1-1-1982

The Hornfaced Bee for Efficient Pollination of Small Farm Orchards

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THE HORNFACED BEE FOR EFFICIENT POLLINATION OF SMALL FARM ORCHARDS

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ABSTRACT

Osmia cornifrons is a highly efficient pollinator of rosaceous tree fruits (Pyrus and Prunus spp.). It is managed commercially in Japanese orchards, and it has been introduced into the eastern United States. Due to its effectiveness, docility, ease of handling and short flight range, it is well adapted for use on small farms.

Keywords: Apple, bee, direct marketing, fruits, honey bee, insecticides, Japan, orchards, Osmia peach, pollination, pome, Prunus, Pyrus, small farms, stone fruits.

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The rosaceous tree fruits, apple, pear (Pyrus spp.), peach, plum, apricot, nectarine and cherry (Prunus spp.) require or benefit from insect visitation for cross- or self-pollination and adequate fruit yields (3, 6).

Due largely to cultural practices and heavy insecticide usage in modern orchards, populations of native pollinators are often inadequate, especially in Europe, North America, and Japan (2, 3, 5). Although honey bees are usually recommended, and hives are commonly placed in orchards for pollination (6), these insects are not fully satisfactory, especially on small farms, for several reasons:

1) Honey bees have a large foraging range (to 3 km) and are apt to leave the vicinity of the hives and orchard.

2) Honey bees are often readily attracted to flowering weeds or plants other than the fruit trees.

3) Honey bee rental for pollination costs (e.g., $14-15 per hive for 7-10 days' use in 1981 on apples in Virginia, according to P. Powers, State Apiculturist).

4) Rental colonies are difficult for small orchardists to obtain.

5) If not rented, colonies must be maintained, fed and protected from pesticides and parasites all year (this may be offset if enough honey and wax are produced).

6) Honey bees sting readily and painfully, therefore colonies are often not welcome in backyard or small farm orchards having much human or animal activity. This may become more significant if breeding with "Africanized" honey bees (Apis mellifera adansonii hybrids) occurs in North America.

Management in Japan

The hornfaced bee, Osmia cornifrons (Radoszkowski), has been commercially employed for fruit pollination in Japan for several decades (7), despite the availability of honey bees and (formerly) relatively cheap labor for hand pollination. The docility and effectiveness this solitary megachilid bee was first noticed by a small farmer, Mr. Eikyu Matsuyama, of Tsurutamachi Village near Hirosaki. In the 1930's he independently devised methods for attracting the bees and maintaining populations in his apple orchard. His technique was spontaneously adopted by neighboring farmers, and subsequently improved by agricultural research. The use of O. cornifrons in Japan has now reached most fruit-growing prefectures (in Hokkaido, Aomori, Akita and Awate, on apples; in Yamagata and Fukujima on apples and cherries; in Nagano on pears and apples, and in Yamaki perfecture on peaches, cherries and plums); the area of use continues to expand (5).

In Aomori prefecture (25,000 ha in apples), about 70 percent of pollination is still traditionally done by hand (fig. 1), despite high cost (30 person-days/ha needed at $800/ha for pollination). The acute shortage of wild pollinators and labor during the two-week bloom period often results in the recruitment of military troops for hand pollination. Hives of honey bees (rental fees $5-40 per colony) are placed in 20 percent, and 10 percent of all orchards are pollinated exclusively by O. cornifrons. The most progressive growers, who use hornfaced bees, are willing to modify cultural practices and to cooperate with neighbors in order to achieve most effective use of these insects. Entire valleys or villages may rely only on these bees for fruit pollination, for example, village Nagauma near Nagano, 350 ha supporting 500 families; Okozawa Village near Hirosaki, 80 ha supporting 80 families.

Orchards of progressive Japanese growers may yield 80 T/ha; the average yield is 20-30 T/ha. The small orchards (average size about 1 hectare or 2.5 acres) are intensively managed, and each can support a family at a comfortable standard of life, including modern conveniences. For example, one progressive farmer's 1.4 ha orchard of "Fuji" apples near Nagano supports a family of 7 (no off-farm income). He also hires 150 harvesters at $20/day each. He nets about $50,000 from the sale of fruit. About 10,000 hornfaced bees are kept as the sole pollinators of his orchard.

