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Pollination of commercial cranberry (*Vaccinium macrocarpon* Ait.) by native and introduced managed bees in Newfoundland

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ABSTRACT

Cranberry flowers must be pollinated by insects for fruit to develop and bees are their main pollinators. Research was conducted on two commercial cranberry farms in western Newfoundland, Canada, to determine which bee species are most important for the pollination of cranberry in this area, and whether importing the commercial bumble bee, *Bombus impatiens,* for supplemental pollination is desirable. The bumble bee, *Bombus ternarius,* and halictid bee *Lasioglossum* (*Dialictus*) spp. were the most common and abundant bees collected and are important for pollinating cranberry. The commercial bumble bee did not increase fruit set and their economic practicality for cranberry pollination in the future should be reviewed. Since several native species and honey bees were observed inside the colonies of the commercial bees, we discuss the potential for disease transmission among and impact on native and managed bees.

RÉSUMÉ

Les fleurs de canneberges doivent être pollinisées par les insectes pour que les fruits à développer, et les abeilles sont leurs pollinisateurs principaux. La recherche a été réalisée sur deux fermes de canneberges commerciales dans l'ouest de Terre-Neuve, au Canada, pour déterminer quelles espèces d'abeilles sont les plus importantes pour la pollinisation de la canneberge dans cette région, et si l'importation du bourdon commercial, *Bombus impatiens*, pour la pollinisation supplémentaire est souhaitable. Le bourdon, *Bombus ternarius,* et l'abeille halicite *Lasioglossum* (*Dialictus*) spp. ont été les abeilles les plus communes et abondantes de celles recueillies, et les deux sont importantes pour la pollinisation des canneberges. Le bourdon commercial n'a pas augmenté la nouaison et son aspect pratique économique de la canneberge pollinisation à l'avenir devrait être revu. Puisque nous avons observé plusieurs espèces d'abeilles indigènes ainsi que des abeilles mellifères dans les colonies des abeilles commerciales, nous discutons de la possibilité de transmission de la maladie, et son impact, chez les abeilles indigènes ainsi que les abeilles domestiques.

INTRODUCTION

The island of Newfoundland is the most easterly landmass in North America and is situated approximately 150 km from mainland Canada. Newfoundland's unique climate and its isolation from mainland areas have resulted in a bee fauna that is much smaller than adjacent areas. The island of Newfoundland has 69 species recorded while Nova Scotia has 231 species (Cory Sheffield, Royal Saskatchewan Museum (RSM), personal communication).

Cranberry (*Vaccinium macrocarpon* Ait.) is a native ericaceous plant that grows on acidic soils and peat (Eck

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1990). Its main distribution lies between 40°N and 50°N and 70°W and 80°W (Vander Kloet 1983). Flowering of cranberry north of 45°N is between mid-July to mid-August (Vander Kloet 1983). North American indigenous and settling peoples have utilized the cranberry over many centuries (Eck 1990), however it remained a small industry in Newfoundland until recently. The Newfoundland cranberry industry began in 2002 with a provincial government initiative to get farmers interested in alternative crops. Since that time there has been an infusion of federal and provincial funding to help launch this fledgling industry. The total Canadian acreage for cranberry in 2011 was 6148 ha (Statistics Canada 2011) with Quebec and British Columbia as the main producers. Total acreage in 2009 for the Atlantic Canadian provinces (Nova Scotia, New Brunswick, PEI and Newfoundland) was 312 ha (Anonymous 2010). Newfoundland had only 9.7 ha of cranberry bogs in production at the time. The allocation of $3 million in 2008 by the Newfoundland government and $7 million in 2014 by both the provincial and federal governments to establish commercial cranberry bogs in several areas throughout the province (Government of Canada 2014) increased acreage to 141.6 ha in 2015 (K. Kennedy, Department of Natural Resources, Government of Newfoundland and Labrador (DNRNL), personal communication).

With this expansion in the cranberry industry, it is important that we understand the pollination requirements of the plant in Newfoundland. The morphology of the cranberry flower, with its poricidal anthers, makes bee buzz-pollination essential (Mackenzie 1994; Cane et al. 1996). In a large-scale study of 600 fields in 41 cropping system, of which cranberry was included, Garibaldi et al. (2013) showed that pollinators enhanced fruit-set. The bees visit the flowers to obtain nectar and pollen as food and inadvertently carry pollen to other flowers. In southeastern Massachusetts, Loose et al. (2005) indicated that native bees play an important role in cranberry pollination. They recorded approximately 80 species of native bees associated with cranberry and suggested that many of the same bees are associated with blueberry fields. Hicks (2011) did not find as many and had only 9 similar species that occurred on the Loose et al. (2005) list associated with blueberry in eastern Newfoundland.

