The Parasites, Predators, and Inquiline Associates of Anthophora linsleyi

E. G. Linsley and J. W. McSwain[1]

Relatively few discussions have been published of parasites, predators or inquilines associated with North American bees of the genus *Anthophora*. Rau (1922 *et seq.*) and Frison (1922) have recorded some of the associates of *Anthophora abrupta* Say, Hicks (1926) those of *A. neomexicana* Cockerell, and Mickel (1928) those of *A. occidentalis* Cresson. The work of Mickel was notable in that he recorded the number of infested cells (out of 249 containing living insects) and made an attempt to evaluate the effects of the associated species on the population of the host. In the following pages data is given on twenty-two species of insects associated with *Anthophora linsleyi* Timberlake in three localities in California. The data were obtained by both field and laboratory observations and by an analysis of 2679 *Anthophora* cells. About two-thirds of the species were sufficiently abundant to enable the writers to definitely determine their relationship with their host.

Anthophora linsleyi Timberlake (1940) is a relatively common bee in areas adjacent to the Mojave Desert, California. It nests gregariously, sometimes in very large numbers, either in banks or flat ground. Apparently the species requires a hard-packed, dry, sandy conglomerate soil in an area where water is available throughout the nesting season. When banks are utilized, exposures which receive the early morning sun are usually selected for nesting sites.

The nest burrows of *linsleyi* are similar to those of other species of *Anthophora* but lack a projecting entrance tube or turret. In banks, the burrow enters at right angles to the surface, inclines downward sharply at a depth of about an inch, and continues as a simple or irregularly forked tube. In densely populated sites modifications are frequently required. The series usually comprises from three to six cells, which are of the normal jug-like shape characteristic of the genus, with the internal dimensions averaging about 10 x 7 mm. When the cell form has been completed, the inner surface is waxed and provisioned to about one-fourth of its depth with pollen. The surface of the pollen mass is covered with a mixture of nectar and water upon which the egg is deposited. After oviposition, the cell is capped with a circular mud plug which is waxed on the concave inner surface. The hatching larva rapidly consumes the stored food and by late summer has attained the prepupal stage (Fig. 3). The fall and winter are passed as an inactive prepupa and

[1] The writers wish to express their appreciation to Mr. G. E. Bohart who materially assisted them during the collection of field data, and to Miss Margaret C. Walker who took the habitat photographs for Figs. 1 and 2.

pupation occurs in the early spring. Under laboratory conditions, the average length of the pupal period of the male was 38 days, of the female 43 days, but in the field this period is sometimes shortened by as much as ten days. After transformation, the adult remains for a day or two in the cell and emerges when weather conditions are favorable. The species is proterandrous and the males normally precede the females by a week or ten days, usually emerging about the middle of March. They spend the days at flowers or flying about the nesting sites, assembling gregariously in resting burrows in the late afternoon. Early in the season the females also spend the night in resting burrows or in old tunnels, but when nest construction has begun, they utilize the new burrows for this purpose. In two localities, the females were observed to collect pollen only from *Salvia carduacea*.

This pollen is bright red and in these areas the bee larvae and pupae have a distinct orange or orange-red color. At a third locality, two or more undetermined flower species were utilized as pollen sources. The pollens were pale yellowish and orange and the bee larvae and pupae were transparent white, yellow or orange in color, depending upon the pollen on which they had fed.

Anthophora linsleyi has been found by the writers nesting in three localities in the vicinity of Mojave Desert, California, although only two of these sites

TABLE 1.—Associated Parasites, Predators and Scavengers in Nests of *Anthophora linsleyi*.

Locality	Little Lake, 10 mi. S., Inyo Co., California.		Bakersfield, 20 mi. E., Kern Co., California.	
	Number of cells	Per cent of total	Number of cells	Per cent of total
Cells examined	1920	100.00	759	100.00
Living *Anthophora*	909	47.34	370	48.75
Anthophora killed by mold	203	10.58		
Hornia boharti (Meloidae)	458	23.85	111	14.62
Trogoderma ajax (Dermestidae)	118	6.14	40	5.27
Melecta californica (Anthophoridae)	75	3.91	44	5.79
Nemognatha apicalis (Meloidae)	6	.31	44	5.79
Anthrax sp. nr. *fur* (Bombyliidae)	76	3.96	33	4.34
Photopsis auraria (Mutillidae)	42	2.19	19	2.50
Photopsis sercus (Mutillidae)			1	.13
Hylemyia cilicrura (Anthomyiidae)	20	1.04		
Ptinus californicus (Ptinidae)			32	4.21
Lytta occipitalis (Meloidae)			11	1.45
Lytta pupurascens (Meloidae)			29	3.82
Lytta chloris (Meloidae)			7	.92
Monodontomerus montivagus (Callimomidae)	5	.26	4	.52
Triepeolus mojavensis (Nomadidae)			3	.39
Chrysis (Chrysis) sp. (Chrysididae)			3	.39
Chrysis sp. (Chrysididae)			3	.39
Plodia interpunctella (Pyralidae)			3	.39
Tineola biselliella (Tineidae)			2	.26
Oryzaephilus surinamensis (Cucujidae)	5	.26		
Gen. et sp. incert. (Ichneumonidae)	2	.10		
Stegobium paniceum (Anobiidae)	1	.05		

have been investigated in detail. One of these areas is in Grapevine Canyon, ten miles south of Little Lake, on the east side of the Sierra Nevada Mountains, near the Inyo-Kern County line. In this locality the bees were nesting in a low bank of hard, sandy conglomerate about sixty yards from a permanent stream. The bank was about four feet high and twenty-five or thirty feet long (Fig. 1).

