Role of Native Bees on Berry Crops in Yukon: Update 2017

Bumblebee on haskap flowers.

Mason bee flying to haskap flowers.

Aphid wasp carrying aphid to nest.

Prepared for the Growing Forward 2 Review Committee and the Agriculture Branch, Yukon.

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Table of Contents

List of Figures

List of Tables

List of Appendix

Introduction

The Yukon has seen rising interest in producing berries commercially for local consumption and the export market (http://www.yukonag.ca/guide/; http://www.yukon-news.com/business/sweet-tarts-haskap-berry-farmers-hoping-to-cash-in-on-japanese-demand/). This includes several cultivars of currants, Saskatoons, strawberries, haskaps, cherries and raspberries. Many factors contribute to the size and quality of the harvest of which one is pollination. Some species, such as haskaps require cross fertilization in order for plants to bear fruit (Bożek 2012). Thus, understanding and recognizing the insect species that provide such pollination service is valuable to farm operations. This project is aimed at providing such information.

In 2016, I initiated a project to collect information on the role of native bees on berry crops in Yukon. The focus was on solitary cavity nesting bees as they are known to pollinate fruit crops elsewhere (Garibaldi 2013) and a protocol exists for collecting and identifying pollen food from their nests (MacIvor et al. 2014). Since then, some of the occupants from the nesting straws have matured and emerged. Jessica Forrest and her students at the University of Ottawa have been identifying some of these occupants and their associated pollen.

Of the domestic berries grown in Yukon, the agricultural community is most interested in cultivating haskaps for commercial enterprises. It was noted in 2016 that the pollinator fauna on haskap flowers comprised of many species that were not solitary cavity nesting bees (Leung 2016). To better document the insect pollinators, more effort was put towards tallying the different insects contributing to the pollination of haskaps in 2017.

This report provides data emerging from nesting straws collected in 2016, a summary of field activities undertaken in 2017, and a discussion of the findings.

Methods

Leung (2016) provides information on the study sites, the dimensions of the solitary bee blocks used to attract solitary bees, and the collection of nesting straws from the bee blocks for analyses. The same five farm sites were visited in 2017. These were Circle D Ranch, Rivendell Farm, Yukon Berry Farm, Yukon Grain Farm and Little Fox Farm (Figure 1). The bee blocks remained at the locations where they were originally erected in 2016 (Appendix 1), totalling eight bee blocks at each farm site. Between 25 April and 7 May 2017, I replenished each bee block with 30 nesting straws to replace the straws removed the previous year.

The presence of domestic honey bees changed from the previous year. In 2016, honey bee hives were present only at Yukon Grain Farm. These are kept at the farm year round and are situated 360m to the west of the berry plantation. In early spring of 2017, honey bee hives were introduced at Circle D Ranch and the Yukon Berry Farm. The hives at Circle D Ranch were placed on the western and eastern edge of the berry plantation. The hives at the Yukon Berry Farm were placed close to the centre of the plantation. The intent was to enhance pollination and berry production. The hives at Circle D Ranch and the Yukon Berry Farm were removed for overwintering elsewhere.

Between 29 May and 7 June, the number of bumblebees (*Bombus spp*), honeybees (*Apis millifera*), other bee species, syrphid flies (Family Syrphidae) and butterflies were counted on haskap flowers. I counted the pollinating insects along all rows at the Little Fox Farm and Rivendell Farms. For the larger haskap plantations (Circle D Ranch, Yukon Grain Farm and Yukon Berry Farm) I counted a subset, comprising of four rows. Unlike all the other berry plantations, the breadth and height of the haskap plants at the Yukon Grain Farm were too large to obtain an overview of the plants, so only insects seen from one side could be recorded. All counts were conducted twice, with the intent of overlapping counts with peak flowering. Data on weather conditions (temperature, wind, cloud cover), time, distance surveyed, and an estimated number of bushes were collected. The number of flowers on five randomly selected bushes was also counted at each site.

From 25 September to 26 September 2017, all nesting straws were collected from the farms. These were candled, and the ones with occupants were sent to Jessica Forrest's lab at the University of Ottawa. The straws are currently in a climate controlled incubator where immature stages will aestivate over winter and eventually develop.

