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NOTE

Native bees (Hymenoptera; Apoidea) collected from Labrador, Canada

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Northern ecosystems are expected to have the earliest and most profound negative impacts caused by global climate change (Prowse et al. 2009). In fact, Sánchez-Bayo and Wyckhuys (2019) indicated that climate change has contributed to insect declines globally. With climate change, the altering of abiotic and biotic ecosystem components in northern habitats will result in changes to insect ranges, life history traits and behaviours (Larson et al. 2019). While Labrador has a rich anthropogenic history, there is limited information available on bee diversity. The current research looks at present day bee diversity and hopes it will contribute as baseline data to future studies on climate change implications on Labrador bee populations.

Labrador is the mainland part of the Canadian province of Newfoundland and Labrador, making up a majority of the province's area (i.e., 294,330 km^2 of the total provincial area of 405,212 km^2). It is located between 53.1355° N, 57.6604°W and is bordered to the west and the south by the province of Quebec (see Figure 1). The indigenous peoples include the Innu and Inuit and while historically they were mostly tied to the sea for subsistence, they also made use of inland resources (Colbourne and Cuff 1991). Europeans (i.e., Norse) first explored the region around 1000AD, with later visits by the Portuguese by 1500AD (Colbourne and Cuff 1991). In 1542, a Basque whaling settlement was established on the south coast at present day Red Bay (Colbourne and Cuff 1991).

Moravian missionaries arrived in 1760 and established several communities along the coast (Colbourne and Cuff 1991). Many of these missionaries were also interested in natural history and collected many plant and animal specimens that were returned to museums in Europe. Some of the insect material collected was sent to pioneer taxonomists including Fabricus and Huebner during the first quarter of the nineteenth century (Freeman 1959), but it is unknown if any bee specimens were among these collections. In addition, Joseph Banks collected insects on the southern shore of Labrador in 1766 (Morris 1983), and Lysaght (1971) suggested that some of these specimens may be present among others that he collected on his global voyage with Cook in the Banksian cabinets at the Natural History Museum in London. While there are bees in this collection from all over the world, it is difficult to know where they originated as they lack detailed locality labels (G. Broad, Natural History Museum (NHM) London, personal communication).

The earliest record of bee collections from Labrador was by Curtis (1835). He recorded three species from material collected by Commander James Clarke Ross on the Melville Peninsula during his voyage of 1829–1833. The bees included: *Bombus kirbiellus* Curtis (= *Bombus balteatus* Dahlbom according to Williams et al. (2014)), *Bombus polaris* Curtis, and *Bombus articus* Kirby (= *Bombus polaris* Curtis according to Williams et al. 2019). In a subsequent survey, Packard (1884) recorded four species of bumble bees from Labrador including: *Bombus lacustris* Cresson (= *Bombus melanopygus* Nylander according to Sheffield et al. 2020) that he reported was commonly found on the whole north coast, *Bombus kirbiellus* from Sloop Harbour and Hopedale, *Bombus frigidus* Smith from Square Island and Hopedale, and *Bombus nivalis* Dahlbom (= *Bombus kirbiellus* = *Bombus balteatus* Dahlbom according to Williams et al. 2014) from Caribou Island and the whole coast northward. Since that time, very little work has focussed on the bee fauna of Labrador, though material from the region has been included in many taxonomic treatments (e.g., LaBerge 1987, LaBerge 1989, Williams et al. 2014).

The purpose of the current research is to further document the diversity and abundance of native bee species from different regions in Labrador, including new collection effort.

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Figure 1. Collection sites for native bees in Labrabor, Canada in 2017.

