Comparison of Sticky Wing and Cone Pheromone Traps for Monitoring Seasonal Abundance of Black Cutworm Adults and Larvae on Golf Courses

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J. Econ. Entomol. 97(5): 1666–1670 (2004)

ABSTRACT Black cutworm, *Agrotis ipsilon* (Hufnagel) (Lepidoptera: Noctuidae), flight activity was monitored on three golf courses in Wisconsin by using two types of pheromone traps: the Texas cone trap and sticky wing trap. The Texas cone trap caught significantly more black cutworm males compared with the sticky wing trap, capturing almost 12-fold more males. Black cutworm males were most abundant during mid-July in 2001 and 2002, between 700 and 800 cumulative degree-days. Flight activity also was detected in early May and mid-August, but these peaks were not as pronounced as in mid-July. No definitive relationship between black cutworm flight activity and subsequent larval infestations on golf course putting greens occurred.

KEY WORDS *Agrotis ipsilon*, monitoring, pheromone traps, pest management

THE USE OF PHEROMONE-BAITED traps to monitor the presence and population level of economically important moth species can be a valuable tool in an integrated pest management program. Detection of a pest species and knowledge of its distribution are crucial for successful management strategies (Horn 1988, Pedigo 1999). The black cutworm, *Agrotis ipsilon* (Hufnagel), is a serious pest of golf courses as well as vegetables and field crops (Crumb 1929, Rings et al. 1975, Potter 1998, Vittum et al. 1999). Black cutworm larval damage to golf course turf, especially putting greens, results in sunken pock-marks or suppressions, reducing uniformity and smoothness of the playing surface (Potter 1998). Black cutworm larvae that damage putting greens originate from eggs laid on putting greens, or more likely from the peripheral turf area surrounding putting greens, including, the putting green collar, fairway, and rough. Because black cutworm is unable to overwinter in Wisconsin, spring infestations result from the migration of adults from southern states via the jet stream (Showers 1997). For this reason, monitoring of black cutworm adults could provide valuable information for predicting larval populations of black cutworm.

Methods of monitoring black cutworm adults and other lepidopteran species by using traps such as light traps or bucket traps, Texas corn traps, and phermone-baited sticky traps have been investigated (Willson et al. 1981, Levine et al. 1982, Durant et al. 1986, Hendrix and Showers 1990). The sex pheromone components for black cutworm are (Z)-7-dodecen-1-yl acetate and (Z)-9-tetradecen-1-yl acetate (Hill et al. 1979). Levine et al. (1982) demonstrated that pheromone traps were more efficient for monitoring spring flights of black cutworm male adults, whereas flight catches during summer and fall were greater in blacklight traps.

Despite work conducted on black cutworm flight activity in relation to conventional agricultural field crops, little is known about the flight activity of black cutworms in relation to golf course turf, especially as it relates to larval populations and damage. The objective of this study was to determine the seasonal flight activity of black cutworm males by using the "Texas" cone trap, also referred to as a *Heliothis* trap (Hartstack et al. 1979), and the sticky wing trap, baited with black cutworm pheromone. The usefulness of black cutworm pheromone trap catches for predicting subsequent larval infestations on golf course turf also was investigated.

Materials and Methods

Three locations in Dane and Rock counties, Wisconsin, were selected to monitor adult black cutworm populations in 2001 and 2002. Traps were placed at three golf courses: Blackhawk Country Club in Madison, Evansville Golf Club in Evansville, and Lake Ripley Country Club in Cambridge. Black cutworm male flight was assessed using two types of pheromone traps: a wire mesh *Heliothis* cone trap (RT1752, Gempler's, Madison, WI) and a sticky wing trap (TRÉCÉ 1-C, Inc., Salinas, CA), each baited with synthetic sex pheromone (BCW3141, TRÉCÉ, Inc.).