A second locality was along Caliente Creek, about twenty miles southeast of Bakersfield, Kern County, near the entrance to the Tehachapi Pass. In this area the bees were nesting along a high, clay and sandstone bluff within 75 feet of a stream (Fig. 2). The population was distributed in a number of dense separate groups. Between the bluff and the stream, flowers were abundant, particularly *Lupinus* sp. and *Salvia carduacea* (March and April) and *Phacelia* sp. (May), but only the last two were utilized for pollen.

The third area (type locality) was near the junction of Deep Creek and the Mojave River, at the base of the San Bernardino Mountains. Here the bees were nesting in the middle of a moderately well-travelled dirt road. The location of the colony made a close examination impossible and observations in this area were confined to flight behavior, pollen visits and a study of the parasites flying about the nesting sites. The females, as in the Bakersfield area, collected pollen from *Salvia carduacea,* a fact which necessitated a flight of more than a mile from the nesting region.

HORNIA BOHARTI Linsley

Figs. 3, 4

Hornia boharti is the most important of the meloid parasites of *Anthophora linsleyi.* In the Bakersfield area 24 per cent and near Little Lake 15 per cent of the cells examined were found to be infested with this species. The adult beetles are wingless (Fig. 4) and ordinarily never come to the surface of the ground. The normal life is two years, the first winter and most of the following year being spent as a fifth instar larva (Fig. 3) within the intact exuviae of the fourth instar. In the winter of the second year, the larva transforms to the sixth instar within the fourth and fifth larval skins. Pupation follows and the second winter is passed as an adult within the exuvial capsule. In early February the male cuts a lateral hole in the side of his cell and tunnels along the edge of the series until he reaches a cell occupied by a female. Meanwhile, the female has cut a terminal opening in her cell sufficiently large for her head and antennae to protrude. The male enters through this hole and copulation takes place within the cell. The period of copulation ranges from a few minutes to half an hour, after which the male leaves and may or may not mate with another female. Occasionally the female will receive another male. After mating, the female almost immediately begins oviposition. This process continues for as long as eight weeks, during which time an average of 549 eggs is laid. Under laboratory conditions, the incubation period averaged forty-three days and eclosion of the larvae extended over an equal period. The primary larvae crawl past the dead or dying female and work their way to the surface of the ground. Here they are very active, even in the hot sun, and if suddenly displaced by wind, are capable of spinning a fine silken thread which can support their weight. The larvae, when moving over the surface of the ground, continuously elevate their heads and spread their mandibles. When contact with a bee has been made they attach themselves to single hairs by means of their toothed mandibles. Upon male bees, the larvae are most commonly found on the ventral hairs of the thorax, on female bees, they are usually atached to those of the propodeum. Whether or not there is an exchange of larvae during copulation has not been established, although the position of the larvae at least suggests this possibility.

The primary larva gains access to the host cell through the medium of the female bee. When it is finally enclosed in the cell, it locates and destroys the bee egg. Immediately after the egg has been consumed, the larva migrates to the upper, dry portion of the cell and transforms to the second instar (all laboratory attempts to induce this development in the absence of an insect egg were unsuccessful). The third and fourth instars follow rapidly while the store of pollen and nectar is consumed. The orange-colored fifth and sixth instars are inactive and remain within a capsule of exuvial skin.

The most important competitor of *H. boharti* in the Bakersfield area was *Nemognatha apicalis*. However, although it was found that both species are commonly introduced into the same cell by the host bee, in every case investigated only the *Hornia* larva was successful in reaching maturity. No secondary parasites of *Hornia* were found in any of the areas under observation, although, in one case, larvae of *Hylemyia cilicrura* were observed to feed upon the eggs.

NEMOGNATHA APICALIS Le Conte

Fig. 5

Nemognatha apicalis is the second most important meloid parasite of *Anthophora linsleyi*. In the Bakersfield area 5.79% of the cells examined were infested with this species although near Little Lake, the percentage of parasitism was only 0.31%. From the time when the primary larva gains access to the bee cell, the early larval development is similar to that of *Hornia*. The winter is passed in the fifth larval instar. This overwintering larva is about the same size as that of *Hornia boharti*, but is reddish in color and is distinctly concave on the ventral surface (Fig. 5). Like *Hornia*, it is an inactive form which remains enclosed in the exuviae of the fourth instar. Transformation of the sixth instar occurs in the spring, within the exuviae of the fourth and fifth instars. This larva may then either transform directly into a pupa, or into a seventh instar. In the former case, the life cycle is usually completed in a single year, but in the latter, it is capable of an indefinite extension of time (one or more years). The seventh instar larva is protected by a tough, dark, resistant capsule formed by the exuviae of the fourth, fifth and sixth instars, the latter two exuviae being very closely adherent. In either case, the adults emerge in late March and early April and fly to flowers, particularly those of the Compositae. Their food appears to consist solely of nectar, and in the laboratory they may be kept alive for weeks by feeding them with a solution of honey and water. Under field conditions the eggs are laid on flowers but the method by which the primary larvae gain access to the bee cells has not yet been established. In the area where the infestation was greatest, the *Anthophora* and *Nemognatha* were visiting different flowers. It is possible, as Pierce (1904) has suggested for rhipiphorid beetles, that the young larvae gain access to the proper bee flowers by transportation on more catholic, polytropic hosts.

