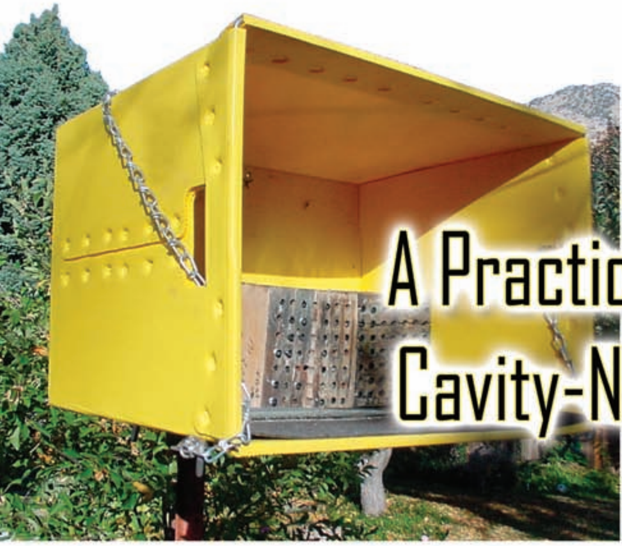

The Logan BeeMail Shelter: A Practical, Portable Unit for Managing Cavity-Nesting Agricultural Pollinators

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Running Head: shelter for cavity-nesting bees

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Abstract: An affordable, durable, portable nesting shelter will be useful to manage cavity-nesting bees for agricultural pollination. A design is described here that is assembled from commercially available components. It has been successfully used during field experiments with the alfalfa leaf-cutting bee and several species of *Osmia* bees. In a 4-year field study with commercial cane fruits pollinated by the bee *Osmia aglaia*, the shelters have proven to be quick to deploy, convenient to store, long-lasting, wind-resistant, and effective for excluding the frequent rains of northwest Oregon.

Introduction: Practical, effective, movable nesting shelters have been integral to managing bees for agricultural pollination. The wooden or plastic hive body serves this purpose for honey bee colonies. Once the Rev. Langstroth had characterized the "bee space" for a movable frame hive, the development of a hive made of interchangeable manufactured wooden parts (supers, cover, bottom board) followed soon thereafter. A functionally comparable mass-produced custom nesting box has likewise helped to propel the management of bumblebee colonies for greenhouse pollination of tomatoes and other crops.

Few non-social or solitary bees are managed commercially for agricultural pollination as yet (Cane 1997; Stephen 2003; Torchio 1994). One prominent exception is the Eurasian alfalfa leaf-cutting bee, *Megachile rotundata*, a pollinator widely managed in North America to produce alfalfa seed (Stephen 2003). Growers deploy mass-produced nesting substrates for this bee. The bees nest either in fitted grooved boards or, more commonly, foam or wooden panels or boards bearing several thousand holes of uniform size (Richards 1984). Alfalfa seed growers in the USA arrange hundreds of these nesting blocks into individual large steel or wooden field shelters (often 10-20 ft wide) of diverse custom-made designs (Stephen 1981). These shelters provide protection from wind, rain, and direct afternoon sun. Sometimes netting is added to exclude birds. These big shelters accommodate nesting by hundreds of thousands of bees needed to pollinate the hundreds of millions of alfalfa flowers that are produced per acre across vast seed fields. However, such huge shelters are impractical for most fruit or other crops, which need far fewer bees per acre for full pollination and cannot accommodate bulky immovable objects in the orchard or field at harvest time. In cooler regions of Canada, 8' x 8' mass-produced plastic domes are used for sheltering nesting alfalfa leaf-cutting bees (http://www.koendersmfg.com/leaf.html), but even these are too big for orchard use.

The initial purpose of this study was to develop a practical and effective nesting shelter for the cane fruit pollinator, *Osmia aglaia,* one that could be readily packed and shipped from our lab to field sites in Oregon. The resulting shelter design consists of only two interchangeable, mass-produced components that are affordable, durable, effective, and quickly deployed and later stored by the grower.