A single Texas cone trap and a sticky trap were placed at each respective golf course. Sticky wing traps were positioned ≈1.5–2.0 m above the turf or ground, and the bottom of the trap was replaced at

≈4-wk intervals, depending on the condition of trap bottom. Texas cone traps were positioned 1.5 m above the turf. Traps were a minimum of 50 m apart. Rubber septa containing the synthetic pheromone were replaced every 4 wk. The number of males captured in trap types was counted from the first week of May through the second week of September in 2001 and 2002. Data were log-transformed and analyzed by analysis of variance (ANOVA) with repeated measure analysis (MIXED procedure, $\alpha = 0.05$), and pairwise mean comparisons were performed using least-squares means in SAS (SAS Institute 1999).

Black cutworm larval populations were sampled at two (i.e., Madison and Evansville) of the three golf courses; the Cambridge location was not sampled because black cutworm larvae were removed via a mowing study. Three putting greens were sampled at 2-wk intervals by using a soap solution consisting of 30 ml of lemon-scented dishwashing detergent (Joy, Proctor & Gamble, Cincinnati, OH) and 7.6 liters of water (Neimczyk 1981, Tashiro et al. 1983). Three 1-m^2 samples were taken from each putting green to estimate larval populations. Larval sampling was terminated when an insecticide treatment was applied to putting greens due to unacceptable black cutworm damage as determined by the golf course superintendent. When this situation occurred, the number of black cutworm larvae on the entire surface area of the respective putting greens treated was counted. Degree-days (DD) for 2001 and 2002 were calculated by subtracting daily mean temperature from the black cutworm developmental threshold of 10°C (Pedigo 1999). Degree-day accumulation (i.e., arbitrary biofix) began on 7 and 10 April in 2001 and 2002, respectively, the first date when the daily degree-day accumulation was >0. Temperature data were obtained from the National Weather Service Forecast Office located in Sullivan Township, Jefferson County, WI (http://www.crh.noaa.gov/mkx/index.php). This location is ≈10 and 28 km from the Evansville and Madison locations, respectively.

Results and Discussion

There were no significant differences in black cutworm adult male populations between 2001 and 2002 (Table 1). No significant two-way interactions between years and locations or trap were detected (Table 1). Significant interactions between locations and traps were detected. Seasonal change (time) also had a significant effect on trap capture. The Texas cone trap caught significantly more black cutworm males than the sticky wing trap in both 2001 and 2002 (Figs. 1 and 2). Mean adult moth captures in the Texas cone trap and sticky wing traps were 17.7 and 1.96 per trap per week in 2001, and 19.6 and 1.25 per trap per week in 2002, respectively. There was a significant difference between the analysis of the data collected in 2001 and 2002, respectively. The mean capture in 2001 and 2002 combined was also significantly greater in cone

Table 1. ANOVA results of pheromone trap captures of black cutworms at three golf courses in 2001 and 2002

Effect	df	*F*	*P*
Year	1,200	2.11	0.1479
Location	2,200	12.45	<0.0001
Trap	1,200	289.35	<0.0001
Time	18,200	8.38	<0.0001
Year*location	2,200	0.08	0.9226
Year*trap	1,200	0.40	0.5279
Location*trap	2,200	7.12	0.0010

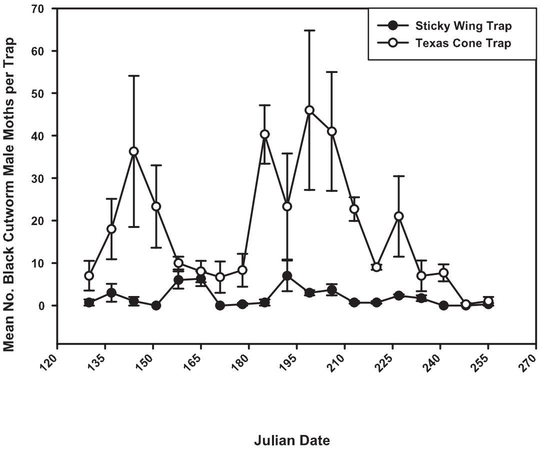

Fig. 1. Mean number of *A. ipsilon* males captured in Texas cone and sticky wing traps each baited with sex pheromone, captured at three golf courses in Madison (Blackhawk Country Club), Evansville (Evansville Golf Course), and Cambridge (Lake Ripley Country Club), Wisconsin, in 2001. Vertical bars represent ±SE.