The occupants and associated pollen in the straws collected in 2016 have undergone some analyses. The most common pollen species associated with the nests built in the straws were identified to taxonomic family, and some cases, to species. Insect occupants were identified to genus for bee species, and to family for other insect groups.

Results

Characteristics of the surveyed transects at each farm appear in Table 1. The distance surveyed varied depending on the farm, ranging from 98m at Rivendell Farm to 1640m at Yukon Berry Farm. The number of bushes encountered along the rows varied widely, from 83 bushes at Rivendell Farm to 1700 bushes at Circle D Ranch. The number of blooming flowers on bushes was much higher on bushes at Yukon Grain Farm than other farms.

Weather conditions were fairly consistent among surveys, with temperatures ranging from 15 to 18˚C, and winds that usually caused small trees to sway. Cloud cover was generally less during the second round of sampling (Table 2).

The number of bumblebees, honeybees, other bees, syrphid flies and butterflies tallied at each farm for each survey date appears in Table 3. Overall, the most common pollinators on haskaps were bumblebees, averaging 73% of the insects counted on surveys and ranging from 96% of insects on haskap flowers at Circle D Ranch on 6 June to 32% of insects on haskap flowers at Yukon Grain Farm on 5 June (Figure 2). The greatest change in percent bumblebees also occurred at the Yukon Grain Farm where bumblebees dropped from 60% to 32% of insect pollinators on haskaps. During the second survey, peak flowering had passed as evidenced by many dropped flower corollas. At this time, many bumblebees were feeding on wild strawberry flowers at the base of the haskap plants. The least common insect pollinators were butterflies ($\bar{x}$ =1%), represented by Canada tiger swallowtails (*Papilio canadensis*) at the Yukon Grain Farm and Little Fox Farm. Honeybees comprised an averaged 7% of the pollinators, with 0% on farms where no hives were present and 13% where hives were present. Other pollinators included syrphid flies ($\bar{x}$=13%), and other bees ($\bar{x}$=5%) such as *Osmia sp.* and *Lasioglossum sp*.

The relative abundance of insect pollinators (# individuals/m) appears in Figure 3. The highest overall relative abundance occurred on the haskap plants at Yukon Grain Farm and the lowest relative abundance occurred at Circle D Ranch. The highest relative abundance of bumblebees occurred during the first survey at Yukon Grain Farm (Figure 4). The second and third highest relative abundance of bumblebees were recorded during the second and first survey at Little Fox Farm respectively. The highest abundance of honeybees and syrphid flies occurred at the Yukon Grain Farm. Rivendell Farm and Yukon Grain Farm had the highest relative abundance of other bees, both occurring during the second round of surveys.

All farms had some occupancy of nesting straws by hymenopterans. Most bee blocks had 7 or fewer straws occupied, averaging 2.25 occupied straws per bee block. There were two notable exceptions. One bee block at Little Fox Farm had 17 occupied straws, and one bee block at Rivendell Farm had 11 occupied straws. The total number of occupied straw was greatest at Little Fox Farm, with 43 occupied straws and 7 of 8 bee blocks with occupancy (Figure 5). Rivendell Farm had the second most, with 20 occupied straws spread among 6 bee blocks. The fewest number of occupied straws occurred at the Yukon Grain Farm, with only 7, and the fewest number of occupied bee blocks occurred at Circle D Ranch, with 3 of 8 bee blocks having hymenopteran nests in straws (Figure 5).

Preliminary identification of hymenopterans from nesting straws collected in 2016 and reared through the winter revealed that mason bees (*Osmia*) and leafcutter bees (*Megachile*) were the most common occupants in the bee blocks (Table 4). Other hymenopterans included masked bees (*Hylaeus*), potter wasps (family Vespidae, subfamily Eumeninae) and sawflies (suborder Symphyta). There was also evidence of aphid wasps (*Passaloecus*) attempting to build nests. So far, the only nest parasites identified are *Trichodes*, a type of checkered beetle. Their presence was detected in nesting straws with Osmia nests and was limited to two bee blocks at one farm.

