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Chapter 12

Orchard Mason Bees

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Biology

Bees in the genus *Osmia* (family Megachilidae) have proven themselves to be effective pollinators of apples and other orchard fruits. These solitary bees nest in hollow reeds or pre-existing holes in wood such as abandoned beetle burrows or nail holes. They may nest in large aggregations if nest holes are abundant. *Osmia* bees partition cells and seal their nests with mud, chewed leaf material, or a mixture of both – hence, they are sometimes called *orchard mason bees*.

The most important member of this group in North America is the native blue orchard bee, *Osmia lignaria*. The eastern subspecies (*O. lignaria lignaria*) occurs from the eastern slopes of the Rocky Mountains to the Atlantic. The western subspecies (*O. lignaria propinqua*) occurs from the western slopes of the Rockies to the Pacific Ocean. Females of the blue orchard bee have a pair of horn-like projections extending from the lower face. The blue orchard bee is shiny blue/black and about two-thirds the size of a honey bee (Fig. 12.1). The male is about a third smaller than the female and has a white patch of hair on the face and long curved antennae. Females have no white on the face and their antennae are about half as long as those of males.

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The horned-face bee (*O. cornifrons*) was introduced from Japan into Utah in the 1960s, and from Utah to Maryland by 1978 (Batra, 1989); it has since become established in many areas of the eastern US and Canada. It has a pair of horn-like projections on the lower face.

The orange orchard bee (*O. cornuta*) was introduced from Spain to California almond orchards in the 1980s (Torchio, 1987). The female is slightly larger than the female blue orchard bee. Its most distinguishing characteristic is an abdomen coated with beautiful, bright orange hair. It also has a pair of horns on the lower face.

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Fig. 12.1. The blue orchard bee, *Osmia lignaria*. (Source: Nancy B. Evelyn.)

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O. ribifloris biedermannii is a metallic green or blue-coloured mason bee native to areas of the western and southwestern US. It is a potential pollinator of highbush blueberry (Torchio, 1990b).

Male and female orchard mason bees emerge from nests and mate in spring when temperatures exceed 50°F (10°C). Males emerge 3–4 days earlier than females and patrol nesting sites looking for females. Males will forage at flowers for nectar but accomplish little pollination. When a new female emerges, a waiting male pounces on her to mate. A female may mate with several males.

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The female finds a suitable nest tunnel and begins making cells in the back-to-back pattern typical of most solitary bees. Usually only one female nests in a given hole. Females do not forage for cell provisions unless temperatures exceed 55°F (12.8°C). The female collects nectar and pollen and makes a pollen mass in each cell. *Osmia* species carry pollen with an abdominal scopa. It takes 11–35 foraging trips to collect enough pollen and nectar for one cell. The female lays an egg, $\frac{1}{8}$ in (3 mm) long and sausage-shaped, with one end embedded in the pollen mass. After the female lays the egg, she partitions the cell from others with a thin wall of mud or chewed leaf material. Each partition takes 8–12 mud-collecting trips, and a female usually completes one cell per day. Female eggs are laid in cells towards the bottom of the tunnel and males are produced near the

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entrance; the average sex ratio is two-thirds male. After she fills the nest tunnel with cells, the female covers the entrance with a thick mud cap.

All stages of development occur between 59 and 86°F (15–30°C). Eggs hatch at about day seven. The larva eats pollen for about 30 days and then defaecates. It rests for several days then starts to spin a pinkish-white silk cocoon around itself, weaving faecal pellets into the cocoon's outer layer. In a few days the cocoon turns a dark brown colour, and after about 30 more days the larva pupates. After two weeks the pupa moults into an adult. It is these new adults that overwinter in dormancy. Temperatures in winter must be lower than 40°F (4.4°C) or adults will not be able to break dormancy and emerge in spring. Adult females provision cells and pollinate for 4–6 weeks and then die. There is only one generation per year.

