

COURTSHIP BEHAVIOR OF OBLIQUEBANDED AND PANDEMIS LEAFROLLER

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Keywords: *Choristoneura rosaceana*, Obliquebanded leafroller, *Pandemis pyrusana*, Pandemis leafroller, courtship behavior

An understanding of sexual behavior is necessary for the development of pest control strategies based on synthetic sex pheromone sources, otherwise failures can occur. It is therefore important to characterize moth courtship behavior prior to evaluation of potential pest control techniques such as attract and kill. Reports of sexual behavior for obliquebanded and Pandemis leafroller lack detailed information about the courtship phase. This research presents preliminary data on courtship behavior for both species.

MATERIAL AND METHODS. Leafroller pupae for both species were obtained from colonies maintained at the Washington State University Tree Fruit Research and Extension Center. Upon emergence adults were maintained at $23\pm 2^{\circ}\text{C}$, $>30\%$ RH, 16:8 (L:D). Two to three days old adults were acclimated 1 h before observations at $21\pm 3^{\circ}\text{C}$, $>30\%$ RH, 2-3 lux, and airflow 25-35 cm/sec. Arenas for observing courtship and mating behavior were; a) plexiglass tubes, b) a wind tunnel, or c) plastic petri dishes (only for taking pictures). Courtship sequences were filmed using video cameras with magnification 3-5x and infrared illumination. The tapes were played back later to describe the sequence. Observable, homogeneous, and discrete steps during courtship were recorded. Pictures were taken using a Nikon Coolpix 950 digital camera with flashcard and magnification lens. Most images were taken through the plastic walls and covered a field 2-3 cm from the female. This procedure allowed us to detail the events occurring under the insect wings. Two ethograms (one for each sex) present conditional probabilities for the steps in successful mating sequences.

RESULTS. Male sequence: Preliminary data correspond to the analysis of 16 successful sequences over a total of 62 attempts. Data used to build the ethograms correspond to recordings during the short-range approach in successful sequences. The general sequence, including observations in all types of arenas, was: a resting male which is exposed to airflow of a calling female raises his body from the substrate, spreads his wings slightly, and projects his antennae forward. This is followed by stationary wing fanning (WF) and WF while walking (WFW). His antennae vibrate, the tip of his abdomen is curved slightly upward, and the hair-pencils are projected backward. In the wind tunnel a male does WFW until he reaches the edge of the release platform, flies upwind, casts close to the source platform, lands on it, and starts WFW. On platform or plexiglass tubes, a male always walks upwind facing forward as he approaches the source. First contact (FC) occurs with the posterior part of the female abdomen (40.3%), her head (27.4%), areas in between (25.8%), or wings (6.5%). The FC occurs usually under female wings, mostly with male antennae and head. Immediately after FC, males usually (87.5%) curve their abdomens (CAB) or, less frequently, move a few steps forward along the females, placing themselves next to the female and start CAB. This is the beginning of the copulatory attempt. The male continues bending his abdomen further and advancing it to her abdominal tip,

displaying his unci and valvae. One antenna (flagellum) seems to be in contact with female abdomen during this phase. Female genitalia is engaged by a rapid maneuver where the male contacts her abdominal tip. This maneuver is successful if the female genitalia is within the male range. However, many times the attempt is unsuccessful (74.2%) because, even the male does the maneuver, the female genitalia is not in the proper location; this suggests that the maneuver is a reflex following FC. After an unsuccessful copulatory attempt the male walks away and either rests or starts WFW in circles and again attempts to mate upon FC. Some males attempted to copulate up to 8 times before a successful sequence.

Female sequence: A resting female switches to calling posture at the beginning of the scotophase. First, a female does intermittent extrusion of her last abdominal segments (8-11). Wings are slightly spread, allowing the extruded segments and valvae to be observed from above. This phase seems to be independent from the airflow. In absence of an approaching male or disturbance, the female tends to extend the tip of the abdomen further and for longer periods and also raises her wings until they meet on top. Thus, her entire abdomen and most of the thorax are uncovered exposing the abdominal tip that is curved down but not touching the substrate. When a male makes FC, the female usually withdraws her abdominal tip (56.3%) and lowers her wings, though not completely. Male acceptance requires the female to stay stationary (>67%) or to step away slowly. Male rejection occurs when a female rapidly steps, jumps, or flies out of male range. A rejecting female also starts the calling sequence again once the male stops copulatory attempts. Successful sequences show that a female tends to expose the tip of her abdomen before the male engages her genitalia. Then, the female stays stationary while the male turns around, heading in the opposite direction. This results in the end to end position with abdomens connected. Usually the female raises her wings to allow the male wings to rest on her body and so her wings remain on top. During mating, moth's posture resembles the resting stage.

DISCUSSION. The courtship sequence was similar in both leafroller species, although most data are from observations of obliquebanded leafroller. Similar sequences have been described in the spruce budworm and codling moth. The male exhibited a highly stereotypic sequence existing a high probability that once the first step in the sequence occurs, the rest will follow. The male approaches the female guided by the pheromone in the airflow until FC. The FC occurs mostly between the male antennae and his head, and different regions of female body. The FC apparently triggers CAB. This allows the male to reach the female abdomen tip, providing she remains stationary or steps away slowly, and he performs the maneuver rapidly. Male and female display several structures of their genitalia prior to a successful mating sequence. The female exhibited a less stereotypic behavior. The female can reject the male by stepping, jumping, or flying out of male range. Even when a female moves out of his range, the male continues through his routine after FC, which leads to many unsuccessful sequences.

Leafroller courtship and mating behavior seem compatible with the use of pheromone in an attract and kill control technique since the pheromone is the only apparent trigger leading to FC. Besides, unlike oriental fruit moth, in obliquebanded and *Pandemis* leafroller there is, apparently, no other releaser than FC leading to copulatory attempts. This is further supported by observations of males conducting FC and copulatory attempts with septa loaded with specific pheromone blends for monitoring in the wind tunnel.