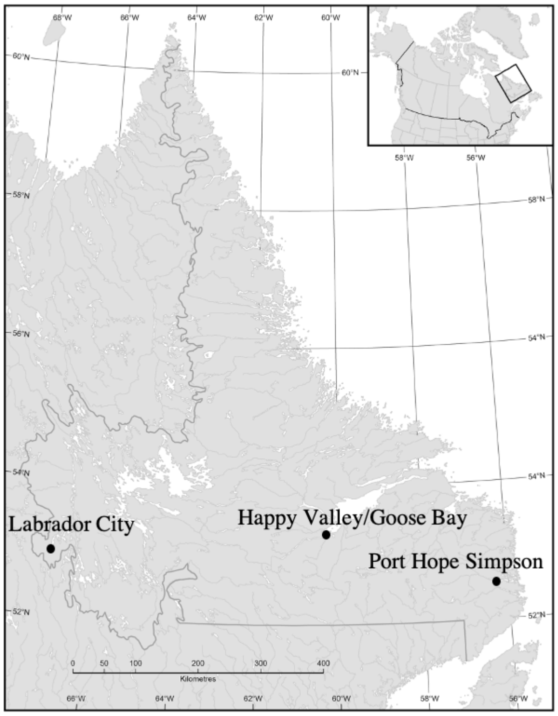

Table 1. Sampling locations of native bees in Labrador during 2017.

Locality	Latitude	Longitude	Dominant Habitat	Set date
Happy Valley/ Goose Bay (HVGB-1)	53.3988N	60.4280W	Pasture	13 June-21 July
Happy Valley/ Goose Bay (HVGB-2)	53.3226N	60.2824W	Forest	27 June-17 Aug
Happy Valley/ Goose Bay (HVGB-3)	53.2976N	60.3513W	Semi-urban	19 June-28 July
Labrador City (LC)	52.9101N	67.0319W	Forest	30 June-4 Aug
Port Hope Simpson (PHS)	52.5266N	56.2914W	Forest	6 July-9 Aug*

*only 4 week collecting period for PHS.

Bees were collected during a 5-wk period during the summer of 2017 by four technicians from the Department of Fisheries, Forestry and Agriculture (Government of NL) and one retired biologist (formally of the College of the North Atlantic, Happy Valley-Goose Bay Campus). Sampling occurred at Labrador City (LC), Port Hope Simpson (PHS) and three sites at Happy Valley-Goose Bay (HVGB) (Table 1 and Figure 1). At each site, the technicians selected habitats and noted their physical characteristics. HVGB-1 was a pasture that was well drained with a composition mostly of grasses and small shrubs. HVGB-2 was forested predominantly with balsam fir, *Abies balsamea* (L.) Mill. (Pinaceae) and black spruce, *Picea mariana* (Mill.) B.S.P. (Pinaceae). HVGB-3 was a semi urban area similar in composition as the pasture site but having more shrubs and herbaceous plants. This site was flooded in the springtime for an extended period before drying up in mid-June. The LC and PHS sites were balsam fir/black spruce forests with open spaces.

The sampling protocol consisted of placing nine alternating cup-traps (3 each of white, yellow and blue) along a 45 m transect in the 5 sites. Each trap consisted of a 13-oz plastic beer cup (10 cm in diameter and 14 cm deep supplied by Solo Cup Company, Toronto, ON) placed in a stand above ground. The cup was ¾-filled with solution of 50% propylene glycol (Eastchem, Mt. Pearl, NL) and 50% water with two drops of blue Dawn® dish washing fluid. The timing of the placement of the traps was dependant on availability of the volunteers (Table1). Once the cups were placed in the field, they were cleared and reset weekly for the 5-wk duration. Specimen identifications were made by the authors using appropriate taxonomic keys (i.e., Mitchell 1960, 1962; Roberts 1973; Gibbs 2010; Gibbs et al. 2013; Williams et al. 2014; Ascher and Pickering 2015). Specimens are housed in the insect collection at the College of the North Atlantic, Carbonear campus.

We collected 617 bee specimens comprising 38 species (Table 2); 18 of the species are considered new records for Labrador, and ten are new records for the province (Table 2). HVGB-1 (pasture) had the greatest abundance and richness of bees with a total of 396 bees collected from 32 species. *Andrena algida* Smith and *Andrena frigida* Smith (Andrenidae) and a number of halictid bees (Halictidae) were the most common species collected (Table 2). The most abundant bumble bee was *Bombus melanopygus* (i.e., 56 of the 68 bumble bees collected). Site HVGB-3 (semi urban) had 80 bees from 18 species, with *Halictis confusus* Smith (Halictidae) the most common species collected. The HVGB-2 (forest) had 71 bees collected representing 18 species, with *Andrena frigida* and *Andrena mandibularis* Robertson (Andrenidae) the most common species collected (Table 2). The LC site had 32 bees collected from 9 species, with *Andrena frigida* being the most common bee collected. At the PHS site, bees were collected for only 4 weeks and 38 bees were collected from 11 species with six species of bumble bees collected more frequently than other bees (Table 2).

