

## Foraging and Nest Provisioning Behavior of the Oligolectic Bee, *Diadasia bituberculata*

(Hymenoptera: Anthophoridae)

ROBERT A. SCHLISING

Pasadena, California 91101

Among bees, oligolecty—a type of flower constancy in which the females of a species restrict their pollen-food foraging to a narrow range of plant types—is receiving considerable attention and is becoming fairly well known (Linsley and MacSwain, 1958; Stephen, Bohart and Torchio, 1969). Bees in the anthophorid genus *Diadasia* Patton are oligolectic (Linsley and MacSwain, 1957, 1958), most species restricting their pollen foraging to plants in the Malvaceae (*Sphaeralcea*, *Callirhoe*, *Sidalcea*, or *Sida*). Other species in this genus are oligolectic on *Opuntia* (Cactaceae), *Helianthus* (Compositae), *Clarkia* (Onagraceae), and *Convolvulus* (Convolvulaceae). One species, *Diadasia bituberculata* (Cresson), is known to be oligolectic on *Convolvulus* Linnaeus (many species of which have recently been transferred to the genus *Calystegia* Robert Brown). The purpose of the present study was to observe details of the pollen foraging and nest provisioning of this one bee species on one species of *Calystegia* (formerly *Convolvulus*).

Oligolectic bees commonly show inherited morphological and behavioral features which adapt these species for existence on a restricted number of food plants (Linsley, 1958). In *Diadasia bituberculata* these include elongated, specialized mouthparts that permit extraction of nectar from flowers with deep tubular corollas (Linsley and MacSwain, 1958), as well as seasonal and diurnal synchronization with flowering of its host plants. Michener (1951) lists the range of *D. bituberculata* as "California," an area in which several species of *Convolvulus* and *Calystegia* occur (Munz and Keck, 1959; Munz, 1968). Although different populations of *D. bituberculata* throughout its range utilize different species of *Convolvulus* or *Calystegia* as their pollen source, this report is limited to observations of these bees at flowers of *Calystegia fulcrata* (Gray) Brummitt at one locality.

This study was conducted in 1971, along Mineral King Road, 3.9 miles southeast of the junction with State Highway 198, near Three Rivers, Tulare County, California. This locality, in the hot dry foothills of the Sierra Nevada, at an elevation of 610 m, is covered

by chaparral with dense shrubs often up to 3 or 4 m tall and trees considerably taller. The commonest woody plants on the steep slopes and in the draws here include: *Adenostoma fasciculatum* Hooker and Arnott, *Aesculus californica* (Spach) Nuttall, *Ceanothus cuneatus* (Hooker) Nuttall, *Eriodictyon californicum* (Hooker and Arnott) Torrey, *Fremontodendron californicum* Coville, *Mimulus longiflorus* (Nuttall) Grant, *Quercus chrysolepis* Liebmman, *Rhus diversiloba* Torrey and Gray, and *Umbellularia californica* (Hooker and Arnott) Nuttall. Both the bees and their "wild morning glory" food plants occur throughout the area—usually along rock outcroppings or other open and grassy spots in the chaparral, or along roadsides and fire trails.

The main pollen source of the bees here was a *Calystegia* population that occupied nearly 50 m of a narrow strip of east-facing roadbank, and grew with very few annual grasses and native herbs (Fig. 1). The creamy-white, nearly scentless flowers of *C. fulcrata* are tubular at the base, and flared or trumpet shaped at the top (Fig. 2). Nectar is secreted at the very base of the corolla tube in five nectary areas; pollen is located on anthers near the top of the tube. These two insect foods are available to foragers only from the early morning opening of the flowers to their wilting and closing by afternoon or earlier. The flowers last but one day (new flowers open each morning), so the total sequence of flower visitors during an individual flower's life can be rather easily studied. The flowering peak was in late May (Table 1), and flowering lasted about seven weeks in 1971, with a few flowers open on 6 May and none remaining on 5 July. Flowers were rather uniformly spread out over the population, but in several areas where the vines were particularly dense, there were as many as 25 to 30 flowers per m<sup>2</sup>.