Some Newfoundland cranberry producers have imported the non-native bumble bee, *Bombus impatiens* Cresson, to supplement the pollination activities of native species with the goal to increase berry yield. Supplementation of cranberry with commercial bumble bees occurs elsewhere (Macfarlane et al. 1994) but because the bee species used are native it is difficult to get a good handle on the contribution of the commercial bees. Newfoundland is an ideal location for this research as *Bombus impatiens* is not native to the island and is not established here. Supplementation of blueberry with *Bombus impatiens* in Quebec increased fruit set by 12.5% over the background pollinator level (Desjardins and De Oliveira 2006). Stubbs and Drummond (2001) showed that *Bombus impatiens* was a better pollinator of blueberry compared to honey bees but in some cases native species accounted for much of the pollination. While anecdotal observations by farmers are mixed on whether the importation of bees affects production, observations within Newfoundland blueberry farms indicates that supplementation with *Bombus impatiens* does not increase blueberry production (Hicks 2011). There are also indications from other areas that supplementation with bees (generally) for increased pollination in cranberry crops may not be necessary (Brown and McNeil 2006).

The purpose of this study was to determine the native bee species that are most important for cranberry pollination in Newfoundland, and the utility of importing commercial bumble bees (*Bombus impatiens*) for supplementing pollination on Newfoundland cranberry farms. Our hypothesis is that supplementation of Newfoundland cranberry fields with *Bombus impatiens* increases the fruit-set.

METHODS

Location

Two cranberry plots were chosen on two separate conventional commercial cranberry farms near Stephenville, Newfoundland and Labrador, Canada (48°32'58"N; 58°34'24"W). Farm-1 fields had sand over the top of an organic soil, and were approximately 200 × 40 m. The farm-1 berms were composed almost entirely of piled sand and since vehicles used the top of the berm, the soil there was considerably compacted with little vegetative growth. Farm-2 was located 15 km away from farm-1. The cranberry plots were composed of organic soil (peat) with a sand layer over the top, and were approximately 150 × 30 m. The farm-2 berms retained the peaty soil and had an abundance of herbaceous and woody shrubs (e.g., *Alnus rubra* and *Vaccinium angustifolium*). Both farms had the Pilgrim variety of cranberry and were harvested in the autumn by flooding the fields.

Supplementation

Twenty-four colonies (6 quads) of *Bombus impatiens* were placed in farm-1 on 15 July 2013 by the farmer (unknown supplier). There was 15-20% bloom of the cranberry plants when these colonies were placed into the field. An additional 16 colonies (4 quads) of *Bombus impatiens* (purchased from Biobest Canada Ltd, Leamington, Ontario) were placed on farm-1 on 31 July, 2013. The quads were spaced 35 m apart down the center of the field. Farm-2 was un-supplemented. On 14 August 2013, all of the researcher-purchased quads of *Bombus impatiens* and one farmer-purchased quad were removed from the fields and frozen at −20 °C to kill all bees. The colonies were opened and the contents searched to determine the number of queens and workers.

Native bee diversity and abundance

On 17 July 2013, two-45-m transects were established on each cranberry farm. Nine cup traps (350 ml plastic cup) of alternating blue, yellow and white cups were placed along transects at 5 m intervals down the center of the fields at each farm. This placement of cup traps along transects was used by Sellars & Hicks (2015) in a study of bees in different habitats of eastern Newfoundland. A similar 45-m transect with 9 cup traps was placed along an adjacent berm on each farm. The cup traps were ¾ filled with a solution containing water and Dawn™ dishwashing detergent. The addition of the detergent caused any insects that entered the cup to easily break the surface tension of the solution and quickly drown. All traps were cleared weekly until 21 August (5 weeks). In addition, 30-minute sweep net samples were taken at each cranberry plot on three separate dates on warm days with light winds (23 July, 8 August, and 13 August). All insects collected in the cup traps and sweep net samples were taken back to the lab and pinned for identification. Specimen identifications were made using appropriate taxonomic keys (Mitchell 1960; Laverty and Harder 1988; Gibbs 2010; Gibbs et al. 2013; Ascher and Pickering 2015) with verification of rare species by Cory Sheffield (Royal Saskatchewan Museum, Regina Saskatchewan). All specimens are retained at the Carbonear campus of the College of the North Atlantic.