Examination of pollen in the nests showed that the solitary bees were using several different plant species to provision their offspring (Table 5). Haskap (*Lonicera*), legume (Fabaceae) and brassica (Brassicaceae) pollen comprised major components (>25%) of mason bee nests. Fireweed (*Chamerion*) and asters (Asteraceae) formed minor components (5 to 25%) of nest pollen. It was suspected that species from the rose family (Rosaceae) contributed to a large part of the pollen composition in mason bee nests, but the pollen grains were often difficult to identify. The leafcutter bees differed and were mostly collecting pollen from asters and fireweed. One leafcutter bee nest had a minor component of heath (Ericaceae). The pollen in the sole nest of masked bee was primarily composed of brassica, with aster forming a smaller component.

Discussion

Cultivating haskaps in a northern climate has special challenges. Formation and size of berries is very limited if cultivars are not cross pollinated with another variety (Bożek 2012). This can be achieved in very low amounts by wind, but for the most part, pollination is only successful if flowers are visited by insects transferring pollen from one cultivar to another (Frier et. 2017). Haskaps bloom in early spring, well before most insect populations have peaked, and during cooler temperatures that may thwart the activity of some insect pollinators. The former is true for bumblebees, but less so for the latter. Bumblebees are at their lowest numbers at the beginning of spring when queen bees are emerging from hibernation. Once a queen bee establishes her nests, she will begin propagating worker bees and the population of bumblebees will grow (Williams et al. 2014). This population increase typically occurs after the main blooming period for haskaps. By contrast, early emerging solitary cavity nesting bees have higher numbers in spring when the progeny of the previous year emerge, then their adult populations drop as the growing season progresses (Wilson et al. 2016).

Despite the availability of bumblebees limited to overwintered queens when haskaps require pollination, bumblebees were the most common pollinator at all five farms sampled. This was also observed in 2016 (Leung 2016). In a detailed study undertaken in Saskatchewan, bumblebees were documented as highly effective pollinators of haskaps. Bumblebees deposited more pollen, visited more flowers within a fixed time period, and remained active in cooler temperatures whereas honeybees deposited less pollen, visited fewer flowers and were less active in cooler temperatures (Frier et al. 2017). In warmer temperatures, honeybees can contribute significantly to haskap pollination as the large numbers afforded by hives can compensate for the lower pollination effectiveness of individual honeybees. Such warmer temperatures in spring are limited in Yukon, implying that bumblebees are far more active throughout the flowering period of haskaps than honeybees.

Domestic honeybees already established at the Yukon Grain Farm were commonly seen feeding on haskap flowers in 2016 and 2017. Although the honeybees had to fly over 350 m from their hives to reach the berry plantation, they were more abundant there than on the two farms where hives were located adjacent to or within haskap plantations. The difference may be due to the relatively high density of haskap flowers at the Yukon Grain Farm, as honeybees will scout and compare potential sources of food, encouraging hive members to forage at the best sources (Winston 2014).

Syrphid flies were also quite common on haskaps although their distribution within a plantation tended to be clumped (pers. obs). Species of native bees other than bumblebees contributed a much smaller proportion to the insect pollinators on haskaps. Analyses of native *Osmia* nests collected from bee blocks showed varying diets, with some collecting pollen from haskaps exclusively to provision their nests. Other *Osmia* nests had no haskap pollen, and notably, no willow pollen. The food preference was different for domestic mason bees (*Osmia lignaria*) in Saskatchewan, where willows were preferred over haskaps (Frier et al. 2017).

Actual pollination rates were not recorded after several attempts showed that an overwhelming number of flowers would have to be observed repeatedly to obtain a minimum sample size of insect pollinators. Nevertheless, the data that was collected showed that the relative abundance of insects on haskaps is generally higher where haskap blossoms were more abundant (Figure 3). The most insects and most blossoms were found at the Yukon Grain Farm. The relative abundance of insects and blossoms was also high at Little Fox Farm. There was some deviation of this trend among the other three farms, with Rivendell farm having a relatively high number of insects despite having relatively few blossoms.