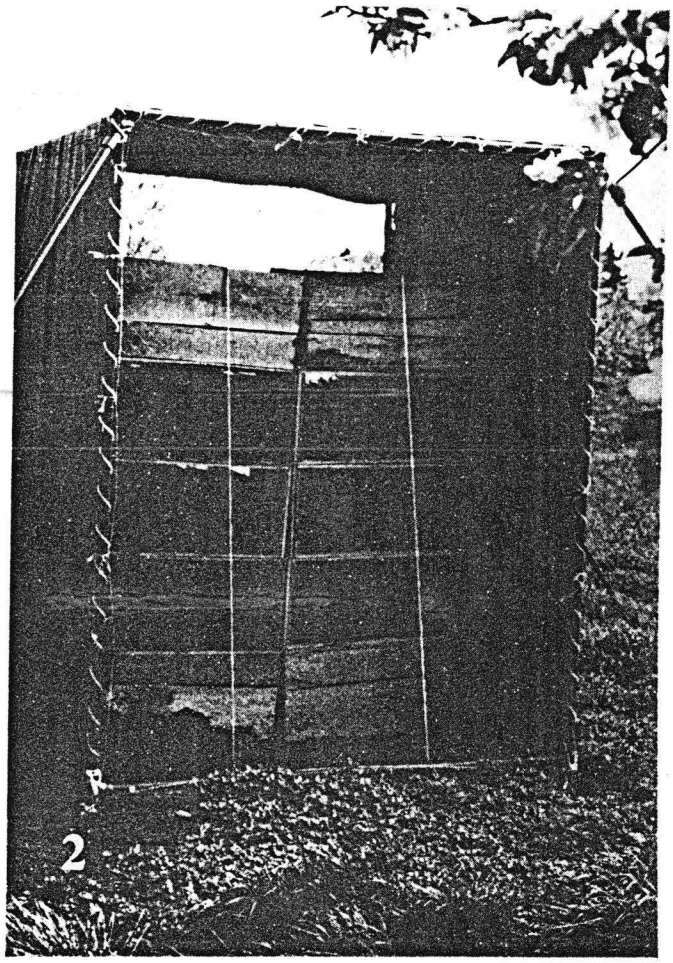
Japanese growers get a good price for their fruit, especially if they are near urban areas. Fruit may be sold through wholesalers, however, higher returns and assured markets are obtained when the grower works on contract for a group of urban consumers (some have had the same customers for 30 years). Pick-your-own operations are also popular; for example, 90 percent of apples at an orchard near Sapporo were harvested by customers and only 10 percent went to market. Apples are grown on about 50,000 ha in Japan, yielding 1 million tons.

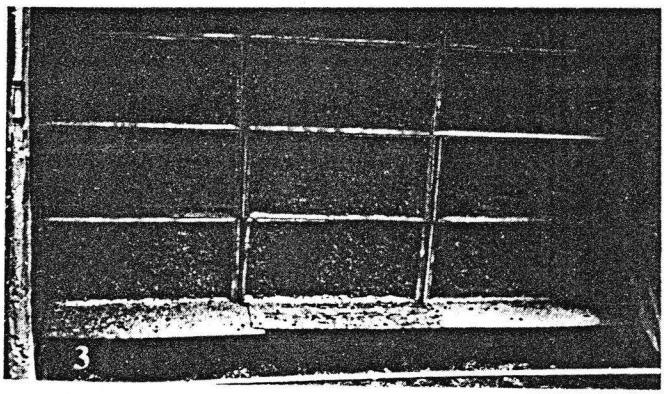
The management of O. cornifrons in Japan is precise. Bees are provided with nesting materials (usually cut, hollow Phragmites reed sections, but occasionally commercial cardboard tubes or "B-tels"). These are bundled and kept under the eaves of buildings or in specially constructed bee shelters in the orchard (figs. 2, 3). The natural emergence of adults of this univoltine bee coincides with the bloom of peach (4), cherry

and plum. It is necessary to delay the emergence and activity period of the bees for pollination of the later-blooming apples (5). In order to delay emergence, the bees' nests (reeds filled with cells) are removed from the orchards in late winter and stored at about 5°C (usually in the apple storage cooler). The nests are replaced in the orchard 7-10 days before apple bloom is expected to begin (the flowering of cherries is used as an indicator). The bees emerge within a few days, mate, and are ready to begin pollination and nesting just as apple bloom begins. The abundance of apple flowers permits rapid reproduction and an eightfold annual increase in bee population may occur under timed-release management (unmanaged populations may double annually). Excess bees are sold (at $0.10 each).

Parasites (particularly Chaetodactylus sp. mites) are controlled by sanitation; the bees are encouraged by selective placement of nesting materials to accept new nest reeds annually and abandon the old ones, which are burned. Bees are protected from insecticides by the elimination of two applications from the usual heavy spray schedule. No pest increase occurs. The last insecticide is applied 2 weeks before buds break for leafroller control. The first insecticide application after bees emerge is applied after all petals fall, which kills adult bees remaining in the orchard. However, most reproduction has been accomplished and the brood is protected by the impervious reeds and cells. Some adult mortality occurs when broadleaf herbicides applied to neighboring rice fields are ingested by females gathering

Fig. 1. Hand pollination is traditional in Japan. Pollen is applied with a brush (arrow). Many wild pollinators have been eliminated by insecticides and intensive cultivation.