Flower to fruit ratio

On 23-24 July 2013, two 10-m transects were established in the cranberry fields at each farm in the center of the fields. At 50 cm intervals, plants were tagged and their flowers counted. After the fruits had developed (21 September 2013), the fields were visited again and the fruit that developed on the tagged plants was counted. At the same time, 25 ripe fruit per plot were randomly sampled and taken back to the lab where their diameter, weight, and number of seeds were determined.

Pollination success by native bees

On 15 July 2013 (15-20% bloom) one row of four 1-m^2 quadrat boxes were placed over the cranberry plants at 18.5 m intervals along the center of each field. The quadrats were made of a wooden frame covered in fine mesh to exclude pollinators. Any opened flowers inside the quadrat boxes were removed at that time. During 80% bloom (farm-2, 29 July 2013; farm-1, 1-2 August 2013), the mesh screens for each quadrat were removed for 1 hour and pollinator activity was observed directly in the quadrats. Visitors to the exposed un-pollinated flowers were identified to the lowest practical taxonomic level. Any flowers visited by a bee were individually covered with small screens to prevent future visits. Fruit that developed on these visited flowers was collected on 21 September, and the diameter, weight and number of seeds were determined for each fruit. The percentage fruit set was calculated by dividing the total number of set fruit by the number of visited flowers.

Density of native bee nests

The density of native solitary bee nests was determined by walking along a 10-m transect on the berm of each farm and counting the number of nest entrances in a 1 m^2 area at 1 m intervals (i.e., 10 observations per transect). Two different 10-m transects per farm were observed on three separate dates (23 July, 8 August and 13 August).

Soil sampling

On 22 July, 5 August, and 12 August 2013, 10 soil samples were taken along each transect occurring on the berms. A standard soil core sampler was used that extracted 78.5 cm^3 of soil to a depth of 25 cm. Each soil sample was placed into a sealed plastic bag for transport to the laboratory. Upon arrival, the wet soil sample was weighed; dried in an oven at 60° C for 5 days and then re-weighed to calculate the percentage soil moisture.

Data handing

Individual rarefaction calculations for the combined berm and on-field data were calculated for each farm using the Estimate S online calculator (Colwell 2013). Shannon-Wiener diversity indices were calculated for each treatment using PAST online calculator (Hammer et al. 2001). PAST was used to compare the diversity indices between the two farms using a t-test described by Poole (1974). A one way analysis of variance was used to compare means of variables between fields (i.e., fruit-set and environmental measurements) after the data was checked for normality. Proportional data and data that did not turn out to have the data normally distributed, were transformed (arcsin and Log_{10}). ANOVA was performed in Minitab© version 15.

RESULTS

Native bee diversity and abundance

The abundance of bees collected in the cup traps from transects located on the cranberry fields was similar between farm-1 (supplemented) and farm-2 (un-supplemented) (Table 1). However, more bees were collected on the berms at farm-1 than at farm-2. The most common bumble bee species collected on both farms by cup traps (Table 2) and sweep netting (Table 3) was *Bombus ternarius*. There were 20 species collected on farm-1, and 16 on farm-2. Two of the recorded species from farm-1 were introduced species (*Bombus impatiens* and *Apis mellifera*), thus there is no meaningful difference in native species richness. Rarefaction analysis (Figure 1) of the trap data between the farms showed no significant difference (by overlap of 95% CF limits) in bee species richness. In addition, there was no significant differences in Shannon-Weiner diversity index calculated for each farm (Table 4). One very interesting observation was native bees or honey bees located inside 58% of the commercial *Bombus impatiens* colonies that were examined. The native species observed included *Bombus ternarius, Bombus terricola, Bombus frigidus,* and *Bombus vagans bolsteri*. This seems to be a common occurrence, at least in Newfoundland, and mirrors observations by Hicks (2011) and by anecdotal observations of bumble bees in honey bee hives. It is unknown why these bees enter commercial hives.

Table 1. Abundance of bees collected in cup traps on cranberry farms in western Newfoundland over a 5-week period (18 July - 21 Aug 2013).

Date	Farm-1 (supplemented)		Farm-2 (un-supplemented)	
	Field	Berm	Field	Berm
Jul 25	10	42	13	16
Jul 31	15	82	16	34
Aug 7	42	108	26	11
Aug 14	21	71	30	20
Aug 21	9	16	23	16
Totals	97	319	108	97
% of total	23.3	76.7	52.7	47.3

Table 2. Bee species and total abundance collected in cup traps over a 5-week period (18 July - 21Aug 2013) in cranberry farms in western Newfoundland.