It appears that the abundance of insect pollinators is influenced by the amount of food resource and the presence of nesting habitats. Rivendell Farm and Little Fox Farm had the highest occupancy of straws in bee blocks in 2017 and the most nests of hymenopterans in 2016. Apart from the sawflies that are often regarded as pests, the occupants of the bee blocks were beneficial insects, either as pollinators in the case of bees, or predators of insect pests as is the habit of many wasps. Both Rivendell Farm and Little Fox Farm grow a variety of berries. In addition to haskaps, raspberries, saskatoons and currants, both also have a diversity of other flowering plants, mainly domestic at Rivendell Farm, and mainly retention of native plants at Little Fox Farm. Both also have hedgerows or patches of forest in the form of linear windbreaks, copses or field edges. These are potential sites to shelter cavity nesting bees and bumblebees. Most bumblebee species in Yukon nest close to or in the ground in places such as old rodent burrows; a few may nest higher up in tree cavities (Williams et al. 2014). Higher pollination rates have been observed in smaller fields which are surrounded by potential nesting habitats that can support populations of bees (Isaacs and Kirk 2010; Woodcock 2012). As haskaps mature into large bushes, they may function as hedgerows. This may be happening at the Yukon Grain Farm, although the forested habitat on three sides of the haskap plantation also offers suitable nest sites for bumblebees.

Implications

It is clear that queen bumblebees are the main pollinator for haskaps in Yukon. Conditions to maintain a supply of queen bumblebees would benefit haskap production. Bumblebees build their colonies throughout the growing season, producing new queens near the end of a colony's lifespan. These new queens mate and overwinter. They will be the ones to pollinate flowers the following spring.

The number of queens produced by a colony is correlated to the size of a colony, which in turn is correlated to food availability (Pomeroy and Plowright 1982; Pelletier and McNeil 2003). Ensuring that there are successive sources of flowering food plants will not only support bumblebees, but also honeybees, should farmers choose to foster honeybee hives simultaneous. Like honeybees, bumblebees are generalists and will forage on a large variety of flowers, including many native species such as kinnickinnick and fireweed as well as cultivated species such as clover. In addition to providing adequate food, retaining or creating nesting habitat would support bumblebee colonies. This can be in the form of a forested copse or field margin with structural diversity (Lye et al. 2009). Queen bees overwinter underground as do most bumblebee species in Yukon (Williams et al. 2014).

The installation of solitary bee blocks can enhance local populations of cavity nesting bees and wasps, especially where there is already a source population. Most occupants of the bee blocks are beneficial, pollinating a wide variety of flowers or controlling pests. However, with regard to haskaps, the overall contribution of occupants in bee blocks to pollination is small compared to bumblebees.

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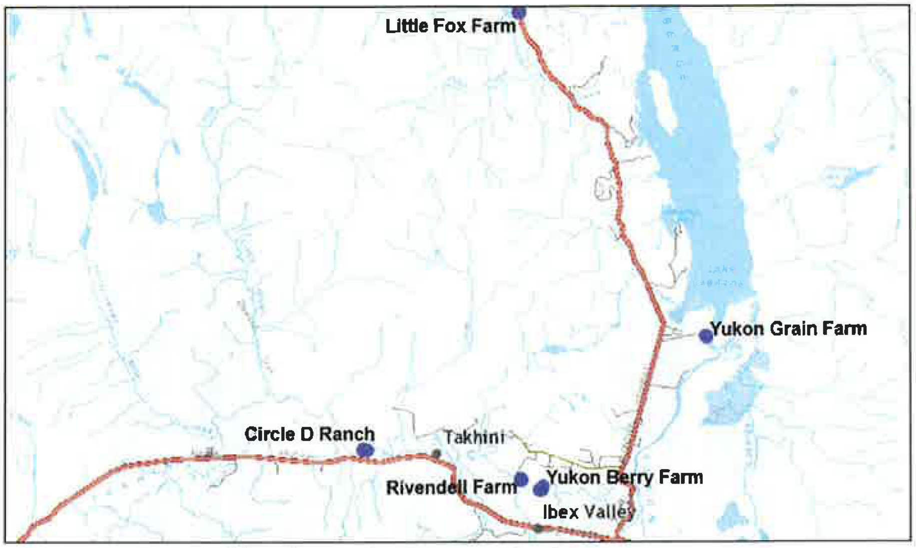

Figure 1. Location of five farms chosen as study sites.

