Adult Emergence Patterns, Population Trends and Activity Patterns of the Hickory Shuckworm, *Cydia caryana* (Lepidoptera: Tortricidae: Olethreutinae) in Pecan Orchards[1]

John R. McVay, Raymond D. Eikenbary[2], Robert D. Morrison[3] and Costas A. Kouskolekas

Department of Entomology
Auburn University
Auburn, AL 36849 USA

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ABSTRACT Emergence of hickory shuckworm, *Cydia caryana* (Fitch), adults from larval overwintering sites was bimodal. The major emergence peak occurred during the period of mid-March to mid-May and the smaller activity period during July and August. Pheromone trapping was effective for monitoring population trends during generations 1 and 5 of *C. caryana* but less so during generations 2, 3, and 4. Activity patterns suggest the species is crepuscular rather than truly nocturnal.

KEY WORDS *Cydia caryana*, emergence patterns, population trends, activity patterns, hickory shuckworm, adult males, pheromone.

The emergence pattern of adult *Cydia caryana* (Fitch) from larval overwintering sites in pecan shucks has been reported by several investigators (Moznette 1938, Phillips et al. 1960, Osburn et al. 1966, Todd 1967, Van Duyn 1967, Calcote and Hyder 1980, Calcote 1989). Most indicate that spring emergence begins as early as February and usually not later than mid-March, with peak emergence occurring during the month of April. It was assumed that emergence of this brood ceased in early summer by most early investigators, although Phillips et al. (1960) reported that moths of this brood may continue to emerge throughout the summer. Calcote and Hyder (1980) and Calcote (1989) monitored emergence season-long in West Texas and reported a second, relatively low, emergence during July through September. The first study reported here monitored the seasonal emergence of this brood in Alabama to determine if a bimodal pattern occurs in the Southeast.

Seasonal population trends of adult *C. caryana* have been investigated, as mentioned above, and post-flight activity information has been obtained through inspection of fruit both abcissed and on the tree (Moznette 1938, Phillips et al. 1960, Osburn et al. 1966, Van Duyn 1967, Ellis et al. 1983). Blacklight traps have been used to determine adult population trends for almost 30 years

[1] Accepted for publication 20 July 1994.
[2] Department of Entomology, Oklahoma State University, Stillwater, OK 74078.
[3] Department of Statistics, Oklahoma State University, Stillwater, OK 74078.

(Tedders and Osburn 1966, Tedders and Edwards 1970, Tedders and Edwards 1972, Tedders et. al. 1972, Smith et al. 1973, Gentry et al. 1975, McVay et al. 1978, Smith and Tedders 1978, McVay and Ellis 1979). Although such traps can be effective monitoring devices, their utility is limited in a practical, grower-oriented program (Tedders and Osburn 1967). The second study reported here determined adult population trends through the use of pheromone traps, the first use of pheromone in such a study involving *C. Caryana.*

Although *C. caryana* has been described as a nocturnal species for many years (Moznette 1938), the only available information concerning flight period activity during the hours of darkness was published by Tedders and Edwards (1970) utilizing blacklight traps. They reported activity throughout the night, with more during crepuscular hours. The third study reported here involved the delineation of nocturnal activity patterns of *C. caryana* males on the basis of capture in pheromone traps.

Materials and Methods

Emergence Patterns from Overwintering Sites. Pecan shucks were collected from 'Stuart' pecan orchards in Baldwin, Bullock and Covington counties, AL, during the first week of December 1988. At each location, two burlap bags normally used for pecan storage were filled with approximately 12 kg of pecan shucks and transported to Auburn, AL. Shucks were transferred to 9 galvanized No. 3 wash tubs (three for shucks from each location) 61 cm in diameter and 27.9 cm in depth. Ten 0.3 cm diameter holes were drilled into the bottom of each tub for drainage. Each tub was placed on 3 baked clay bricks to maintain them 10.2 cm above the soil surface and filled to within 5 cm of the top with shucks (shuck depth approximately 22.9 cm). Shucks were placed loosely into the containers to approximate the consistency of post-harvest shuck piles normally found in pecan orchards. Each tub was securely covered with fine mesh hardware cloth to prevent escape of emerging adults. Access ports were cut into the hardware cloth to facilitate removal of insects. The ports were wired shut except for those times when adults were removed. The containers were maintained in a screen house until 1 March 1989 and were checked regularly for adult emergence.

