A Method for 'Hiving' Solitary Bees and Wasps

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Transparent trapnests are stacked in conspicuous colored hive bodies of Langstroth dimensions that stand on platforms on greased poles. This conveniently concentrates woodnesting bees and wasps for regular observation and eventual selection. The method is primarily intended for scientists and educators, but may also suit beekeepers or fruit growers interested in developing new pollination or organic farming services.

1. Introduction Very few species of solitary bees or wasps have been farmed [1,2]. As these beneficial insects amount to very many species, which are adapted to most environments, a few occurring even in the inner cities, this failure leaves an enormous renewable resource untapped ---in a world where underexploited resources are rare. For example, there are about 660 species of solitary bees in Eastern North America, and at least two major obstacles to studying them. (1) A serious difficulty for most people is giving an insect a useful and accurate name. The few experts who classify and identify to the species level have high work loads. Fortunately, it is quite practical to use the *nest architectures* as an interim classification until expert help is really needed ---because the nest construction immediately suggests the subfamily, genus or subgenus. Table 1 shows the nest constructions and names of the bees and wasps that I have trapnested in my area. In midwinter, for example, when I count up the annual yields of grubs (prepupae) for the different species, I can refer to so many 'leaf bee', 'resin bee', or 'resin wasp' grubs without needing to have captured and identified the mother insect in the summer, or alternatively having to wait three weeks to 'force' a sample of the grubs to hatch into adults. (2) A more serious problem is that current methods of collecting these insects are suited to laboratory study, but not to frequent easy observation in the field, because the usual nesting materials (drilled sticks and straws) are opaque and placed in many locations. This inconvenience discourages wider scientific study, education, and public awareness. The present method places many transparent nests in conspicuous hives in a few locations where they can be repeatedly inspected and studied throughout the year. It is hoped that this approach will encourage more people to observe these beneficial insects, and help in the selection of candidate species for innovative methods of mass rearing. Conservation, education

Constructions (+Provisions)	Families	Subfamilies	Genera	Common Names
BEES				
Cellophane	**COLLETIDAE**		*Hyleus*	Masked bees
Felt	**MEGACHILIDAE**		*Anthidium*	Carder bees
Leaf	**MEGACHILIDAE**		*Megachile*	Leafcutter bees
Mastic/Mud	**MEGACHILIDAE**		*Osmia*	Spring orchard bees
Resin	**MEGACHILIDAE**		*Megachile*	
WASPS				
Mud cup+spider	**POMPILIDAE**		*Auplopus*	Spider wasps
Mud+beetle grubs	**VESPIDAE**	Eumeninae	*Symmorphus*	Potter wasps
Mud+caterpillars	**VESPIDAE**	Eumeninae	*Ancistrocerus, Monobia*	Potter wasps
Mud+spiders	**SPHECIDAE**	Trypoxyloninae	*Trypoxylon*	Mud daubers
Resin+aphids	**SPHECIDAE**	Pemphredoninae	*Passoloecus*	Aphid wasps

Table 1: Nest constructions and provisions link to the taxonomy, providing a pragmatic alternative to the Latin names for the beekeeper, fruit grower, educator or naturalist, and an initial working classification for the scientist. Bore width provides an additional classifier.