The nesting site of the bees was located about 200 m northwestward, around a corner and out of sight of the *Calystegia* food plants. Nests

→

FIG. 1. Location of *Calystegia fulcrata* population, on lower chaparral-facing slopes of roadside bank, from foreground to curve of road in distance. FIG. 2. Stems and flowers of *C. fulcrata* ( $\times 0.25$ ). FIG. 3. *Diadasia bituberculata* nest site, with most burrows in three areas to left of arrows. FIG. 4. *D. bituberculata* female, with full scopal loads of *C. fulcrata* pollen ( $\times 3$ ). FIG. 5. *D. bituberculata* female from rear, showing dense plumose hairs of scopae, with very few pollen grains to left of arrow ( $\times 4$ ). FIG. 6. Two turrets, amid dried annuals at top of bank in Fig. 3, with turret entrance and top of tumulus to left of arrows ( $\times 0.25$ ). FIG. 7. Typical position (posed specimen), of *D. bituberculata* male in *C. fulcrata* flower, with tongue reaching nectaries and dorsum of abdomen brushing stamens and (outlined) stigma ( $\times 2$ ).

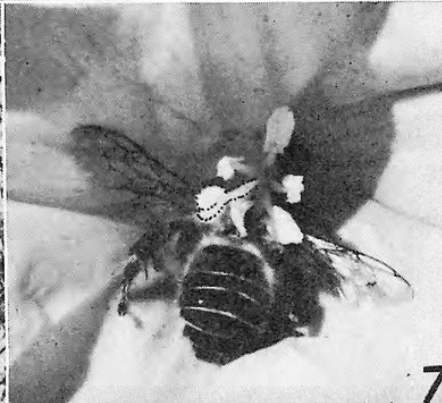
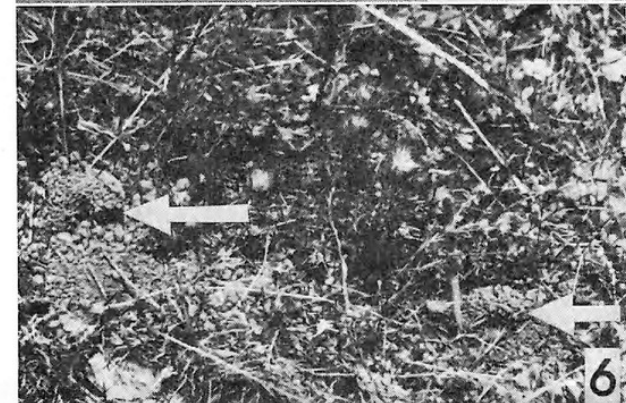
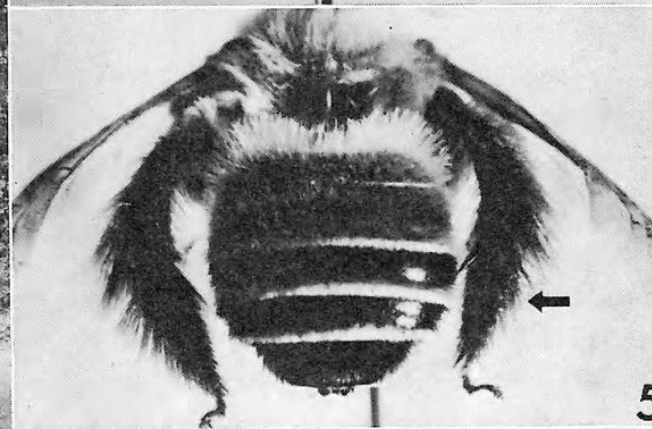
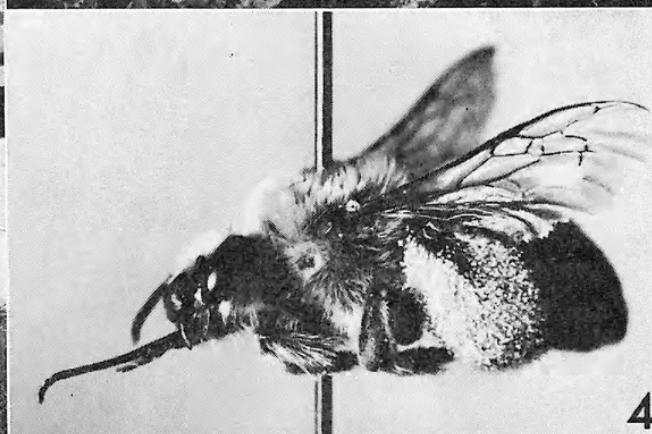


TABLE 1. Dates and number of hours of observation in 1971, noon air temperatures ( $^{\circ}\text{C}$  in shade 0.5 m above flowers and nests), and number of open *Calystegia* flowers in the main population.

