

OBSERVATIONS ON THE MATING BEHAVIOR OF
*ANTHIDIELLUM NOTATUM*¹ AND *ANTHIDIELLUM*
*PERPLEXUM*¹

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ABSTRACT

Observations made on the mating behavior of *Anthidiellum notatum* (Latreille) and *Anthidiellum perplexum* (Smith) during 1971 and 1972 at the Archbold Biological Station in Florida indicate that both species mate in the vicinity of the flowers visited by females. *Bidens pilosa* (Compositae) is especially attractive to *A. perplexum*, while *Tephrosia chrysophylla* (Leguminosae) is attractive to both species. Males are territorial, and the bees' activity is closely correlated with the flowering period of *T. chrysophylla*.

This is a report of observations made on the mating and foraging behavior of *Anthidiellum perplexum* (Smith) and *Anthidiellum notatum* (Latreille) in Florida during March of 1971 and 1972. *Anthidiellum perplexum* is found from North Carolina to Florida. Two subspecies of *A. notatum*, *A. n. notatum* (Latreille) and *A. n. rufimaculatum* Schwarz, were present in the study area. *Anthidiellum n. notatum* is found from Illinois and Massachusetts to Mississippi and Florida, while *A. n. rufimaculatum* is known only from Florida (Mitchell 1962). The subspecies differ chiefly in the coloration of the maculated areas; these areas being yellow in *A. n. notatum* and red in *A. n. rufimaculatum*. Intermediates were found in this study.

Both species are polylectic. Mitchell (1962) recorded 17 genera of plants visited by *A. perplexum* and 14 genera visited by *A. notatum*. In this study *A. n. notatum* and *A. n. rufimaculatum* were observed on both *Tephrosia chrysophylla* and *Bidens pilosa*. *Anthidiellum perplexum* were collected on *Tephrosia*, a genus not listed as a host by Mitchell.

Schwarz (1928) described 2 nest cells of *A. n. rufimaculatum* from Florida. One cell, yielding a female, had been placed on a scrub palmetto leaf, and the second, yielding a male, was on a pine needle. These cells had been made individually and were constructed of a resinous material.

There are no previous published accounts of the mating behavior of members of the genus *Anthidiellum*, and few observations of mating of other Anthidiini have been recorded. Kurtak (1973) studied *Anthidium manicatum* (Linnaeus), an immigrant from Europe, in New York State, and reviewed previous reports on this species. During her study 205 matings were observed, which lasted a mean of 10 sec each. Male *A. manicatum* patrol specific territories. When patrolling, a male flies directly for 30-60 cm and then hovers

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in place. His next direction is determined by the presence of other insects in his territory. He actively seeks these out, and challenges these insects by flying directly at them, often striking them with his body. The patrolling is frequently interrupted to take nectar from flowers or to rest. Territoriality in the Anthidiini was also noted by Jaycox (1967) in *Anthidium banningense* Cockerell. He believes that territoriality aids in the dispersal of sexually mature males in addition to reducing interference in mating and resting in that species.

METHODS

During March 1971 and 1972 studies were conducted at the Archbold Biological Station in Lake Placid, Florida. Observations were made in an open field at an approximate elevation of 210 ft above sea level. This field included 3 pineapple patches and was surrounded by scrub pine, turkey oak, orange, and mango trees. The entire field was sparsely covered with grass, small weeds, and scattered flowers. In 1971, studies were concentrated on the bees visiting Spanish needles, *Bidens pilosa* (Compositae). *Anthidiellum perplexum* was the predominate anthidiine bee found at this time. In 1972 both species of *Anthidiellum* were studied, principally upon the hoary-pea, *Tephrosia chrysophylla* (Leguminosae). Bees were captured, individually marked with numbered plastic disks glued to the thorax, and released. Several bees which had been marked on the first 2 days of the study were observed 9 days later. These disks did not appear to hamper flight or the bee's ability to copulate.

During 1971, 46 bees were marked and released. Of these, 11 were observed later. In 1972, of the 119 (75 female and 44 male) bees which were marked and released, 62 (36 female and 26 male) were observed later. A total of 74 copulations (21 in 1971 and 53 in 1972) were observed during this study.

A considerable effort was made to find nests of *Anthidiellum*, with negative results. According to C. D. Michener (personal communication) nest cells are difficult to locate and are usually found by chance.