LYTTA OCCIPITALIS Horn

Fig. 6

Lytta occipitalis is one of the characteristic meloid species of the southern San Joaquin Valley. As a parasite of *Anthophora linsleyi,* it has been found only in the Bakersfield area, where 1.45% of the cells examined were infested. The primary larvae, having gained access to the host cell, develop very rapidly but may require the contents of more than one bee cell in order to complete their growth. As fully fed fourth instar larvae they leave the anthophorid series and construct an overwintering cell an inch or more behind the bee burrow. This cell is larger than that of the host bee, averaging 10 x 22 mm. in internal dimensions. The winter is passed as a naked, fifth instar larva (Fig. 6) with the exuviae of the fourth instar attached to the apex of the abdomen. This larva is entirely inactive and lies motionless on its dorsum. In the late spring (April) it transforms into a more active but non-feeding sixth instar (Fig. 6). It remains in this stage for from two to three weeks during which time it tunnels toward the surface and constructs a pupal cell. Pupation follows and normally requires about eight days. The adults emerge in early May and feed on the petals of flowers and to some extent upon pollen. They are gregarious, gathering on plants, where mating takes place. Presumably the eggs are deposited in or on the ground and the primary larvae crawl up the plants to contact the host, but this fact was not definitely established. In the laboratory a few egg masses were obtained in glass vials.

LYTTA PURPURASCENS Fall

Fig. 7

Lytta purpurascens occur in the southern San Joaquin Valley and has been recorded from as far south as San Diego County. Near Bakersfield 3.82% of the cells of *linsleyi* were infested with this species.

Its biology is similar to that of *L. occipitalis,* but the adults emerge a month or more earlier, usually in March. They gather gregariously on flowers of *Lupinus* and *Salvia.*

LYTTA CHLORIS Fall

Lytta chloris is smaller than *L. purpurascens* and the adults are brilliant green with cinerous pubescence. Its life history is very similar to that of the two previous species, but due to its smaller size, the larva requires the contents of but a single bee cell. As a parasite of *Anthophora linsleyi,* this species was found only in the Bakersfield area, where but 0.92% of the cells examined were infested.

TROGODERMA AJAX Casey[2]
Fig. 8

Trogoderma ajax is primarily a scavenger in old used cells of *Anthophora*. The larvae feed on old exuviae, insect parts, dead insects and occasionally unused pollen. The writers have never observed them attacking living insects or found any evidence to suggest that this ever takes place. However, they are not infrequently responsible for the death of bees by prematurely cutting into cells and exposing the occupants to the external environment or to mold and other parasites or predators. The length of the life cycle varies as does the number of larval instars. Pupation occurs in the last larval skin (Fig. 8) and the adults emerge and are active during March, April, May and June.

PTINUS CALIFORNICUS Pic
Fig. 9

Ptinus californicus has been reared by the authors from the cells of two other species of *Anthophora* in both of which it is uncommon. Normally, it is a depredator in the nests of Osmiine bees. It was found at Bakersfield in only 4.21% of the *Anthophora* cells examined and was taken only in those areas where the host population was most dense. In the nests of *Osmia*, the species passes the winter in the adult stage within cocoons. Emergence is accomplished in early spring by means of two steps; the first involves cutting a terminal hole in the cocoon, the second, making a single lateral hole in the cap of the bee cell. The beetles are not synchronous with their host and adults may be taken several weeks prior to the emergence of the bees. They are active in late afternoon when they emerge in large numbers from cracks, crevices and bee burrows and wander about on the face of the cliffs. Mating takes place on the surface of the ground. After mating the female deposits her eggs directly in the open cells being provisioned by the bees even though the bee is usually present in the burrow at the time. The eggs hatch after an incubation period of 18 to 20 days and the young larval bee dies, probably either as a result of starvation or the liberation of toxic substances in the food mass. The period of larval development varies with the amount of available food and climatic factors, although under optimum conditions, it is completed in about eight weeks. There are five larval instars and during the fourth instar, the larva constructs a cocoon among its thread-like feces (Fig. 9), attaching the cocoon to the side of the bee cell. The cementing material is secreted from the anal opening and when dry, is brittle and semi-transparent. The average number of beetles in a single *Osmia* cell is four, but variation from one to six has been observed. In the nests of *Anthophora linsleyi*, *Ptinus* is not usually a depredator, but lives mainly in old cells, particularly those which had been previously occupied by *Hornia*. Under these conditions, the larvae feed upon fecal pellets and old pollen and only one larval occupant occurs in a cell. No parasites of *Ptinus californicus* were taken in the Bakersfield area but a small chalcidoid wasp has been reared from their cocoons in the nests of *Osmia lignaria* Say at Pittsburg, California.

2 Identification by H. S. Barber.

ORYZAEPHILUS SURINAMENSIS (Linn.)