1. Nesting shelter. A reinforced plastic tub or tote, laid on its long side, serves to house the bees' nesting materials (Fig. 1 & 2). These totes are currently manufactured for mail handling (hence the adopted trade name) and for picking and transporting fruit in orchards and vineyards. The totes are made from laminated, corrugated sheets of polyethylene plastic whose seams are spot-welded. The opening is reinforced with a rigid embedded rectangular rim of

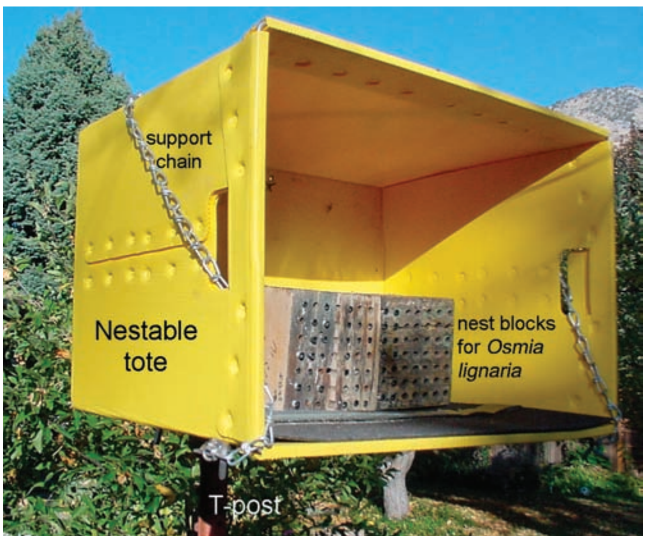

Figure 1. Logan BeeMail shelter with wooden nesting blocks for the blue orchard bee, *O. lignaria*.

Figure 2. Logan BeeMail shelter outfitted with foam block to receive 300-400 female *O.aglaia* for pollinating farmed blackberries (background). Here the support frame is of the older, custom welded prototype.

3/16” (0.5 cm) wire. Tapered sides allow stacking during storage and transport. Two cut hand holds facilitate lifting, as does their light weight (3 lbs. or 1.4 kg for full depth tote). Bright color choices make them visible to equipment operators and allow coding (e.g. orchard or year). These shelters have proven to be durable; after four years of use (five months per year) in western Oregon, our somewhat faded shelters show no structural degradation.

Manufacturers offer many dimensions of totes. I am pleased with a tote whose opening has external dimensions of 15 ½” x 23 ½” (39.5 x 60cm). Tote depth is a compromise. A deeper tote (15 ½” or 39.5cm) better protects the contents from wind-driven rain. On the other hand, a shallower tote (11 ½” or 29 cm deep) is cheaper, less bulky, and favors solar warming of nests (and bees) on chilly mornings. These totes were purchased from American Postal Manufacturing of Milwaukee Wisconsin USA, where, ironically, they are named “nest’ or “nestable” totes as though anticipating this unusual application! Their current price is about $15 US per tote.

2. Shelter support. The plastic tote is sturdily supported off the ground by a rigid support bracket made of galvanized tubular steel. It was co-designed with the grape arbor manufacturer, Quiedan Inc (Carmel, California USA). The bracket is quickly bolted to a single metal T-post or grape stake using two offset U-bolts. Each bracket weighs only 4 lbs (1.8 kg). A light metal chain (or rope) passes through the tote’s hand holds and around welded hooks to firmly hold totes of differing depths. Where wind vibration is a problem, I have tied two short lengths of guy rope from the support arms to tent stakes driven into the ground. Once affixed, these units have survived persistent 60 MPH (96 KPH) winds and even snow without twisting, slipping, shifting, loosening or loss of their content of nesting bees. A support bracket can be attached to a T-post in the field in two minutes; a shelter can be attached or removed with comparable speed. The projected price for one support bracket is about $5US from the manufacturer. An earlier prototype made from iron pipe and steel strapping was much heavier though equally compact, and required some welding; its design is available from the author.

