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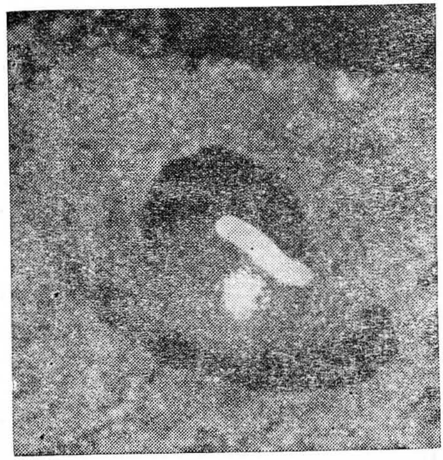
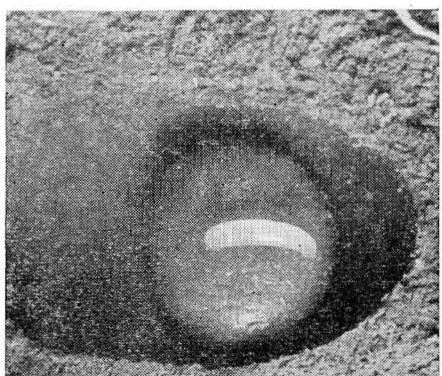


Fig. 1. Pollen ball and egg of Nomadopsis scutellaris (Fowler).

Fig. 2. Pollen ball and egg of **Halictus farinosus** (Smith).



Dietary Problems

THE THREE KNOWN species of **Apis** are the only bees that feed their young with glandular secretions rather than pollen and honey. The larvae of queen honeybees receive nothing but this royal jelly. Some authorities state that the larvae of drones and workers receive principally pollen and honey after the first two days, but others claim that the diet continues to come from the glands of the workers.

Stingless bees produce more "queenly" queens than honeybees but, so far as anyone knows, both queen and worker larvae are fed nothing but pollen and nectar. However, the queens are fed more generously. The same situation seems to hold true for bumblebees. If they add glandular secretions to their larval diets, we have yet to find out about it.

Only honeybees, bumblebees, and the xylocopid genus **Allodape** feed their young progressively. Their nursing habits will be discussed in a later chapter on social behavior. All the other bees, even the highly social stingless bees, practice mass provisioning; that is, they completely provision each cell, then lay an egg among the provisions, and seal the cell. Of course, the cuckoo bees don't have to bother with provisioning at all.

Setting the Table

Bees vary greatly in the way they lay eggs and store food in the cells. Many genera and even some species can be distinguished on these characteristics alone. Most of them fashion their provisionings into more or less uniformly shaped balls or loaves of honey-moistened pollen. However, bees in the most primitive family (Colletidae) simply pack the food into the end of the cell. The rations they prepare are usually too "soupy" to hold much shape anyhow. Strangely, the same habit reappears among the long-tongued bees, but that gets us ahead of our story.

Let's look more closely at the pollen balls that are so neatly and uniformly prepared by most of the short-tongued solitary bees. The mother bee's main object in shaping her provisions into a ball seems to be to reduce the area of contact between food and cell. There is always danger that moisture will be withdrawn from the food by the cell or absorbed into it from the cell, in the first case drying out the food and in the second producing a soupy mess.

In general, pollen balls are given the best form in cells that provide the least protection from changes in moisture. **Nomadopsis,** which makes unlined cells, prepares perfectly spherical balls that appear to be coated with a fine waxy film (Fig. 1). **Dasypoda**, a European member of the family Melittidae, which also makes unlined cells, reduces the zone of contact between cell and food by fashioning three little legs under its pollen balls. Members of the huge genus **Andrena** usually make spherical balls even though their cells are partially varnished. Halictids stick with the ball shape but show more individuality. For example, species of **Halictus** generally make a short, rounded-off block, with a slight saddle on the top (Fig. 2). The alkali bee, **Nomia melanderi**, makes a grapefruit-shaped ball resting on the bottom of the cell (Fig. 5). **Nomia nevadensis** fashions a rim around the equator of the ball by which it is suspended from the walls of the cell (Fig. 3). This appears to be a biological character of subgeneric significance.

