

Comparative studies on the bumblebee (Hymenoptera, Apidae, *Bombus* Latreille, 1802) fauna of the small Ekkerøy peninsula in the subarctic part of northern Norway from 1990 and 2023

MARTIN HALLMEN

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Current bumblebee (Hymenoptera, Apidae, *Bombus* Latreille, 1802) observations on the small subarctic peninsula of Ekkerøy in the Varanger Fjord in Northern Norway are presented and compared with data from the same location in 1990. 6 bumblebee species were detected in 1990 and 9 in 2023. Newly detected species were *Bombus hortorum* Linnaeus, 1761, *B. pratorum* Linnaeus, 1761 and *B. bohemicus* Seidl, 1837. The most common species both years was *B. lapponicus* Fabricius, 1793. The abundance of all other species fluctuated greatly in some cases. A comparison of individual days showed considerable differences in the composition of the bumblebee communities at the same location. The same applies to a day on which two surveys were carried out at different times. *B. hortorum* is in the process of colonising the Varanger peninsula. The sequence of the most important forage plants for bumblebees could be determined for Ekkerøy over the entire bumblebee season. Further changes in Ekkerøy's bumblebee diversity are expected in the future due to climate change.

Zusammenfassung. Aktuelle Hummelbeobachtungen auf der kleinen subarktischen Halbinsel Ekkerøy im Varanger-Fjord in Nord-Norwegen werden vorgestellt und mit Daten aus dem Jahr 1990 vom selben Ort verglichen. 1990 konnten 6 und 2023 9 Hummelarten nachgewiesen werden. Als neue Arten ergaben sich *B. hortorum*, *B. pratorum* und *B. bohemicus*. Die häufigste Art war in beiden Jahren *B. lapponicus*. Die Häufigkeit aller anderen Arten schwankte zum Teil sehr stark. Auch der Vergleich einzelner Tage sowie eines Tages, an dem zwei zeitlich versetzte Untersuchungen stattfanden, zeigten erhebliche Unterschiede in der Zusammensetzung der Hummelgemeinschaften am selben Ort. *B. hortorum* ist gerade dabei, die Varanger-Halbinsel zu besiedeln. Die Abfolge der wichtigsten Futterpflanzen für Hummeln konnte für Ekkerøy über die gesamte Hummelsaison ermittelt werden. Für die Zukunft sind aufgrund des Klimawandels weitere Veränderungen in der Hummeldiversität Ekkerøys zu erwarten.

Key words: Hymenoptera, Bumblebees, *Bombus*, Ekkerøy, Varanger, Northern Norway, Fennoscandia, subarctic, arctic, comparative study, forage plants.

Martin Hallmen, Barbarossastraße 40, D-63517 Rodenbach, Germany. E-Mail: Hallmen@t-online.de

Introduction

Bumblebees of the genus *Bombus* Latreille (1802) are among the most important pollinators of wild and cultivated plants in subarctic and arctic regions (Bruholt et al. 2020, Koch et al. 2020, Zoller & Knight 2022). However, their distribution as well

as local and supraregional diversity are currently changing globally (Cameron et al. 2011, Pantoja 2015, Christman et al. 2022, Scharnhorst et al. 2023). In many mountain ranges, an upshift of many bumblebee species can be observed (Marshall et al. 2020, Ghisbain et al. 2021, Thierolf 2021, Biella et al. 2017, 2024, Maihoff

et al. 2023). The predicted migration to more northerly regions (Lenoir & Svenning 2015, Rasmont et al. 2015, Martinet et al. 2015) has also been documented for numerous bumblebee species (Kerr et al. 2015, Pantoja 2015, Martinet et al. 2015, Soroye et al. 2020). The shrinking or even disappearance of populations, especially of species adapted to colder climates, is a result of these changes (Zoller et al. 2023).

Changes in land use (Marshall et al. 2017, Newbold et al. 2023, Pioltelli 2024), changing plant communities (Straub et al. 2023) or the use of pesticides (Nicholson et al. 2023, Straub et al. 2023) and their interactions (Ghisbain et al. 2023) have been identified as the causes of these processes. Irrespective of these factors, however, climate change is considered to be the main cause of global changes in bumblebee diversity (Pantoja 2015, Rasmont et al. 2015, Martinez-Lopez et al. 2021, Liu et al. 2023). Rising temperatures have been recorded in most Fennoscandian countries since the middle of the last century (Pekkarinen & Teräs 1993). The extent of climate change in the arctic and subarctic regions is well above the global average (Post et al. 2009). Bumblebees are considered good natural indicators of climatic changes (Biella et al. 2024).

