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Attraction of *Heliothis belladonna* (Henry and Edwards) to the Sex Pheromone of the Corn Earworm Moth, *Helicoverpa zea* (Boddie) (Lepidoptera: Noctuidae)

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ABSTRACT: Several males of *Heliothis belladonna* (Henry and Edwards) were initially captured in traps baited with commercial pheromone lures for the corn earworm moth, *Helicoverpa zea* (Boddie). Significant numbers of *H. belladonna* moths were subsequently captured in traps baited with a 4-component blend of corn earworm pheromone composed of Z-11-hexadecenal, Z-9-hexadecenal, Z-7-hexadecenal, and hexadecenal, and with a 2-component blend composed of Z-9-hexadecenal and Z-11-hexadecenal. Males of *H. belladonna* were not captured in traps baited with Z-11-hexadecenal alone. *Heliothis belladonna* were captured in traps during March, April, and early May in eastern Washington, which is before monitoring of corn earworm by growers normally begins, and before the corn earworm flight is anticipated. Therefore, the capture of this non-target species is unlikely to be a problem for the monitoring of corn earworm moths.

KEY WORDS: *Heliothis belladonna*, *Helicoverpa zea*, corn earworm, monitoring, pheromone, trap, attractant

The corn earworm *Helicoverpa zea* (Boddie) has a broad North American distribution and is a pest of numerous crops. In the Pacific Northwest of the United States, including the state of Washington, it is primarily a pest of sweet corn. Traps baited with sex pheromone lures are used to monitor the onset of corn earworm moth activity in early summer and as a means of determining the need for pesticidal applications (Adams, 2001; Mayer *et al*., 1987). On occasion, captures of other species of moths in corn earworm traps can cause confusion and result in false positives; conclusions of the presence of corn earworm moths where they are not present. In eastern Washington, this can occur when numbers of *Heliothis phloxiphaga* (Grote and Robinson) moths are captured in traps baited with commercial corn earworm pheromone lures (Adams, 2001).

The attractive sex pheromone of the corn earworm is a blend of the major component Z-11-hexadecenal (Z-11-16:Ald), with lesser amounts of Z-9-hexadecenal (Z-9-16:Ald), Z-7-hexadecenal (Z-7-16:Ald), and hexadecenal (16:Ald) (Klun *et al*., 1980a; Pope *et al*., 1984). Commercial pheromone lures are generally blends of these four compounds. The major component of the corn earworm pheromone (Z-11-16:Ald) is, by itself, an attractant for several related species of moths, including *Heliothis ononis* (Fabr.) (Steck *et al*., 1982), *H. phloxiphaga* (Kaae *et al*., 1973) and *Schinia meadi* Grote (Steck *et al*., 1982), and is part of the pheromone blend of additional species of moths (Mayer and McLaughlin, 1991).

We report here that males of an additional species of Heliothine moth, *Heliothis belladonna* (Henry and Edwards), are captured in traps baited with commercial corn earworm pheromone. We demonstrated that the response of the moth to commercial corn earworm pheromone lures can be attributed to a 2-component subset of that commercial

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4-component pheromone blend. Additionally, we provide a description of the seasonality of occurrence of this moth in traps in eastern Washington.

Materials and Methods

Initial observations were of male *H. belladonna* moths captured in corn earworm monitoring traps. These were Universal moth traps (UniTraps®, AgriSense-BCS Ltd, Norwich, UK), each with a 5 cm^2 piece of Vaportape® (Hercon Environmental, Emigsville, Pennsylvania) in the bucket of the trap to kill captured moths. Four traps baited with commercial corn earworm lures (Trece Inc., Palo Alto, CA) were established on 2 April 2004, outside of fields to be planted to corn. These traps were maintained throughout the growing season. Four field sites were the Moxee Field Station, Toppenish, and Donald, all in Yakima, County, and the Washington State University Irrigated Agriculture Experiment Station, near Prosser, Benton County, Washington. Traps were checked once per week and lures were replaced each month.