On 1 March, the tubs were placed under the canopy of a large pecan tree. Adult emergence was recorded three times weekly from 1 March until 29 Sept 1989. Emerging adults were removed but were not sexed.

Seasonal Population Trends. Seasonal population trends for adult male hickory shuckworms (HSW) were determined from captures in pheromone traps loaded with a commercial preparation of sex pheromone. Five traps were located in an orchard of mature 'Stuart' pecan trees in Mobile Co., AL, and 14 were located in a similar orchard in Baldwin Co. Trees were planted on 18.2 m (60 ft) centers. All were healthy trees with no visible mechanical or other damage. Additional trees of the same variety were located on each compass point from the trap tree, and trees with traps were separated by at least two trees without traps (54.6 m). In the Mobile Co. orchard, all traps were located 9.1 m above the orchard floor on the west side of the tree near the vertical center of the canopy. At the Baldwin Co. location, seven traps were situated 9.1 m above the orchard

floor and seven were located 4.57 m above the floor as part of another study designed to delineate optimum trap placement. Traps were situated on the west facing near the vertical center of the canopy. Pherocon Ic traps were used at both locations. Traps were suspended in the three canopies with a rope and pulley arrangement. Traps were installed and pheromone added on 2 May 1989 and 6 March 1990 in Mobile Co. and in Baldwin Co. on 25 April 1989 and 20 March 1990. The sex pheromone lure used was a commercial preparation marketed by Scentry, Inc. of Buckeye, AZ and consisted of grey rubber septa charged with 50 micrograms of attractant blend (100: 0.6 E, E -8, 10-DD-A and E, Z-8, 10-DD-A). Traps were monitored at 7-day intervals throughout the growing season in 1989 and until early June in 1990. The number of males captured was recorded and all insects removed from the trap on each visit. Lures and trap bottoms were replaced every 28 days to insure optimum performance. Old lures and trap bottoms were removed from the orchards.

Nocturnal Activity Patterns. In 1989, six sex pheromone baited Pherocon Ic traps were monitored for adult males during periods of heavy shuckworm activity as indicated by traps involved in other studies. Three traps were located in a Mobile Co., AL, orchard and three in a similar orchard in Baldwin Co. Both orchards consisted of mature trees, 60 to 70 yr. old. Trees in which traps were placed were randomly selected by the same criteria described in the previous study. Traps were suspended 9.1 m above the orchard floor near the vertical center of the canopy on the west side of the tree. Installation of pheromone-baited traps was as previously described. The pheromone lure obtained from Scentry, Inc. was used throughout the study. Traps were installed on 2 May 1989. Fresh lures and trap bottoms were installed every 28 days.

Once sustained shuckworm activity was detected, each trap was monitored throughout the night. Traps were lowered and cleaned of insects prior to sunset and re-suspended. Beginning 1 hour after sunset, each trap was lowered, the total capture recorded, captured insects removed, and the trap repositioned. The procedure required about 2 min per trap and was continued hourly until 12 hours after sunset with the last reading occurring about 1 hour after sunrise the following morning. Traps at each location were monitored in this manner on 9 and 25 Sept and 9 Oct 1989, in Mobile Co. and 15 May, 18 Sept and 19 Oct 1989, in Baldwin Co.

In 1990, only the Mobile Co. location was monitored. Traps were installed on 6 March 1990 and nocturnal activity was monitored on 26 March, 4 April, 18 April and 2 May. The same trees were utilized in 1989 and in 1990. All other aspects were identical in both years except that in 1990 the study was terminated after 2 May. Hourly captures were analyzed by a test for least significant differences by location, by year and by all captures combined.