With a few exceptions bees in the long-tongued families do not make ball-shaped provisions. Carpenter bees (Xylocopidae) make a loaf-shaped pollen mass. The other families (Megachilidae, Anthophoridae, and Apidae) generally pack their provisions into the end of the cell. Among the exceptions are the Old World long-horned bees in the genus **Eucera** (Anthophoridae). They make pollen balls like the Andrenidae and in

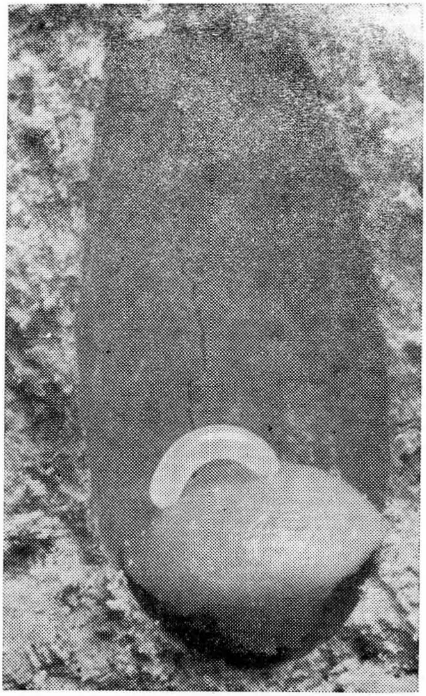


Fig. 3. Brood cell of Nomia nevadensis Cresson with pollen ball and egg.

Fig. 4. Pollen balls of Diadasia enevata (Cresson). Note egg in groove at bottom of each ball.

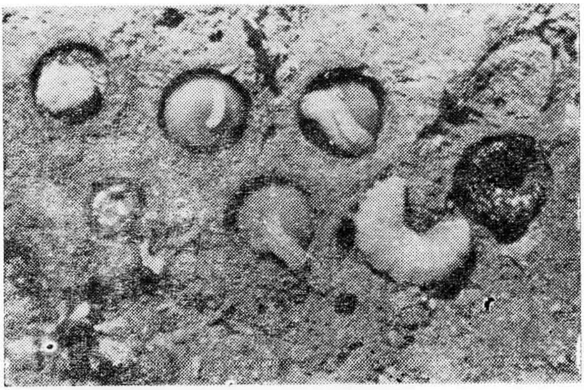
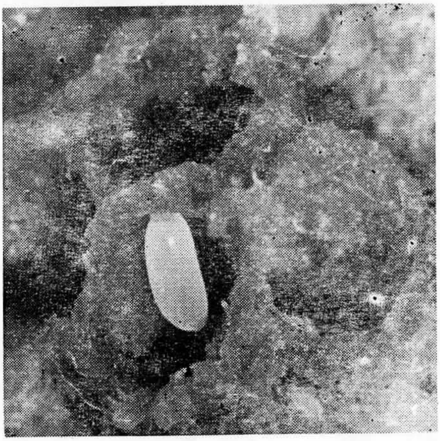
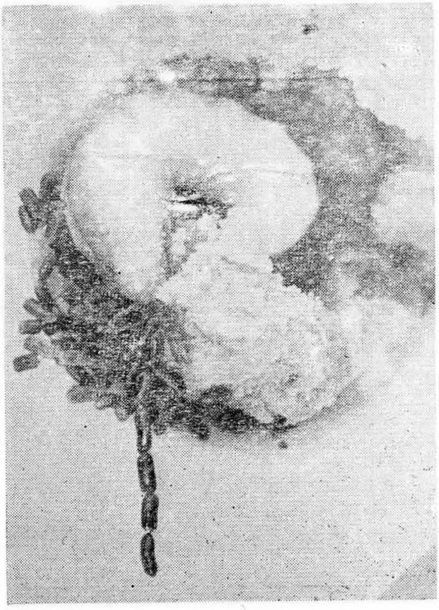