An experiment tested the hypothesis that male *H. belladonna* moths are attracted to the major component of the corn earworm pheromone lure, which is Z-11-hexadecenal (Z-11-16:Ald). Universal moth traps were used, with Vaportape. The three treatments (chemical attractants) were: 1) one mg of Z-11-16:Ald, 2) a 4-component blend of the corn earworm pheromone (West Co., Lyonvile, PA), and 3) no lure in the trap as a control. The 4-component blend consisted of one mg of Z-11-16:Ald, 74 μg of 16:Ald, 29 μg of Z-9-16:Ald, and 15 μg of Z-7-16:Ald. All lures were dispensed from red rubber septa (West Co., Lyonvile, PA). A randomized complete block experimental design was used, and the 5 block replicates (each replicate with the 3 treatments) were set up at the Moxee Field Station at the edge of an irrigated cherry orchard and adjacent to native steppe habitat to the south on Rattlesnake Ridge, Yakima County. This experiment was begun on 16 April 2004 and was maintained until 7 May 2004. Traps were mounted on stakes at a height of 0.7 meters and were 20 m apart. The experiment was repeated on 1 March 2005, when 6 replicates of the same experiment were set up, with two replicates of the treatments placed at each of 3 sites along Rattlesnake Ridge. These sites were all native steppe habitat. Two sets or replicate blocks of the traps were put up at each of three trap sites, and the trap sites were 3 to 13 km apart. Traps were checked once per week for 3 weeks. Trap positions were randomized initially and again each time that the traps were checked.

A second trapping experiment was set up to test the hypothesis that male *H. belladonna* are attracted to a subset of the 4-component corn earworm pheromone, specifically the major component Z-11-16:Ald and a secondary component. Treatments were 1) a blank septum with no pheromone, 2) one mg of Z-11-16:Ald, 3) the 4 component blend corn earworm pheromone described above, 4) one mg of Z-11-16:Ald and 74 μg of 16:Ald, 5) one mg of Z-11-16:Ald and 29 μg of Z-9-16:Ald, and 6) one mg of Z-11-16:Ald and 15 μg of Z-7-16:Ald. All lures were in red rubber septa. Four replicates of this experiment were set up on 21 March 2005 at two of the three sites used for the preceding study on Rattlesnake Ridge. These treatments were randomized initially and were randomized each week when the traps were checked. The experiment was maintained for two weeks. However, the 4 traps in this test that were baited with the 4-component corn earworm pheromone blend were further maintained through May to document the extent of the flight period of *H. belladonna* in 2005. These traps were checked weekly and lures were replaced every 4 weeks.

For each of the two comparative trapping tests, numbers of male *H. belladonna* captured in traps baited with different lures were compared using Tukey's test following an

Table 1. Mean numbers of male *Heliothis belladonna* captured in un-baited traps, in traps baited with Z-11-hexadecenal, in traps baited with 2-component blends, and in traps baited with the 4-component pheromone of the female corn earworm moth.

	Test 1	Test 2
Control	0 ± 0a	0.0 ± 0.0a
Z-11-16:Ald	0 ± 0a	0.1 ± 0.1a
Z-11-16:Ald/16:Ald		0.1 ± 0.1a
Z-11-16:Ald/Z-7-16:Ald		0.1 ± 0.0a
Z-11-16:Ald/Z-9-16:Ald		5.2 ± 1.3b
4-component blend	2.4 ± 0.7b	4.6 ± 1.7b

Means followed by the same letter are not significantly different by Tukey's test at $P < 0.05$.

ANOVA and a significant F test ($P < 0.01$). Voucher specimens of male *H. belladonna* moths from traps are deposited in the James Entomological Collection, Department of Entomology, Washington State University, Pullman, WA.

Results

During 2004, 39 male *H. belladonna* moths were captured in the four traps baited with corn earworm pheromone and used for season-long monitoring of corn earworm moths. Captured moths were in the traps near Toppenish (10 moths), at the Moxee Field Station (27 moths), and the Prosser Experiment Station (2 moths). All of these moths were captured from early to mid April. No *H. belladonna* moths were captured in corn earworm traps during the remainder of the season, through September. There were no unbaited traps in this study to serve as experimental controls for the pheromone lures. Thus, there are no statistical comparisons of trap catch data.