Results and Discussion

Emergence Patterns from Overwintering Sites. A total of 1,368 *C. caryana* adults emerged from the shucks collected in the fall of 1988 and monitored throughout 1989. The three containers of shucks from the Baldwin Co. location produced 587 adults while 528 and 253 emerged from the Bullock and Covington counties shucks, respectively. First emergence occurred on 1 March

from the Baldwin and Bullock Co. samples and on 8 March from those collected in Covington Co. The final moth emerged from Covington Co. shucks on 11 Sept, from Bullock Co. samples on 25 Sept and from those collected in Baldwin Co. on 27 Sept.

Most emergence occurred between 6 March and 1 June (Fig. 1). During that period, 1,124 adult shuckworms were collected from all samples (82.2% of the total). The samples from Baldwin, Bullock and Covington counties produced 467, 440 and 217 adults respectively. Peak emergence occurred during the period 7 April to 5 May, when 756 (60% of the total) adults were collected. Of the 244 moths that emerged after 1 June, sporadic emergence of individuals occurred until 27 Sept, after which emergence ceased. However, 117 (8.6% of total emergence) were collected during July and 104 (7.6% of the total) in August and September. This study confirmed the reports of Calcote and Hyder (1980) and Calcote (1989) which indicated a bimodal emergence pattern for adults of overwintering larvae.

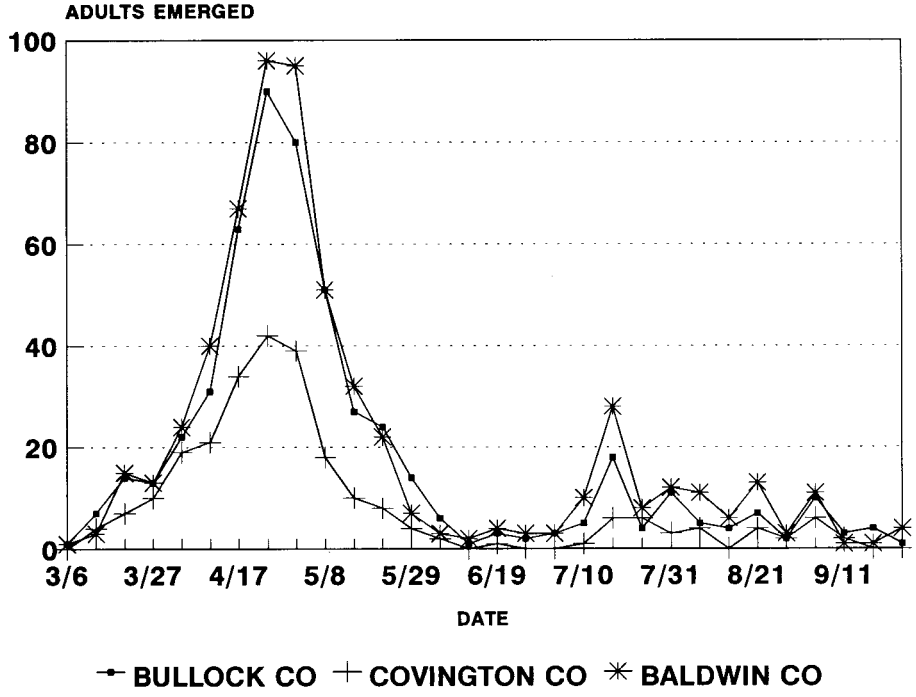

Fig. 1. Emergence patterns of hickory shuckworm adults of the overwintered generation.

Late season emergence is significant in that abscissed fruit due to HSW feeding are common in July and some investigators feel that the shuckworm causes its most significant damage to the current year's crop during the months of August and September (Moznette et al. 1981). The second activity peak was much lower than that of the initial spring activity but both appeared to occur over similar periods of 6 to 7 weeks duration. Additionally, the second period may be more important from a crop damage standpoint as the majority of adults of the spring emergence go primarily to native hickories (Moznette 1938, 1941).

Seasonal Population Trends. Seasonal capture of male *C. caryana* in pheromone traps in pecan orchards was similar in Mobile (Fig. 2) and Baldwin (Fig. 3) counties in Alabama over 1989 and 1990. In both orchards, the greatest activity occurred during March and April, coinciding with the emergence of the bulk of adults from the overwintering generation. This period of activity ended in mid-May at both locations. Only sporadic activity was evident during the months of June and July and a small surge of activity was detected during the first week of August. This was followed by a late activity period which began in early September and peaked in late September to early October.