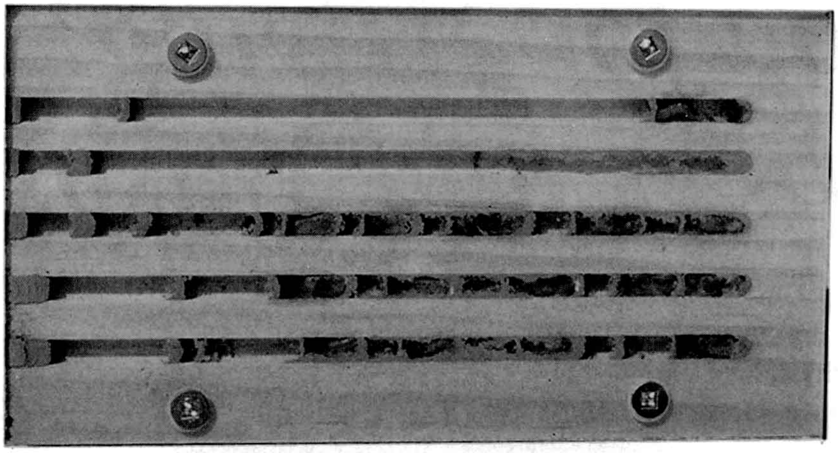

Fig. 1 An observation nest block in mid summer with 3.2 mm bores partitioned into cells by mud walls. Some cells are empty, others contain pale watery Potter Wasp larvae that have just consumed their provisions and not yet hardened for the winter freeze.

and agriculture will then be better served.

Conservation. Global population and land clearance are large and extensive and still rapidly increasing, with 16-23% of Earth's land surface already completely converted for human use [3]. In the North America and European countryside, agricultural and urban expansion stress the populations of natural pollinators, and curtail geographic ranges [4]. Adverse practices include tilling huge areas of land and planting with a single crop, without preserving undisturbed soil and vegetation as hedgerows, sanctuaries or woodlots, and excessive pesticide usage. Within the cities old gardens provide refuges that are not entirely safe from redevelopment, 'weeding' out the wildflowers, tidying away the dead wood (before it has a chance to get nicely lively), planting low nectar-secreting ornamentals, etc. The rapidity and extent of the changes in environment and lifestyle in the last 50 years warn that we may need widespread methods for propagating beneficial insects soon, perhaps within 20 years.

Education. People are increasingly isolated from what is left of 'Nature' by urban work and urban leisure. There is a fear of insects, especially of bees and wasps. Adult solitary bees and wasps only sting if the female is pinched with the fingers or trapped in one's shirt [5]. This docility makes this group ideal for biological education, and for displays promoting beekeeping, fruit growing and integrated pest management.

Farming and apiculture. Honey bees are good pollinators, available in mass, with valued products. But beekeepers are narrowly focused on costs, efficiency and honey ---when managing a clients' beneficial insects offers the possibility of supplementary revenue [6]. It is certainly possible that the demand for honey bee pollination services may soon outstrip supply, but orchards in richly diverse countryside nearly always do well. In principle, beekeepers (or for that matter fruit growers, market gardeners or landscape services) with a modest knowledge of beneficial insects could charge fees for advice and maintenance of trapnests in favorable natural areas. The beekeepers would not forego honey, as honey bees out-compete other bees [4]. Of course, this rather implies that beekeepers' and fruit growers' groups will be prepared to promote the idea of a connected wide-ranging network of refuges for native pollinators.[4]

Extant methods. The great majority of solitary bees and wasps nest in the ground and, apart from the Alkali Bee *Nomia*, there are no methods for getting them to nest where desired [1,2]. Fortunately, some species nest in wood. Trapnesting exploits the tendency of female wood-nesting bees and wasps to partition artificial tunnels by a series of transverse walls into a linear series of *cells*, within which they store food and lay eggs, just as they do in beetle burrows or similar cavities. Trapnests are really more handling tools than traps because the females are free to come and go, as are the offspring when they mature. The sequence of cells in a tunnel or *bore* are separated by transverse walls constructed by the mother insect from a wide variety of family-specific or genus group-specific materials, such as mud, resin, secreted cellophane, felt (made from plant hairs), leafcuttings, masticated leaves (mastic), wood chippings, sand, gravel, etc (Table 1). Krombein's rather dry book is the classic summary of a large body of work using drilled sticks that are then split and taped together again [7]. Targetting infested roofs, bushes or trees with many small bundles of sticks, or drilled blocks fitted with paper straws, can be very effective and a lot of fun. But the approach is inherently labor intensive and, as observation and inspection are difficult, the nests are usually taken back to the laboratory for dissection, observation and sacrifice.