In the experiment comparing the major component Z-11-16:Ald and the 4-component sex pheromone of the corn earworm, all male *H. belladonna* moths were captured in traps baited with the 4-component corn earworm pheromone blend (Table 1). When compared to the un-baited control, numbers of moths captured in traps baited with the 4-component pheromone were significantly greater. Sixty-seven male *H. belladonna* moths were captured in traps during this test.

In the evaluation of 2-component blends in comparison to the 4-component corn earworm pheromone, numbers of male *H. belladonna* captured in traps baited with the 4-component blend and in traps with the combination of Z-11-16:Ald and Z-9-16:Ald were statistically greater than in un-baited traps or traps baited with Z-11-16:Ald alone (Table 1). In that same experiment, the numbers of males captured in traps baited with that two component blend (Z-9-16:Ald/Z-11-16:Ald) or with the 4-component blend were similar (5.2 ± 1.3 and 4.6 ± 1.7 males per trap, respectively). Fifty-seven male *H. belladonna* moths were captured in traps during this experiment.

Male *H. belladonna* moths were captured in pheromone traps in March, April, and May (Fig. 1A). In 2004, corn earworm males were captured beginning in the second half of May and continuing into October (Fig. 1B).

Discussion

These results demonstrated attraction of male *H. belladonna* to the 4-component corn earworm pheromone, which consists of Z-11-16:Ald, Z-9-16:Ald, Z-7-16:Ald, and 16:Ald,