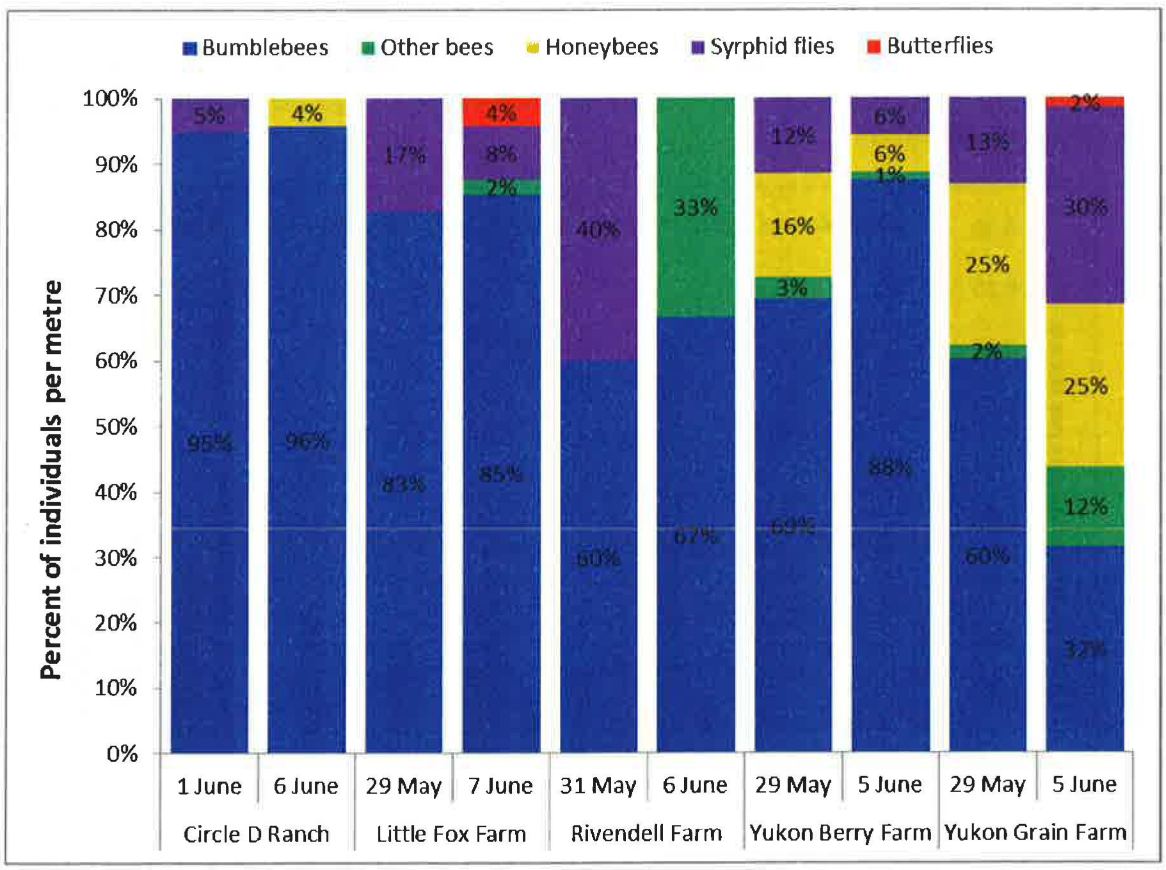

Figure 2. Composition of insect pollinators at each farm during each survey.