2. The new method[8] Features of my method echo Krombein, Western Canadian

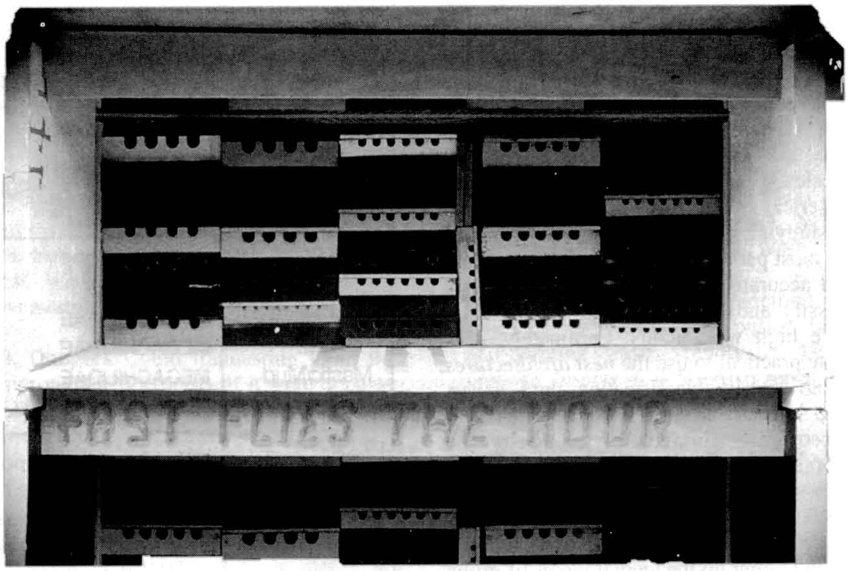

Fig. 2 The entrances, or atria, of a pair of hives to show the painted fronts of the nest blocks. The top hive is fully shown and it can be seen that there is little space left for bats. Both hives sport removable notched crossbars introduced in 1998 to solve problems that proved imaginary (as hives have never warped or toppled). The lower bar carries a motto ("Fast flies the hour").

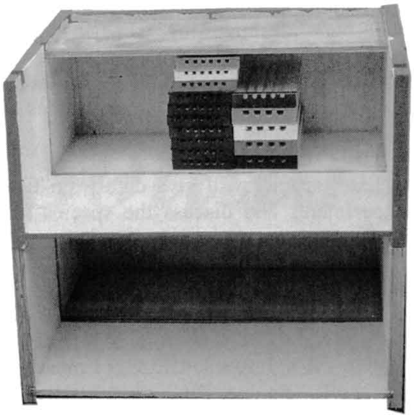

Fig. 3 A pair of hive bodies with the typical beehive roof removed, to show the construction. Nestblocks are sitting in the unpainted rear nest cavity. A long narrow gap (the drain) separates the rear floor board from the painted floor of the atrium, which is sloping slightly down towards the entrance. When hive bodies are stacked, the atrium floor acts as a louver that reduces rain entering the hive body below.

leafcutter bee farming[9], and honey bee practices. A handsized grooved board is closed with a transparent acrylic lid to provide an observation trapnest or *nestblock* of 4-8 Krombein-sized bores (Fig. 1). Unlike traditional leafcutter beeboard, the nest block is strong, well-sealed, and of a size that is easily inspected and photographed in the field, examined under a dissecting microscope in the laboratory, or passed around an audience of young people. The fronts of the blocks are painted, 60% of them black and the rest in wildflower colors (Fig. 2). Upto fifty blocks are stacked for protection from the rain within a brightly painted *hive* that by a stretch of the imagination is a minature of a Western Canadian leafcutter bee enclosure (Fig. 3). This hive has the outer dimensions of a Langstroth hive body, but is partly floored and roofed and completely open along one side as a flight entrance (Fig. 4). Hives are stacked on platforms on greased poles for protection from ants and porcupines, etc. at a convenient height (4 ft or1.5m) for taking notes and photographs (Fig. 5). They might perhaps be alternatively placed directly on a honey bee hive. A fully loaded hive of 23 lb (10.4 Kg) is easily carried, through the bush if necessary, to a *site* within a few meters of trees, shrubs, and wildflowers. Hives are best placed in the field at the end of winter, before spring.