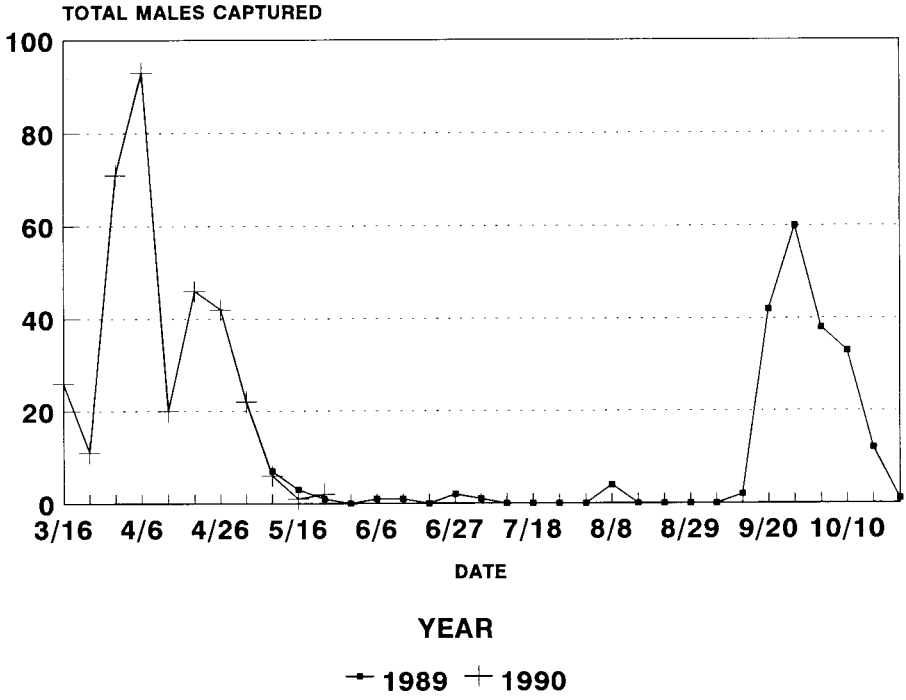

Fig. 2. Seasonal population trends of the hickory shuckworm determined by pheromone traps in Mobile Co., AL.

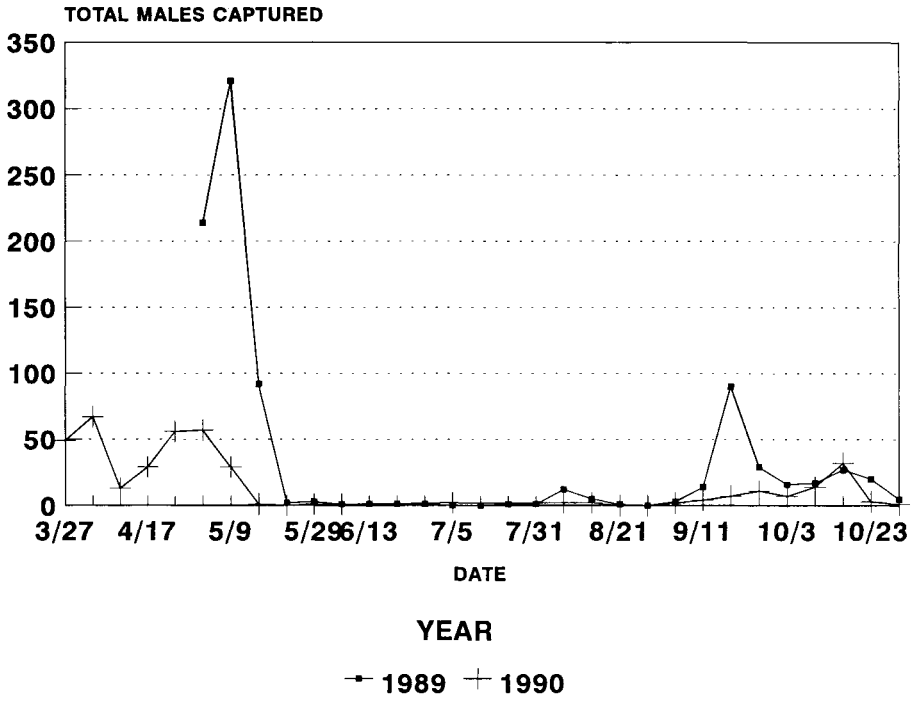

Fig. 3. Seasonal population trends of the hickory shuckworm determined by pheromone traps in Baldwin Co., AL.