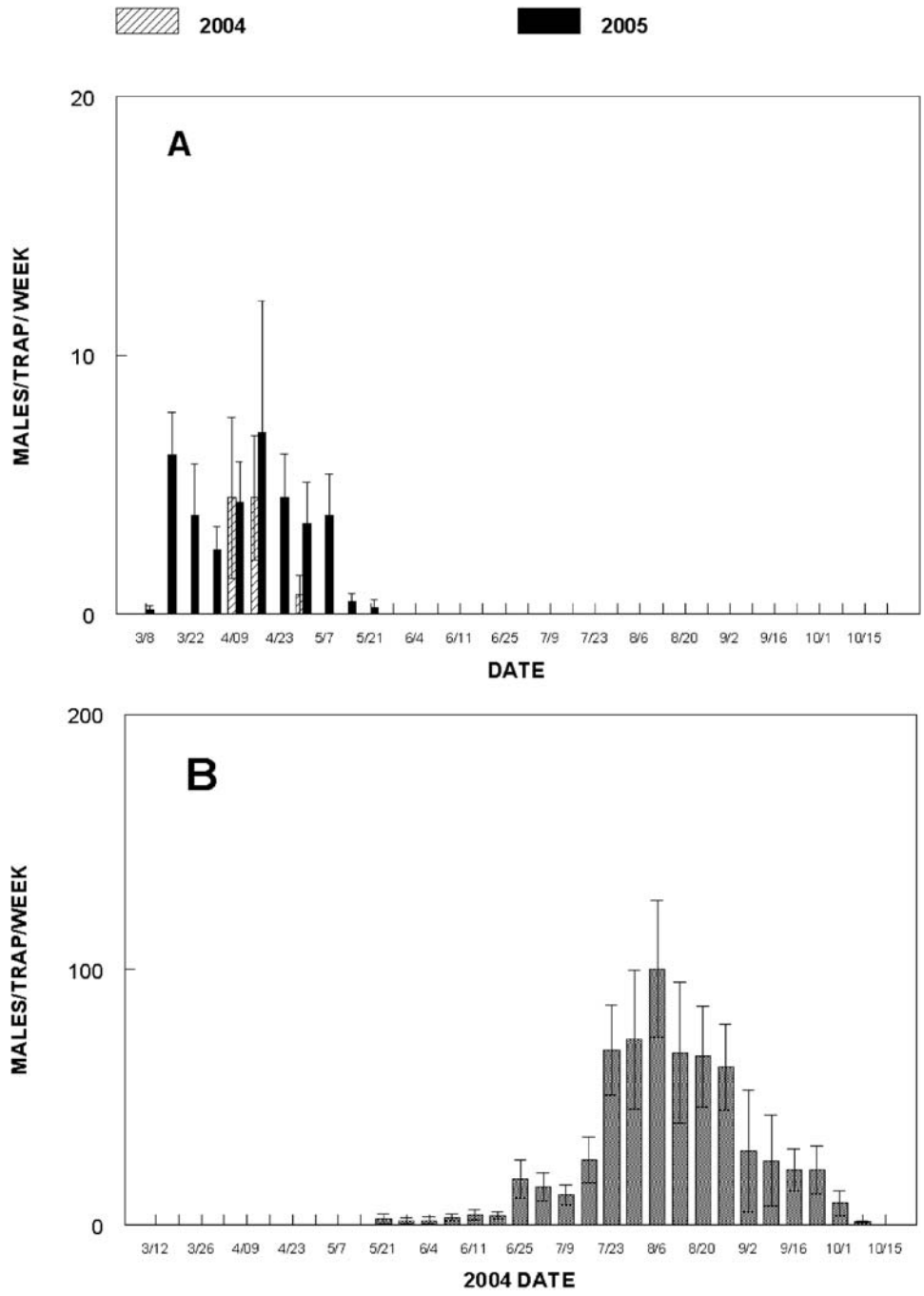

Fig. 1. (A) Mean numbers of male *H. belladonna* moths captured per trap per week, in traps baited with the 4-component corn earworm pheromone (2004) and (2005). (B) Mean numbers of male *H. zea* moths captured per trap per week, in traps baited with the 4-component corn earworm pheromone (2004).

and indicated that the major component of the corn earworm pheromone (Z-11-16:Ald) was not by itself attractive to *H. belladonna*. Subsequent testing of blends indicated however, that male *H. belladonna* are attracted to the combination of Z-11-16:Ald and Z-9-16:Ald. The *H. belladonna* male response to this 2-component blend appears to account for the observed response of this moth to the corn earworm pheromone, which includes these two chemicals. There also was no indication of any negative effect of either Z-7-16:Ald or 16:Ald on *H. belladonna* response to the combination of Z-11-16:Ald and Z-9-16:Ald.

There are overlaps in sex pheromone chemistry among these and other species of moths in the noctuid subfamily Heliothinae, and within the genus *Heliothis*. The female sex pheromone of *H. phloxiphaga* for example includes 3 of the corn earworm pheromone components (16:Ald, Z-9-16:Ald and Z-11-16:Ald) and Z-11-hexadecenol (Raina *et al*., 1986). Males of *H. phloxiphaga* are attracted to lures comprised of Z-11-16:Ald and Z-9-16:Ald (Raina *et al*., 1986), (which is also attractive here to *H. belladonna*), and are captured in traps baited with corn earworm pheromone (Adams, 2001). The female sex pheromone of *Heliothis subflexa* (Guenee) also includes Z-11-16:Ald and Z-9-16:Ald among other compounds (Klun *et al*., 1982; Teal *et al*., 1981). Female *H. virescens* (Fabr.) pheromone includes all four components of the corn earworm pheromone (Klun *et al*., 1980b), and males can be trapped with the combination of Z-11-16:Ald and Z-9-16:Ald (Tumlinson *et al*., 1975).

Males of *H. belladonna* fly very early in the spring in Yakima County of eastern Washington. In 2004, males were captured in the first week in April when traps were first placed in the field, and were not captured after early May. In 2005, males were captured from early March into late May, with most activity in April. Hardwick (1996) indicated *H. belladonna* moth activity from April into early August, depending on elevation. This moth was not captured in the same general area of Yakima County in 2004 in corn earworm pheromone traps that were maintained from mid May into October. The seasonality of flight for *H. belladonna* in eastern Washington then makes it unlikely that there will be significant temporal overlap of this moth with corn earworm moths. In multiple years of monitoring for corn earworm moths in the same area of eastern Washington, first occurrence of corn earworm moths has consistently been in mid to late May (Adams, 2001). We do not then expect *H. belladonna* moths to be captured in traps used to monitor corn earworm moths in commercial corn fields in Washington. This difference in seasonality of the two moths is also a likely reason why there have not been previous reports of *H. belladonna* in traps baited with corn earworm pheromone lures.

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