RESULTS

As a general rule, females spend more time on the flowers collecting both pollen and nectar and spend proportionately less time flying than do males. The males follow any bee or other flying insect in the vicinity of the flowers, flying approximately 10 to 20 cm behind them. After following for 0.5 to 2 m, a male either flies away or attempts to copulate. Often, if the insect is a second male, one will pursue the other for several meters, and then both will resume patrolling in the area. In most cases of a successful copulation attempt by a male, the male followed a female to a flower, hovered behind her, and then pounced upon her from above and behind her after she had landed on the flower. Nearly all of the 31 copulations observed for *A. perplexum* and the 43 copulations for *A. notatum* occurred on the flowers visited by the females. The exceptions were 2 pairs of *A. notatum*, one of which copulated in the collecting net, and the other which copulated on a leaf of the hoary-pea approximately 3 cm from a flower.

There were no apparent differences between the mating behaviors of *A. perplexum* and *A. notatum*. Copulations of undisturbed pairs of *A. notatum* lasted a mean of 3 min and 25 sec, $n=12$, S.D.=66 sec, with the longest

recorded time being 5 min and 25 sec. In *A. perplexum*, copulations lasted a mean of 2 min and 53 sec, $n=9$, S.D. = 36 sec, with 4 min and 5 sec being the longest time recorded. In many pairs the actual initiation of copulation was not observed, but due to the frequency of observation only a few seconds should have elapsed since copulation had begun. In both species the female remained relatively motionless throughout copulation except for irregular opening and closing of her mandibles. She occasionally walked across the flower. The male was situated above and to the rear of the female during copulation (Fig. 1,2). Immediately after the beginning of copulation, the male