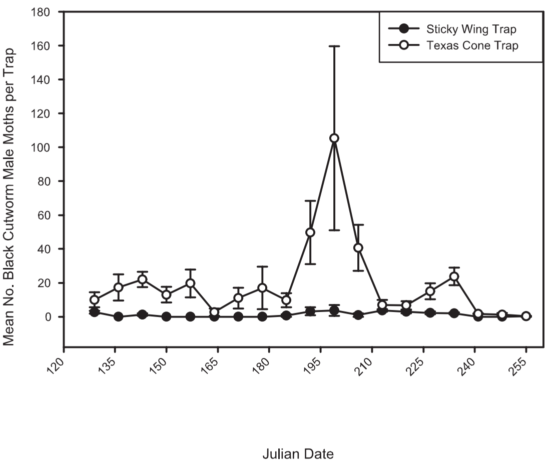

Fig. 2. Mean number of *A. ipsilon* males captured in Texas cone and sticky wing traps, baited with sex pheromone, captured at three golf courses in Madison (Blackhawk Country Club), Evansville (Evansville Golf Course), and Cambridge (Lake Ripley Country Club), Wisconsin, in 2002. Vertical bars represent ±SEM.

Table 2. Black cutworm adult male captures and larval populations at golf courses in Madison and Evansville, WI, 2001

Male sampling date	Adult population		Larval population on greens		Cumulative degree-days
	Texas cone trap	Sticky wing trap	Larval sampling date	Mean ± SEM larvae/m²	
Madison					
10 May	10	0	—[a]	—	137
31 May	31	0	—	—	219
14 June	10	3	11 June	0.0 ± 0.0	317
28 June	16	1	25 June	0.0 ± 0.0	459
5 July	54	2	—	—	528
12 July	14	2	9 July	0.22 ± 0.2	611
19 July	83	4	—	—	703
26 July	68	1	23 July	1.78 ± 0.5	805
2 Aug.	26	1	—	—	904
			6 Aug.	1.89 ± 0.5	965
9 Aug.	9	1	9 Aug.	0.65 ± 0.2[b]	1,018
16 Aug.	40	2	—	—	1,078
23 Aug.	14	1	20 Aug.	0.0 ± 0.0	1,146
30 Aug.	11	0	—	—	1,225
6 Sept.	1	0	3 Sept.	2.67 ± 1.6	1,279
Evansville					
17 May	23	7	—	—	181
24 May	51	3	—	—	209
31 May	35	0	—	—	220
14 June	11	8	13 June	0.22 ± 0.2	317
21 June	2	0	—	—	385
28 June	6	0	26 June	0.0 ± 0.0	459
5 July	32	0	—	—	528
12 July	8	5	12 July	0.44 ± 0.2	611
19 July	33	3	—	—	703
26 July	34	5	26 July	1.56 ± 0.6	805
2 Aug.	25	0	—	—	904
9 Aug.	10	1	7 Aug.	0.34 ± 0.1[b]	1,018
16 Aug.	12	3	—	—	1,078
23 Aug.	5	3	—	—	1,146

[a] No larval sampling was conducted.
[b] Insecticide was applied to putting greens by the golf course superintendent due to black cutworm larval damage.

than sticky wing traps, 18.7 and 1.6 per trap per week, respectively. Webster et al. (1986) demonstrated that more European corn borer, *Ostrinia nubilalis* (Hübner) males were captured in cone traps (13 of 18 males) compared with sticky wing traps (three of 22 males), even though similar numbers of European corn borer males were attracted (not captured) to both traps. European corn borer males usually tend to fly upward when encountering a lure in a cone trap, thus facilitating capture, whereas males that entered sticky wing traps rarely approached the lure or sticky surface at the base of the trap. This phenomenon may help to explain the results of our study; black cutworm males may exhibit similar behaviors.

