An Effective, Manageable Bee for Pollination of Rubus Bramble Fruits, 
Osmia aglaia

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Abstract

The non-social cavity-nesting bee Osmia aglaia Sandhouse (Apiformes:  
Megachilidae) shows promise as a manageable and effective pollinator for  
commercial raspberries and blackberries (Rubus). Floral visits by honey bees (Apis  
mellifera L.) or by less numerous caged O. aglaia yielded red raspberries of  
equivalent size; berries from unvisited caged flowers were significantly smaller.  
Female O. aglaia readily visited flowers of various blackberry cultivars too. Female  
foraging behavior on top of a flower’s pistil maximizes the chances for pollen  
transfer to innermost stigmas. The bee readily nests in inexpensive commercial foam  
nesting substrates modified from those already used for the alfalfa leaf-cutting bee.  
An affordable, durable nesting shelter and practical support frame has also been  
field tested. Large nesting populations have been increased in commercial bramble  
fruits in Oregon USA. Within its range in western Oregon and California USA, this  
effective native pollinator of Rubus could be a sustainably managed bee for  
cultivated bramble fruits.

INTRODUCTION

The honey bee remains the managed pollinator of choice for field crop and  
orchard pollination, with few exceptions. In the USA, migratory beekeepers truck their  
hived colonies to a series of sequentially flowering crops. Growers pay rent for the  
pollination service. Honey bees are not always the most effective or faithful pollinators  
for particular crops, but they are often satisfactory. Honey bees continue to dominate the  
crop pollinator market because their numerous foragers can be provided cheaply (ca. 100  
foragers for $1US), with some of their management costs offset by honey sales.

In the past few decades, several non-social cavity-nesting native bees of the genus  
Osmia (Hymenoptera: Megachilidae) have been shown to be more effective pollinators of  
particular crops. They can be practical to manage, at least in pilot field trials (Bosch and  
Kemp, 1999; Yoshida and Maeta, 1988; Torchio, 2003). To date, these species are not yet  
broadly adopted for commercial pollination of North American fruit or almond crops.  
However, there is growing interest in manageable Osmia bees because honey bee  
pollination services continue to be bedevilled by three problems: exotic disease-bearing  
mites, invasion of warmer growing areas by defensive African honey bees, and  
nationwide loss of feral populations and hobbyist beekeepers (circumstances which can  
leave smaller growers without honey bees altogether).

The diminishing availability of sufficient honey bees for pollination is a relevant  
concern for US bramble fruit growers. Individual farms growing raspberries or  
blackberries (Rubus) typically farm less, often much less, than 20 ha of bramble fruit.  
Many of the numerous smaller growers probably relied on either feral honey bee colonies  
or hived colonies provided by local hobbyist beekeepers. Both of these sources are  
increasingly unreliable. Nonetheless, bee pollination is necessary to yield fully formed  
raspberry and blackberry fruits of marketable size (Jennings, 1988). Since the future  
availability of feral or managed honey bees remains uncertain, an alternative manageable  
pollinator for cultivated Rubus is desirable.
DISCOVERY AND FLORAL ASSOCIATION

The association of *O. aglaia* with *Rubus* was unexpected. The 146 pinned specimens with floral records in our lab’s extensive collections were taken in central and southern California, mostly at flowers of the Hydrophyllaceae or Fabaceae (among 10 other plant families), suggesting that it is a floral generalist. The sole specimen from the Rosaceae was taken at *Adenostoma*. In southern Oregon, individuals and nests of this brilliant green bee were initially noticed together with alfalfa leaf-cutting bees (*Megachile rotundata* Say) in commercial wooden nesting boards (Ron von der Hellen, pers. comm.). Although it nested alongside alfalfa leaf-cutting bees, *O. aglaia* proved to be a disinterested and incompetent alfalfa pollinator (Cane, 2002).

Subsequent field observations revealed that those female *O. aglaia* were visiting feral Himalaya blackberries (*R. procerus* Muell.) growing around that alfalfa field (Karen Strickler and Robbin Thorp, pers. comm.). Pollen sampled from larval nest provisions contained pale, round, striate tricolporate pollen. It was indistinguishable in size or appearance from sampled *R. c." pollen. However, this general morphology is common and therefore not diagnostic. Foraging *O. aglaia* were subsequently observed foraging for nectar and pollen at flowers of a dozen blackberry and raspberry varieties at a small variety trial garden in southern Oregon (Cane, 2005). Interestingly, flowers of Himalaya blackberry, although an exotic weed in the Oregon and California, may be subsidizing reproduction by native *O. aglaia*. Fortunately, since *R. procerus* is an Old World apomictic blackberry, it is not expected to benefit particularly from this bee’s pollination service.

