$). No moths were caught in 25 control traps during the experiment.

Water traps were far more effective than sticky traps (Pherocon 1C and Pherocon 1CP) in capturing males, perhaps because the moths can leave scales or even legs behind in the sticky material and still fly away. Once they touch an oil-water surface, they are drowned. Water traps also have a much greater capture capacity than sticky traps, because they have no sticky surface to dry out or to become covered with scales or moths.

Preliminary field tests were conducted by placing the pheromone on cotton wicks, but these were effective only for one night. Two commercial formulations that extend the pheromone's effective period up to several weeks are currently being tested. Traps containing the formulated pheromone can now

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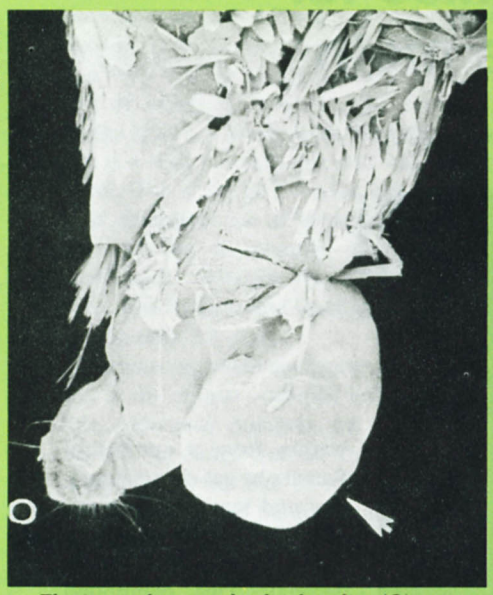


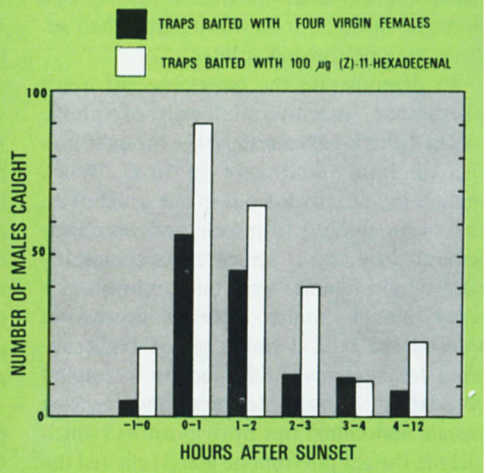
Electron micrograph of ovipositor (O), expanded lobe of pheromone gland (arrow).

M. M. McChesney

One type of water trap currently being used in artichoke fields to monitor plume moth populations.

Jack Kelly Clark

Virgin female plume moth releases pheromone from extended gland (arrow).



Pheromone traps lured more males than female-baited traps except three to four hours after sunset.

be used easily and effectively to monitor moth flights and to time insecticide applications. When this monitoring method is combined with estimates of population density in the field, such as egg sampling, a good idea of the relationships between numbers of moths trapped and future population levels can be expected. This knowledge should help in reducing pesticide use.

One of the most exciting prospects with this pheromone is the possibility of using it as a direct control treatment by the male confusion technique. Many pheromone dispensers would be dispersed throughout the crop so that the air would become permeated with pheromone. Most males, unable to distinguish the natural female pheromone from the high background level of synthetic pheromone, would not locate virgin females or mate. Small-scale field tests of the confusion technique indicate that trap catches can be reduced by over 95 percent. Such a technique also has fewer technical problems with a single-component pheromone system than with more complex pheromones.

Since only 10,000 acres of artichokes are grown in California, and most of these are in one county, the entire crop could be treated with pheromone. This may be the ideal crop-insect system to provide a real test of the male confusion technique. The reduction in insecticide use should not create problems with other insects, because the plume moth is the only important artichoke pest. Clear requirements have been developed for registration of pheromones for agricultural use, so there should be relatively few delays in obtaining a registered product. These factors, plus current insecticide costs, mean that the male confusion alternative using pheromone may be economically very attractive.

Any pheromone control technique used by itself could lead to development of "resistance," because males may rapidly evolve other ways to locate females. However, used along with cultural control methods and a variety of new insecticides, control of the artichoke plume moth may be transferred from a classic example of the insecticide "treadmill" to a model of success in integrated pest management.

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