The Great Lakes Entomologist

Volume 18
Number 4 - Winter 1985 *Number 4 - Winter 1985*

Article 1

December 1985

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LONGEVITY AND WEIGHT LOSS OF FREE-FLYING MALE CECROPIA MOTHS, *HYALOPHORA CECROPIA* (LEPIDOPTERA: SATURNIIDAE)

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ABSTRACT

During their spring flight season, free-ranging male cecropia moths lived a maximum of 12 days (one of 124 recaptured moths of 387 released moths). The number of survivors declined precipitiously after day five; five to seven days is probably the usual life span. The recaptured moths did not have different initial weights than those that were not recaptured. The larger the moth the more absolute weight it lost and the faster it lost weight during the first few days. A moth lost about 20% of its weight during the first night of flight and accumulated about a 40% weight loss during the remainder of its life.

Adult saturniid moths do not feed and live only a few days in captivity (Rau and Rau 1912, 1914; Janzen, 1984). The details of their brief adult lives have not been studied with free-living adults. Here we ask how long free-flying adult male cecropia moths live in nature and how much weight they lose as they age. This information is important to understanding how resource harvest as a larva is integrated with the duration of the non-feeding post-larval stages, and how weight loss influences flight dynamics (Janzen 1984).

Cecropia, *Hyalophora cecropia* (L.) (Lepidoptera: Saturniidae), ranges over the United States and southern Canada east of the Rocky Mountains (Ferguson 1972, Lemaire 1978). Its natural history and ecology have been most intensively studied in Illinois (e.g., Marsh 1941, Waldbauer and Sternburg 1973, Sternburg et al. 1981). As part of the Illinois studies, the two senior authors released, weighed, and individually marked newly emerged adult males in the contiguous cities of Champaign and Urbana during the natural 1968 cecropia flight season (mid-May to early July). Many were reweighed after being recaptured in traps baited with virgin females.

Adult cecropias usually emerge from the cocoon about 5 h after sunrise (ca. 1000 h). Emergence is delayed on cool days. They crawl a few centimeters to a place where the wings can expand and then remain there until sunset. Shortly after sunset both newly emerged and old males make a dispersal flight that, judging by the activities of caged males, may continue for as long as an hour. The newly emerged virgin females are inactive until an hour before dawn; then they evert the gland that produces the sex attractant pheromone. The males, again active at this time, seek out the females by flying to the pheromone source. These activities cease at dawn. Pairs stay coupled about 16 h, until the following sunset. The males then disperse and the females fly for the first time, seeking oviposition sites. Mated females make oviposition flights every night but are not known to mate or release sex pheromone again. Mated males continue to disperse just after sunset and to fly in search of unmated females just before dawn each day (Waldbauer and Sternburg 1979).

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MATERIALS AND METHODS

The moths emerged from overwintered cocoons that had been collected in Champaign-Urbana or reared outdoors from local stock as described by Waldbauer and Sternburg (1973). All cocoons were held until emergence at ambient outdoor conditions. The moths emerged synchronously with the wild population, putting our traps in competition with a large population of wild females (Sternburg and Waldbauer 1969, Fig. 4).

Males were released on the day they emerged. They were first numbered in sequence with a waterproof felt pen on the underside of the left hind wing and then weighed to the nearest 10 mg between 1300 and 1500 h, long after they had excreted the meconium. Some dribbled a bit of meconium afterward. These were reweighed except for a few that dribbled slightly at the time of release. The males were released between 16 May and 30 June in a park near the center of Champaign-Urbana. Those released in daylight (40%) were put in trees or shrubs where they were hidden by foliage. Those released around dusk (60%) were tossed into the air and flew off. The number of moths recaptured and the number reweighed differs because five recaptured moths that had been damaged by birds were not reweighed.

The traps (Sternburg and Waldbauer 1969) were constantly baited with at least two virgin females that were replaced at least every three days. A trap at the home of GPW was 2.9 km west of the release point. Another, at the home of JGS, was 3.9 km east of the release point. The area between the traps consists mostly of urban residential areas with many trees and shrubs. At the time of the study it had a large wild cecropia population (Sternburg et al. 1981).