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Orchard Mason Bees as Pollinators

Osmia are used for commercial crop pollination in some parts of the temperate world, most notably Japan where native *O. cornifrons* is used to pollinate orchard crops. Mason bee management in North America has not progressed much beyond the experimental or hobbyist stage in spite of research evidence that they are efficient pollinators. Early-stage studies typically measure pollinator potential by observing bee reproduction. If bees can rear a brood with the pollen and nectar from a particular crop, then the potential for pollination is there. Introductions of exotic *Osmia* into North America have met with mixed success, and commercial-scale production like that of honey bees, alkali bees, and leafcutting bees is not worked out. One recurring problem is the high number of females that disperse away from the orchard when they are released in spring. Nevertheless, these bees are good pollinators where they occur in large numbers, whether as natural or introduced populations.

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Blue orchard bees (*O. lignaria propinqua*), when introduced into California almond orchards, collect almond pollen, occupy man-made nests, and increase in population size, all of which indicates that they are potential pollinators for this crop (Torchio, 1981a,b). However, over 50% of females disperse away from the release site before nesting when they are released in February (Torchio, 1982). Orange orchard bees (*O. cornuta*) were introduced into California almond from Spain in 1984; the bees overwintered in commercial orchards, emerged in synchrony with almond bloom, nested gregariously in man-made nests, landed directly on the sexual parts of the flowers, collected almond pollen, and the immatures developed normally on provisions of almond pollen and nectar (Torchio *et al.*, 1987). But, as with blue

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orchard bees, many females dispersed away from the orchard before nesting. It may be possible to minimize spring dispersal by releasing bees in their natal nests rather than by mass-releasing them in adult emergence boxes (Bosch, 1994a). Overall, efforts to develop almond pollination with orange orchard bees seem justified; each *O. cornuta* female visits 9500–23,600 almond flowers during a season, and only three females per tree are needed to achieve maximum pollination (Bosch, 1994b).

Blue orchard bees (*O. lignaria lignaria* and *O. lignaria propinqua*) are efficient pollinators of apple because they land directly on the anthers and stigma of the blossom, thus maximizing the chance of successful pollination (Torchio, 1985). Honey bees, on the other hand, sometimes rob an apple flower of its nectar without pollinating it; this happens most often with the 'Delicious' apple variety. In North Carolina orchards of 'Delicious' apples in which *O. lignaria lignaria*, *O. lignaria propinqua*, and *O. cornifrons* were experimentally released, fruit-set was higher in areas near *Osmia* nests than in areas without *Osmia* nests, even if those areas had honey bee hives. Apples grown from areas near *Osmia* nests had comparatively more seeds and better fruit shape (Kuhn and Ambrose, 1984). However, these introduced populations of *Osmia* did not establish well in the test orchards, so the long-term benefit of these introductions was doubtful. The authors blamed this on pesticides, rain, dispersal of adults away from the site, and high mortality of immature bees from unknown causes. In a Japanese apple orchard with honey bees and horned-face bees, the horned-face bees visited more apple flowers per minute (15) than did honey bees (8.5), and in 15 min made more contact with the sexual column of flowers (105 contacts versus 4) (Batra, 1982). *O. cornuta* prefers almond pollen but will switch to apple if it is more readily available (Márquez *et al.*, 1994).

O. ribifloris are efficient pollinators when they are released in California highbush blueberry orchards (Torchio, 1990b). The female is fast-flying, and it takes at least 11 foraging trips to provision one brood cell. The bees visit flowers legitimately, working the flower with the front legs to release pollen (*O. ribifloris* does not buzz-pollinate blueberry although males 'buzz' during courtship). An *O. ribifloris* female spends about three seconds at each blueberry flower, and the bee's head morphology ensures pollen transfer between blueberry plants. In the California study, the introduced bees provisioned cells with blueberry pollen exclusively and the immatures developed normally. *O. ribifloris* females do not disperse away from the orchard as readily as do other *Osmia* species. The bees nest in man-made structures. Field-trapped bees can be overwintered and transported, and their emergence can be synchronized with blueberry bloom. The California study was not without problems.