Date		Total hours	Temperature	Open flowers
May	12	2.5	—	121
	13	5.0	22.5	235
	15	7.0	22.0	360
	16	7.25	17.0	375
	24	7.5	27.5	392
	25	6.0	28.5	373
June	4	6.25	24.0	285
	5	8.75	27.5	279
	10	2.0	—	—
	11	8.75	28.5	226
	12	6.0	32.5	223

were located in an exposed southeast-facing bank of the roadcut that was 3 m from the road and nearly devoid of vegetation (Fig. 3). A few plants of *C. fulcrata* grew on this bank, and several more occurred 50 m away on a fire trail, but it is believed that the nesting bees observed here primarily utilized the large population 200 m to the southeast.

The dates and numbers of observation hours here are listed in Table 1, along with noon air temperatures. No measurable precipitation occurred during the hours of observation, but weather records (U. S. Dep. Commer., 1971) for Three Rivers (elevation 290 m) show that the 7.37 cm of precipitation that occurred in May was 5.13 cm above the normal (based on a 30-year average) for the month; June precipitation was zero, or 0.53 cm below normal. Total annual precipitation averages 53.90 cm here. Most study days were sunny, with moderate breezes in the afternoons. The bees, particularly at the nest site, were very docile and could be watched at very close range. They appeared to be totally unaffected by observers sitting only decimeters away.

#### FEMALE FORAGING BEHAVIOR

Females of *Diadasia bituberculata* are completely reliant on *Calystegia fulcrata* for nest provisioning at this site, and emergence from nests and the beginning of foraging activity is synchronized with the first availability of pollen. Anther dehiscence, which is regulated in some



species by air temperature and relative humidity (Percival, 1965), was usually very early near Three Rivers. On 5 June the first female was seen at 5:10 a.m. (Pacific Standard Time), when some powdery, freshly dehiscent pollen was available on the anthers, and in the next ten minutes visits by females became abundant. An overcast and humid morning inhibits both anther dehiscence and foraging activity of the bees. On 16 May, for example, flowers were fully open by 5:15 a.m. when it was light, but there was a heavy cloud cover and the air, at 10° C, was very moist with a gentle mist; female bees did not come to flowers that morning until 10:40, when the first anther dehiscence occurred. Nectar presentation seems to occur as or before the anthers dehisce.

A foraging female typically flies directly to, and “dives headlong” into a *Calystegia* flower, where she spends one to eight (rarely up to 30) seconds taking nectar by inserting her tongue into one to five of the nectaries at the base. Early in the morning the females may first probe the nectaries for a second or more in nearly each flower visited, but later in the day they may take nectar from fewer of the flowers visited (Table 2). Early in the morning each female spends an average of at least 2.5 times longer collecting pollen in individual flowers than she does later in the day. Mean pollen-collecting time for 6 bees was 23 seconds per flower at 5:30–6:30 a.m. and 9 seconds at 9:30–10:30 on 5 June (Table 2). Although Linsley and MacSwain (1957) noted that the elongated, specialized mouthparts of this species (Fig. 4) permit simultaneous gathering of pollen and nectar from *Convolvulus* flowers, females at this site very rarely took pollen from the anthers while also taking nectar. They consistently climb onto the anthers (which are well elevated above the nectar bearing areas) for pollen gathering *after* taking nectar—or they settle immediately on the anthers without taking nectar.

When collecting pollen, females usually position themselves on the outer surfaces of the anthers or slightly below them on the filaments, where they can rotate their bodies (sometimes buzzing loudly) inside the flower, one to three times around the cluster of five anthers. Pollen is removed with the forelegs and transferred to the scopae—the dense, plumose hairs on the hind legs (Figs. 4, 5). Occasionally a female sits *on top of* the five anthers a few seconds, grooming pollen from her face and thorax, but usually she flies from the flower immediately after taking pollen.

A female does not complete her pollen load with pollen from one flower only, but leaves a flower still bearing abundant pollen for other

TABLE 2. Representative timings (in seconds) of foraging by 4 females of *Diadasia bituberculata* in flowers of *Calystegia fulcrata* on the morning of 5 June.