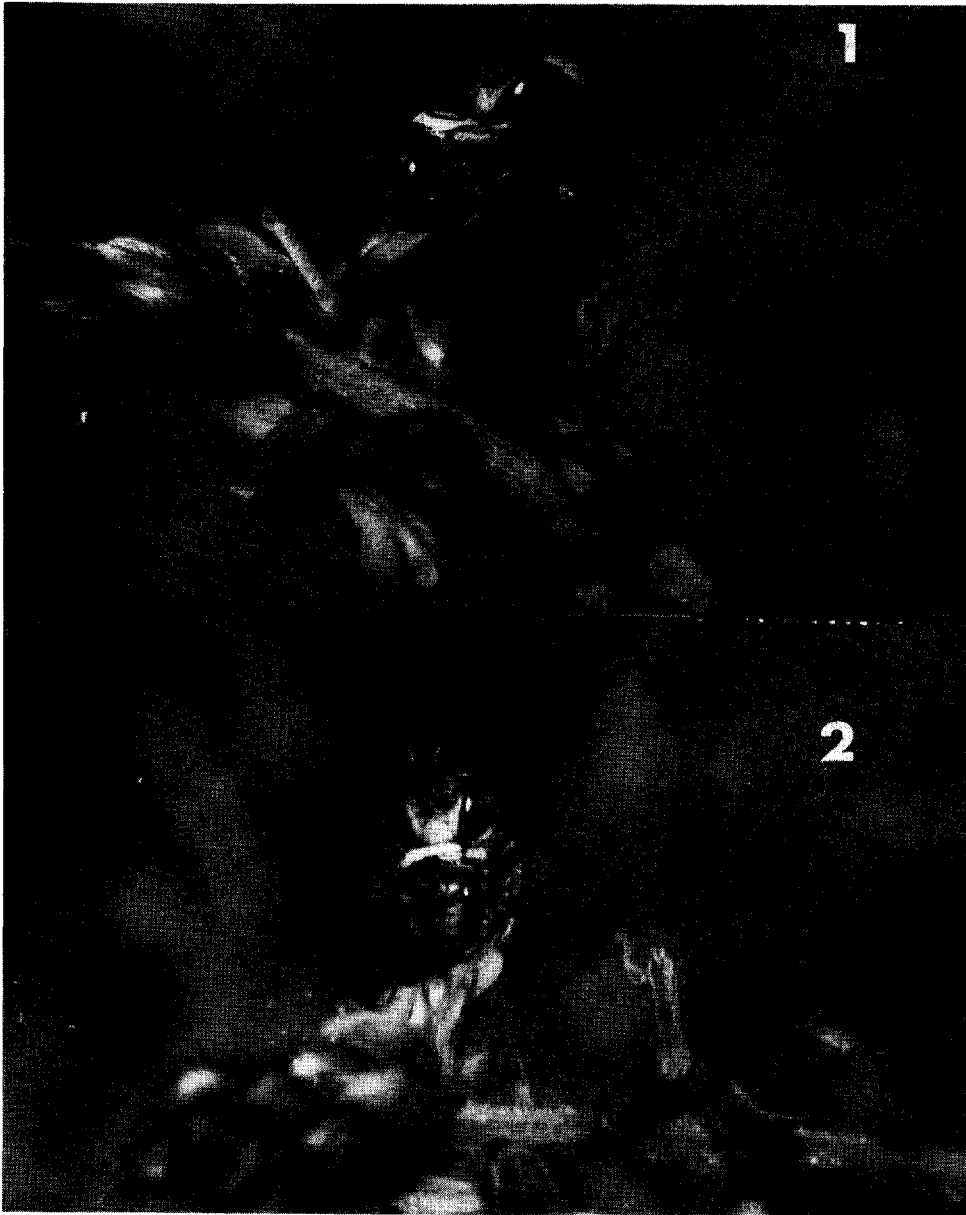


Fig. 1-2. Copulating pairs of *Anthidiellum notatum* on flowers of *Tephrosia chrysophylla*. Male is dorsal to female in both views. 1, lateral view; 2, frontal view. Note numbered disks used for individual identification.

made rocking motions back and forth over the female's dorsum. With each forward rocking motion, the male's hind legs vibrated 3 to 5 times against the sides of his abdomen. Simultaneously, the apices of the male's antennae rotated in a circular motion. There also appeared to be a slight wing vibration associated with each rocking motion. Approximately 10 to 15 sec prior to the end of copulation, the circular movement of the antennae stopped. Both bees remained motionless during the final 5 sec. Upon completion of copulation, the male crawled forward over the top of the female and flew. The female either resumed feeding on the same flower or moved to a nearby flower.

In 1972, the bees' activity, particularly mating, appeared to be closely correlated with the flowering period of the hoary-pea, whose flowers opened at approximately 9:30 AM. The flowers wilted and the corolla fell off between 12:30 and 3:30 PM depending on the weather. On cooler days the flowers lasted longer. The males arrived earlier than the females in the morning, often before the first flowers had opened, and usually stayed later in the afternoon. For instance, on 17 March 1972 the first male arrived at 9:45 AM and the first female was not observed until 10:43 AM at which time there were 4 males present in the area. Those males which did arrive early in the morning often perched for up to 5 minutes at a time on the leaves or unopened buds of the hoary-pea. In 1972 the earliest mating was observed at 9:33 AM while the latest was at 2:26 PM. The majority of copulations for each species occurred between 10:00 AM and 12:00 noon, when 65% and 70% of all matings for *A. notatum* and *A. perplexum*, respectively, occurred (Table 1).

Observations made in 1972 showed that both sexes in both species are capable of copulating more than once. A single male of *A. notatum* was observed to copulate 12 times over a 3 day period in 1972. On 15 March he was observed to copulate at 9:33, 10:08, 10:48 (with the same female as at 10:08), 11:15 (with the same female as 9:33), 11:21, and at 11:29 AM. A male of *A. perplexum* was observed to copulate with 5 different females over a 4 day period.

Repeated observations of the same marked male bees indicated territoriality in both species. The male of *A. notatum* that copulated 12 times was observed flying in only 1 area, approximately 2 m wide by 5 m long. In this area he (marked G5) was apparently the dominant male. For instance, on 14 March, out of 3 copulations observed in the area, 2 were with G5. On 15 March, G5 participated in 6 out of 10 copulations observed in the area, and on 16 March he took part in 4 out of 5. While G5 was the dominant male in the described area, other males were found in this area. In this area, 7 males (5 *A. notatum* and 2 *A. perplexum*) were observed on 14 March, 9 males (7 *A. notatum* and 2 *A. perplexum*) on 15 March, and 7 males (6 *A. notatum* and 1 *A. perplexum*) on 16 March.

On one occasion, G5 disrupted a copulating pair of *A. notatum* in the area and the copulating male flew away. G5 then mated with the same female on the same flower. However, other males of *A. notatum* and *A. perplexum* were successful in copulating in the area while the dominant male was present. This agrees with the findings of Kurtak (1973) for *Anthidium manicatum*.

The *Anthidiellum notatum* which were collected during this study were separated by G. C. Eickwort into either *A. n. notatum* or *A. n. rufimaculatum* on the basis of color characteristics given in Mitchell (1962) without his knowing which ones were mating pairs (Table 2). Intermediates were present. A Chi square test applied to the results was significant at the .05 level,

TABLE 1.—TIME AND NUMBER OF MATINGS FOR *Anthidiellum notatum* AND *A. perplexum* IN MARCH 1972.