Figs. 2, 3. Hornfaced bees nest in reed sections kept in shelters placed in the orchards. Each reed contains the nest of one female bee, consisting of about seven cells. About 7,000 bees per hectare are required for adequate pollination.

mud for brood cell construction. Nets over shelters prevent raids by predatory birds.

Hornfaced bees are more efficient pollinators of apples than honey bees, due to their preference for apple bloom, short flight range (about 100 m), rapid flower visitation rate, and consistent anther contact. The two pollinators were compared at an orchard in full bloom near Hirosaki, at noon on a sunny day. Three trained observers each independently watched a 9 sq m area of apple bloom (in different trees) for 15 minutes, and data were pooled. Selected branches were equidistant (50 m) from an apiary of 29 hives with supers (1,160,000 honey bees) and a shelter with 20,000 nesting O. cornifrons. Honey bees visited flowers at an average rate of 8.5/minute; hornfaced bees averaged 15 flowers/minute. More significantly, honey bees pollinated (actually contacted anthers and stigmas) of only 4 flowers, but hornfaced bees pollinated 105 flowers during the same period (71 ♀ collecting pollen, 20 ♀ collecting nectar, and 14 ♂ pollinated). Evidently numerous honey bees were foraging outside the orchard that had hired their services. Several Japanese scientists informed me that this behavior pattern is normal.

Trials in the United States

Osmia cornifrons was first established in the United States at Beltsville, MD, in 1978 (1). Since then, the population has doubled annually, and bees have been redistributed to scientific collaborators elsewhere in Maryland for trials on apples and peaches (1978-81); at Rutgers, New Jersey (1980), and at Ithaca, New York (1980) for apples; at Raleigh, North Carolina (1980-81) for apples and peaches; and in the District of Columbia (1980) for use on urban fruit trees. Reproduction and survival was good in all areas except the central Adirondack Mountains (N.Y.), where the winter temperature reached -40° C.

Native Phragmites reeds were the most satisfactory nesting material (average of 7 cells/reed produced); native Monodontomerus sp. wasps were able to penetrate nests in paper soda straws, destroying many bee larvae so that reproduction (1.1 bee/straw) was below population replacement level. Plastic soda straws were subject to fungus infestation. It was possible to eliminate Monodontomerus by using reeds, and also by storing cell-filled reeds during the summer in insect cages kept in a dry, shady place. Monodontomerus wasps emerging from nests during summer were attracted to light and died inside the cages. Parasitism was thus reduced to below one percent by the 1980 season. Some predation by mockingbirds (Mimus polyglottos) could be prevented by covering bee shelters with nets; however, these birds ate many mating bees that had settled on plants.

At Beltsville, the first male bees emerged about a week before (3/23-4/1) the first females (4/1-4/7). Nesting and pollen collection by mated females (4/7-4/10) began about three days after first females appeared. This coincided with the beginning of bloom of apricots, cherries, plums, almonds, pears and early peaches during four seasons (1977-1980). Apple bloom began about 10 days after nesting activity started, thus resembling conditions in Japan. Therefore, the most effective utilization of this insect on apples would require timed release management.

A multiple-choice test, in which cut branches of flowering fruit trees were placed near a bee shelter indicated the following selection (based on number of bee visits per minute) in declining order of preference: crabapple; Royalvee peach; Early Redhaven peach; Loring 51-24 early peach; early apricot No. 8; B-69 plum; Delicious apple; Tex PT-21 plum; Faroria peach; Bartlett pear; U.S. No. 220 pear. Bees did not visit pear No. 278; Magness pear (pollenless); and native Amelanchier canadensis (highly attractive to native Andrena and other solitary bees).

Osmia cornifrons can be successfully used for fruit pollination in the United States. Major obstacles still to be overcome are:

1) Obtaining or rearing sufficient bees for redistribution. Imported bees must be individually inspected to detect parasites. A colony may be started with about 200 bees; however, about 7,000 bees per hectare are needed for pollination.

2) Finding an inexpensive commercially available substitute for Phragmites reeds, necessary if the bees are to be widely used.

3) Educating growers to slightly modify their spray schedules.

4) Increasing public awareness of the economic potential of certain solitary bees that are "tailor-made" for use on specific crops.

I thank Y. Maeta, T. Kitamura, M. Yamada, S. F. Sakagami, H. Fukuda, K. Goukon, and the many horticulturalists and small farmers recently visited in Japan, for their excellent hospitality and information.

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