Species (Bowl traps)	Farm-1 field	Farm-1 berm	Farm-2 field	Farm-2 berm
Bombus ternarius	43	129	33	9
Bombus impatiens	6	15	0	0
Bombus terricola	4	9	1	0
Bombus frigidus	2	7	0	0
Bombus vagans bolsteri	4	9	3	1
Bombus borealis	1	1	4	2
Bombus rufocinctus	1	0	1	1
Bombus (Psithyrus) fernaldae	0	1	1	0
Apis mellifera	0	4	0	0
Lasioglossum (Dialictus) spp.	31	137	38	66
Lasioglossum leucozonium	1	1	21	9
Lasioglossum athabascense	0	2	0	1
Lasioglossum quebecense	1	0	0	3
Halictus rubicundus	0	1	0	0
Andrena carolina	1	0	1	1
Andrena rufosignata	0	1	0	0
Andrena frigida	0	1	0	3
Andrena hirticincta	1	0	2	0
Andrena vicina	0	1	0	0
Hylaeus modestus	0	0	2	0
Megachile frigida	1	0	0	1
Megachile melanophaea	0	0	1	0
Total Bees	97	319	108	97

Table 3. Bee species and total abundance collected during 30 minute sweep net samples over five weeks (18 July - 21 Aug 2013) in cranberry farms in western Newfoundland.

Species (Sweep net)	Farm-1	Farm-2
Bombus ternarius	4	26
Bombus terricola	1	3
Bombus frigidus	2	2
Bombus vagans bolsteri	0	2
Bombus borealis	0	1
Lasioglossum (Dialictus) spp.	1	2
Andrena carolina	0	2
Osmia bucephala	0	1
Total Bees	8	39

Flower to fruit ratio

The un-supplemented farm (farm-2) had a higher fruit set (62.2%) when compared to the supplemented farm (farm-1) (53%) (Table 4), although this difference was marginally non-significant ($F_{(1,77)}$ = 3.87, P = 0.053).

Pollination success by native bees

In the cranberry fields, the Halictidae (likely all *Lasioglossum*, but not distinguishable from other halictids on the wing) were the most efficient, pollinating 36.8% of the flowers that they visited once (Table 5). Compared to halictids, native *Bombus* species had a slightly lower but similar success rate (34.8%). Interestingly, imported *Bombus impatiens* had the lowest pollination success rate

Figure 1. Rarefaction curves for cup-traps from combined berm and on-field data including 95% CI for bees collected on two cranberry farms in Newfoundland. Farm-1 was supplemented with *Bombus impatiens*; farm-2 was unsupplemented.

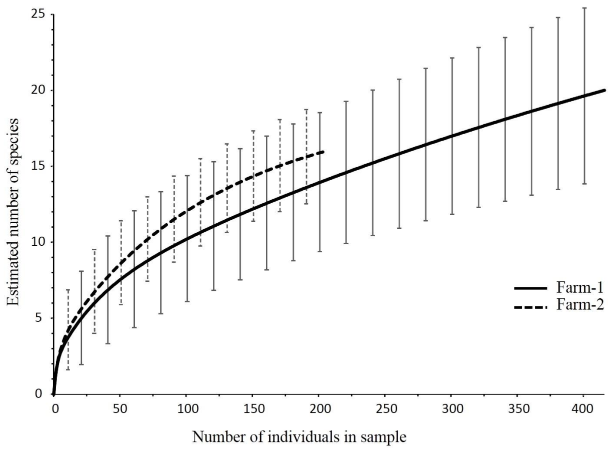

Table 4. Species richness, Shannon diversity index, abundance of bees and fruit set on cranberry farms in western Newfoundland during summer 2013. N = the number of all bee specimens. N = the numbers of flowers studied.

Location	Richness	Diversity	N	% Fruit set (n)
Farm-1 (supplemented)	20†	1.432a‡	416*	53 (40)a
Farm-2 (un-supplemented)	16	1.525a	205	62.2 (39)a

† This number includes the 2 non-native, managed species, *Bombus impatiens* and *Apis mellifera*
‡ Values in columns followed by the same letter are not significantly different (p = 0.05)
*This value includes 25 specimens of *Bombus impatiens* and *Apis mellifera*.

during a single flower visit (14.3%; Table 5) although this must be interpreted with caution due to the small number of observations. Generally, single visits to flowers by the larger bees appeared to result in larger fruit with a larger number of seeds than visits by the smaller bees (Table 5), although the small sample size and low statistical power preclude any meaningful statistical comparison.

