INVERTEBRATE CONSERVATION FACT SHEET

Tunnel Nests for Native Bees

Nest Construction and Management

There are many simple and successful ways to make artificial nests for native bees.

However, keeping the nests clean is important to limit disease build-up and maintain healthy bee populations.

Artificial nest sites like bamboo tubes in a plastic bucket are effective, but need maintenance. *Photograph by Eric Mader*

About 30 percent of the four thousand species of bees native to North America nest in small tunnels such as hollow plant stems, abandoned borer-beetle holes in snags, and similar locations. This includes some of our best known native bees, the blue orchard bees and leafcutters. The absence of these features in intensively farmed landscapes can limit nesting opportunities for these important crop pollinators.

Artificial nests consisting of wood blocks drilled with a large number of dead-end tunnels have been promoted as a way to attract bees and boost their local populations. This can be an effective way to enhance bee populations but these nests do need some tending to maintain the benefits. This fact sheet provides an overview of tunnel-nesting bee biology, and guidance on how to make and manage nests.

TUNNEL-NESTING BEE BIOLOGY

The vast majority of native bee species, including tunnel-nesting bees, lead solitary lives. While they may have gregarious tendencies, preferring to nest near other members of their species, each female individually constructs her own nest and provisions it with food for her offspring.

To make a nest, a female bee builds partitions to divide the tunnel into a linear row of brood cells. Depending on the species, the partitioning walls may be constructed of mud, plant resins, leaf pieces, flower petals, and even cellophane-like glandular secretions.

The female provisions each brood cell with a mixture of pollen and nectar, onto which she lays a

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single egg before sealing the cell and moving on to supply the next cell. Her offspring pass through the egg, larval, and pupal stages in the cell before emerging as adults to renew the cycle, usually the following year. After several weeks of nesting, the mother bee generally dies.

Nesting bees may not fill the entire length of a tunnel with cells, or they may die before an entire length of a tunnel is filled. For these reasons it can be difficult to tell if a nest tunnel is occupied from outside observation. A bee that is able to fill an entire tunnel with eggs before dying will plug the tunnel entrance with mud, leaf pieces, or other nesting substrates to prevent predators from attacking her brood.

Bees have the unique ability to determine the sex of the egg they lay; most male eggs are laid closest to the tunnel entrance. Because each female may mate with several males, males are more expendable from an ecological standpoint. Thus, the advantage of laying male eggs closer to the nest entrance is that they are the first to fall victim to predators such as nest-invading insects, or woodpeckers, while the developing females remain safe deeper within the nest. Being closer to the entrance, male bees emerge prior to the females, and will often wait outside, ready to mate with the females who will appear several days later.

Depending on the species and climate, there may only be a single generation of bees per year (univoltinism), or multiple generations per year (multivoltinism). Some species may also have parsivoltine lifecycles, laying dormant for over a year, waiting for the appropriate weather conditions to spur their emergence. The latter lifecycle is most commonly observed at high elevations, in deserts, areas prone to forest fires, and other extreme environments.

About 30 percent of North America's bee species nest in tunnels, generally abandoned beetle borings in a snag or, as here, the center of a pithy twig. The female bee divides the tunnel into a series of brood cells, each one supplied with nectar and pollen. Small carpenter bee (genus *Ceratina*), photographed by Edward S. Ross.

Making Artificial Nests

Commercially produced bee blocks, consisting of a wood block drilled with a series of dead-end tunnels are now widely available. These types of bee nests were initially developed in the 1960s by alfalfa seed producers in the western U.S. to attract and manage large numbers of the non-native alfalfa leafcutter bee (*Megachile rotundata*). More recently artificial nests have been modified to manage the blue orchard bee (*Osmia lignaria*) for orchard fruit and almond pollination. These artificial nests contain tunnels that are a uniform size and depth. However, because they are designed to suit specific species, they may be either too large or too small for many other species. Also, the blue orchard bee is active only in the spring and will not pollinate later-flowering fruits and vegetables. Nest blocks with a greater diversity of hole sizes and depths are necessary to attract a variety of bees that are active throughout the year.