Species	Number of matings observed													
	9:30-9:59	10:00-10:29	10:30-10:59	11:00-11:29	11:30-11:59	12:00-12:29	12:30-12:59	1:00-1:29	1:30-1:59	2:00-2:29	2:30-2:59			
<i>A. notatum</i>	1	7	7	10	4*	2**	4	3	4	1	0			
<i>A. perplexum</i>	1	2	2	2	1*	0**	0	0	1	1	0			

*On 3 out of 10 days no observations were conducted during this time period.

**On 6 out of 10 days no observations were conducted during this time period.

TABLE 2.—INTER AND INTRASUBSPECIFIC COPULATIONS OF *A. n. notatum* AND *A. n. rufimaculatum*.

Male	Female	
	<i>notatum</i>	<i>rufimaculatum</i>
<i>notatum</i>	12	5
<i>rufimaculatum</i>	3	9

indicating a significant preference of each subspecies for mating with members of its own subspecies rather than with members of the other subspecies.

DISCUSSION

The mating and territorial behavior of *A. notatum* and *A. perplexum* observed in this study are similar to the behavior of *Anthidium manicatum* as described by Kurtak (1973), and of *Anthidium banningense* as reported by Jaycox (1967). In all 4 species, the males patrol the flowers visited by the females, and copulation takes place at the flower site. In both genera, each territory is dominated by a single male.

Some differences should be pointed out. Unlike *Anthidium*, in which males are considerably larger than females, males are subequal in size to females in *Anthidiellum*. This may be related to the fact that male *Anthidium manicatum*, and to some extent *A. banningense*, forcibly strike intruding insects, while the *Anthidiellum* usually follow or chase other insects without actual physical contact. In this, they more closely resemble *Megachile ericetorum* Lepeletier as reported by Haas (1960).

The territorial boundaries and the dominance hierarchy were not as well defined in the *Anthidiellum* studied as in the *Anthidium* described by Jaycox (1967) or Kurtak (1973). Also, intraspecific interactions were more physical in nature in *Anthidium* than in *Anthidiellum*. This indicates that the territorial behavior of the *Anthidiellum* studied is relatively primitive when compared with that of either *Anthidium manicatum* or *A. banningense*.

Duration of copulation also differed markedly between *Anthidium manicatum* and *Anthidiellum*. While copulations lasted a mean of 3 min, 25 sec for *Anthidiellum notatum* and 2 min, 57 sec for *A. perplexum*, Kurtak (1973) reported a mean duration of only 10 sec for *Anthidium manicatum*.

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CIRCADIAN RHYTHMS OF LOCOMOTION IN ADULT CARIBBEAN FRUIT FLIES—(Note). Recent damaging infestations of the Caribbean fruit fly, *Anastrepha suspensa* (Loew), in grapefruit and the potential for its adaptation to other commercial fruit crops in Florida (R. W. Swanson and R. M. Baranowski; *Proc. Fla. State Hort. Soc.*, 1972, 85:271) prompted us to study fundamental events in its life history. Daily rhythms of activity, age-specific behavior, longevity, and overall vigor were identified by studying the temporal patterns and relative intensities of locomotion in aging populations.

The insects were derived from a laboratory colony that had been cultured for more than 40 generations (P. D. Greany et al., *Entomophaga*, 21:in press). Pupae and flies were held in provisioned cages maintained at $26 \pm 1^\circ\text{C}$ and $80 \pm 10\%$ RH with a 15-hr photophase (310-750 nm, 17-29 ft-c); 1 to 2-day-old adults were transferred to monitored cages and isolated in the same environment. Circadian rhythms of locomotion (impacts against the cages) were recorded from populations of 40 males, 40 females, or 20 pairs per cage by using a vibration-sensitive actograph system (N. C. Leppla and H. G. Spangler, *Ann. Ent. Soc. Am.*, 1971, 64:1431). Trials were replicated 3 times.

The strip chart record from a cage containing 20 pairs of flies was characteristic of all test populations. Activity was restrictively diurnal and occurred in 3 typical phases during the ca. 4-wk existence of the adults (Fig. 1). Phase I, maturation of the integument (J. L. Nation, *Ann. Ent. Soc. Am.*, 1974, 67:731) and associated skeletal muscles, required 5-6 days. During this initial phase, flies ambulated and fed, but flew only intermittently. Peak flight, mating, feeding, and oviposition occurred throughout the next 11-12 periods (phase II, days 7-18). The next 10+ periods (phase III, days 19-28) were characterized by increased mortality and a gradual decrease in activity. Nearly 25% of the flies died by the 19th and 50% by the 28th day. To de-

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