Near Little Lake larvae or adults of this common storage pest were found in five cells of *Anthophora linsleyi*. They appeared to be feeding upon old pollen.

STEGOBIUM PANICEUM (Linn.)

This species, like the preceding, probably feeds on the pollen store of the bee. Near Little Lake, adults and larval remains were found in a single cell of *A. linsleyi*.

ANTHOCOPA XEROPHILA (Cockerell)[3]

Anthocopa xerophila is one of a number of species of Osmiine bees which are associated with anthophorids through the appropriation of their used burrows. The *Anthocopa* cells are constructed with macerated plant material, and provisioned with moist pollen upon which the egg is laid. The young larvae complete their growth in a few weeks and spin a tough yellowish cocoon. Pupation and transformation to the adult occur in the spring. Near Little Lake, hundreds of *xerophila* were flying about the nesting site of *A. linsleyi*, and in some areas of the bank, a large proportion of the old but intact burrows had been appropriated. Our observations suggest that the *Anthocopa* have little effect upon the population of *Anthophora* except through the possibility of introduction or overflow of new parasites or predators. The presence of *Ptinus californicus* in the nests of *A. linsleyi* near Bakersfield may well have been the results of such a relationship since the *Ptinus* is normally associated with Osmiine bees.

MELECTA CALIFORNICA Cresson
Fig. 10

This parasitic anthophorid is widely distributed along the Pacific Coast of North America. It is commonly associated with *Anthophora urbana* Cresson (Linsley, 1939) but has been reared by the writers from the nests of *A. edwardsii* Cresson and *A. stanfordiana* Cockerell as well as from those of *A. linsleyi*. The female deposits her egg just inside the opening of the uncompleted cell of the host. The *Melecta* egg is similar to that of *Anthophora linsleyi* but smaller and is attached to the wall of the cell by one end. The incubation period of the egg is shorter than that of the host and the hatching larva destroys the egg of the latter by means of its long, slender mandibles. The *Melecta* larva then consumes the pollen store and when mature, constructs a large cocoon (Fig. 10), which completely fills the cell. This cocoon is tough, brown and uniform in texture, quite unlike that of other associated parasites. The winter is passed as a prepupal larva within the cocoon and pupation occurs in the spring. The pupa, in contrast to that of its host, has a pair of spiny tubercles on the mesonotum, and is capable of considerable activity. Under laboratory conditions the pupal period averages 30.5 days. The adults emerge in April and May and the peak of their activity is from four to six weeks after the emergence of their host. They are numerous about the nesting site and commonly visit flowers in search of nectar. The larvae are

[3] Identified by C. D. Michener.

subject to secondary parasitism by most of the parasites of *Anthophora linsleyi*, particularly *Photopsis* and *Anthrax*.

TRIEPEOLUS MOJAVENSIS Linsley

Little is known of the biology of this species other than that it is a parasite of *Anthophora linsleyi*. It was found both at Deep Creek and near Bakersfield. The percentage of parasitism in the latter locality was only 0.39%. In the former area three examples, all females, were taken flying about the nesting site and exploring burrows.

PHOTOPSIS AURARIA (Blake)*

This species is the commonest mutillid parasite found associated with *Anthophora linsleyi*. The adults are noctural and are active toward the close of, or immediately following, the anthophorid season. The female burrows into the bank along the side of a completed *Anthophora* series and cuts a conical pit at the basal (pollen) end of a cell. Through this opening the ovipositor is inserted and the egg is laid. The young *Photopsis* larva usually attacks the prepupal bee. Upon the completion of feeding and growth, it spins a loose network of threads within the cell wall. Within this framework a tough, brown, diagonally-placed cocoon is constructed. The winter is passed in this cocoon and pupation occurs late in the following spring or early summer (average length of pupal period: nineteen days). The percentage of parasitism near Little Lake was 2.19% of the cells examined, near Bakersfield, 2.50%. In both areas the species was also reared from *Melecta californica*, but whether or not it attacks non-hymenopterous parasites of *linsleyi* is unknown. The *Photopsis* itself is frequently subjected to parasitism by *Monodontomerus montivagus* and as many as 21 specimens have been reared from a single cocoon.

PHOTOPSIS SERCUS Viereck*

One male reared from a cell of *A. linsleyi* near Bakersfield, Calif.

CHRYSIS (CHRYSIS) sp.

In the locality near Bakersfield, three cells of *A. linsleyi* were found which contained fragments of *Chrysis (Chrysis)* sp. It was not possible to identify the species with certainty and there were no active adults in the area at the time (late March and early April).

CHRYSIS sp.

This species was also represented by fragments in three cells of *linsleyi* from near Bakersfield. It is probable that neither this nor the previous form is an important parasite of the *Anthophora*.