Under the best circumstances artificial nests can attract large numbers of tunnel-nesting bees and boost their local populations. However because these nests concentrate bee populations in unnaturally large numbers in a small space, they can become infested with parasites and disease spores after several seasons.

Without regular sanitation or the phasing out of nest materials, these parasites and diseases threaten long-term pollinator health wherever they are used. Because contaminated nest blocks left unattended in the landscape continue to attract wild bees from the surrounding area, they have the potential to do harm. With proper management, however, these nests can maintain healthy bee populations indefinitely.

Wooden Blocks

To construct wooden nest blocks use preservative-free dimensional lumber: 4 by 4 for blocks with smaller diameter tunnels (¼" or less), or 4 by 6 for blocks with larger diameter tunnels (greater than ¼").

In one side, drill a series of nest tunnels between 3⁄32" and 3⁄8" in diameter. We recommend that you have only one diameter of tunnel in each block. Tunnels of ¼" or less in diameter should be 3" to 5" deep. Tunnels larger than ¼" should be 5" to 6" deep. Because the female bee controls the gender of her offspring and usually finishes the nest with a few male brood cells, a deeper tunnel ensures space for more female brood.

The tunnels should be about ¾" from center to center, and no closer than that to the edges. Attach a backing board if you drill all the way through your block, because bees will not use a tunnel that is open at both ends. With smaller diameter drill bits, you may not be able to

Two styles of tunnel nest: a wooden block (left) and a stem bundle (right, being sealed by a mason bee). The wooden block can be redrilled and washed to maintain nest hygiene. The stem bundle must be disposed of after a couple of years and replaced. Photographs by Matthew Shepherd (L) and Mace Vaughan (R).

achieve the 3-inch minimum recommended depth. If that is the case, simply drill as deeply as you can; bees that use tunnels of smaller diameters will often nest successfully in ones that aren't as deep.

Bees may avoid a rough interior, so tunnels should be perpendicular to the wood's grain, and drilled with a sharp bit. You can buy paper straws to line the holes, although it may be hard to find straws that fit all diameters. One solution is to wrap your own paper straws out of parchment or newspaper using dowels of various diameters that match the inside diameters of your drilled tunnels. Paint the outer tips of the straws black to help attract bees.

The exterior of the block can be any color, although there is some anecdotal evidence that bees are most attracted to dark blocks, which can be achieved by lightly charring the front surface with a propane torch. Whatever the color, bees are likely to use it as long as the tunnels are of appropriate diameters and depths, and hung in an appropriate location. As a final step, attach an overhanging roof to provide additional shelter from the rain.

Colonization by wild bees is often more successful when blocks are attached to a large visible landmark (such as a building), rather than hanging from fence posts or trees. Another drawback of hanging nest blocks from trees or fence posts is that they are likely to move or shake in the wind, which is disruptive to nesting and larval development. Nest blocks should be at least a few feet off the ground to avoid getting splashed by rain or covered by vegetation. They should be hung in a bright but protected location. Direct sunshine in the morning will help bees warm themselves up to flight temperature, so if possible place nests facing east, allowing the morning sun to fall on the entrance holes. However, direct sunlight later in the day can be detrimental, causing brood to die.

To protect against woodpecker damage, store nests in an unheated building at the end of the season. Alternatively, they can be protected over the winter by surrounding them with hardware cloth. Be sure to remove it before nesting resumes as hardware cloth can disorient nesting bees and damage their wings.

Stem Bundles

In addition to wooden blocks, artificial nests can be constructed with bundles of reed, teasel, cup plant, or bamboo, cut so that a natural node forms the inner wall of the tunnel.

Cut each stem below the nodes (usually indicated

Three styles of tunnel nest suitable for crop pollination.
Top: Bamboo stems in plastic tubs. The lidded tub on the top left is an emergence box, allowing replacement of the stems, and the chicken wire protects the bees' nests from woodpeckers.
Middle: Commercially made grooved wooden boards, occupied by leafcutter bees. The boards can be separated to expose the brood cells for cleaning.
Bottom: Styrofoam blocks molded with nest tunnels. This is designed for leafcutter bees and have raised designs to help bees locate their nest.
Photographs by Eric Mader.

by a ridge) to create a handful of tubes each with one open end. Strap the tubes together into a tight bundle with wire, string, or tape, making certain that the closed ends of the stems are all at the same end of the bundle. A variation on this is to tightly pack the stems—open ends out—into a tin can, paper milk carton, square plastic buckets,, short section of PVC pipe, or other container. The bundles should be placed in a sheltered location (such as the side of a barn or garden shed) with the stems horizontal to the ground.