3. Positioning. Shelters should be placed and oriented in the orchard so that nesting materials (and their awakening bees) can be warmed by direct morning sun. In mid-May in sw Oregon, *O. aglaia* nesting in an open shed only began foraging once shade air temperatures were 62F (16C) and were busy by noon (66F or 19C). Optimal solar orientation depends on the season and local climate. Shelter openings should be faced southward in cool seasons, but more eastward when and where it becomes hot by late morning. Proper orientation favors quick warm-up and early flight by mother bees who are peeking from their nest entrances soon after daybreak. In Logan, Utah on a sunny day at spring equinox (March 22), the sunlit face of one of our foam nesting blocks mounted in a south-facing shelter had already warmed to be flight temperature (66F or 19C) just 90 mins after sunrise (0630 MST), when shaded surfaces temperature would still be too cold for bee flight (53F or 12C). Only two hours later did shade temperature warm enough for bee flight. Hence, the sunlit shelter warmed quickly, favoring earlier morning bee flight. By noon on that day, the shelter interior was shading the nesting materials, keeping the bee brood warmer (98F or 37C) than ambient shade (77F or 25C) but still safe from overheating. Shelters and substrates hold no significant residual heat (all cooled to 36F or 2C that night). The pattern repeated on the following four days. A warm-up mat for the floor of the shelter, cut from black roofing shingle, was ineffective for dissuading chilly emerging bees from risking predation when they choose to sun on bare patches of ground in front of the shelter. Conversely, in a shelter faced eastward around the summer solstice (June 24-28), when at solar noon ambient shade temperature peaked at 105F (41C), temperatures in foam nesting blocks were cooler (97F or 36C) because by then the face of the foam block was shaded earlier by the shelter. Nesting shelters thoughtfully oriented for the season can favor bee flight on cool but sunny spring days, but protect bee progeny from the fierce heat of summer.

4. Predator exclusion. Birds and rodents occasionally learn to extract nesting straws and immature bees from their nesting substrates. To prevent such damage, we screen the shelter entrance. Birds are deterred by a shelter entrance fence cut from rectilinear mesh netting made from durable UV-stabilized polypropylene. It is sold to homeowners as deer fencing, and comes in several mesh sizes (1.75” square or 1” x 0.75”). Bees half the size of honey bees, such as *O. aglaia*, flew through the smaller mesh unimpeded. The larger mesh should better suit larger bees, but for big-bodied bees, it would be wise to check. Such plastic netting is easily cut, carried, handled, and attached, and does not fray or cut bees’ wings. Determined rodents can chew through the plastic mesh, however, requiring a metal mesh such as chicken wire, despite its other disadvantages compared with plastic netting. If ants are a problem, they are best excluded using a persistently adhesive coating (e.g. Tanglefoot, Stick-em Special) applied to the support stake and any guy ropes.

5. Nesting materials. I have successfully used the shelters for several bee species. Two large early spring species, the blue orchard bee (*Osmia lignaria*) and *O. californica*, nested in heavy 6”x6”x4” drilled wooden blocks set in the shelter (block manufacturing instructions at:

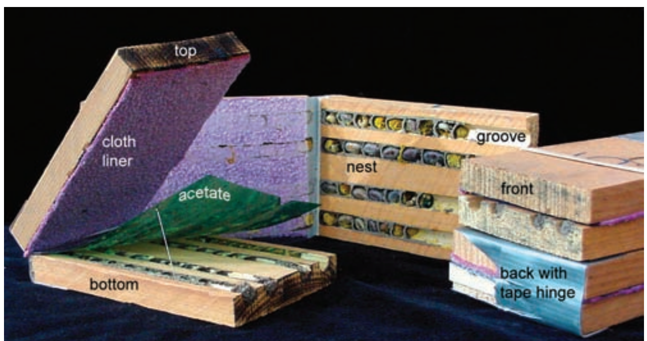

Figure 3. Grooved observation nests from different perspectives. Two insect pins are holding the cover and the acetate up for viewing purposes. In the background are *in situ* nests of *O. lignaria* showing nest cells, mature larvae and cocoons.

