THE STATUS OF *LYGUS* PHEROMONE RESEARCH

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Abstract

A sex pheromone has been characterized in only one species of Miridae (Heteroptera). Female *Campylomma verbasci* produce two butyrates, which, together, attract males to traps (Smith et al. 1991). Little new knowledge of the chemistry of *Lygus* species female-produced sex pheromones has been gained since the review of Aldrich (1988). While some sexual dimorphism was reported in volatiles recovered from *Lygus lineolaris*, the tarnished plant bug of the eastern U.S., no such dimorphism was found in females of the western tarnished plant bug, *Lygus hesperus*. Field tests of candidate materials from the volatiles of each species have failed to reveal a useable attractant for males. Although a good deal is known about the pheromone biology of these *Lygus* species, the development of reliable bioassays has proven elusive. No behaviorally-active extracts of native materials have been obtained from either species. There are occasional instances in which excised portions of the last abdominal segments from virgin females have elicited upwind flight orientation and aggregation of conspecific males.

Introduction

Lygus bugs are key pests of cotton in the San Joaquin Valley of California and throughout much of the U.S. cotton belt. Infestations begin when adults fly into the cotton from winter and spring hosts that have been harvested or have begun to mature and dry out. Many common broadleaf weeds are hosts. Lygus bugs often migrate to cotton when weeds are mowed or disced, or when weeds in fields, roadsides, waste areas, and rangeland begin to dry out. Lygus bugs that fly into cotton sometimes leave again in as little as a day, or may remain and begin to reproduce. Because lygus bugs migrate to cotton, management should begin by assessing populations outside the field and then turn to intensive monitoring within fields during critical periods of squaring. This is difficult to accomplish with such mobile insects with such a wide host range. Presently, monitoring for lygus bugs in cotton is by beat net. This method is tedious, time consuming, and requires considerable replication to get accurate estimates of population sizes. Beat nets are inefficient in small cotton and can damage the plants. Movement among the many hosts in the San Joaquin Valley and most cotton growing areas is on a scale that cannot be monitored by any existing method with existing resources. Any tool that enhances the ability of cotton production managers to monitor the movement and presence of lygus bugs would be useful.

Sex pheromones have become indispensable tools for detection and monitoring agricultural insect pests. The development of such a tool would facilitate the scouting and timing of control measures for lygus bugs in cotton and other crops attacked by these insects. Two possible additional uses for lygus pheromones would be as direct control agents through mating disruption or mass trapping or as a means of population assessment or manipulation of natural enemies that may use them as cues for locating their lygus hosts.

Prior and Current Research

It is now clear that semiochemicals play an important role in hemipteran behavior. Scales (1968), Strong et al. (1970) and Graham (1987) have demonstrated that the north American plant bug species *Lygus lineolaris* (tarnished plant bug), *L. hesperus* (western tarnished plant bug), and *L. elisus*
(another western species) have female-produced sex pheromones that attract conspecific males.

Field Trapping With *Lygus Hesperus*

McLaughlin, (1996) reported virgin females of *L. hesperus* from 7 to 14-days-old reliably attract males. Female *L. hesperus* less than 7-days-old rarely are attractive to males. Attraction occurs in the morning hours, mating of females dramatically reduces attractiveness. Virgin female-baited trap captures of males increased and decreased along with the numbers of males captured by conventional sweep net method. Trap captures were indicative of the population magnitude in the immediately adjacent area of the field.

Additional studies with the western tarnished plant bug, *Lygus hesperus*, (McLaughlin, unpublished) have determined that pheromone production and male response occur at about 30 min. to one hour after sunrise if the temperature has reached about 12 degrees C. Pheromone-based behavior is dependent upon light winds, occurring between 0.3 and about 5 mph. The behavior ceases in still air. Males are commonly observed resting in the tops of plants early in the morning, facing upwind and waving their antennae. Females tend to rest a few inches below the tops of the plants. Males respond in a series of short upwind flights, rarely observed to be over 3 meters in length.