Fig. 5. Horizontal section through a series of brood cells of the alkali bee, Nomia melanderi Ckll. Left to right (1) finished pollen ball, (2) mother bee in main burrow, (3) pollen ball and egg, (4) second-or third-instar larva, (5) young fourth-instar, larva, (6) full-grown larva (fourth instar), (7) "diseased" larva.



that regard seem to show a relationship to the short-tongued bees. There are other oddities among the Anthophoridae. **Diadasia** and several related genera fashion a pollen ball that fits into the cell like a finger in a glove, but it is formed as an independent body instead of being merely packed into the end of the cell (Fig. 4. **Anthophora**

Fig. 6. Brood cells of Bombus nevadensis Cresson. Early nest of queen with her first completed cell opened to show egg.



and its near relative **Emphoropsis** drown their pollen mass in a watery liquid. You could never mistake their cells once you have smelled the peculiar fermented odor of that liquid. It can still be detected in nesting sites abandoned for years.

So far as we know, all the Megachilidae pack their provisions into the end of the cell. Some store a thick gruel and others make a heavy dough dusted with dry pollen. Most of the bees that pack their pollen into the cell leave a slightly concave surface at right angles to the long axis of the cell. However, some of the megachilids leave a slanted surface.

Fig. 7. Two-thirds grown larva of Osmia lignaria Say feeding and defecating.

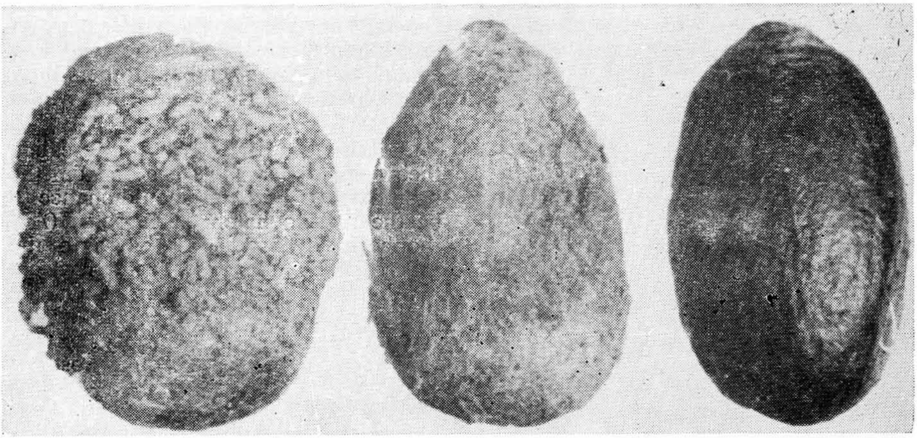


Fig. 8. Three cocoons of Osmia texana Cresson, showing outer, middle, and inner layers, Outer layer with fecal pellets.

Egg Laying

Bees lay their eggs in almost as many different ways as they provision their cells. Honeybees, most bumblebees (Fig. 6), and **Allodape** lay their eggs before supplying food to the nursery. All the others, except for cuckoo bees, lay their eggs on or in the food supply. When the provisions are liquid, as in the case of **Hylaeus**, the egg is merely floated on the surface. When the food is solid, the egg is usually laid on top in the form of a drawn bow, with both ends touching the food (Fig. 3). The arch is sometimes made more pronounced by a depression in the middle of the ball. Some of the species that pack their pollen into the cell achieve the same result by arching their eggs over the concave surface. **Diadasia** and its relatives (Anthophoridae) break from tradition by fitting their egg into a

Fig. 9. First-instar larva of Nomadopsis scutellaris (Fowler) starting to feed.