BEE LIFE HISTORY

Relevant life history attributes for management of *O. aglaia* are mostly common for its genus, but previously unreported. It has a single adult generation per year, with foraging adults present for 3–5 weeks near the middle of summer in Oregon. They overwinter as adults in their natal cocoons. Like their floral hosts, the bees require sufficient chill hours during winter diapause (I have used 6 months at 4°C in the lab). Thereafter, they require either prolonged spring temperatures or a week of incubation at summer temperatures (30°C) to emerge properly. Males emerge first. In the wild, females probably choose to nest in pre-existing old beetle tunnels in deadwood. By evaluating female nest choice and progeny sex ratio and production, I have found the optimal nest cavity diameter to be 4.6 mm and its depth to be 15 cm. These dimensions are conveniently met either using drilled wooden blocks or a double-depth of commercial foam nesting boards used for alfalfa leaf-cutting bees. Removable paper straw inserts facilitate sanitary management, as straws can be periodically replaced to avoid accumulations of larval disease spores in nest cavities. These substrates are acceptable to nesting bees and satisfactory for good offspring production.

RASPBERRY POLLINATION

Bees were compared for their relative values as pollinators of red raspberry. At a red raspberry farm in northern Utah (where the bee is not native), a captive nesting population of *O. aglaia* females was confined to forage in a 7 x 7 x 2 m field cage. Hived honey bees flew outside of the cage. Budded floral racemes were tagged inside and outside of the cage; half were left open, whereas the other half were enclosed in fine mesh bags to exclude floral visitors. Later, 40 fruits from each treatment were harvested and their complement of druplets counted (Cane, 2005).

Female *O. aglaia* were at least as efficacious as free-flying honey bees for pollinating two red raspberry cultivars, ‘Canby’ and ‘K81-6’. Flowers visited freely by either bee species yielded fruits of equivalent counts of druplets and fresh weights. These fruits were 20–40% larger on average than those arising from unvisited flowers in the experiments; many fruits of unvisited flowers were unacceptably small and crumbly (Fig. 1). Seven female *O. aglaia* in the cage serviced 7 m of raspberry row; outside the cage, bloom on 7 m of row was on average visited by 10 honey bees. For several hundred
observed floral visits, foraging female or male *O. aglaia* were seen to invariably stand centrally on top of the red raspberry flower, pivoting to reach the nectaries and anthers. This behaviour ensures contact with the stigmas of the central pistils, which are the ones that are incapable of mechanical self-pollination. The result is more thorough pollination and a fully formed, firm fruit. Female *O. aglaia* were seen handling eight commercial blackberry cultivars in a similar manner, and so presumably the species effectively pollinates them as well.

**NESTING NEEDS**

Affordable, practical nesting systems are being developed to manage nesting *O. aglaia* on farmed bramble fruits in its native range of western California and Oregon (Cane, 2006). The shelter for holding the nesting substrates is manufactured from reinforced polyethylene laminate (Fig. 2). These utility totes or tubs are used by the US Postal Service ("nestable totes" from American Postal Manufacturing, Milwaukee, Wisconsin, USA) and increasingly as a tote for harvested fruit. An inexpensive custom-manufactured metal bracket cradles the tote and firmly attaches it to a metal fencepost or grape stake (Quiedan Inc, Carmel, California, USA). The cost of one shelter with bracket and foam nesting board should not exceed $25US. Thus far, these shelters have endured 5 years of field use. One shelter filled with the foam board nest substrate and stocked with one female *O. aglaia* per two holes is calculated to provide sufficient bees to pollinate $\frac{1}{2}$ ha of blooming raspberries. The cost of this arrangement for *O. aglaia* is competitive with the annual costs of renting hived honeybees for $140US (Burgett, 2004) at the recommended stocking density of 4 colonies per ha (Free, 1993).

