BLUEBERRY AND CRANBERRY (*Vaccinium* SPP.) POLLINATION: A COMPARISON OF MANAGED AND NATIVE BEE FORAGING BEHAVIOR

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Abstract

The foraging behavior of honey bees, Bumblebees, and leafcutting bees on three *Vaccinum* crops: lowbush blueberry, highbush blueberry, and cranberry was studied in a greenhouse flight-cage. Flower handling time, flower visitation behavior, and pollen grain deposition were compared. Based on these criteria, no single species of bee emerged as the best pollinator for all three crops.

1. Introduction

Interspecific differences in bee foraging behavior has important implications for plant reproduction, fruit set, and yield. Lowbush blueberry, highbush blueberry, and cranberry are economically important crops in the United States and Canada. Bees are essential for pollination of these crops in order to obtain commercial size yields (Eck, 1988, 1990).

Presently, rented honey bee colonies are the primary pollinators of these crops in Maine, USA, (Stubbs, *et al.* 1994, Jadczak, 1995). However, the availability of honey bee colonies is decreasing while the rental price is increasing. In order to insure sustainable cost-effective pollination, we have been investigating the efficacy of alternative pollinators for these crops.

The objectives of the present study were to compare flower handling behavior, flower handling time, and pollen deposition of three managed, commercially available species *(Apis mellifera* L, honey bee; *Bombus impatiens* Cresson, Bumblebee, *Megachile rotundata* Fabricus, alfalfa leafcutting bee) and a native leafcutting bee *(Osmia atriventris* Cresson) on blueberry and cranberry.

2. Materials and methods

Foraging behavior bioassays on lowbush blueberry, *Vaccinium angustifolium* Ait. were initiated in 1993 in a screen flight cage (30 m x 5.5 m x 6.4 m) in a greenhouse at the University of Maine, Orono, Maine, USA. We conducted the bioassays on highbush blueberry, *Vaccinium corymbosum* L. (cultivars: Patriot, Blue Ray, Blue Jay, and Jersey), and cranberry, *Vaccinium macrocarpon* Ait. (cultivar: Stevens) in the greenhouse flight-cage in 1996.

Dormant cut lowbush blueberry stems and potted lowbush and cranberry plants were maintained in cold storage at 4° C for at least 1000 hrs in order to break dormancy and induce bud break. Highbush blueberry stems were cut from March-May, prior to flowering and kept in cold storage. Plants and stems were then brought into the greenhouse and allowed to flower as needed.

Generally one species of bee and its nesting materials were maintained in the flight-cage at a time. The A. *mellifera* hives contained a Queen and two frames of bees. *Bombus impatiens* were greenhouse colonies, each colony contained approximately 60 workers. Only one hive or colony was in the flight cage at a time. Approximately 200 female *M.*

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rotundata, from incubated leaf cells from Saskatchewan, Canada, were housed in Poli Surrounds, a commercial nesting material. Forty female *Osmia atriventris,* reared from 15.2 cm paper straws (6 mm inner tunnel diameter) nests produced in trap nesting blocks set out around blueberry fields in Maine, were housed in wooden nesting blocks.

Bees in the flight cage bees were maintained on potted flowering buckwheat, *Fagopyrum esculentum* Moench, which served as a forage plant for all the bees and as a source of leaf material for the nesting *Megachile* and *Osmia* females. Several hours prior to the onset of a bioassay session, the buckwheat plants were removed from the flight cage or covered with plastic or insect barrier cloth. Sugar syrup and water were also provided.

The procedure for the bioassay sessions was as follows: three cut blueberry stems or cranberry uprights were placed in a moistened floral styrofoam block. The block was placed in the flight cage approximately 1 m from the bee domicile. Observations of bee foraging behavior, flower handling time, and the number of bee visits to individual flowers were recorded. Stems were left in the cage for 1 hr or 10 visits to a single flower on one of the stems, whichever came first. Also, in order to obtain sufficient single visits to flowers, in some cases, an individual flower was excised from the stem after one visit and placed in a petri dish. Pollen tetrads on individual stigmas were counted under a dissecting microscope at 30x and the number of grains present per single visit recorded.

The stigmas from three control flowers, which were handled in the same manner as visited flowers per bioassay session, were also examined microscopically and any pollen grains recorded.

3. Results

Intraspecific differences existed for flower visitation behavior. For all bee species, some individuals visited only one flower per stem, whereas other individuals visited two to all available flowers per stem.