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Death rate of immatures was high at one site and the population declined. Parasitism was high during 2 years, and male production ranged from 2.2 to 4.6 males per female (males are comparatively inferior pollinators). Nevertheless, *O. ribifloris* seems to be a good candidate for commercial pollination in highbush blueberry.

Osmia bees are promising candidates for lowbush blueberry pollination. Adult emergence in Maine is well synchronized with crop bloom, and the bees forage in a wide range of temperatures, provision nests exclusively with blueberry pollen, and successfully overwinter in the field (Stubbs *et al.*, 1994). Wild populations of *O. atriventris*, *O. inspergens*, and *O. tersula* are known visitors of lowbush blueberry in Québec, but they are probably minor pollinators (Morrissette *et al.*, 1985). *O. inermis* and *O. proxima* in Nova Scotia collect lowbush blueberry pollen to provision their cells (Finnamore and Neary, 1978).

Overall, *O. cornifrons* and *O. lignaria propinqua* have not been satisfactory pollinators of orchard crops in Washington (D.F. Mayer, unpublished data). Reproduction of spring-introduced bees in cherry and pear ranged from 10 to 50%, and bees were rarely seen visiting cherry or pear flowers. Females apparently foraged on many non-crop flowers and dispersed away from the orchards.

Recommended Bee Densities

For almond, Bosch (1994b) recommends three *O. cornuta* females per tree. For apple, as few as 250 nesting *O. lignaria propinqua* can pollinate 1 acre of apple (618 bees for 1 ha) (Torchio, 1985). For a variety of orchard fruits, Batra (1982) recommends 2834 *O. cornifrons* $acre^{-1}$ (7000 ha^{-1}). For highbush blueberry, Torchio (1990b) recommends 300 nesting female *O. ribifloris* $acre^{-1}$ (741 ha^{-1}).

Rearing and Managing Orchard Mason Bees

Orchard mason bees readily nest in man-made nesting materials such as smooth holes drilled in solid blocks of wood, hollow natural reeds, and cardboard tubes (Griffin, 1993; S.W.T. Batra, unpublished report). Regardless of the nesting material used, nest holes should be $\frac{5}{16}$–$\frac{3}{8}$ in (8–10 mm) in diameter and about 6 inches (15.2 cm) deep. Nest hole diameters smaller than $\frac{5}{16}$ in will encourage high production of males which are comparatively poor pollinators.

Cardboard tubes are especially suitable because they are relatively inexpensive, disposable, and thick enough to discourage entry of many parasites (Fig. 12.2). Paper soda straws are easily penetrated by

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nest enemies, and plastic soda straws retain too much moisture. Cardboard tubes are available from local paper supply companies or from vendors listed in Appendix 1.

Nest materials must be housed in some kind of weather shelter. It is possible to make an adequate shelter by stretching a tarp over a frame or by using a lean-to, clean empty drums, garbage cans, or overhanging eaves of buildings. Shelters must shield bee nests from rain and direct afternoon sun. The shelter opening and nest entrances should face east, south, or southeast so that the morning sun can warm bee nests and stimulate early flight. Shelters must be ventilated to prevent excess heat build-up. They should be painted a light colour, but not in a bright metallic finish because the shine may repel bees. It is a good idea to cover shelter entrances with bird netting or with $1\frac{1}{2}$–2 in (3.8–5.1 cm) chicken mesh in order to repel birds, racoons, or other animals that may attack the nests. Bird netting is the preferred material because chicken wire can damage bees' wings.