Adobe Blocks

Some solitary bees nest in cracks, or cavities in soft sandstone and dry exposed soil embankments. Some of these species, such as *Anthophora abrupta*, and *Anthophora urbana*, two important visitors of some fruit and vegetable crops, will excavate tunnels in cliff sides by using water or nectar to soften the hard soil surface. These species are quite common in the southeastern and southwestern U.S. respectively.

To attract these species, adobe bricks can serve as the equivalent of a wooden nest block. Such bricks can sometimes be purchased, in which case you can increase their attractiveness to bees by drilling nesting holes following the size recommendations listed above for wood blocks.

Adobe blocks can also be easily made where clay soils are common. To create one, half-fill a large bucket with clay soil, then fill the bucket with water. Stir the mixture together, creating a slurry, and allow it to settle. Remove any sticks or debris floating on the surface, and slowly pour off most of the water. Finally, pour the remaining sediment into a mold (such as a wooden box or small Styrofoam cooler), and allow it to dry for several days or weeks. Before it completely dries, make several one-inch-deep indentations, using the diameter guidelines above, to make it more attractive to bees.

Mount the brick, either singularly, or in a stack. Adobe will not hold up well in wet climates, and many need sheltering from rain.

Maintenance of Tunnel Nests

Regardless of type, the tunnel-nest will need routine management and regular replacement to prevent the build-up of parasites and diseases that affect the developing brood.

The hardest of these to control is the fungal disease chalkbrood (*Ascosphaera* spp.). Several species of the fungi exist among cavity nesting bees, all of which are different from the chalkbrood disease that attacks honey bees. Bee larvae become infested with disease spores through contaminated pollen, either collected from a flower by the mother bee, or accidentally spread when the mother bee

Artificial nest sites lead to bees nesting in densities seldom reached in naturally, and pests and diseases can proliferate unless the nests are carefully maintained. This bamboo stem has been infested with chalkbrood; none of the bees survived. Photograph by Eric Mader.

emerges from a contaminated nest tunnel.

After they are ingested, the chalkbrood spores germinate inside the gut of the developing larva, producing long filaments (hyphae) that eventually penetrate the gut wall, killing the larva. These dead larvae pose a hazard to bees deeper within the nest block that, upon emergence, must climb over or chew through the spore-infested cell to escape the nest. Bees that emerge under these circumstances have a high likelihood of spreading the spores to their own offspring. Similarly, bees searching for unoccupied nest tunnels in which to lay their eggs frequently investigate, and often select, previously used tunnels. Over time, chalkbrood spores are spread throughout a nest block in this way.

Along with chalkbrood, pollen mites in the genus *Chaetodactylus* can be a persistent problem in nest blocks that are in continuous use for several seasons. Unlike the mites that attack honey bees, pollen mites do not feed on the hemolymph (blood) of the bee. Instead, pollen mites are "cleptoparasites," feeding on the pollen provision and causing the developing bee larva to starve.

Adult pollen mites are white, tan, or orange in color and measure about 500 microns in width (about the size of the period at the end of this sentence). As with chalkbrood, adult bees may accidentally pick up mites at flowers while foraging, or when emerging from contaminated nest tunnels. Migratory mite nymphs cling to a bee's hair and are transported to new brood cells where they feed on the pollen provision and reproduce rapidly. In a single provisioned cell, mite numbers can quickly climb into the thousands. While pollen mites usually cannot break through cell partitions, they can persist for many months without food, until a bee deeper within the nest emerges from the tunnel and breaks the partition walls, allowing them to escape. It is not uncommon to see bees emerging from infested nest blocks covered with so many migratory mite nymphs that they have difficulty flying.