MONODONTOMERUS MONTIVAGUS Ashmead

Monodontomerus montivagus is a common parasite of bees, particularly of the gregarious anthophorids. In the Bakersfield area 0.52 % of the cells of *A. linsleyi* were parasitized; at Little Lake 0.26%. The females hibernate in

* Identified by C. E. Mickel.

the nesting area and oviposit in early spring. In the field the number of individuals in a cell averaged 26 for females and 40 for males. Cells containing females outnumbered those with males in a ratio of three to one, and only one call with mixed sexes was encountered (23 ♀♀, 7 ♂♂). The pupal period requires from 18 to 20 days. Emergence of both sexes occurs in late spring, with the males preceding the females by a few days. Mating takes place immediately upon the appearance of the females and the latter mate only once although a male may fertilize several females. Copulation is preceded by a preliminary "courtship" pattern. The male assumes a position far forward on the back of the female, with his mouthparts in the space between her head and thorax. The front legs grasp the neck and the hind legs are free in the air. The antennae are then placed between those of the female, laid flat on the front of her head and then vibrated rapidly on her face. After several minutes of this activity, the female extends the tip of her abdomen, the male dismounts, and copulation takes place for a few seconds. The males do not seem to be able to distinguish between mated and virgin females and spend much time in unsuccessful "courtship" of those which have already mated. Although the males usually die within a few days after mating, the females are long-lived and spend the day on the surface of the cliffs, flying about and crawling into burrows. Oviposition apparently does not occur until early in the following spring. The first instar larvae have been recovered from the intersegmental membranes of prepupal bees. Normally only the prepupal stage is attacked but in one case, the writers reared *Monodontomerus* from an unemerged adult *Anthophora*. As a parasite of *A. linsleyi,* this species is relatively unimportant. However, as a secondary parasite of *Photopsis* it was found in 37 per cent of the cells examined. Only about half as many *Monodontomerus* emerge from a single *Photopsis* cocoon as from a normal cell of *Anthophora*. Since the *Photopsis* are active after the bee season and tunnel into the banks in order to oviposit, the *Monodontomerus*, which lay their eggs even later, have ready-made access to the same cells. This probably explains the high percentage of parasitism in *Photopsis*.

ICHNEUMONIDAE (Gen. et sp. incert.)

In two cells of *Anthophora linsleyi* from near Little Lake, dead pupae of an undeterminable ichneumonid were found. Its status as a parasite of the bee is unknown.

HYLEMYIA CILICRURA Rondani[4]

Hylemyia cilicrura was found associated with *Anthophora linsleyi* near Little Lake where 2.7 per cent of the cells were affected. The flies were taken as full-grown larvae, pupae and freshly-emerged adults in the first week of April, and adults continued to emerge in the laboratory for a period of three weeks. The pupae were commonly found in the surrounding earth or burrows at a distance of from one-half an inch to an inch away from the host cell. The number of individuals varied from one to five with an average of four

[4] Identified by C. H. Curran.

to each cell. Frison has recorded a related Anthomyid, *Pegomyia affinis* Stein, from the cells of *Anthophora abrupta* Say, and interpreted the association as being that of a scavenger on old pollen and other detritus in the cells. *Hylemyia cilicrura* is known in economic literature as the seed corn maggot (for an account of its life history, immature stages, etc., see Hawley, 1922). It attacks a variety of young plants and is also said to breed in decaying vegetation and in manure. This or a related species was recorded by Riley (1878) as feeding upon locust eggs in Kansas and other western states. Near Little Lake two larvae, taken by the authors, were feeding on a freshly-laid egg mass of *Hornia boharti* and several others on prepupal and pupal bees. However, in the latter cases it was not possible to determine whether or not the flies had been responsible for the death of the bees. Thus, the exact status of this species as a parasite or scavenger has not been established, but its effects, if any, are probably slight.

ANTHRAX sp. near FUR O. S.[5]

Fig. 12

This species was the only observed Bombyliid attacking *A. linsleyi.* The adults have the same period of activity as the bees and spend most of their time about the nesting area. Mating takes place during the warmest part of the day. The pairs remain in copulation for a considerable period of time and when disturbed they will fly away without separating. After each mating, the female hovers about the nest entrances and throws two or more eggs into each burrow. No discrimination between old and new burrows was evident. The incubation period of the eggs and the activities of the primary larvae were not determined. However, the latter apparently do not attack the bee immediately, but wait until it has attained the prepupal stage. The larvae are usually found attached to the intersegmental membrane behind the head. When ready to feed, they pierce this membrane and consume the body contents of the bee. On one occasion an immature bombyliid larva was found attacking a bee pupa, further evidence that they wait a considerable length of time before attacking the host. Full-grown larvae may occasionally be found in March although most individuals have pupated by that time. The adults emerge at about the same period as the female bees. The pupal bombyliid cuts its way to the surface of the bank by rotary motions and use of the head spines. At the surface emergence takes place and the adult fly is capable of flight almost immediately. No observations were made upon the food habits of the adults, but they were never seen to visit flowers or suck nectar.

MYOPA RUBIDA Bigot

This species of conopid is a parasite of adult *Anthophora* in the Bakersfield area. Three individuals were taken as live puparia within the abdomen of the bees. However, the percentage of parasitism is probably too low to have much effect on the total population.

5 Identified by R. H. Painter.

TINEOLA BISELLIELLA Hummel[6]

This species was found in two cells of *Anthophora* near Bakersfield. It is apparently a scavenger on old insect parts and detritus.

Plodia interpunctella (Hubner)

Plodia interpunctella appears to be a scavenger on old pollen. It was reared from one *Anthophora* cell in the Bakersfield area.