Early flight activity was detected in cone traps in the third week of May in 2001 and 2002 (Julian date ≈145 and ≈140, respectively); however, very few black cutworm males were collected in sticky wing traps. These results suggest that sticky wing traps are relatively poor predictors of black cutworm flight activity. Overall, black cutworm males were most abundant during mid-July in 2001 and 2002 (Julian date between 195 and 200, respectively). It is suggested by Showers (1997) that the first peak adult capture of black cutworm males that typically occurs in May is the result of immigrating adults from the southern United States. Furthermore, based on the results published by Darwish (1991) that suggest black cutworm development from egg to adult is ≈700 DD, it is probable that the second generation of adults that are captured in mid-July (Tables 2 and 3) are likely the progeny of the first generation immigrants. Showers (1997) further substantiates this hypothesis, suggesting that subsequent generation adults are likely the result of first generation immigrants.

Black cutworm moth captures varied among locations (Table 1). Mean captures were most abundant at the Madison and Evansville sites compared with the Cambridge site, with 29.9, 20.9, and 10.2 captures per day, respectively. Overall, three distinct peaks of black cutworm flight activity were detected at each location (Fig. 3), and patterns of black cutworm flight activity throughout the growing season were similar among the three locations.

Black cutworm larval infestations in vegetable and conventional field crops are unpredictable and intermittent (Willson et al. 1981). The results of our study were similar; no definitive relationship between black cutworm flight activity and subsequent larval infestations on putting greens occurred (Tables 2 and 3). Yet, in August 2001, ≈30 d (≈270 DD) after peak adult capture, independently, the golf course superintendents at both golf courses (i.e., Evansville G.C and Blackhawk Country Club) applied an insecticide to all

Table 3. Black cutworm, *Agrotis ipsilon* (Hufnagel), male moth captures and larval populations at golf courses in Madison and Evansville, WI, 2002

Male sampling date	Adult population		Larval population on greens		Cumulative degree-days
	Texas cone trap	Sticky wing trap	Larval sampling date	Mean ± SEM larvae/m^2	
Madison					
23 May	31	2	—[a]	—	103
30 May	22	0	27 May	0.0 ± 0.0	147
6 June	35	0	—	—	189
13 June	7	0	10 June	0.0 ± 0.0	265
20 June	22	0	—	—	329
25 June	3	0	24 June	0.0 ± 0.0	404
4 July	3	0	—	—	537
11 July	78	8	8 July	0.0 ± 0.0	626
18 July	200	10	—	—	711
25 July	61	3	24 July	0.0 ± 0.0	799
1 Aug.	13	5	—	—	903
8 Aug.	10	2	—	—	972
15 Aug.	22	1	15 Aug.	0.0 ± 0.0[b]	1,056
22 Aug.	33	1	—	—	1,127
29 Aug.	2	0	—	—	1,202
Evansville					
16 May	24	0	—	—	92
23 May	17	2	—	—	103
30 May	7	0	30 May	0.0 ± 0.0	147
6 June	17	0	—	—	189
20 June	10	0	—	—	329
25 June	42	0	25 June	0.0 ± 0.0	404
4 July	9	0	—	—	537
11 July	56.5	0.5	11 July	0.22 ± 0.2	626
18 July	104	1	—	—	711
25 July	46	0	25 July	0.0 ± 0.0	799
1 Aug.	4	3	—	—	903
8 Aug.	8	5	8 Aug.	0.0 ± 0.0	972
15 Aug.	17	4	—	—	1,058
22 Aug.	23	3	22 Aug.	0.0 ± 0.0	1,127
29 Aug.	1	0	—	—	1,202
5 Sept.	1	0	5 Sept.	0.0 ± 0.0	1,273