Female *L. hesperus* caged singly or in small groups capture more males per female than larger groups females. Females reared on an artificial diet (Debolt and Patana 1985, Patana and Debolt 1985) are as attractive to males as are females reared on snap beans.

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A system of virgin female-baited traps was placed in the spring of 1996 about the foothills of the southern San Joaquin Valley and along river bottoms leading into the valley. Also, two transects east-west across the valley, one south of Bakersfield and the other 20 miles north of Bakersfield were established. The pattern of captures of males in these traps coincided with the expected movement of *L. hesperus* as weed hosts matured. The pattern of trap captures also indicated that alfalfa within the valley serves as a significant reservoir for overwintering lygus and foci for development of populations that move into cotton. Also, large numbers of lygus were captured from weed hosts within almond orchards.

Chemical Identification

Lygus bugs are within the hemipteran family Miridae. The only identified sex pheromone within this group is that of the mullein bug, *Campylomma verbasci* (Smith et al. 1991). The behaviorally-active pheromone consists of two female-produced chemicals butyl butyrate and E2-crotyl butyrate.

Aldrich (1988) summarized the status of pheromone identification for *Lygus* species. He found some sexual dimorphism in the airborne chemicals recovered from male and female *L. lineolaris*, but was unable to attract males to traps baited with candidate chemicals.

Aldrich (1988) reported no sexual dimorphism in airborne chemicals recovered from *L. hesperus*. This finding has been confirmed by chemists in the laboratory of J. Millar at the University of California, Riverside (J. Millar, personal communication). Female *L. hesperus* reared singly produce more volatiles than females reared in groups and females produce greater volumes of volatile materials as they mature.

Chinta and Dickens (unpublished) conducted electroantennogram (EAG) studies with *L. lineolaris* and concluded that male antennal receptors are well-adapted for detection of chemical messages from their environment and the selectivity and sensitivity of male antennal receptors to butyrate compounds may be indicative of their role in sexual behavior. Millar (personal communication) conducted simultaneous gas chromatograph analysis of volatiles collected from female *L. hesperus* and EAG assessment of male and female antennal response to these volatiles. He determined that both male and female antennae can detect butyrates that might be a part of the pheromone. Candidate pheromonal compounds with EAG activity were field tested at Riverside and Shafter, California. None of the 120 binary combinations of 16 chemicals were attractive to male *L. hesperus*.

Bioassay

At this time there are no known reports of successful extraction of behaviorally-active native materials from the tissues of *Lygus* species or from volatiles trapped from entrained streams of air passed over sexually mature virgin females or males. McLaughlin (unpublished) has obtained occasional field response of male *L. hesperus* to crushed abdominal tips excised from sexually mature females and there are anecdotal reports of similar response in *L. lineolaris* (Millar, personal communication).

Research is severely hampered by the lack of laboratory-based bioassays for males response to live females. Various research programs have attempted to develop such assays, but no reliable assays that are sufficiently robust to support a pheromone identification project have been reported. McLaughlin (unpublished) has investigated numerous assay devices for *L. hesperus* including wind tunnels and various manifestations of Y-tube, single tube, and arena devices. Only occasional laboratory-based responses were observed. On several occasions, a large wind tunnel containing potted alfalfa plants was placed within an alfalfa field and assays conducted at the same time that male response to caged females were observed. Males would sometimes move upwind in the tunnel and contact the cages containing females, but this response was rare and never exhibited with the intensity of excitation and flight behavior observed for the free-flying males in the adjacent areas.

McLaughlin (unpublished) has developed a greenhouse-based assay in which males are contained within large screen cages containing alfalfa plants. When fans are placed to provide the appropriate air movement over the plants, males will respond to caged virgin females in the same manner exhibited by free-flying males in the field.

Conclusion

Identification of lygus sex pheromones is severely hampered by the inability of the research community to recover the native materials in behaviorally active form from the tissues of the insect or from entrained volatiles. This difficulty is compounded by the difficulties encountered in the development of reliable bioassays to track the isolation and chemical identification of candidate pheromonal materials.

These insects, which respond vigorously and in good numbers to caged females in the field are a tantalizing problem for the research community.

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