Soils and density of bee nests

Soil moisture was significantly higher on farm-2 berms: 81.9% ± 3.42 compared to 22.6% ± 15.12 (both N = 30; mean ± 1 SE) on the farm-1 berms ($F_{(1,59)}$ = 439.74, P = <0.001). Although there were differences in soil moisture, it did not appear to affect *Lasioglossum* sp. nest entrance abundance along transects sampled (farm-2 = 1.3 nests/m^2, farm-1 = 1.0 nests/m^2).

Table 5. Pollination success of single visits to virgin blossoms by selected bee species observed in cranberry farms in western Newfoundland.

Bee type	# of obs.	# of fruit	% Fruit set	Mean dia. (mm)	Mean Wt (g)	Mean # seeds/fruit
Bombus spp.	46	16	34.8	11.8	0.613	12.8
Bombus impatiens	14	2	14.3	11.9	0.654	14.0
Halictidae	19	7	36.8	10.4	0.421	9.5
Andrenidae	4	1	25.0	9.1	0.368	9.0

DISCUSSION

Bombus ternarius and *Lasioglossum (Dialictus) spp.* are important bee species in the cranberry farms studied here. MacKenzie and Avrill (1995) found 36 species of bees on cranberry bogs of south-eastern Massachusetts. MacKenzie and Winston (1984) collected only 4 species on cranberry bogs in British Columbia. The overall diversity in Newfoundland cranberry farms was low (Shannon-Weiner index; farm-1 = 1.43; farm-2 = 1.53) but comparable to that found on cranberry bogs in Massachusetts (Shannon-Weiner index; range 1-2; MacKenzie and Avrill 1995) and higher than in British Columbia (Shannon-Weiner index; range 0.10-0.40; MacKenzie and Winston 1984). The Massachusetts and British Columbia studies did not find a high abundance of non-Apidae bees. MacKenzie and Avrill (1995) observed that non-apid bees were rare, comprising only 2.3% of the collected bees, compared to the current study in which 53% of the total were non-apid bees. Small bees, such as the *Lasioglossum (Dialictus)* species that were abundant in these fields, are often overlooked as important pollinators by farmers, but their high abundance suggests that they may be important. Hicks (2011) also found that the *Lasioglossum (Dialictus)* spp. was abundant in Newfoundland blueberry farms. He did not collect any *Bombus ternarius* on blueberry farms but another bumble bee, *Bombus vagans bolsteri* was very common. Mackenzie and Winston (1984) indicated that the dominant bumble bee species differed among different berry fruit plants in British Columbia and this is probably the case in Newfoundland. However it is unclear whether the dominance of *Bombus ternarius* over *Bombus vagans bolsteri* in the present study reflects a geographic difference in the species abundance or whether it reflects difference in foraging preference of these bee species.

The percentage of flowers developing into fruit was not different between the two farms (Table 4). Moreover, the farmer-reported yields from the experimental cranberry fields also suggest that supplementation is not effective (farm-1 = 12,500 lbs/acre: farm-2 = 14,545 lbs/acre). The data suggests that supplementation of cranberry fields in Newfoundland is not effective in increasing fruit set. The density of commercial *Bombus impatiens* on the supplemented farm was low for the stocking rates used during this study (2 hives/ha). While the *Bombus impatiens* colonies used were productive over the study period (the colonies contained on average of 97 bees, n = 13, range 48-154 bees at the end of the study), it is unclear presently why *Bombus impatiens* density was low in the fields. One possible explanation may be that the commercial bees visited flowers outside the study area. Results of the present study showing no effect by supplementation in cranberry, supports Hicks (2011) who showed that supplementation of Newfoundland blueberry farms with *Bombus impatiens* did not increase fruit set. *Bombus impatiens* is a non-native bee in Newfoundland that is not presently known to be established and thus it may not be an effective pollinator of native species under the environmental conditions experienced in the region.

Compared to halictids, visits from native *Bombus* species resulted in slightly lower fruit set (34.8%). Interestingly, imported *Bombus impatiens* had the lowest pollination success rate during a single flower visit (14.3%; Table 5) although this must be interpreted with caution due to the small number of observations (n = 14). Although there was no data for the fruit set of flowers that were not exposed to pollinators during this study, in a separate experiment on the same farm during the following summer (2014), the fruit set where bees were excluded was 15.1%, while open flowers (with pollinator access) had a fruit set of 53.2% (J. Sircom, unpublished data). It appears that *Bombus impatiens* is ineffective at pollinating cranberry in Newfoundland. Generally, single visits to flowers by the larger bees appeared to result in larger fruit with a larger number of seeds than visits by the smaller bees (Table 5). This trend, of larger bees pollinating flowers that then produce larger fruit has been observed in other ericaceous crops (Javorek et al.2002; Ratti et al. 2008).