Host Relationships

The various species of insects associated with *Anthophora linsleyi* in the localities investigated may be roughly divided into several groups with regard to their host relationships as follows:

GROUP I. Scavengers living on excess pollen, insect parts, etc., in old cells; not injurious to the bee.

(1) *Stegobium paniceum*
(2) *Oryzaephilus surinamensis*
(3) *Ptinus californicus*
(4) *Tineola biselliella*
(5) *Plodia interpunctella*

GROUP II. Scavengers which do not attack living insects but which indirectly cause the death of the host by opening its cell and exposing it to the external environment.

(1) *Trogoderma ajax*

GROUP III. Depredators which live at the expense of the food store of the host and usually cause its death.

(1) *Ptinus californicus*

GROUP IV. Facultative predators which may either feed on the eggs of the host or may be a scavenger upon vegetable materials.

(1) *Hylemyia cilicrura*

GROUP V. Species which are egg predators in the first instar, pollen feeders in subsequent instars.

(1) *Hornia boharti*
(2) *Nemognatha apicalis*
(3) *Lytta occipitalis*
(4) *Lytta purpurascens*
(5) *Lytta chloris*
(6) *Melecta californica*
(7) *Triepeolus mojavensis* (?)

GROUP VI. External parasites or predators of larvae or pupae.

(1) *Anthrax* sp. near. *fur*
(2) *Chrysis (Chrysis)* sp.
(3) *Chrysis* sp.
(4) *Monodontomerus montivagus*
(5) *Photopsis auraria*
(6) *Photopsis sercus*

GROUP VII. Internal parasites of larva.

(1) Undet. Ichneumonid.

GROUP VIII. Internal parasites of adult.

(1) *Myopa rubida*

---

[6] Identified by H. H. Keifer.

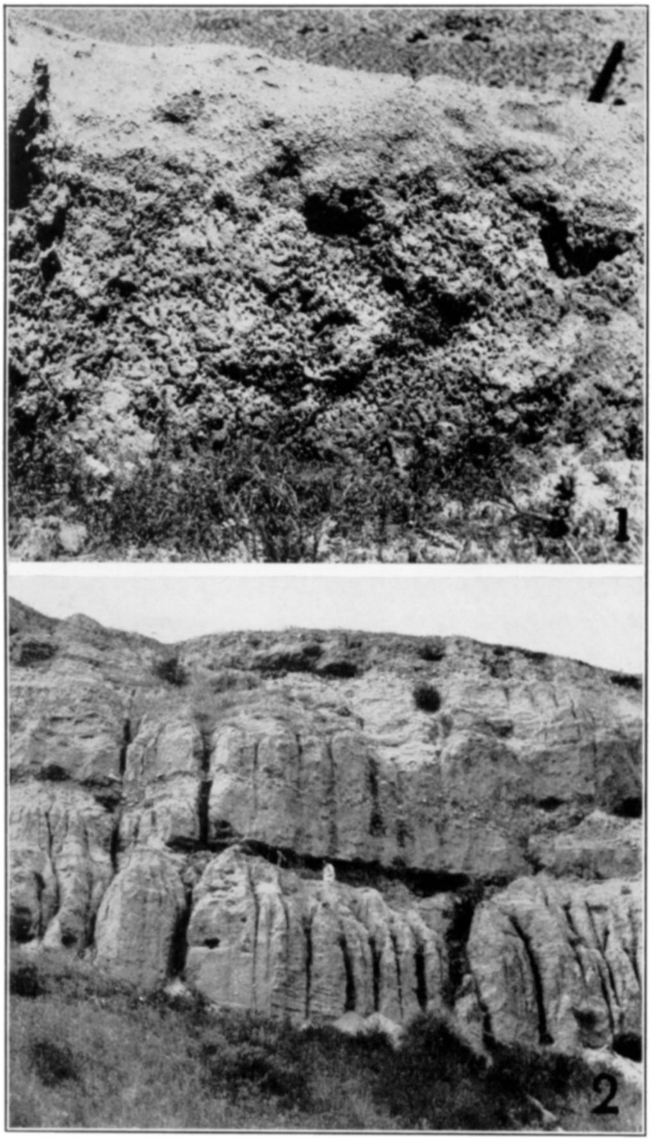

Fig. 1. Nesting site of *Anthophora linsleyi* Timb. near Little Lake, Inyo County, Calif.

Fig. 2. Nesting area of *Anthophora linsleyi* Timb. near Bakersfield, Kern County, Calif.