Bee	Flowers visited	Nectar <sup>a</sup>	Pollen	Resting
1 <sup>b</sup>	1	8	61	0
	2	0	20	0
	3	4	41	0
	4	0	47	0
	5	0	18	0
	6	0	28	8
2 <sup>b</sup>		0	7 <sup>c</sup>	0 <sup>d</sup>
	1	7	45	4
	2	0	20	0
	3	3	10	0
	4	2	20	6
	5	1	19	0
	6	3	20	0
	7	3	43	0
	8	0	3	0
	9	3	4	0
	10	5	36	3
3 <sup>e</sup>		0	6 <sup>c</sup>	0
	11	2	32	9 <sup>d</sup>
	1	0	8	0
	2	2	65	0
	3	0	9	0
	4	0	8	0
	5	0	6	0
	6	0	6	0
	7	0	5	0
	8	0	10	0
	9	0	2	0
4 <sup>e</sup>	10	0	10	2
	11	0	8	0
	1	0	3	0
	2	0	3	0
	3	0	9	0
	4	0	5	0
	5	0	5	0
	6	0	13	0
	7	0	3	0
	8	0	3	0

<sup>a</sup> Nectar collection always preceded pollen collection in the same flower.

<sup>b</sup> Observed between 5:30-6:30. Bee started foraging with little or no pollen on scopae.

<sup>c</sup> Bee continued pollen collection after rest in same flower.

<sup>d</sup> Bee left flower (probably for nest) with full scopae.

<sup>e</sup> Observed between 9:30-10:30. It was possible to record only short series of uninterrupted flower-visit sequences at this time of day, due to the very fast and erratic flight patterns of the bees.

*Calystegia* flowers. To obtain "full" scopal loads of pollen (Fig. 4) a female may visit from five or six to perhaps 15 flowers early in the morning. When flowers are nearly depleted of pollen later in the day up to 30 or more flowers are visited to obtain loads, and some loads brought to nests later are much smaller. During the main pollen collecting period females may fly to, but immediately desert, flowers that still have pollen in them. Most flowers are frequently visited and foraged in—often by one bee a few seconds after another.

The times at which pollen foraging cease vary, apparently with weather conditions (and with times at which foraging starts) and with the number of females of *Diadasia* collecting from the limited number of flowers at one locality. In mid May, with lower air temperatures (Table 1), and possibly fewer females present, remaining pollen was still being collected at 3 p.m.—even if the flowers were already partially folded shut and wilted. But later in the season pollen supply was depleted and foraging was completed by about 12:30 p.m. on 24 May or even by 9:30 a.m. on 12 June. When the females cease pollen foraging (even as early as 9:30) they start nest construction, although visits to *Calystegia* flowers for nectar may continue through the afternoon. After pollen foraging was over for the day females were also seen utilizing three other herbaceous species for nectar (but not pollen) near the nest site: they were occasional in flowers of *Penstemon laetus* Gray and rare in flowers of *Clarkia speciosa* ssp. *polyantha* Lewis and Lewis and *Calochortus superbus* Purdy ex J. T. Howell.

All *Calystegia fulcrata* flowers examined at this site had the pollen removed by bees—probably by *D. bituberculata* in all cases—during study days, and there is no doubt that bees of both sexes, and particularly the females, bring about pollination of the flowers. During pollen collection, the style and stigma project above the parts grasped by the bees. But stigmas are frequently brushed as females enter, leave, or forage in flowers, and pollen is found lodged between the weakly appressed stigmatic lobes after *Diadasia* visits. These flowers, during their one-day life, commonly receive as many as 50 individual visits by the bees. Similar high numbers of bee visits per flower have been reported for tropical oligolectic bees closely related to *Diadasia*, to flowers related to *Calystegia* (Schlising, 1970). The situation at Three Rivers is remarkable however, because it is nearly individuals of one species alone—*D. bituberculata*—that exploit and pollinate the plants.

## FEMALE NEST PROVISIONING BEHAVIOR

At Three Rivers these bees utilized three areas of an eroded bank (Fig. 3) for their nests: 1) the nearly horizontal surface at the top, covered with short grasses and other low annuals (Fig. 6), 2) the exposed, nearly vertical, mineral soil surface, and 3) the nearly level deposits of soil washed down, sparsely covered with annual grasses. The densest aggregation of nests—27 per  $m^2$ —was on this flatter area only 2 m from the road edge. Most burrows had curving or straight horizontal turrets made of dried mud pellets covering the burrow entrances (Fig. 6); turrets varied from about 1.0 to 2.5 cm long, and entrances faced every direction.