Most species of bees build their nests in the soil (Cane 1991) but the specific nesting requirements for each bee species is largely unknown (Loose et al. 2005). Cane (1991) found variation in the soil moisture requirements among ground nesting bees, with nests most commonly found in sandy soils with moistures below 37%, and not found in clay or silt soils. Soil moisture along the berms does not appear to be a limiting factor in *Lasioglossum* sp. nest construction in Newfoundland cranberry fields as nest density was similar between the two farms even though there was a difference in soil moisture. However, we must be cautious in our interpretation as some bees may burrow deeper than the 25 cm depth that we sampled soil from and the soil conditions there may be different and may affect bee nesting differently. There was a higher diversity and abundance of plants on the farm-2 berms compared to farm-1 (although we did not measure it directly). We anticipated a greater abundance of bees on the farm-2 berms because that habitat appeared to provide greater forage than on farm-1, but farm-1 berms had a greater abundance of bees than farm-2 berms. In this case, the soil characteristics of the farm-1 berm (lower moisture and sandy soil) may attract more ground nesting bee species and may have played an important role in the greater abundance that was observed there. The berms on the cranberry fields are the best habitat for nest construction because these areas are not sprayed directly with insecticides or covered with water during berry harvest. Loose et al. (2005) suggested that bees around cranberry fields in Maine prefer sandy loam banks that are common around the cranberry agroecosystem.

Presently, Newfoundland is in an enviable position regarding its honey bee population. The province has strict importation regulations and because of its geographical isolation it does not harbor the same parasites such as *Varroa destructor*, *Acarapis woodi*, *Aethina tumida*, Israeli acute paralysis virus-Kashmir bee virus complex or sacbrood virus that plague honey bees in other areas worldwide (Williams et al. 2010; Shutler et al. 2014). The parasites and diseases of native Newfoundland *Bombus* species have not been studied and we are unsure of their impact on native populations. Commercially-reared bumble bees harbor several pathogens and parasites that have been documented to infect other species including native *Bombus* and *Apis mellifera* (Colla et al. 2006; Graystock et al. 2013; Fürst et al. 2014; Sachmann-Ruiz et al. 2015; Graystock et al. 2015). The observation of several native bumble and honey bee specimens inside the colony boxes of *Bombus impatiens* raises the possibility of the direct transmission of diseases to the native species and honey bees. Such transmission does not even require direct contact, as foraging on the same floral resources may transmit the diseases (Graystock et al. 2013; 2015). While it is unclear what impact that novel parasites and diseases may have on native bee species, they have been implicated as the cause of the decline of important bee pollinators in North America (Berenbaum et al. 2007).

CONCLUSIONS

Supplementation of cranberry fields with commercially supplied *Bombus impatiens* did not increase fruit set. The practice of buying non-native bees for boosting yields is not supported by the data and should be reconsidered in the future. Purchasing hives is a considerable financial outlay which appears to have little or no economic payoff, and the presence of these imported bees may put native bees and the commercial honey bee industry at risk.

Bombus ternarius was the most abundant bumble bee species on the cranberry farms and appears to be an important pollinator of this crop. In addition, *Lasioglossum (Dialictus)* spp. (Halictidae), small native bees, are abundant and may also play an important role as pollinators of cranberry. This was a single year study, however, and it is unknown how populations of these bees fluctuate over time. Growers require reliable pollination services, and work is underway to determine how natural fluctuations of these key bee species affect pollination rates and crop yield, and to identify means of minimizing the impact of population variation.

Honey bees may provide a viable alternative to imported bumble bees for supplemental pollination or to mitigate the effects of population fluctuations in native bee populations. There is conflicting evidence of their effectiveness in cranberry (Mohr and Kevan 1987; Ratti et al. 2008; Evans and Spivak 2006; Broussard et al. 2011), so this warrants investigation. If honey bees are effective pollinators in Newfoundland cranberry fields, their use would eliminate the risks associated with the use of imported bumble bees. This would help maintain the disease-free status of the honey bees, support the honey bee industry provincially, provide reliable pollination services to commercial cranberry growers, and protect native bee populations.

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