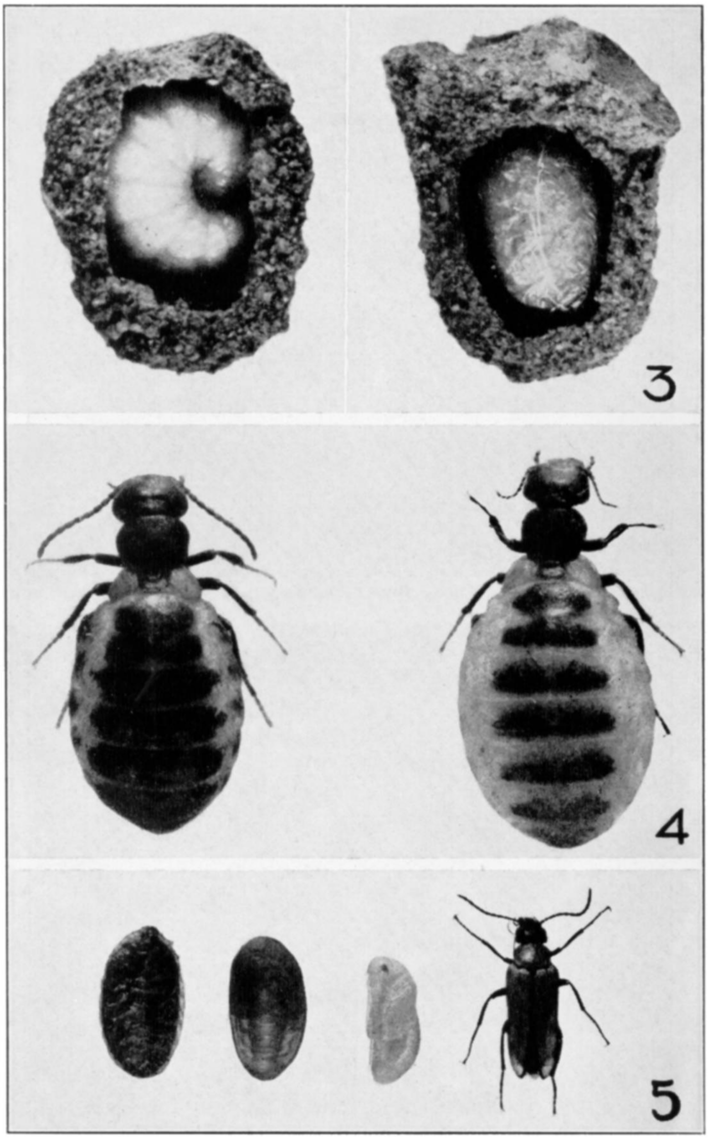

Fig. 3. Cells containing prepupal larva of *Anthophora linsleyi* Timb. (left) and fifth instar larva of *Hornia boharti* Linsley (right), ×3.

Fig. 4. *Hornia boharti* Linsley. Adult male, left, adult female, right, ×5.

Fig. 5. *Nemognatha apicalis* Lec. Fifth instar larvae within exuvial capsule (left) and removed from exuvial capsule (left center), pupa and adult, ×2.

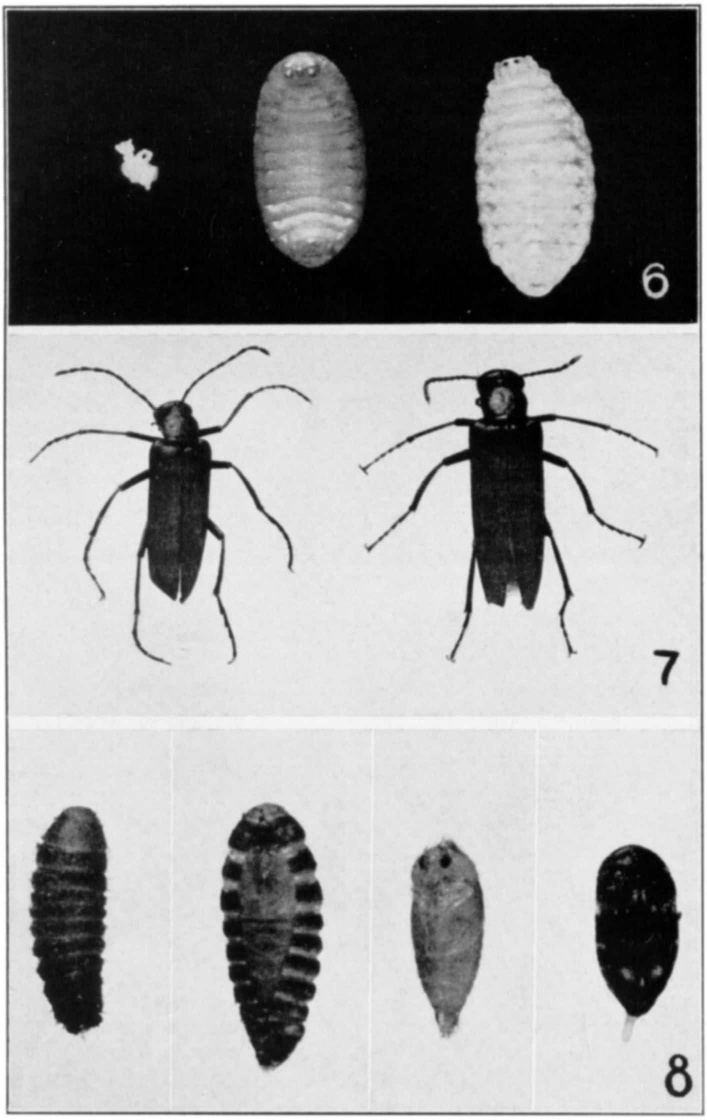

Fig. 6. *Lytta occipitalis* Horn. Eggs, (left) fifth larval instar (center), sixth larval instar (right).

Fig. 7. *Lytta purpurascens* Fall. Adult male (left) and female (right).

Fig. 8. *Trogoderma ajax* Casey. Larva (left), pupa within last larval skin, pupa removed from skin, adult (right).