Morning emergence of females from nests was observed on 5 June at 4:50 a.m., when the air temperature 20 cm above the nests was  $10.5^{\circ}$  C. The first bee seen to emerge flew in a small circle over the nests, then slowly to a *Calystegia* flower on a bank 2 m away, where she rested in the sun, took nectar, and finally pollen. During the next 15 minutes other females emerged, and by 5:15 were abundant at the main *Calystegia* population, collecting both nectar and pollen. Observations made during the night and also as these bees emerged indicate that surface plugs are not constructed to close burrow entrances when occupied by females at night.

When returning to her nest with a pollen load in the morning, a female typically enters her turret (or her burrow, if it has no turret), until she is barely but entirely within it (out of the sun), with her hind pollen-laden legs resting on the dorsum of her abdomen. Then, with a twitching of the hind tarsi the only visible motion of her body, she rests here for 0.25 to 7 (occasionally up to 15 or 17) minutes. Then she crawls down into the nest, and 4 to 8 squeaky buzzes, each about one second long, are heard as she removes the pollen from her scopae. After these buzzes, a female usually appears at the burrow entrance in a few seconds, and flies away immediately.

Such provisioning behavior is repeated throughout the foraging period. Variation in timing among different foragers is of interest, since all females were probably collecting pollen from the *Calystegia* 200 m from the nests. Representative provisioning timings are shown in Table 3 for four females followed over a 2-hour period on 5 June. Bee #1 averaged 8.0 minute trips in collecting apparently "full" loads of pollen (Fig. 4), while bees #2, #3 and #4 averaged 9.6, 14.2 and 21.0 minute trips in collecting similar loads. These same four bees averaged (respectively) periods of 5.3, 3.6, 2.2 and 1.0 minutes spent in the nest between foraging trips, so it appears that the faster



TABLE 3. Times of nest provisioning activities by 4 females of *Diadasia bituberculata* on 5 June, from 6:40–8:40 a.m.

Bee #1		Bee #2		Bee #3		Bee #4	
Return	Leaving	Return	Leaving	Return	Leaving	Return	Leaving
6:43	6:48	6:44	6:46	6:57	6:59	7:25	7:26
6:57	? <sup>a</sup>	6:59	7:00	7:14	7:16	8:04 <sup>b</sup>	8:05
7:02	7:05	7:14	7:16	7:35	7:37	8:15	8:16
7:15	7:17	7:23	7:25	7:48	7:51	8:31	8:32
7:19	7:30	7:31	7:33	8:05	8:07		
7:35	7:37	7:41	7:47	8:25	8:27		
7:48	7:51	7:58	8:08	8:35			
8:02	8:11	8:16					
8:19	8:28						

<sup>a</sup> Flight from nest not seen.<sup>b</sup> Longest (and highly atypical) foraging flight recorded during early morning.

foragers may spend longer periods in the nest. Foraging time periods later in the day became less uniform, for all individuals timed, as pollen became scarcer, and it commonly took 2 to 4 times longer for a forager to return with a pollen load. In-burrow periods also became longer and fluctuated more among individuals and within the population as a whole later in the day, until all bees ceased foraging and began new cell construction in the nests.

Later in the season, at least, foraging and cell provisioning are not alternated with new cell construction while *Calystegia* pollen is still plentiful. On days when *Calystegia* pollen was being used up rather early, some bees were still collecting at 9:30–10:00 a.m., but others had turned to further cell excavation in their burrows—not to return to foraging and provisioning of these cells until the next morning. Females of *D. consociata* Timberlake, on the other hand, may collect pollen throughout the day from *Sida hederacea* (Douglas) Torrey, and will make three or four pollen trips in succession (Linsley et al., 1952a), but apparently do not restrict their cell excavation activities only to times after pollen foraging is completed for the day.