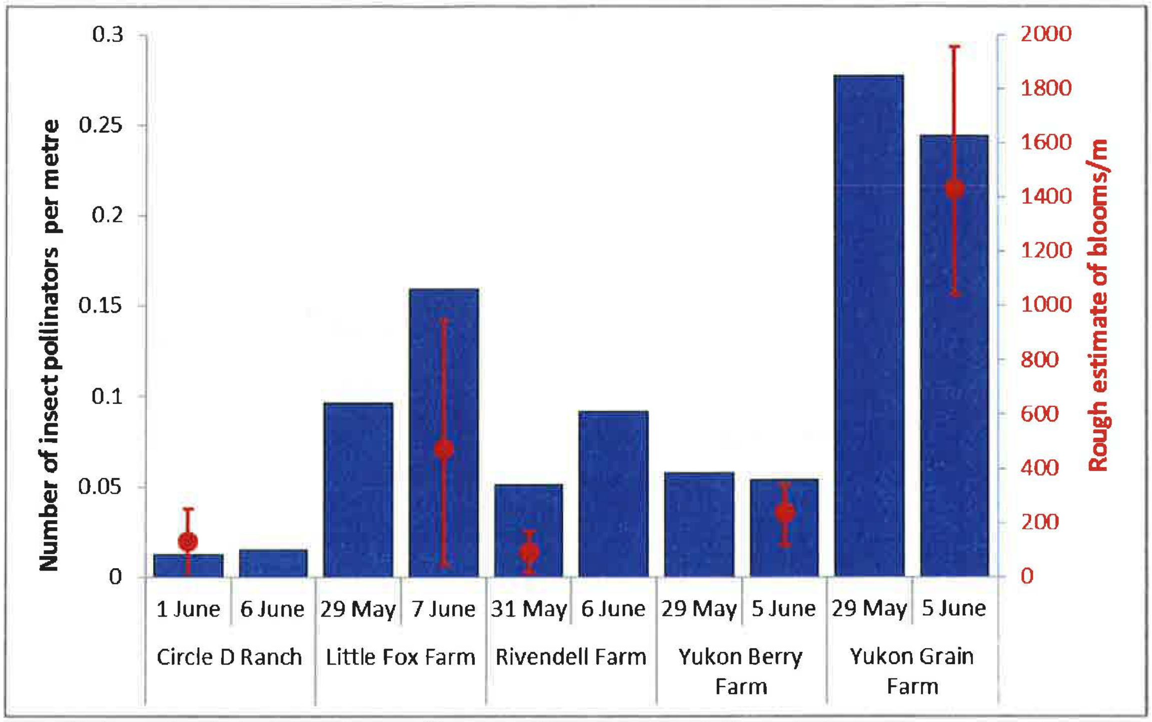

Figure 3. Overall relative abundance of insect pollinators at each farm during each survey and estimated # haskaps blossoms/m. Red dots and bars indicate the average and range of blooms/m from a limited sample size (n=5).