The traps were examined daily. Recaptured males were reweighed at the laboratory between 1300 and 1500 h and re-released at the trap in which they had been caught, in late afternoon at the GPW trap and just after dark at the JGS trap. If released in daylight at the JGS trap, they were attacked by blue jays (*Cyanocitta cristata*) and common grackles (*Quiscalus quiscula*). Release time had no significant effect on the probability of recapture; at the GPW and JGS traps, 38.5% and 36.0% respectively, of the re-released moths were recaptured at least once more ($x^2 = 0.016$, $P = 0.9$, 1 d.f., continuity corrected).

RESULTS

Of the 387 released males, 68% were not recaptured. Of the remaining 124 (32%), 99 (79.8%) were first caught in the GPW trap, 24 (19.4%) in the JGS trap, and one (0.8%) in a more distant trap in the country. Only one moth appeared at two traps. The GPW trap was closer to the release point, but we believe it caught more moths mainly because it was west of it. The prevailing winds were from the west, and males must fly upwind in search of females (Wilson and Bossert 1963).

Figure 1 shows that males varied in how long they circulated in nature before they were first recaptured. About 80% of the 124 recaptured males were first caught within four days, but one did not appear until the 12th day.

The most recaptures (including re-recaptures) occurred on the third and fourth nights after release (Fig. 1), but 30% of them occurred five or more days after release. The results were affected by competition from free-living females that were releasing sex attractant pheromone during the experiment, and a similar but ecologically less relevant experiment done when wild cecropia females are absent (July and August) would probably give different results.

The weight loss data for 119 males that were recaptured 180 times are combined in Table 1. The live weight of all moths at the time of release varied from 1.05 to 4.48 g ($\bar{x} = 2.41$ g, SD = 0.65). The mean initial live weight of the moths that were not recaptured was 2.46 g (SD = 0.65) while the mean initial live weight of those that were recaptured was 2.33 g (SD = 0.64); the difference is not significant ($t = 1.821$, 385 d.f., $0.01 < P < 0.05$). The moths that were recaptured on the fifth or later nights had an initial mean

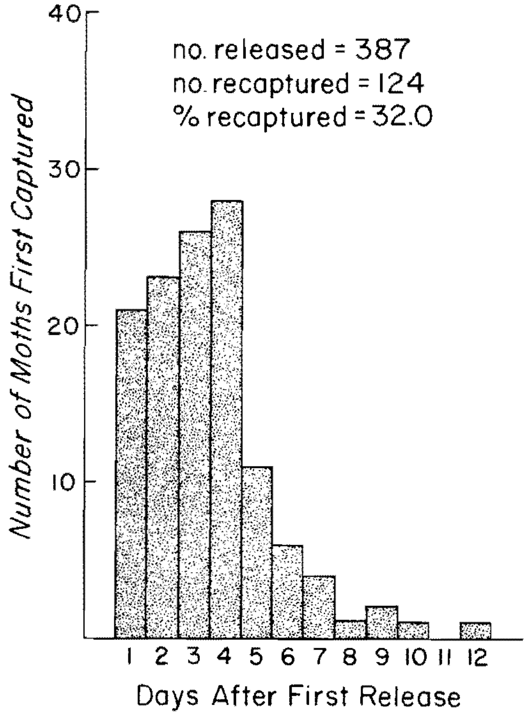

Fig. 1. The numbers of adult male cecropia moths that were first recaptured on each day following day of eclosion.

weight of 2.49 g (SD = 0.71), which is not different from either the entire set of released moths or the entire recaptured subset (by inspection). The moth that was recaptured on the 12th day was one of the heaviest (3.49 g at release), but one recaptured on the 10th day was one of the lightest (2.73 g at release). There is no suggestion that heavy individuals have different life spans than light individuals.

Male cecropias lose weight as they age, rapidly at first and more slowly later (Table 1, Figs. 2 and 3). For example, the weight of a male that was recaptured on the first–fifth days after release declined 22, 6, 4, 1, and 5% from the original 2.60 g on successive days, each day losing 22, 7, 6, 1, and 7% of the previous day's weight. For the entire set of recaptured moths, the cumulative average absolute weight loss starts at 0.38 g and accumulates to 1.09 g by day five. (Sample size for the sixth and following days is too small to merit detailed examination.) These losses represent 16–47% of the weight of the average released moth. Over the same five-night progression, the standard deviation in absolute weight loss doubles from 0.18 to 0.38. The regression of absolute weight loss against initial live weight appears to have a progressively steeper slope each day after release (Fig. 2), but only day one is significantly different from the other days. It seems clear that the larger the moth, the greater the absolute weight loss per day of life. The correlation coefficients for the first five days of life (Fig. 2) are also high enough to suggest a real relationship between the rate of weight loss and body weight.