During nest construction a female may alternate cell excavation with turret construction or repair. A few seconds after entering her burrow for excavation, a bee backs out, kicking pebbles of soil removed from below. Although the ground is very hard and dry where the nests are dug, these pebbles are moist; some are used to fashion the turret and the rest accumulate as a tumulus. Frequent flights away from the nest during construction serve in obtaining nectar as

a source of energy and also in obtaining moisture used in wetting the hard soil. Bees in the genera *Ptilothrix* Smith (= *Emphor* Patton) and *Melitoma* Lepeletier and Serville, in the same tribe as *Diadasia*, are among the bees known to collect water used in moistening soil in nest construction (Grossbeck, 1911; Rau, 1930; Linsley et al., 1952a, 1956; Stephen et al., 1969). No species of *Diadasia* has been recorded as collecting water for nest construction, according to Linsley and MacSwain (1957), but these authors suggested the possibility of nectar being used in soil softening. Roy Snelling, of the Natural History Museum of Los Angeles County, Los Angeles, California, has observed females of *D. bituberculata* collecting nectar in *Penstemon* flowers in the San Gabriel Mountains of Los Angeles County, and feels that such nectar may be the liquid used to soften soil in nest construction (personal communication). The very short periods excavating bees spent away from their nests at Three Rivers suggest a source of liquid close by. Close freewater sources were examined during excavation periods, but no *Diadasia* individuals were seen taking water. Females were collected nearby taking nectar from the four species already listed; the use of nectar from these or other flowers in nest construction is very probable but has yet to be demonstrated with certainty here.

While observations were not made on below ground aspects of the nests, information is available for several species of *Diadasia*, including *D. bituberculata*, on various aspects of burrow and cell structure, nest contents, parasites, larval overwintering, and adult emergences (Linsley and MacSwain, 1952, 1957; Linsley et al., 1952a, 1952b). Although there is no published record on number of cells per nest for this species, Linsley and MacSwain (1957) listed anywhere from 1 to 42 cells per nest for other species of *Diadasia*, and noted that nesting habits for *D. bituberculata* are similar to those of *D. consociata*, which produces 1 to 15 (commonly 5 to 10) cells per burrow. Of the 10 females observed provisioning and then excavating on 5 June here, only one was still working at the same nest 6 days later. It is not known how long a female takes to completely provision one nest, but Linsley et al. (1952a) have recorded females of *D. consociata* taking as long as 5 or 6 weeks to construct and provision a burrow with 10 or more cells. They also noted that females of *D. consociata* may construct more than one burrow; this may be true of *D. bituberculata* as well, for between 25 May and 12 June at Three Rivers new nests were continually being initiated. After nests were provisioned, some females completely removed their turrets and

filled the burrows to the surface with pieces of turret and soil from the tumulus.

#### MALE BEHAVIOR AND MATING

At Three Rivers males of *D. bituberculata* are found from about 6:30 a.m. to 3:30 p.m. or later visiting flowers of *C. fulcrata* during a characteristic cruising flight over the plants. They follow a low, zig-zag flight 10 to 30 cm above the flowers, as if searching for females, and enter only 5% of the open flowers. A male may fly directly into a flower, and while rotating his body in the corolla, take nectar from three to five of the nectaries. Nectar visits last from one or two (usually four or five) to 25 seconds, and while the tongue is inserted into the nectar, the abdomen and hind legs extend into the area of anthers and stigma (Fig. 7). Males often rest for up to 2.5 minutes, with legs on one side of the body on the anthers and stigma and legs of the other side on petals, or with the body curled around the stamens at the level of the anthers or lower. In either position, a male may sit quietly, or—often with considerable squirming—groom head and thorax with the front legs. These males usually have abundant pollen on abdomen and legs; they frequently brush the stigma when entering or leaving, or while in a flower, and undoubtedly promote pollination.

While most commonly observed cruising *Calystegia* flowers, males can also be found flying over the nest site. At Three Rivers males were also found in flowers of the three species of plants utilized for nectar by females. They were common in the deep tubular flowers of *Penstemon laetus* and in the cup-shaped flowers of *Clarkia speciosa* ssp. *polyantha*, and were rare in the cup-shaped flowers of *Calochortus superbus*. These flowers are utilized by males as nectar sources and as resting places, mostly, but not exclusively, later in the day when *Calystegia* flowers are partially or totally closed. *Penstemon* flowers as well as closed *Calystegia* flowers had sluggishly active males in them late in the afternoon, but numerous flowers pinched at night contained no sleeping males, and it is not known where males spend the night.