Comparisons of historical observations and

collections (Rakosy et al. 2022, Weller 2023) with currently collected data (Pantoja 2015, Korten & Sann 2021, Zoller & Knight 2022, Gaulhofer 2023, Zoller et al. 2023) can provide important insights into changes in bumblebee diversity over longer periods of time. Unfortunately, such historical data is rare in most regions. This applies to a greater extent to the less researched subarctic and arctic regions (Namin et al. 2021, Zoller & Knight 2022).

The intention of this investigation is to present the data collected in 2023 on bumblebee diversity on the Ekkerøy peninsula in the Varanger fjord in northern Norway and to compare it with older observations from the same location from 1990 (Hallmen 1992).

Material and methods

The Ekkerøy peninsula is located in the far north-east of Norway 15 km east of Vadsø at the coordinates 70°04'33"N/30°06'12"E (Ekkerøy village) (Figure 1). The peninsula is 2.7 km long, 1.2 km at its widest, its highest point is 53 m a.s.l. near the centre of the island and the connection to the mainland, the isthmus, is 850 m long. It is located in the subarctic coastal fringe of the

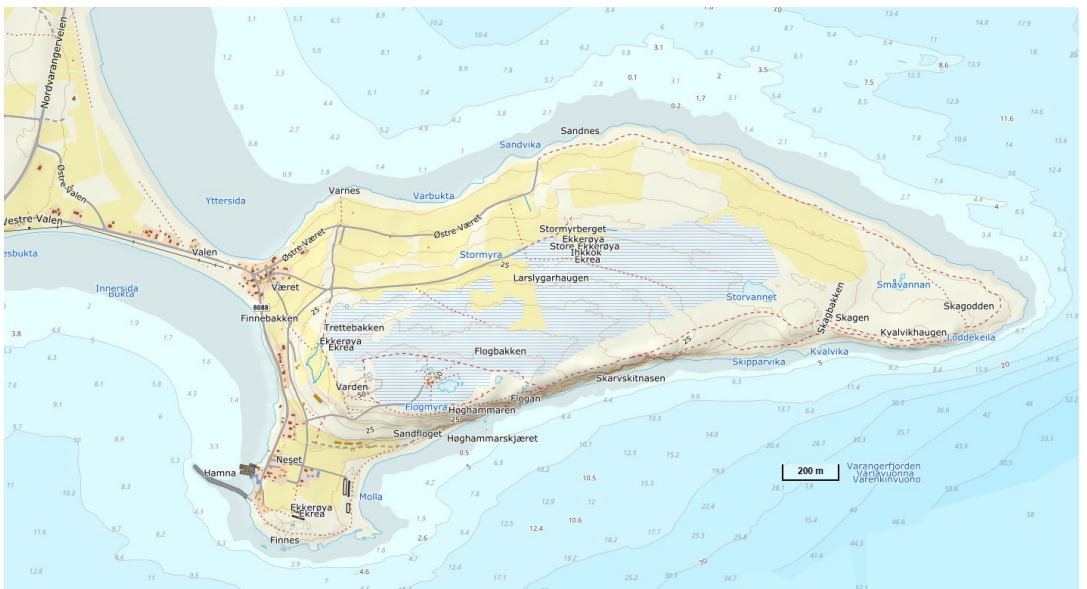


FIGURE 1. The Ekkerøy peninsula in the Barents Sea (Map source: www.norgeskart.no 2024)

Varanger fjord, at the transition to the arctic "fjells" of the Varangerhalvøya.

The research in 2023 took place from June 10 to July 4. The comparative data from 1990 were from July 12 to August 2. The sites were identical (Hallmen 1992).

Data collection in both study periods was mainly based on observations, mostly on flowers in the field. Occasionally, individual specimens were caught, examined more closely in a tube and then released again. Some specimens of species/individuals that could not be identified in the field were killed and examined under a binocular. The date and geodata were noted for all observations, and the time, duration of stay, food plant, temperature, cloud cover and wind conditions were also noted for the 2023 findings (the latter 3 estimated in each case). All specimens are in the Hallmen private collection.