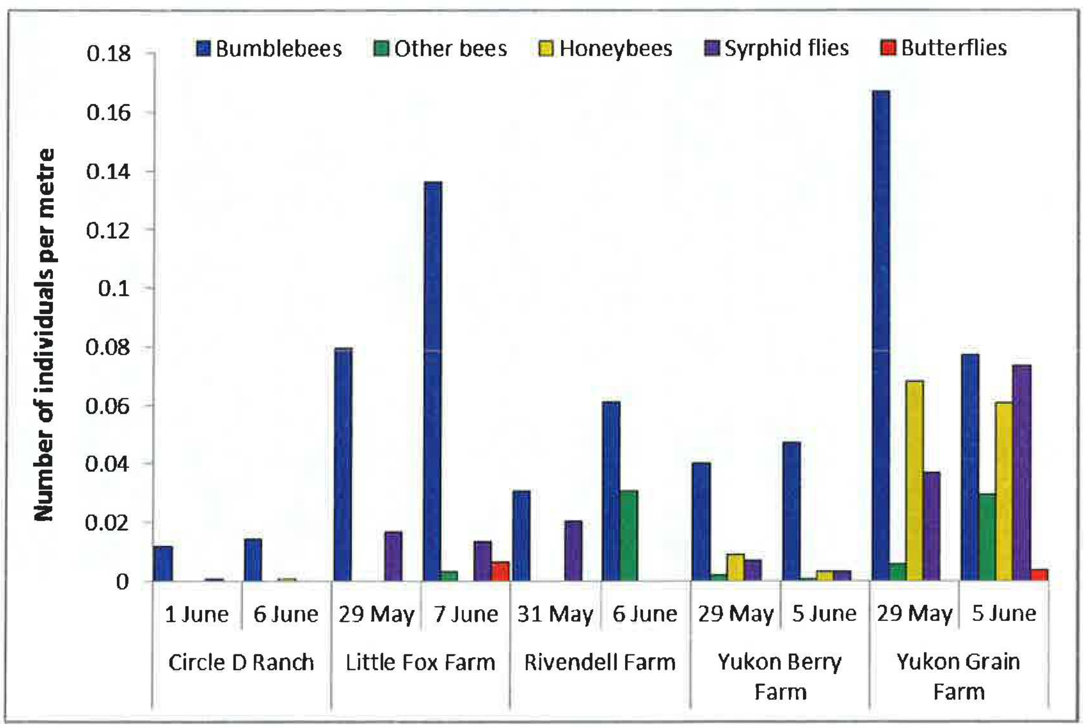

Figure 4. Relative abundance of insect pollinators at each farm during each survey.

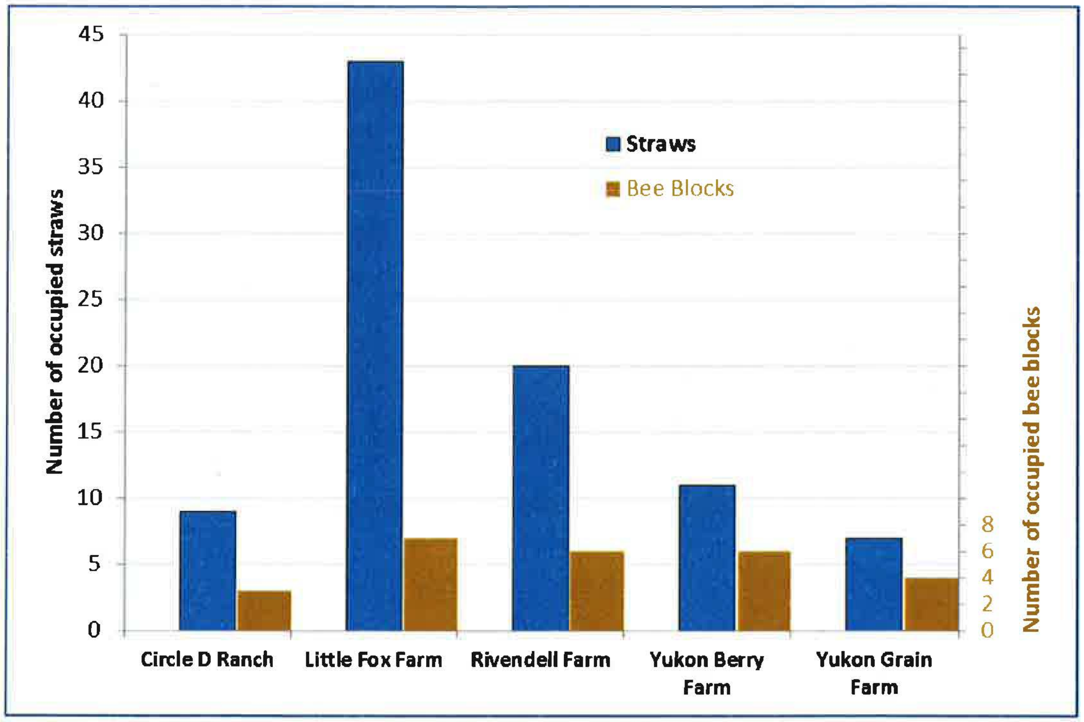

Figure 5. The number of straws and bee blocks occupied by hymenopteran nests at each farm.

Table 1. Characteristics of the transects at each farm.

	Distance surveyed (m)	Number of bushes	# open flowers/ bush
Circle D Ranch	1596	1700	0 to 250
Little Fox Farm	301	357	40 to 800
Rivendell Farm	98	83	20 to 200
Yukon Berry Farm	1640	1600	120 to 350
Yukon Grain Farm	545	355	1600 to >3000

Table 5. Pollen associated with solitary cavity nesting bees collected from bee blocks. Pollen species is considered a major component if it is ≥25% biovolume in the sample examined and a minor component when <25% and >5%.