Mating of *D. bituberculata* bees was reported by Linsley et al. (1952a) as occurring in flowers of *Convolvulus*; at Three Rivers mating may occur in flowers of three species. Bee encounters thought to be matings were observed once only in flowers of both *Clarkia* and *Calochortus*. Mating was more clearly seen on two occasions (13 May at 10:00 a.m. and 5 June at 6:40 a.m.), commencing in flowers

of *Calystegia fulcrata*. In each case a cruising male pounced on a pollen-collecting female, and with a loud buzzing fell from the flower to the ground with her. In the first encounter the bees remained in contact on the ground for eight or ten seconds before separating and flying off. The other encounter lasted about five seconds; the male then flew off, and the female flew to another flower and continued pollen collecting. The very few matings seen during the 67 hours of observations suggest that mating may mainly occur at the beginning of the foraging season here (which probably began one week or more before observations started on 12 May). Observations here do show agreement with the suggestion of Linsley et al. (1952a), that males persist throughout the nesting season.

#### DEPENDENCE OF *DIADASIA BITUBERCULATA* ON *CALYSTEGIA*

Linsley and MacSwain (1958) and Stephen et al. (1969) emphasized that the pollen food-plant restriction called oligolecty must be considered a *relative* phenomenon, with some species more highly oligolectic than others. Some bees that are typically highly oligolectic may turn to other plants in times of shortage of their "preferred" pollen sources. For example, *Diadasia australis californica* Timberlake, a desert cactus oligolecte, has been found collecting pollen from nearby *Phacelia* flowers when the local cactus pollen supply was exhausted (Linsley and MacSwain, 1957, 1958). All females of *D. bituberculata* examined at Three Rivers had only *C. fulcrata* pollen on their scopae. Yet, the very beginning or end of the foraging season was not studied here and it may be interesting to see if these bees are less faithful in pollen collecting early in the season or during the final days of foraging when the preferred pollen sources are very scarce. Throughout its entire geographic range however, Linsley and MacSwain (1957) believe that none of the oligolectic species of *Diadasia* is restricted to a single species of a plant genus. They encountered *D. bituberculata* in several localities, but always taking pollen only from the introduced and weedy *Convolvulus arvensis* Linnaeus; they suspected that this species also visited native and less widely distributed species of plants in this group. This bee is able to utilize at least four plant species, for during the spring of 1971 pollen-taking females of *D. bituberculata* were collected on three native species of *Calystegia* in different localities in California: *C. fulcrata*, in Tulare, Kern and Los Angeles Counties; *C. longipes* (Watson) Brummitt, in Tulare and Kern Counties; and *C. purpurata* (Greene) Brummitt, in Ventura County.

Stephen et al. (1969) have noted that some bees that are highly



oligolectic in collecting pollen also take nectar from a very limited number of species, and Linsley (1958) noted that in some cases male flower response may be as specific as that of the female. At Three Rivers in 1971 both sexes of *D. bituberculata* were found taking nectar from no more than the four species listed earlier (*Calystegia*, *Penstemon*, *Clarkia* and *Calochortus*), although flowers of many species were searched for the bees. The perennial *Calystegia fulcrata*, the preferred pollen source, probably also serves as the preferred nectar source each year; the same plants of *Penstemon* and *Calochortus*, also perennials, may be utilized each season as well. Compared with nectar sources listed for some other species of *Diadasia* (Linsley and MacSwain, 1957; Linsley et al., 1952a), the nectar plants known for *D. bituberculata* at Three Rivers are a restricted set.

Since these bees restrict their foraging to few plants it was of interest to record the possible competitors they have, and the total range of *C. fulcrata* flower visitors was sampled at Three Rivers. Other than a very occasional ant or clerid beetle, bees were the only flower visitors. Only a few instances of pollen collection were noted during the study period, by females of *Halictus farinosus* Smith and *Lasioglossum punctatoventre* (Crawford), so females of *D. bituberculata* had essentially no competition for pollen here. (Linsley et al., 1952a, similarly noted that the oligolectic *D. consociata* had no competition for pollen on *Sida hederacea*.) *Calystegia* nectar was taken by *Emphoropsis rugosissima* Cockerell, *Osmia gabrielis* Cockerell, *O. nemoris* Sandhouse, *O. subaustralis* Cockerell, and *Synhalonia stretchii* (Cresson), but it seems very unlikely that these nectar collectors were ever common enough to diminish the supply of nectar needed by *Diadasia* bees. Thus, in 1971 this population of *D. bituberculata* had very little competition for food—in spite of their flower visits being restricted to only one plant species for pollen and to only four species for nectar.

#### ACKNOWLEDGMENTS

Appreciation is expressed to P. H. Timberlake, University of California, Riverside, and to R. R. Snelling, Natural History Museum of Los Angeles County, Los Angeles, for identifying or verifying identifications of bees. Thanks are also extended to C. O. Balogh and L. A. Bellue for help in collecting field data.