Flower handling time varied among the bee species for the three species of *Vaccinium* (Table 1). *Vaccinium* spp. appears to be least preferred by honey bees based on the amount of time spent trying to observe and record 25 single flower visits to each *Vaccinium* crop (Table 2).

The only pattern observed for pollen deposition on stigmas was that *A. mellifera* consistently deposited the least per single visit (Table 3). *Osmia atriventris* deposited the most pollen per single visit on lowbush blueberry, followed by *M. rotundata.* On highbush blueberry and cranberry, *B. impatiens* deposited the most pollen per single visit.

4. Discussion

Based on foraging behavior and pollen deposition, no single species of bee emerged as the best pollinator for all three crops. Pollination intensity or stigma pollen load per visit (Inouye *et al.*, 1994), where virgin flowers are exposed to single bee visits and the deposited pollen grains counted, is one technique for measuring pollinator effectiveness (Dafni 1992). Our flight-cage bioassays indicate that in all cases the honey bee was the least effective.

The native *O. atriventris,* was the most effective on lowbush blueberry. Unfortunately it was not available in sufficient number to evaluate as thoroughly on highbush blueberry or cranberry as were *B. impatiens* and *M. rotundata. Osmia atriventris* has been found foraging on and collected from a natural stand of highbush blueberry, near Ithaca, New York (MacKenzie, 1994a).

For managed pollinators, *M. rotundata* continued to have very good potential as an alternative on lowbush blueberry (Stubbs, *et al.* 1994). However, on cranberry, it deposited relatively few tetrads compared to *B. impatiens.* Interestingly, Cane *et al,* (1966) found a native conspecific *M. addenda* to be very effective on cranberry in New

Jersey where *M. addenda* deposited an average of 28.3 ±5.5 (S. E. M) tetrads per single visit.

The managed Bumblebee, *B. impatiens,* seemed most effective on cranberry. Field studies by MacKenzie (1994b), demonstrated that Bumblebees had purer pollen loads, faster foraging rates, and were more legitimate foragers than honey bees on cranberry.

Dafni (1992) aptly pointed out that the pollen load on a stigma does not always relate to seed production. Therefore, field studies are currently under way that examine the effect of A. *mellifera, B. impatiens, M. rotundata,* and native bees on fruit set and yield for these crops in order to determine which bee or bees are most cost-effective.

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Table 1 - Average flower handling time (~~min~~ sec) + S. E. M deposited per individual *Vaccinium* spp. flower by bees. (Range is in parentheses. Asterisks indicate less than 25 observations were made.)

Bee Species	Lowbush blueberry	Highbush blueberry	Cranberry
Apis mellifera	13.2 ± 3.1 (2 - 48)	2.6 ± 0.8* (1 - 5)	4.2 ± 1.8* (1 - 15)
Bombus impatiens	1.5 ± 0,2 (1 - 4)	2.9 ± 0.4 (1 - 9)	6.7 ± 1.0 (1 - 22)
Megachile rotundata	3.4 ± 0.1 (1 - 5)	7.0 ± 1.4 (1 - 30)	2.8 ± 0.5 (1 - 9)
Osmia atriventris	1.9 ± 0.2 (1 - 5)	2.4 ± 0.5* (1 - 5)	-----

Table 2 - Time (min) elapsed observing bees in the flight cage in order to obtain 25 observations of a single visit to individual flowers. (Values in parentheses are the number of single visits observed if n = less than 25 visits observed.)

Bee Species	Lowbush blueberry	Highbush blueberry	Cranberry
Apis mellifera	293	330 (5)	300 (7)
Bombus impatiens	45	49	22
Megachile rotundata	188	209	279
Osmia atriventris	178	120 (7)	-----

Table 3 - Average number of pollen tetrads ± S. E. M. deposited on individual *Vaccinium* spp. stigmas by bees in single visits. (Range is in parentheses.)

Bee Species	Lowbush blueberry	Highbush blueberry	Cranberry
Apis mellifera	11.6 + 3.7 (0-70)	0	4.5 ± 1.4 (0 - 10)
Bombus impatiens	16.0 + 1.9 (0-41)	38.4 + 7.5 (0-167)	45.4 + 7.3 (0-120)
Megachile rotundata	23.1 + 8.3 (0-89)	10.3 + 2.5 (0-52)	8.3 + 1.4 (0-25)
Osmia atriventris	33.8 + 8.5 (0-202)	14.2 + 4.0 (0-78)	-----
Control	1.2 ± 0.4 (0 - 6)	0.7 ± 0.3 (0 - 6)	0.5 ± 0.3 (0.- 4)