The greatest absolute weight loss during the first 24 h was 0.72 g (27% of a 2.68 g moth), while the smallest was 0.18 g (11% of a 1.62 g moth). The greatest percent loss

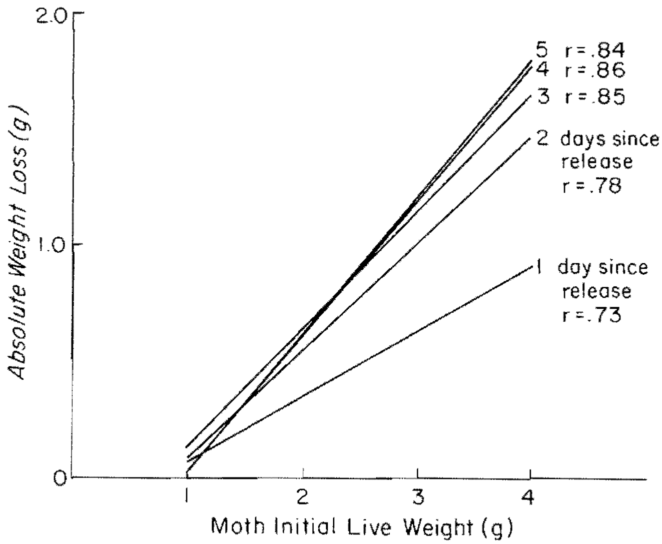

Fig. 2. Relationship of initial live weight (x) to absolute weight (y) loss by free-ranging male cecropia moths that were recaptured 1–5 days after the day of eclosion. The number of moths recaptured and the regression equation for each day are (1) 17, $y = -0.2039 + 0.2768x$; (2) 29, $y = -0.3682 + 0.4643x$; (3) 39, $y = -0.3700 + 0.5047x$; (4) 40, $y = -0.1911 + 0.4927x$; (5) 26, $y = -0.0864 + 0.4718x$.

for the first 24 h was 28% of a 2.55 g moth. For all recaptures after any time, the greatest absolute loss was 2.32 g, which was 52% of a 4.48 g moth by the sixth day after release.

The average cumulative loss in body weight per gram is highest on the first day and then levels off at about 0.45 g by day six (Table 1, Fig.3). The standard deviation of this parameter also rises rapidly and then approaches an asymptote at about 0.09–0.10. The longer the moth lives, the less it loses per gram of initial weight per day. The regression of percent weight loss against initial live weight (Fig. 3) shows, as did Figure 2, that larger moths lose weight at a faster rate than do small ones, but that this difference seems to be disappearing by the fifth day of recapture (Fig. 3). However, the correlation coefficients are so small (Fig.3) that this relationship must be viewed as very general, rather than one that can be used to predict the behavior of a particular individual. Visual inspection of the actual data points through which the regression lines in Figure 3 pass suggests that the low correlation coefficients are due to great scatter rather than a tight but curvilinear relationship being forced onto a straight line model.

DISCUSSION

The results show that at least half of the recaptured males survived for five or more days, with one surviving for 12 days. Rau and Rau (1912, 1914) found that mated male cecropias generally had a mean survival of from 7.52 to 10.85 days when caged at ambient St. Louis conditions during their natural flight period. However, they (1912) found that, while males that emerged in June survived a mean of 10.62 days, males that emerged in April and May survived a mean of 17.40 days, by far the longest mean life span that they found for mated males. The difference is probably due to the cooler temperatures experienced by the early emergers. Although all but two of our moths were recaptured in