The bumblebees were mainly identified using the identification keys of Løken (1973, 1984), Amiet (2017) and Rasmont et al. (2021) as well as the plates and images of Bollingmo (2012) and Ødegaard et al. (2015). The findings from 1990 (Hallmen 1992) were re-determined and partly revised with the support of Rasmont (pers. com. 2024).

In order to analyse the sightings of *B. alpinus* (Linnaeus, 1758) and *B. monticola* Smith, 1849, their ratio in the prepared animals was transferred to that of the pure field observations. The comparison of the frequency on different days covers all animals on the isthmus along a transect of approximately 300 m.

Results in 2023

Species and their abundance

Bumblebees were observed on 13 days during the observation period. The majority of the animals were found in the dune landscape of the isthmus at the entrance to the Ekkerøy peninsula (Figure 2) and on the side of the main road. Other locations were close to the bird cliffs, in the small settlement and on the Northern beach of the peninsula (Figure 1).



FIGURE 2. As in 1990, the sandy areas of the isthmus turned out to be the best places to find bumblebees on the Ekkerøy peninsula in 2023 as well. Photo: M. Hallmen.

During the observation period, a total of 289 bumblebees of the genus *Bombus* were observed, divided into 9 species (Figure 3). The distribution across the casts was 188 ♀♀ (65.1 %), 92 ♂♂ (31.7 %) and 9 ♂♂ (3.1 %). The most common species were *B. lapponicus* (Fabricius, 1793) 31,8 % (n = 92) (Figure 4), *B. jonellus* (Kirby, 1802) 23,5 % (n = 68) and *B. balteatus* Dahlbom, 1832 16,3 % (n = 47). Moderately frequent appeared *B. hortorum* (Linnaeus, 1761) 8,7 % (n = 25). Less frequent were *B. monticola* 5,9 % (n = 17), *B. alpinus* 4,8 % (n = 14), *B. cryptarum* (Fabricius, 1775) 4,8 % (n = 14) and *B. pratorum* (Linnaeus, 1761) 3,8 % (n = 11). Of *B. bohemicus* Seidl, 1837 0,4 % only 1 specimen could be detected. The visual findings of *B. alpinus* / *B. monticola* are included with their ratio in the dry preparations.

The first ♂♂ of all bumblebee species were observed on Ekkerøy in June (Table 1). *B. alpinus* and *B. monticola* showed the earliest appearance of ♂♂ on 10.VI.2023 and *B. cryptarum* the latest on 24.VI.2023. No ♂♂ of *B. hortorum* could

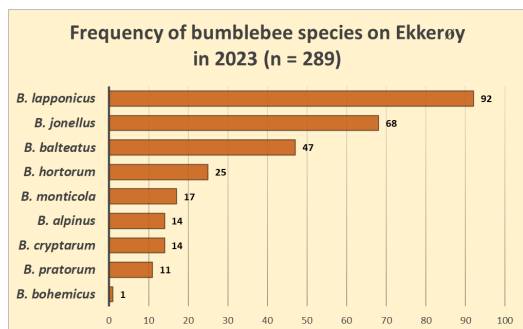


FIGURE 3. Diversity and abundance of bumblebees on Ekkerøy in the Varanger fjord



FIGURE 4. Queen of *Bombus lapponicus* (Fabricius, 1793) on *Salix* sp. Photo: M. Hallmen.

be found. Only 2 bumblebee species ♂♂ flew during the observation period: *B. lapponicus* (30. VI.2023) and *B. jonellus* (3.VII.2023).

The bumblebees flew at temperatures between 6 and 20 °C. The wind conditions varied between calm and very strong, gusty winds. When it was

TABLE 1. First observations of ♀♀ and ♂♂ of bumblebees (*Bombus*) on Ekkerøy in 2023.

Species	first ♀	first ♂
<i>B. alpinus</i>	10.VI.2023	-
<i>B. balteatus</i>	23.VI.2023	-
<i>B. cryptarum</i>	24.VI.2023	-
<i>B. hortorum</i>	-	-
<i>B. jonellus</i>	16.VI.2023	3.VII.2023
<i>B. lapponicus</i>	14.VI.2023	30.VI.2023
<i>B. pratorum</i>	22.VI.2023	-
<i>B. monticola</i>	10.VI.2023	-