3. Nestblocks End-stopped round-bottomed grooves (U-shaped in cross section) are routered lengthwise for strength along the grain in 6¾" (171 mm) long blocks of "1 by 4" (or "¾ by 4") pine, and closed by ⅛" (3.2 mm) thick acrylic lids held by four screws. The depth of the U-cut is adjusted to give the cross-sectional area of a circular hole of the same radius. The bores in the resulting 'observation nestblocks' are ⅛", 3/16", ¼", 5/16" or ⅜" wide and 6" long, with a minimum wall thickness of ¼" (3.2, 4.8, 6.4, 7.9,or 9.5 mm wide by 150 mm long with a 6 mm wall). Size is coded by the number of bores per nestblock (8, 7, 6, 5, and 4 respectively). The ⅛-¼" bore (8-6 bore) nestblocks are made of "¾ by 4" pine, the ones with larger bores of 1" by 4" pine. A cheaper 'selection nestblock', convenient for cleaning, but not for inspection or shipping, uses 6 mil (0.15 mm) polyethlyene building film and ⅛" (3.2 mm) sponge spacers in place of the acrylic lid. Blocks are stacked to minimize spaces that might be used by paper wasps or bats.

4. Hives Five stacks of 7-10 nestblocks each are held inside a hive body of Langstroth dimensions. The rear half of the hive is the *nest cavity* which contains the stacks (Fig. 3). The front half forms the entrance or flight chamber (which I call the *atrium*). It may help to imagine a Langstroth hive body made of fir plywood that has the long front missing, making a very large entrance, with the 16¼" (41.3 cm) short ends and long back held together by one long roof board and two long floor boards (Fig. 4). The 20" (50.8 cm) long back, with the ends and its narrow roof and floor board, forms a 7" deep x 18½" wide by 6½" high *nest cavity* (17.8 x 47 x 16.5 cm). Five Allen set screws in the roof board, and a few shims, apply light pressure to the five stacks of nestblocks, reducing infiltration by tiny black chalcidoid wasps. The remaining 7¼" deep floor board is the floor of the atrium and serves to shed water. It is separated from the floor board of the nest cavity by a ¾" gap (the drain) and slopes down slightly towards the atrium entrance. This design provides wide access to the nest cavity. When the hives are stacked (and topped with a typical beehive roof) the sloping atrium floor boards form a set of louvers against rain or excessive sun, and still allow good access. Hives are painted in wild flower colors.

5. Refinements This design leaves little space for unwanted wildlife, allows some room for ventilation, but also requires small fingers to dislodge the stacks of blocks for inspections! It is therefore convenient to seat at least one of the central stacks in each hive on a ⅛" masonite paddle about 3 ¼" wide by 7 ¼" deep. After sliding this "key" stack out on its paddle, there is room to grasp one of the remaining four stacks and slide it out onto the floor of the atrium for block by block inspection. Another refinement is seating each stack on a thin rectangular sponge pad, slightly smaller than a block, with a tongue removed (i.e., ⊓ in shape), to facilitate compression by the Allen screws and rainwater drainage.

6. Inspections How frequent and invasive can inspections can be? In 1997 and 1998 nestblocks were unstacked weekly for inspection. This disorients foraging mothers returning to missing nests, but does not bother those already at home if the blocks are restacked in the original order. No veil or protective clothing is necessary. If you use insect repellent against mosquitoes, spare your finger tips. Overwintering nests in 1998-9 were kept for several weeks in a refrigerator at subfreezing temperatures and every cell was dissected open and inspected by undergraduate students before return to the field [10]. Half an hour or so exposure to a hot room in midwinter does no obvious harm. Otherwise overwintering nests should be stored out of doors away from building heat.