#### LITERATURE CITED

- GROSSBECK, J. A. 1911. A contribution toward the life history of *Emphor bombiformis* Cress. J. N. Y. Entomol. Soc., 19: 238-244.

- LINSLEY, E. G. 1958. The ecology of solitary bees. *Hilgardia*, 27: 543-599.
- LINSLEY, E. G., AND J. W. MACSWAIN. 1952. Notes on some effects of parasitism upon a small population of *Diadasia bituberculata* (Cresson) (Hymenoptera: Anthophoridae). *Pan-Pac. Entomol.*, 28: 131-135.
1957. The nesting habits, flower relationships, and parasites of some North American species of *Diadasia* (Hymenoptera: Anthophoridae). *Wasmann J. Biol.*, 15: 199-235.
1958. The significance of floral constancy among bees of the genus *Diadasia* (Hymenoptera, Anthophoridae). *Evolution*, 12: 219-223.
- LINSLEY, E. G., J. W. MACSWAIN, AND R. F. SMITH. 1952a. The bionomics of *Diadasia consociata* Timberlake and some biological relationships of emphorine and anthophorine bees (Hymenoptera, Anthophoridae). *Univ. Calif. Publ. Entomol.*, 9: 267-290.
- 1952b. The life history and development of *Rhipiphorus smithi* with notes on their phylogenetic significance (Coleoptera, Rhipiphoridae). *Univ. Calif. Publ. Entomol.*, 9: 291-314.
1956. Biological observations on *Ptilothrix sumichrasti* (Cresson) and some related groups of emphorine bees (Hymenoptera, Anthophoridae). *S. Calif. Acad. Sci. Bull.*, 55: 83-101.
- MICHENER, C. D. 1951. in MUESEBECK, C. F. W., K. V. KROMBEIN, H. K. TOWNES, ET AL. Hymenoptera of America north of Mexico—synoptic catalog. U. S. Dep. Agr. Monogr., No. 2. 1420 pp.
- MUNZ, P. A. 1968. Supplement to a California flora. Univ. Calif. Press, 224 pp.
- MUNZ, P. A., AND D. D. KECK. 1959. A California flora. Univ. Calif. Press, 1681 pp.
- PERCIVAL, M. 1965. Floral biology. Pergamon Press, London, 243 pp.
- RAU, P. 1930. The nesting habits of *Emphor bombiformis* Cresson. *Bull. Brooklyn Entomol. Soc.*, 25: 28-35.
- SCHLISING, R. A. 1970. Sequence and timing of bee foraging in flowers of *Ipomoea* and *Aniseia* (Convolvulaceae). *Ecology*, 51: 1061-1067.
- STEPHEN, W. P., G. E. BOHART, AND P. F. TORCHIO. 1969. The biology and external morphology of bees. *Agr. Exp. Sta., Oreg. State Univ.*, 140 pp.
- U. S. DEP. COMMER. 1971. Climatological data—California, 75: 145-220.

## INSECT PINS

**\$4. / 1000 (10 Pkgs.)**

**(Plus Postage)**

**PROMPT DELIVERY**

**LOWEST PRICES IN AMERICA**

CLAIR ARMIN  
191 W. Palm Avenue  
Reedley,  
California 93654



Schilsing, Robert A. 1972. "Foraging and nest provisioning behaviour of the oligolectic bee, *Diadasia bituberculata* (Hymenoptera: Anthophoridae)." *The Pan-Pacific entomologist* 48(3), 175–188.

**View This Item Online:** <https://www.biodiversitylibrary.org/item/229411>

**Permalink:** <https://www.biodiversitylibrary.org/partpdf/240992>

#### **Holding Institution**

Pacific Coast Entomological Society

#### **Sponsored by**

IMLS LG-70-15-0138-15

#### **Copyright & Reuse**

Copyright Status: In copyright. Digitized with the permission of the rights holder.

Rights Holder: Pacific Coast Entomological Society

License: <http://creativecommons.org/licenses/by-nc-sa/4.0/>

Rights: <https://biodiversitylibrary.org/permissions>

This document was created from content at the **Biodiversity Heritage Library**, the world's largest open access digital library for biodiversity literature and archives. Visit BHL at <https://www.biodiversitylibrary.org>.