The temporal distribution of bee species collected, as indicated in Table 2, shows that the bee fauna of Labrador, with few exceptions, is adapted to a shorter growing season. The majority of the bees collected are species that winter as adults and emerge in the spring. The halictid bees collected from Labrador are interesting because some of them are considered facultatively eusocial. Some of the halictid bees are likely eusocial in southern parts of their range but may be solitary in Labrador (e.g., *Halictus rubicundus* (Christ), *Halictus virgatellus* Cockerell) (see Eickwort et al. 1996; Packer et al. 1989, 2007). Packer et al. (1989) showed that some halictid bees such as *Lasioglossum comagenense* (Knerer and Atwood), in Nova Scotia, have flexible social systems in marginal climates thus allowing colony survival in areas where the season is too short to complete the regular eusocial colony cycle. *Halictus confusus* and *Lasioglossum lineatulum* (Crawford) may be the only obligatorily eusocial halictid bees in Labrador; *Lasioglossum novascotiae* (Mitchell) is presumed eusocial (Gibbs 2010), though it is possible that it shows flexibility in sociality; species of halictid bees that are solitary or at least show flexibility for a shorter season are indicated in Table 2. The species of Andrenidae collected are ground nesting bees that typically emerge in the early summer in Labrador. After laying eggs and provisioning cells with larval food, most adults will die off by mid-summer, especially some of the *Andrena* which are floral specialists on early season plants, such as *Salix* Linnaeus (Salicaceae). The larvae finish feeding, pupate and moult into adults that remain in the soil nest until the next summer. In the case of bumble bees, the potential queens emerge in the late summer of the previous year, mate and locate a place to overwinter, while the other castes from the

Table 2. Abundance of native bees during weekly collection from various localities in Labrador. HVGB-1 (Happy Valley-Goose Bay, pasture), HVGB-2 (Happy Valley-Goose Bay, forest), HVGB-3 (Happy Valley-Goose Bay, semi-urban), LC (Labrador City), PHS (Port Hope Simpson). Species marked with "*" are considered new records for Labrador; "†" represents halictid bees that likely show flexibility in sociality and may be solitary in Labrador.

	Week 1					Week 2					Week 3					Week 4					Week 5					Week 6					Week 7					Totals				
	HVGB 1	HVGB 2	HVGB 3	LC	PHS	HVGB 1	HVGB 2	HVGB 3	LC	PHS	HVGB 1	HVGB 2	HVGB 3	LC	PHS	HVGB 1	HVGB 2	HVGB 3	LC	PHS	HVGB 1	HVGB 2	HVGB 3	LC	PHS	HVGB 1	HVGB 2	HVGB 3	LC	PHS	HVGB 1	HVGB 2	HVGB 3	LC	PHS	HVGB 1	HVGB 2	HVGB 3	LC	PHS
Andrenidae																																								
*Andrena algida**	49		1			16		4			3	4	1																							68	4	6		
Andrena carolina	1																																			1				
Andrena frigida	16		1			2		2			7	5	1	1				2	5	1	2	3		4			5		3			3				27	16	6	13	1
*Andrena mandibularis**	4		1			1		5			2	10					1					6					4									7	21	6		
Andrena miranda	6		2								3							1					1													9		4		
Andrena w-scripta	2																																			2				
Apidae																																								
Bombus borealis						1		1																												1		1		
Bombus flavidus																																			1					1
Bombus frigidus																1	1					2		4	1					2		1		2	7	1	4		7	10
Bombus melanopygus	2					4					8					23					19	3			1					2		1			5	56	4			8
Bombus mixtus	1																							1					1							1				
Bombus rufocinctus								2					1	1																								3		
Bombus sandersoni	2					1					1										1			1						2					3	5			1	5
Bombus lapponicus sylvicola																								1	4					1									1	5
Bombus terricola	3											1				1																1			1	4	2			1
Nomada pymaea								1																								1					1	1		
Nomada ceanothi												1																									1			
*Nomada valida**	2																																			2				
Colletidae																																								
Colletes consors mesoscopus																					1		4				1					1				1	2	4		
Hylaeus annulatus														1		1											1									1	1		1	
*Hylaeus gaigei**						1																														1				
Halictidae																																								
*Halictus confusus**	6		9			4		8				1	3					5					1													10	1	26		
Halictus rubicundus†	15		1			7		2				1	1																							22	1	4		
Halictus virgatellus†						1																														1				
Lasioglossum (*Dialictus*) *lineatulum*	17		1			14					1																									32		1		
*Lasioglossum (Dialictus) novascotiae**	17					6																														23				
Lasioglossum (*Dialictus*) *tenax*†	1		1					1										2											1							1		4	1	