These results with pheromone traps parallel results of Tedders and Osburn (1967), Tedders et al. (1972), and Gentry et al. (1975), all of whom utilized blacklight traps to determine population trends. Interestingly, blacklight traps appear to more accurately detect the smaller activity peaks during the months of June, July, and August. These activity periods coincide with adult activity of generations 2, 3 and 4 of the shuckworm in the Southeast. All three of these generations are damaging to commercial orchards. Generations 2 (June) and 3 (July) can cause losses due to fruit abscission, and generation 4 (August) contributes heavily to late season damage due to shuck mining.

Tedders et al. (1972) reported 88.5% of females captured in blacklight traps had been mated prior to capture. This, considered along with the lack of activity detected by pheromone traps during these generation, suggest that much of the infestation and resulting damage attributable to generations 2-4 may be due to movement into the orchard by mated adults from nearby foci in native hickory trees. This is further supported by the indications of increased activity with succeeding generations throughout the season (generations 2-5). As more progeny are able to complete development in the pecan orchard within each generation, more unmated males are available that may be attracted to the sex pheromone.

Nocturnal Activity Patterns. Of 262 adult male shuckworms captured at hourly intervals following sunset in 1989 and 1990, 180 (68.7%) were taken during the first 4 hours (Table 1). Fifty males were collected during hours 9 to 12 with the peak of activity occurring during hours 9 and 10, the last two prior to sunrise. At hour 12, the sun had been up for about 1 hour. The remaining 32 adults (12.2%) were collected during hours 5 to 8. These data agree overall with the report of Tedders and Edwards (1970) which determined activity patterns with blacklight traps placed in a pecan orchard. Data from pheromone traps indicated slightly less activity during hours 5 to 8 than did light trap data. Thus *C. caryana* adult male activity may be more crepuscular than truly nocturnal in southeastern pecan orchards.

Table 1. Relative captures of adult male hickory shuckworms at hourly intervals by pheromone traps in Alabama pecan orchards.

Hours After Sunset	Mean No. Captured by Location*				
	1989-B**	1989-M	1989-Tot	1990-M	Both Yr.
1	4.7 b	4.3 a	4.5 ab	8.7 b	5.9 a
2	6.3 a	4.7 a	5.5 a	11.3 a	7.4 a
3	2.3 cd	4.7 a	3.5 b	5.7 c	4.2 b
4	1.3 def	2.3 b	1.8 cd	3.7 cde	2.4 cd
5	0.7 ef	0.7 bcd	0.7 def	1.3 ef	0.9 def
6	1.0 ef	0.7 bcd	0.8 ef	1.0 f	0.9 def
7	1.0 def	0.3 cd	0.7 def	0.3 f	0.6 ef
8	1.7 cde	1.3 bcd	1.5 cde	0.7 f	1.2 cdef
9	2.7 c	1.7 bc	2.2 c	2.0 def	2.1 cde
10	2.0 cde	1.3 bcd	1.7 cd	4.3 cde	2.6 c
11	0.3 f	0.3 cd	0.3 ef	1.7 ef	0.8 def
12	0.0 f	0.0 d	0.0 f	0.3 f	0.1 f
LSD =	1.6	1.2	1.3	1.6	2.6

Values within columns followed by the same letter are not significantly different; LSD, $P = 0.05$.
* Mean number of adults captured per hour per night for 3 nights in 1989 and 4 nights in 1990.
** Letters indicate location: B = Baldwin Co., AL and M = Mobile Co., AL.

This initial effort to use a sex pheromone to study aspects of *C. caryana* biology and habits indicates a degree of usefulness for this tool. However, it appears that additional refinement of the pheromone formulation may be necessary for it to prove a meaningful tool for pecan IPM programs.

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