7. Cleaning This is best done by hand in the open air, during hive inspections in the late summer. Machinery would concentrate dusts and molds, which are hazards of the leafcutter bee industry. Hand cleaning also salvages occasional unemerged, presumably biennial, cells that are more common at higher latitudes. Summer emerged or damaged nests are scraped clean with machinists' steel pin blanks of appropriate diameter. Moldy blocks are rare and can be treated with drugstore hydrogen peroxide. Dirty lids are washed by hand or in a dishwasher. Empty blocks are stored in the warmth indoors to disrupt the lifecycles of pathogens. Methods for mass rearing will need to use disposable nest blocks.

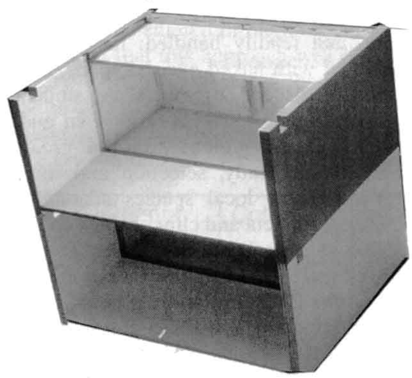

Fig. 4 Another view of a pair of hive bodies. The drains are well shown, as are notches and dados for equipment options.

8. Advantages The new method offers scientific standardization, highly convenient observations, and generally slight labour. (i) *Standardization* The present bore widths and lengths systematize those of Krombein. This size range, if extended to include a ½" (12.6 mm) bore, should accommodate all solitary bees and wasps in one's locality, including the large Carpenter Bees, *Xylocopa*. (ii) *Con-*

Fig. 5 The prototype hive in April 1997, showing the heavy roof brick (unnecessary), roof (far too heavy) and two hive bodies loaded with observation nestblocks. The plastic flowers were celebratory. Since 1998 blocks have been routered with 0-3 more bores per block, and some blocks are of thinner pine, depending on the bore size, as described in Methods.

venience Bore length is generally well utilized. Nest blocks are strong, conveniently sized, and readily handled; they can be inspected with naked eye, handlens, camera or microscope, by specialists, students or laypersons, or passed around an audience. This convenience should greatly facilitate the study, selection and initial propagation of local species adapted to your environment and climate. By comparison, leafcutter beeboard comes in only one bore size, is fragile and hard to inspect. (iii) *Labor* Because the nestblocks can be concentrated in a few hives at a few sites, inspection is greatly speeded. If one is lucky enough to locate high concentrations of nests infesting a barn roof or tree, it might still be resourceful to make the effort to target these with directly applied small bundles of blocks, and then use 'loaded' blocks to seed next year's hives, as flight distances are believed to be short.

9. Disadvantages This design of hive is intended for an environment like Southern Ontario where there is often considerable rain, which will otherwise split blocks and cause mold, and good pine is not cheap! For this reason the hive atrium is proportionally twice as deep as the leafcutter bee shelters of the Canadian Prairies. Over four seasons (2200 block X years, 45 hive X years) splitting of blocks by rain or possible "burn" of the grubs by heat have never been a problem. Could the hives ever be too dry? Possibly the atrium should be shortened or eliminated for the deserts of the US Southwest where rain triggers flowering and softening of nests. Could the transparency of the the ⅛" lids disorient emerging adults as to which direction is the nest block exit? Note that the exposed front ends of the lids are opaquely painted. Disorientation has been seen in one *Osmia* nest where the lid was accidentally reversed.

10. Dangers Could trapnesting harm the environment? Certainly, if it were done on a large scale with operators destroying 'unwanted' species in the process of selection, or moving unusual species and infested gear across national or natural boundaries. Work in progress includes (i) finding a way to allow unwanted insects to escape woodenware without return, so that it can be cleaned and reused, and (ii) experimenting with fumigation to limit parasitoid wasps.

11. Limitations This is a method for observation and selection. The remaining large problem is mass propagation, which will take fewer years of research, the more the number of interested individuals trying their hand at trapnesting, whether they be educators, beekeepers, fruit growers or scientists. But the fun is unlimited, and every species, no matter how small, seems to have some value for humans. [11]

Later articles will give data from field experiments and discuss the species further.

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