Table 2. cont'd.

	Week 1					Week 2					Week 3					Week 4					Week 5					Week 6					Week 7					Totals				
	HVGB 1	HVGB 2	HVGB 3	LC	PHS	HVGB 1	HVGB 2	HVGB 3	LC	PHS	HVGB 1	HVGB 2	HVGB 3	LC	PHS	HVGB 1	HVGB 2	HVGB 3	LC	PHS	HVGB 1	HVGB 2	HVGB 3	LC	PHS	HVGB 1	HVGB 2	HVGB 3	LC	PHS	HVGB 1	HVGB 2	HVGB 3	LC	PHS	HVGB 1	HVGB 2	HVGB 3	LC	PHS
Lasioglossum (*Hemihalictus*) *inconditum*†	26					11		1			1	3									1			2					1					2		39	3	1	5	
Lasioglossum (*Sphecodogastra*) *boreale*†	17		1			6		1			2	1				3																				28	1	2		
Lasioglossum (*Sphecodogastra*) *comagenense**	14		1			2		2					1			2			1						1											18		4	1	1
Lasioglossum (*Sphecodogastra*) *quebecense*†	12					2		2			2	3						1												2					2	16	3	3		4
Lasioglossum (*Sphecodogastra*) *seillean*†	7		1			2		1			1						1	1												1						10	1	3		1
Sphecodes solonis						1		1				1																								1	1	1		
*Sphecodes levis**	1																																			1				
Megachilidae																																								
*Coelioxys sodalis**																					1															1				
Megachlie melanophaea																2					3															5				
Osmia nigriventris																									1															1
*Osmia tarsata**	1											1					2					1														1	4			
Totals	222		20			82		34			31	32	8	3		33	5	12	6	1	28	15	6	13	8		11		6	10		8		4	19	396	71	80	32	38

previous season die with the onset of cold weather. Most bees in Labrador become active in the spring or early summer, with females initiating new nests in the soil, or for *Bombus*, in abandoned rodent holes or under thatch (Michener 2007). For social species, the queens feed the first small brood of worker larvae and after approximately three weeks (dependent on temperature) the adult workers emerge and take over foraging duties for nectar and pollen, with the queen remaining in the nest for the rest of her life. The numbers of worker bees produced in the nests of social species slowly build up over the summer months. This trend is shown in our data with most bumble bees, presumably workers, being collected from mid-July onwards. The PHS site likely had more bumble bees collected than any other bees because the sampling started later in the season compared to other sites (Table 1), when solitary bees were mostly finished for the season.

Even though the pasture and the semi-urban site in HVGB are located close together and had similar plant composition, the abundance and diversity of bees differed between them (Table 2). The HVGB-1 (pasture) was well drained while the HVGB-3 (semi-urban) site was flooded in the springtime. Extended periods of waterlogged soils will delay the emergence of ground-nesting bees or may kill them by drowning. The difference in the drainage of water during the springtime between the two sites may have affected their bee faunas and contributed to the differences observed. However, multiple year surveys would be necessary to determine if differences among sites are significant.

This study constitutes an important list of bee species that will contribute to future studies of faunistics for the area and may assist in future studies on the impact of climate change on northern ecosystems. While bees have been collected in the past, we are not aware of any widespread collecting or systematic surveys in the area. Future studies should concentrate the effort in northern areas and along coastal habitats where there are many gaps in bee collections and where indigenous communities can be involved.

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