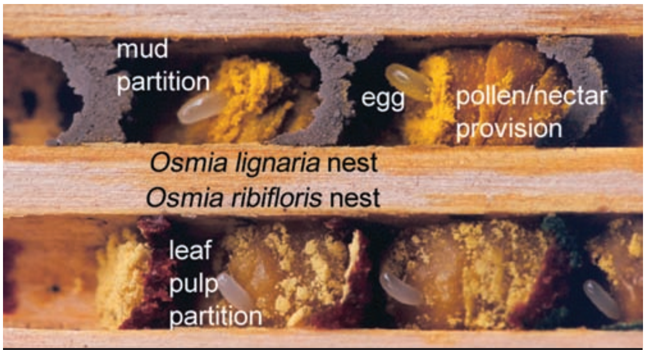

Figure 4. Close-up view of nest cells made by *O. lignaria* and *O. ribifloris* in adjacent grooves of one observation nest. These nests eventually yielded live adult progeny.

(http://www.ars.usda.gov/News/docs.htm?docid=10743). Nesting activity by *O. californica* was normal, their nest orientation and recognition was quick, and their population increased using the nesting shelter (Cane 2005). Two smaller, summer-flying bees were also given nesting trials in the shelters. In Logan, alfalfa leaf cutting bees were given bundles of grooved wooden boards. They quickly established nesting and continued to nest for more than 3 weeks. In Oregon, nesting *Osmia aglaia* were given 6" paper straws inserted in commercial lightweight polystyrene foam nesting boards (Beaver Plastics Inc., $7 US per shelter) and flown in commercial raspberries and blackberries. For *O. aglaia*, a double-layer of the 3" deep foam board was attached to the back wall of the shelter using a long thin bolt passed through each corner hole, which is then punched through the tote wall and secured with a washer and wing nut (Fig. 2). Field installation was quick (1 min). If nesting substrates nearly fill the nest shelter, they can be held in place with wooden wedges. One shelter can hold enough nesting substrate for these *Osmia* species to thoroughly pollinate about an acre of their respective crops (250 large-bodied *Osmia lignaria* in apple or cherries; 400 smaller-bodied *Osmia aglaia* in raspberries and blackberries). Other nesting substrates should also work well in the shelters, such as nesting tubes made from reeds or pithy stick nests, although they should probably be bundled or wedged together to resist jostling in high wind.

6. Watching bees nest. I recommend the use of an observation nest in at least some shelters to better learn a bee species' nesting habits, evaluate their nesting success, and track nesting schedules and progeny development. Imagine understanding the nesting activities of honey bees without a movable frame hive! Such an observation block for cavity-nesting solitary bees is very analogous to the "book hive" used by the Swiss naturalist, Francois Huber, for his pioneering observations of colony activities of honey bees. Similar observation nests (Hallett 2001 page 135) have been described, built from boards cut into 6" lengths and grooved using a router. I found that fence slat made from western red cedar was convenient in size and weight, dimensionally stable and soft to cut. For easier access, I have modified Hallett's design, using a piece of clear acetate sheeting sandwiched beneath a hinged wooden lid (Fig. 3). A piece of soft thick cloth (I cut up an old sweatshirt) is glued under the lid to press the acetate down snugly to the grooved floor. This serves to exclude tiny parasites as well as any stray light from entering a groove, which would deter bees from nesting. Bees build their linear nests in the grooves. With care, I have daily watched, moved, and even manipulated larvae and provisions of *Osmia lignaria, O. ribifloris and O. aglaia* in these observation nests without larval mortality or even abandonment by the mother bee. A colleague in Brazil found them very useful for watching intranest behaviors by tropical solitary bees of the genus *Centris*, suggestive of the observation block's broad appeal to the diverse bee species that "rent" existing cavities in wood to nest.

7. Anticipated applications. Because the components of these shelters are already commercially available, there is no "chicken and egg" dilemma in which a manufacturer awaits a large enough market to justify retooling, while the custom pollinator market awaits convenient nesting systems before scaling up. These shelters should be practical for most crops pollinated by cavity-nesting bees, excepting those few cases such as commercial seed alfalfa that require many millions of bees per field. Users may come to include home and market gardeners, orchardists, and growers of berries and specialty seed, as well as researchers and personnel maintaining germplasm lines at seed repositories. It is my hope and expectation that these shelters will facilitate modification and innovation by clever users interested in using cavity-nesting bees as pollinators. In like manner, the moveable frame hive of the Rev. Langstroth facilitated the invention of mass-produced hive components, centrifugal extractors, and more recently the palletized hiving system so effectively used for commercial pollination by migratory beekeepers today.

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