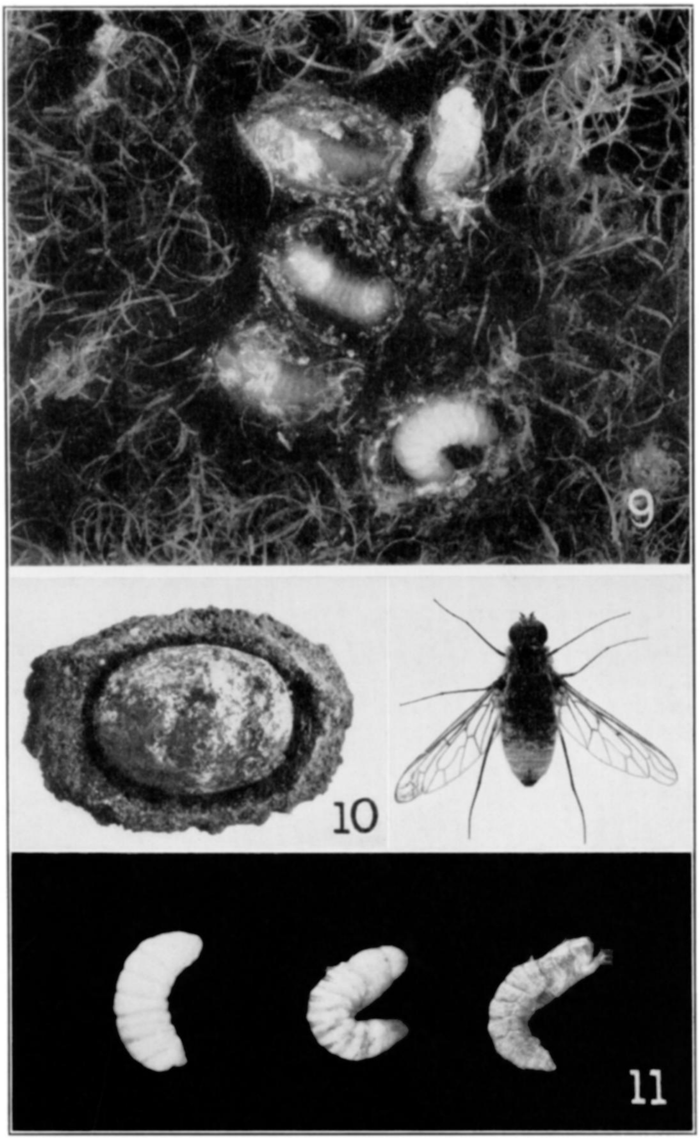

Fig. 9. *Ptinus californicus* Pic. Larvae and pupae in mass of fecal strands.

Fig. 10. *Melecta californica* Cresson. Cocoon within cell of *Anthophora*.

Fig. 11. *Anthrax* sp. nr. *fur* O. S. Adult (above), larva (lower left), pupa (lower center), pupal skin (lower right).

REFERENCES

FRISON, T. H. 1922—Notes on the life history, parasites, and inquiline associates of *Anthophora abrupta* Say, with some comparisons with the habits of certain other *Anthophora*. Trans. Am. Ent. Soc. **48**:137-156.

HAWLEY, I. M. 1922—Insects and other animal pests injurious to field beans in New York. Cornell Agr. Exp. Sta. Mem. **55**:949-1037, pls.

HICKS, C. H. 1926—Nesting habits and parasites of certain bees of Boulder County, Colorado. Univ. Colo. Studies **15**:217-252.

LINSLEY, E. G. 1939—A revision of the Nearctic Melectinae. Ann. Ent. Soc. Am. **32**:429-468.

——— AND J. W. MACSWAIN. 1942a—The bionomics of *Ptinus californicus*, a depredator in the nests of bees. Bull. So. Calif. Acad. Sci. **40** (in press).

———1942b—The bionomics of the meloid genus *Hornia*. Univ. Calif. Pub. Ent. (in press).

MICKEL, C. E. 1928—The biotic factors in the environmental resistance of *Anthophora occidentalis* Cresson. Ent. News **39**:69-78.

PIERCE, D. W. 1904—Some hypermetamorphic beetles and their hymenopterous hosts. Nebr. Univ. Studies **4**:153-190, pl. 1.

RAU, PHIL. 1922—Ecological and behavior notes on Missouri insects. Trans. Acad. Sci. St. Louis **24**(7):1-71, pls. 1-8.

———1926—The ecology of a sheltered clay bank; a study in insect sociology. Trans. Acad. Sci. St. Louis **25**:157-260, pls. 14-21.

———1929—The biology and behavior of the mining bees, *Anthophora abrupta*, and *Entechnia taurea*. Psyche **36**:155-181, figs. 1-15.

RILEY, C. V. 1878—The Anthomyia egg-parasite (*Anthomyia angustifrons*, Meigen). 1st Rept., U. S. Ent. Comm., pp. 285-289.

TIMBERLAKE, P. H. 1941—A new species of *Anthophora* from California. Pan-Pac. Ent. **17**:34-36.

DEPT. OF ENTOMOLOGY AND PARASITOLOGY,
UNIVERSITY OF CALIFORNIA,
BERKELEY, CALIFORNIA.