A horizontal section of white 3 in (7.6 cm) polyvinyl chloride (PVC) pipe makes a good shelter for bees nesting in cardboard tubes. One end of the PVC pipe can be cut at a 45° angle so that the top sticks out past the bottom and acts as a rain shield. The other end is closed with a plastic cap. The bottom part of the PVC pipe (the long run constituting the floor) must be at least 8 in (20.3 cm) long. One can then take standard $\frac{5}{16} \times 16$ in (0.8×40.6 cm) cardboard tubes, fold each in half to make two 8 in (20.3 cm) lengths (tunnels must dead-end or bees will not nest in them), and place a bundle of tubes

Fig. 12.2. Orchard mason bees will readily nest in cardboard tubes. Each tube is folded in half to produce two dead-end tunnels. (Source: Keith S. Delaplane.)

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Fig. 12.3. A field shelter for orchard mason bees. A section of PVC pipe is filled with cardboard nesting tubes, each of which is folded in half to make two dead-end tunnels. The front of the PVC pipe can be cut to produce an overhang for rain protection, and the back should be sealed with a plastic cap. The shelter should be securely tied to fence posts or trees so that it does not sway in the wind. (Source: Keith S. Delaplane.)

horizontally inside the PVC pipe. In the orchard, each pipe full of cardboard tubes is securely fastened on to a tree or a stand at least $2\frac{1}{2}$ ft (0.8 m) off the ground (Fig. 12.3). Shelters must not be hung in such a way that they sway in the wind. There must be a source of mud at each site so that bees will have a ready supply of mud for making nest partitions.

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If the objective is to encourage and augment existing natural populations of orchard mason bees, one simply needs to put out shelters full of empty nesting material in early spring as soon as bees become active. Chances are good that bees will nest in the shelters. If one is releasing dormant bees overwintered in nest tubes, the shelters must be placed in the orchard in early spring 3–7 days before crop bloom. If the weather turns cold and bloom is delayed, bee emergence can be delayed by putting the nest material full of bees in a refrigerator at 39–40°F (3.9–4.4°C). Bees must be removed from refrigeration 3–7 days before expected crop bloom. Adult males begin emerging shortly thereafter, and females begin emerging 2–3 days later. It is best not to move shelters once females start nesting. If they must be moved, it is preferable to move them at night and take them at least $\frac{1}{2}$ mile (0.8 km) away from the old location.

Nest materials full of developing bees should be removed from the orchard after nesting season and stored, protected from parasites and

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nest enemies, in a cool, unheated, dark place. Dormant bees must experience some freezing temperatures before they can break dormancy in spring, and ambient winter temperatures will work adequately except in areas that experience cold spells below 5°F (−15°C). During these cold snaps, it is advisable to store bees in slightly warmer conditions at 10–40°F (−12.2–4.4°C). Some growers leave dormant bees outdoors in their shelters all winter. If this is practised, it is important to screen shelter entrances to exclude nest enemies.

Bee parasites may emerge from cells during storage. It may be possible to catch these parasites with a strip of flypaper hung near a window or other source of light. If mice are a problem the nest materials must be stored in mouse-proof screened boxes.

Bees will reuse old nest tunnels, but nest materials should be replaced every 2–3 years to avoid build-up of diseases and enemies. One way to phase out old nest material is to place it, full of bees, inside a black plastic bag. When bees are ready to be released in spring, the bag of old, occupied nest material is placed in the shade towards the rear of the shelter (this method works best with spacious shelters such as old drums). The mouth of the bag is reduced just enough to let air in and bees escape, and it is turned to face towards the shelter entrance. New, clean, empty nest material is placed in front of the old material and closer to the shelter entrance. When bees return to the shelter they tend to occupy the new nest holes, ignoring the old ones at the rear. The old nest material is then discarded or, in the case of drilled solid wood blocks, sanitized in an oven.

Some experts recommend using several small nests rather than one large one because large concentrations of bees may attract bee-eating birds and raccoons or cause a build-up of parasites. Having nests in several places also improves pollination efficiency because individual orchard mason bees rarely fly beyond 300 ft (92 m) from their nest.

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