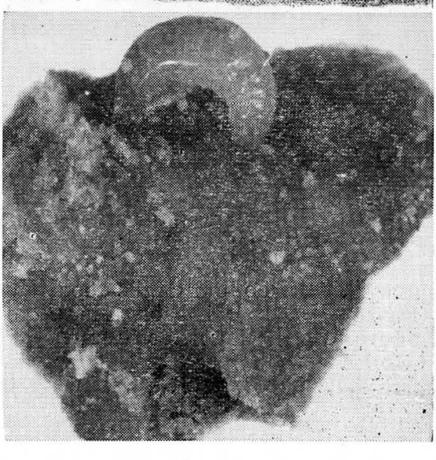


Fig. 10. First-instar larva of Osmia lignaria Say starting to feed.

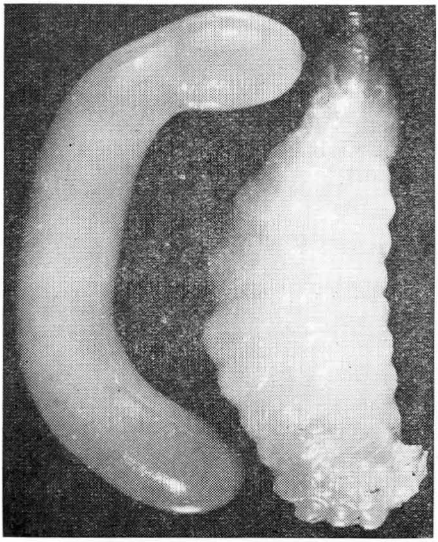


Fig. 11 Full-grown larva of the alkali bee with its mid-gut removed.

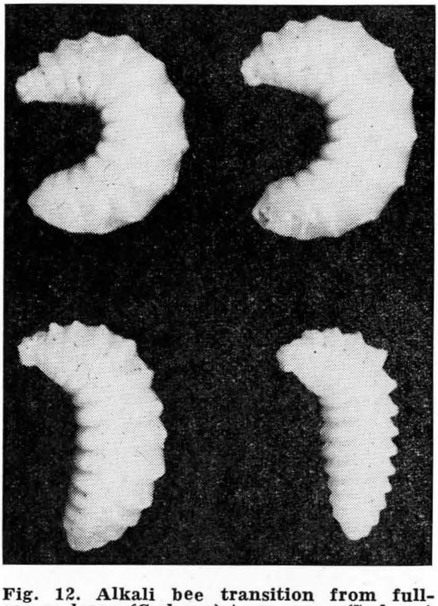


Fig. 12. Alkali bee transition from full-grown larva (C-shape) to prepupa (7-shape)

groove at the bottom of the food mass (Fig. 4). They probably shape the groove with the tip of the abdomen just before laying the egg. Megachilids display the same sort of individuality in egg laying that they show in selecting nesting materials. Within the genus **Osmia**, some species float their eggs on top, others poke the posterior end into a small depression, and still others bury it in a pocket at the center of the food mass.

Parasitic bees are adept at concealing their egg from the host bee or from the host larva, if the latter should chance to be the first to hatch. **Triepeolus** (Anthophoridae) inserts her egg into the wall of a **Melissodes** cell and **Melecta** (Anthophoridae) hangs hers from the ceiling of an **Anthophora** cell. Other cuckoo bees conceal their eggs in the food mass of the unsuspecting host.

Raising Bees

Few epicures are more exacting than bee larvae. Let the loaf of pollen become ever so slightly dry or fermented or dusted with a few specks of soil, and the larva sickens and dies. It is usually disastrous to disturb a cell containing an egg or young larva. You can see from this that the mother bee must arrange uniform conditions for her offspring for the week or two it takes them to complete their growth.

The eggs and larvae of megachilids are much tougher and more liberal in their requirements than those of other bees. With reasonable care you can transfer them from one food mass to another and rear them at ordinary room temperatures if the relative humidity is kept somewhere above 50 per cent.