[a] No larval sampling was conducted.
[b] Insecticide was applied to putting greens by the golf course superintendent due to black cutworm larval damage.

putting greens and tee boxes on 7 and 9 August 2001, Evansville Golf Course and Blackhawk Country Club, respectively (Table 2). The golf course superintendents' justification for making the insecticide application was based on a perceived (not confirmed) black cutworm larval infestation as well as observed turf (suspected insect) damage to other putting greens and tee boxes, and not the putting greens used in this study. As well, the superintendents made a decision to apply an insecticide to putting greens and tee boxes again in August 2002 to control a suspected infestation of black cutworm larvae; however, only one black cutworm larva was found on the three putting greens combined after (≈2 h) the insecticide application (Table 3). This phenomenon may likely be a result of the golf course superintendents' false perception of a problem associated with black cutworm rather than an actual (i.e., confirmed) larval infestation. Although the golf course superintendents' rational for making an insecticide application was not based on quantitative larval sampling data, such aforementioned insecticide applications were coincidentally closely aligned with degree-day data (Darwish 1991) that are useful for determining black cutworm larval development. Nonetheless, it remains unclear why low populations of black cutworm larvae were detected on putting greens. We formulated several hypotheses for the lack of black cutworm larvae detected on the putting greens sampled. They include the potential lack of reliability of the larval sampling technique as well as other factors, including physical removal of larvae on putting greens, via early morning mowing (i.e., before sunrise); predation by invertebrates and vertebrates; or possible pupation before larval sampling. For this reason, further research of factors involved in the relationship between black cutworm adult activity and subsequent larval populations on golf course putting greens is needed.

Acknowledgments

We thank Blackhawk Country Club (Madison, WI), Evansville Golf Club (Evansville, WI), and Lake Ripley Country Club (Cambridge, WI) for collaboration. D. Held (Mississippi State University) critically reviewed the manuscript. Funding has been provided for this research and publication from the USDA–CSREES project WIS04435.

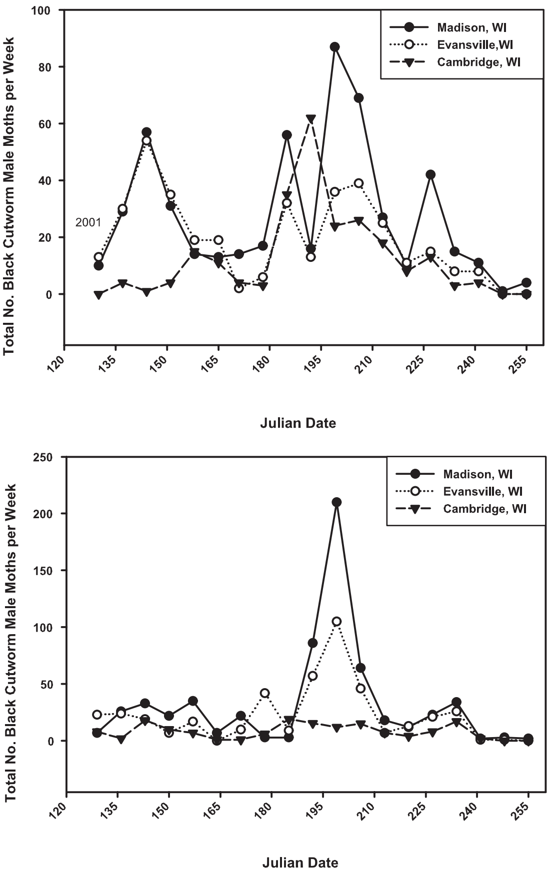

Fig. 3. Total number of *A. ipsilon* males captured at three golf courses in 2001 and 2002. Each data point indicates the combined number of male moths captured in both the Texas cone trap and sticky wing trap at each golf course in Madison (Blackhawk Country Club), Evansville (Evansville Golf Course), and Cambridge (Lake Ripley Country Club), Wisconsin.

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Received 1 December 2003; accepted 15 June 2004.