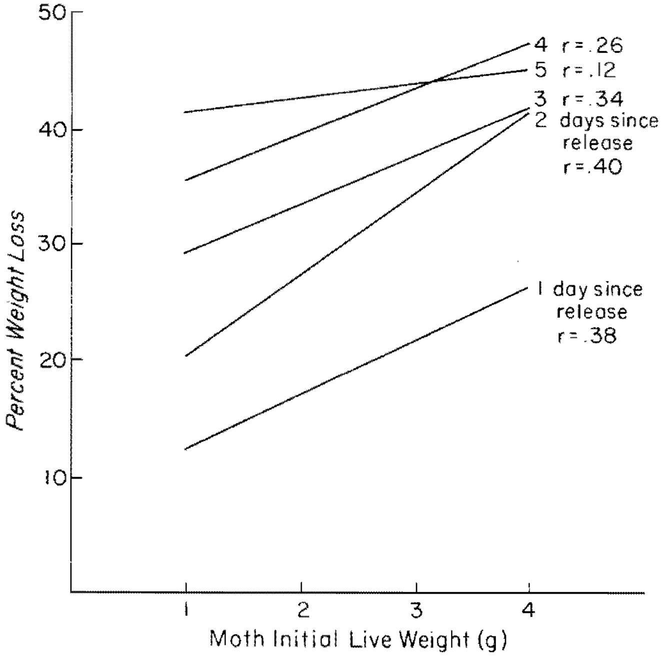

Fig. 3. Relationship of initial live weight (x) to percent weight loss (y) by free-ranging male cecropia moths that were recaptured 1–5 days after the day of eclosion. The number of moths recaptured and the regression equation for each day are (1) 17, $y = 7.8783 + 4.4578x$; (2) 29, $y = 13.23 - 7.1598x$; (3) 39, $y = 25.1394 + 4.2134x$; (4) 40, $y = 32.0828 + 3.6335x$; (5) 26, $y = 39.6050 - 1.5362x$.

June, the difference between our results and those of the Raus suggests that living free in nature decreases longevity.

The recaptured males probably flew much farther than the minimum 2.9 or 3.9 km distance between the traps and the release point. Before its first recapture and between any two recaptures, a male makes at least one evening dispersal flight and one morning flight in search of a female, either of which may continue for an hour. These flights are probably circuitous and long. A searching male could, for example, locate and follow several pheromone trails that eventually fade out because another male reaches the female first.

Variation in the longevity of our cecropia males may have been affected by at least the following: (1) predation; (2) frequency of recapture (recaptured males were protected from predation while they were in the trap or the laboratory); (3) number of days spent in copulo (the male expends resources to fertilize the female, and a pair of moths may be more apparent to predators than a single moth); (4) nutrient and water reserves at the time of eclosion (adult cecropia neither feed nor drink); (5) weather, distance flown, and rate of expenditure of energy, water, and perhaps other reserves due to variations in body size; (6) choice of diurnal and nocturnal roosting sites (this could influence the probability of predation and desiccation).

The data at hand do not allow us to examine these causes of variation except to note that there was no relation between initial body weight and longevity as measured by recapture. However, large moths lost body weight absolutely faster and faster per gram of their body weight than did small moths. As the moths aged, this relationship was accentuated, at least if one compares the first night of flight with subsequent nights. Perhaps it costs the most to fly when heaviest, or perhaps the moths fly the most on the first night. However, as the moths age, the percent of their body weight lost per night becomes more nearly equal for

Table 1. Weight loss parameters for recaptured male cecropia moths based on combined data for 119 males that were recaptured 180 times. All losses are expressed in grams.

	Number of nights since release on the day of eclosion											
	1	2	3	4	5	6	7	8	9	10	11	12
$\bar{X}$ cumulative absolute loss (g)	0.38	0.65	0.86	0.92	1.09	1.27	0.96	1.80	1.44	1.58		2.17
SD	0.18	0.26	0.32	0.34	0.38	0.55	0.32	0.68	0.93			
$\bar{X}$ loss each successive day (g)	0.38	0.27	0.21	0.06	0.17							
$\bar{X}$ cumulative loss/g	0.18	0.29	0.35	0.40	0.43	0.45	0.45	0.55	0.45	0.58		0.62
SD	0.06	0.08	0.07	0.08	0.09	0.09	0.05	0.05	0.22			
$\bar{X}$ cumulative loss/day/g	0.18	0.15	0.12	0.10	0.09	0.08	0.07	0.07	0.05	0.05		0.05
SD	0.06	0.04	0.02	0.02	0.02	0.02	0.01	0.01	0.03			
$\bar{X}$ loss each day/g	0.18	0.11	0.06	0.05	0.03							
N (no. recaptures)	17	29	39	40	26	12	7	5	3	1		1

all initial body weights. Presumably, this is because the non-expendable parts of the moth's flight apparatus are more similar in initial weight across the variation in initial total moth weight than are the initial weights of water, fat, and other expendable resources.

ACKNOWLEDGMENTS

The Illinois Natural History Survey, through Dr. W. H. Luckmann, provided a screened outdoor insectary and trees on which to rear cecropias. Analysis of the data and preparation of the manuscript were supported largely by NSF grant DEB 80-11558 to D. H. Janzen.

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