Nest Block Sanitation

With appropriate management, the worst parasite and disease problems can be minimized or avoided. Specifically, one of three approaches should be taken:

Use Paper Straws

The holes of wood nest blocks can be lined with tight-fitting removable paper straws. To facilitate removal, and prevent excess drying of the pollen provision, some beekeepers use custom manufactured waxed paper straws. At the end of the nesting season (autumn), the straws are gently removed, and placed in a ventilated container and stored either in a refrigerator, or an unheated barn or garage. The nest block is then disinfected by submerging it in a weak bleach-water solution for a few minutes. In the spring, fill the block with clean, unused paper straws and return it to its location. The old straws (with bees in them) are placed alongside the nest block, and the bees allow to emerge naturally. When the old straws are empty, they are disposed of.

Replace Nest Blocks

Nest blocks, and stem bundles can be phased out every two years by placing them inside a dark container, such as a light-proof wooden box, a dark-colored plastic bucket with a tight-fitting lid, or even a sealed milk carton that has been spray-painted black to reduce light infiltration. A single ⅜" exit hole is drilled in the bottom of the light-proof container, and the entire contraption is hung adjacent to a new, previously unused nest block or stem bundle. To facilitate ease of exit, this escape hole should be located on the bottom of the dark container so that bees can crawl, rather than attempt to fly out.

As bees emerge from the old nest, they are attracted to the light of the exit hole, and emerge to find the new nest hanging near by.

Unless a single bee species with a known emergence time is being managed, leave the nest block inside the emergence box for a full year. Even under this timeline not all parsivoltine species may emerge. If this is a concern, leave nest blocks in the emergence box for two seasons.

After bees have been allowed to emerge from the nest block, clean it by re-drilling the tunnels to loosen any debris then submerge it in a solution of bleach and water (1:2 by volume) for five minutes. Even when cleaned in this way some viable chalkbrood spores may be present. The only guarantee against chalkbrood is the complete disposal of old nests.

Several Small Blocks

The last alternative is to create multiple small nest blocks or stem bundles with only a few nest tunnels (four to six), and hang them at widely distant intervals. This prevents the unnaturally high populations of bees found at nest blocks with many holes, and mimics natural conditions of limited, spatially separated nest sites. These smaller nests also decompose more rapidly, and can be allowed to simply deteriorate naturally, while new small nests are added to the landscape periodically.

References

Bosch, J., and W. Kemp. 2001. *How to Manage the Blue Orchard Bee as an Orchard Pollinator*. 88 pp. Beltsville: Sustainable Agriculture Network. [Available at http://www.sare.org/publications/bee/blue_orchard_bee.pdf.]

Dogterom, M. 2002. *Pollination with Mason Bees: A Gardener's Guide to Managing Mason Bees for Fruit Production*. 80 pp. Coquitlam: Beediverse Books.

Griffin, B. 1999. *The Orchard Mason Bee*. 128 pp. Bellingham: Knox Cellars Publishing.

Meyer, R., and D. McBride. 1989. *Alfalfa Seed Production and Leafcutting Bee Management.* (EB-54.) 10 pp. Fargo: North Dakota State University Extension Service.

Richards, K. 1984. *Alfalfa Leafcutter Bee in Western Canada*. (1495E) 54 pp. Ottawa: Agriculture and Agri-Food Canada.

Shepherd, M. — *Nests for Native Bees*. 2 pp. Portland: The Xerces Society for Invertebrate Conservation. [Available at http://www.xerces.org/fact-sheets/.]

Stubbs, C., F. Drummond, and E. Yarborough. 2002. *Field Conservation Management of Native Leafcutting and Mason Osmia Bees.* (Wild Blueberry Fact Sheet 301.) 4 pp. Orono: University of Maine Cooperative Extension. [Available at http://wildblueberries.maine.edu/factsheets.html.]

Vaughan, M., M. Shepherd, C. Kremen, and S. Black. 2007. *Farming for Bees: Guidelines for Providing Native Bee Habitat on Farms*. (2nd edition). 44 pp. Portland: The Xerces Society for Invertebrate Conservation. [Available at http://www.xerces.org/guidelines/.]

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