Most bees that nest in the soil have more delicate and sensitive larvae than those that nest in twigs or other above-ground situations. If eggs are moved from cells in the soil, they may not hatch. If the young larvae lose their original position, they may never resume feeding. Variations of more than a few degrees from their accustomed narrow range of temperature and humidity are likely to stop their development.

Larval Growth

First-and second-instar larvae of bees generally retain their original attachment to the egg while feeding. The young larvae of andrenids and halictids hug the food mass with leg-like protrusions of the body segments (Fig. 9). Young megachilid larvae arch them-

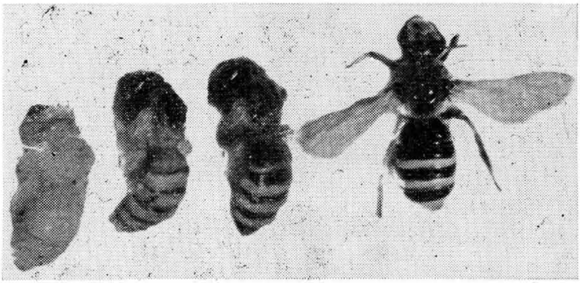


Fig. 13. Three alkali bee pupae, showing progressive pigmentation, and a freshly emerged female with her wings still unhardened.

selves in a C-shape above the food mass (Fig. 10). Young anthophorid larvae, on the other hand, usually lie in the cell in much the same position that honeybee larvae assume. This applies to those that feed on solid food as well as the ones, such as **Anthophora,** that float on a pond of liquid food.

As any beekeeper knows, honeybee larvae avoid befouling their cells with fecal material until they are through eating. Nature ensures this by not connecting their mid and hind guts until they are full grown. The same fastidiousness is characteristic of all other bees, with one glaring exception, the Megachilidae. These unsanitary creatures start producing fecal pellets when they first reach the final instar (Fig. 7). At this time they are only about half grown. They pile their pellets in one area of the cell, ready to be used as building blocks in the outer fabric of their cocoons (Fig. 8).

Most bee larvae are like cows when it comes to food—they bolt it down and digest it at leisure. After cleaning up the last scrap of food, the full-grown larva contains a tremendous mid-gut full of pollen, which must be digested and absorbed before the waste products can be eliminated and the resting period begun (Fig. 11) For many bees this takes about two days, but honeybee larvae, which eat a relatively refined diet, can defecate quickly. Megachilids take a little longer to feed than other bees, but they are ready to spin a cocoon as soon as they finish eating. In fact, they have been observed to take some final nourishment and continue defecating while making the outer framework of their cocoon.

Resting Stages

After defecating, bee larvae enter a resting stage known as the prepupal period. Those that spin cocoons must also finish that task before they earn their rest. In general, prepupae of short-tongued bees are very stiff and immobile (Fig. 12). Those of long-tongued bees are usually more curved and flacid. When undisturbed they are quiescent, but they can be stimulated to move. Some of the megachilid prepupae become quite active when disturbed.

The prepupal period may last only two days, as in honeybees, or nine or 10 months, as in most single-brooded short-tongued bees and anthophorids. In desert regions prepupae of this sort may remain unchanged for several years until moisture conditions are right at the proper season for emergence. Some species of **Andrena** and many kinds of megachilids remain as prepupae for only a few weeks, then pupate and transform to adults, only to spend the winter in their cells. In bees with more than one brood per season, it is only the final brood that undergoes such long rest periods. The pupal period for bees is always rather short. Pigmentation and hardening take place under the ivory-smooth pupal sheath in a week or two (Fig. 13). A third method of overwintering is employed by **Halictus** and its relatives and by bumblebees. They emerge in the late summer as active adults, mate, and crawl back into the soil to pass the autumn and winter. Honeybees and humans employ a fourth system of overwintering. They maintain a warm micro-environment in the winter, thus eliminating any need for hibernation.