	Straw	Species	Major pollen	Minor pollen
Circle D Ranch				
SB68	2	*Osmia*	Rosaceae?	Asteraceae
	4	*Osmia*	Rosaceae?	*Chamerion*, Asteraceae
SB69	1	*Osmia*	unknown[1]	
	3	*Osmia*	unknown[1]	
	5	*Osmia*	unknown[1]	
	6	*Osmia*	Rosaceae?	
	7	*Osmia*	Rosaceae?	*Chamerion*
Little Fox Farm				
SB60	4	*Megachile*	*Chamerion*	
SB61	1	*Megachile*	*Chamerion*	Ericaceae, Asteraceae, Rosaceae?
	2	*Megachile*	*Chamerion*, Asteraceae	
SB62	1	*Osmia*	unknown[1]	Asteraceae
	2	*Osmia*	unknown[2]	Asteraceae, *Chamerion*
Rivendell Farm				
SB74	1	*Osmia*	unknown[2]	
	2	*Osmia*	Fabaceae	
	3	*Hylaeus*	Brassicaceae	Asteraceae
	4	*Megachile*	*Chamerion, Asteraceae*	
	5	*Megachile*	*Asteraceae, Chamerion*	
SB77	2	*Osmia*	Corydalis?, Brassicaceae	*Chamerion*
	3	*Osmia*	unknown[1]	
SB78	1	*Osmia*	Rosaceae?	*Lonicera*
Yukon Berry Farm				
SB82	1	*Megachile*	*Chamerion, Asteraceae*	
Yukon Grain Farm				
SB54	1	*Osmia*	unknown[1]	Asteraceae
SB56	1	*Osmia*	*Lonicera*	
	2	*Osmia*	*Lonicera*	
	3	*Osmia*	*Lonicera*	

1-could be Rosaceae; pollen grains collapsed

2-could be Fabaceae or Rosaceae; pollen grains collapsed

Appendix 1. Coordinates for each solitary bee block.

Location Name	ID#	Latitude	Longitude
Circle D Ranch	SB50	60.861450	-135.555690
Circle D Ranch	SB49	60.861750	-135.555800
Circle D Ranch	SB51	60.861360	-135.555710
Circle D Ranch	SB68	60.861270	-135.554890
Circle D Ranch	SB69	60.861170	-135.551350
Circle D Ranch	SB70	60.861180	-135.552310
Circle D Ranch	SB66	60.861110	-135.549670
Circle D Ranch	SB67	60.861000	-135.556000
Rivendell Farm	SB72	60.846170	-135.337940
Rivendell Farm	SB76	60.846330	-135.338420
Rivendell Farm	SB74	60.847120	-135.339420
Rivendell Farm	SB71	60.846840	-135.340130
Rivendell Farm	SB75	60.845910	-135.339980
Rivendell Farm	SB77	60.845870	-135.340210
Rivendell Farm	SB73	60.846670	-135.338560
Rivendell Farm	SB78	60.846080	-135.338730
Yukon Berry Farm	SB45	60.840270	-135.310210
Yukon Berry Farm	SB44	60.839900	-135.313540
Yukon Berry Farm	SB42	60.841050	-135.309600
Yukon Berry Farm	SB48	60.841920	-135.309200
Yukon Berry Farm	SB41	60.842910	-135.308810
Yukon Berry Farm	SB80	60.840210	-135.314320
Yukon Berry Farm	SB84	60.839820	-135.312360
Yukon Berry Farm	SB82	60.840020	-135.311490
Yukon Grain Farm	SB58	60.946090	-135.096850
Yukon Grain Farm	SB55	60.946030	-135.096450
Yukon Grain Farm	SB54	60.945880	-135.095310
Yukon Grain Farm	SB57	60.945240	-135.095500
Yukon Grain Farm	SB59	60.945490	-135.095310
Yukon Grain Farm	SB56	60.944910	-135.095860
Yukon Grain Farm	SB86	60.945950	-135.096070
Yukon Grain Farm	SB85	60.945400	-135.095380
Little Fox Farm	SB63	61.153420	-135.370740
Little Fox Farm	SB60	61.153710	-135.370590
Little Fox Farm	SB62	61.153330	-135.368130
Little Fox Farm	SB64	61.153660	-135.368350
Little Fox Farm	SB61	61.153720	-135.368770
Little Fox Farm	SB65	61.153720	-135.369350
Little Fox Farm	SB79	61.153270	-135.369080
Little Fox Farm	SB83	61.152980	-135.369980