**POPULATION MANAGEMENT COMPARED WITH OTHER BEES**

Captive populations of *O. aglaia* are being sustainably managed during pilot trials in commercial bramble fruits in Oregon. Disease, parasitism and predation must be minimized in managed populations. Nests from the wild Oregon source population of *O. aglaia* hosted large numbers of a parasitic wasp, *Sapyga pumila* Cresson. Each wasp larva consumes the immature host bee and its provision mass, costing one bee offspring. To reveal overwintering wasp larvae in nests, we examined X-ray images of straws nests of most of the starting population of *O. aglaia*. Using the images, we could precisely locate, excise and destroy infested nest cells. By this procedure, we were able to reduce the infestation rate by *Sapyga* from 24% in the trap-nested population to just 6% in the resulting generation in commercial bramble fruits. Partly as a consequence, population increases were obtained for all 8 nesting shelters, ranging from 110–330%, yielding a managed population of about 7000 individuals.

Management of *O. aglaia* and other non-social bees will fundamentally differ from that of other agricultural pollinators. Migratory beekeepers temporarily rent their honeybee colonies to growers, pollinating a sequence of crops during the long growing season. Honeybee colonies lose strength on some flowering crops, such as seed onion, almond or pear, but their numbers can be recovered with other more resource rich crops, such as citrus. Since many solitary bees such as *Osmia* have a single annual generation, adults are actively nesting for just 3–4 weeks each year. This leaves time to pollinate just one crop with a non-social bee such as *O. aglaia*, so the crop must be satisfactory to sustain progeny production.

Commercial bumble bees present a contrasting, single-use model. Their colonies are shipped and sold as disposable single-use units. This practice is only economically rational when they are confined with high-value, pollinator-dependent crops such as greenhouse tomatoes. Managing non-social bees as disposable pollinators for field crops is impractical and expensive. Besides the cost and uncertainty of annually trap-nesting from wild populations of fluctuating size, a sizeable "by-catch" of non-target nesting species is typically wasted, or worse, goes unrecognized and is transported and released along with the desired pollinating species. Worse still, wild populations are infested with parasites, predators and diseases. Unless these are mostly removed, pestilence threatens to
proliferate in densely managed nesting populations, jeopardizing productivity of subsequent generations of their non-social bee hosts. The likely management model for non-social bees will be active bee husbandry by the grower.

To be sustainably managed, a non-social bee species, such as *O. aglaia*, will initially be trap-nested from nature. After pestilence clean-up, subsequent generations will be managed in manufactured nesting substrates. The pollinator population must be capable of reliably increasing on the pollinated crop. It may also be practical to “ranch” bees on alternative forage if it is convenient and yields rapid population growth. I anticipate that smaller, more meticulous bramble fruit growers will be the first to sustainably manage *O. aglaia* to pollinate their raspberries and blackberries, partly because their pollination needs are otherwise not being met. After a few years, population growth of *O. aglaia* will surpass a small grower’s pollination needs. Annual excess bee production then can be harvested and sold to other growers as a profitable secondary commodity (akin to honey sales by beekeepers).

**FUTURE STUDIES**

Several remaining questions are under investigation. This bee’s fidelity to raspberries and blackberries will be observed in the open field. Shelter placement is being evaluated, as greater population growth of *O. aglaia* may be possible where bees have access to several nearby *Rubus* species and varieties that afford more prolonged bloom. A rotational scheme for nest straw re-use will be tried, one that continues to minimize disease incidence but takes advantage of the olfactory attraction that old nests have for young females. Traps for *Sapyga* parasitic wasps are being designed and evaluated. Lastly, small nesting populations of several other related *Osmia* species of the western USA have been obtained. One of these, *Osmia bruneri*, is showing good promise for manageability and pollination efficacy on bramble fruits grown in western regions of the USA where *O. aglaia* is not native.

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**Literature Cited**


Figures

Fig. 1. Pollinator effectiveness compared using counts of druplets per red raspberry fruit. Treatments contrast fruits from unvisited flowers with fruits from flowers visited freely by nesting female *O. aglaia* (in a field cage) or foraging honey bees.

Fig. 2. Assembled nesting shelter for *O. aglaia*. The image shows the interior of a tub (= tote) with its content of one emergence box (left) and a block of polystyrene foam with 690 nesting holes. The shelter is mounted on a metal bracket that is bolted to a metal fence post.