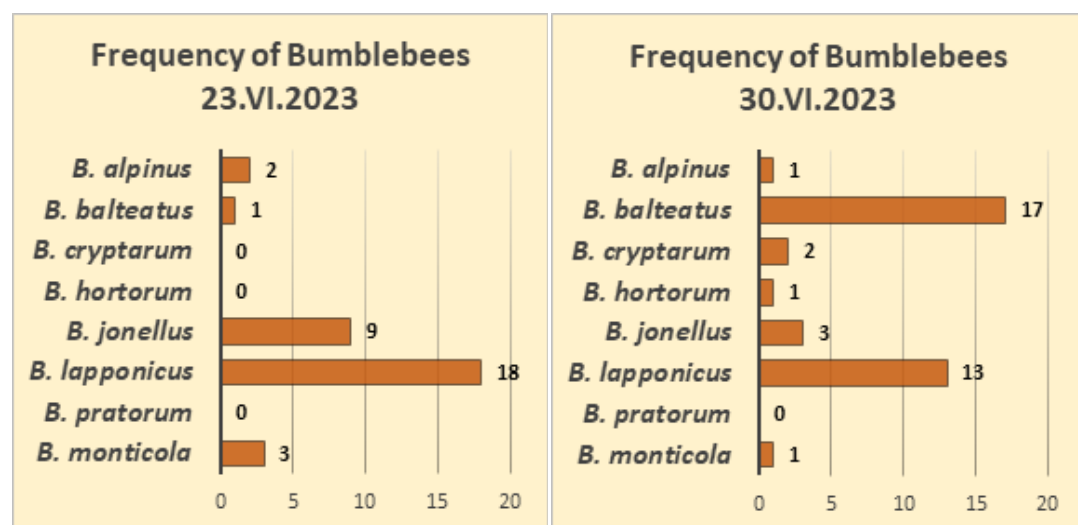
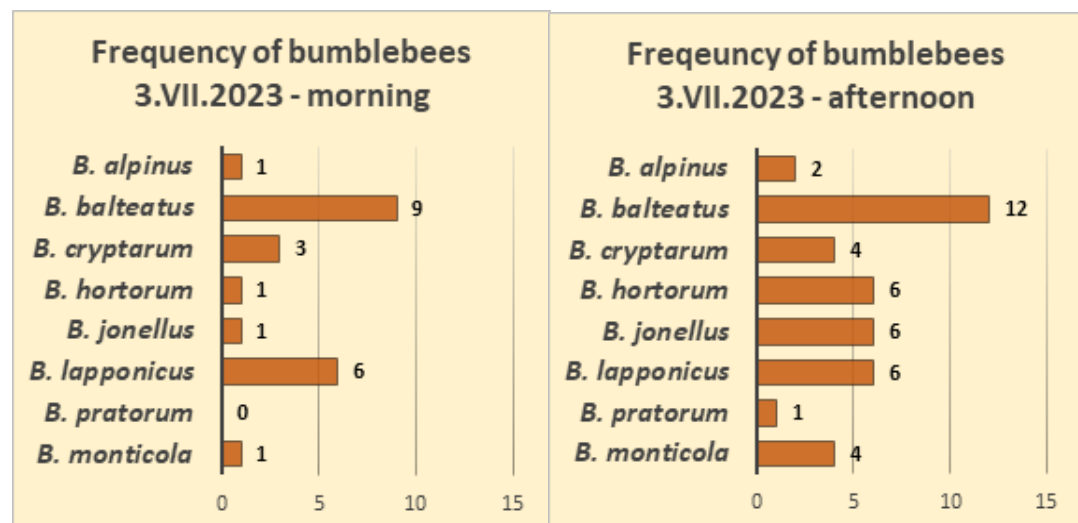
windy, the bumblebees flew very close to the ground. On some observation days, the animals flew even between small showers. In fog, however, no flight activity was observed.

Day comparisons

In some cases, strong daily fluctuations in the composition of the bumblebee communities were observed. While the species *B. alpinus* and *B. monticola* were still very common on 23.VI.2023, they were not found at all just one day later under comparable weather conditions.

A comparison of the inspections of the 300 m standard transect on 23.VI.2023 and 30.VI.2023. revealed very different frequencies of the bumblebee species in some cases (Figure 5). *B. lapponicus* and the species *B. alpinus*, *B. cryptarum*, *B. hortorum*, *B. monticola* and *B. pratorum*, which were rarer on this day, were almost equally abundant. *B. balteatus*, on the other hand, was only found with one specimen in the morning, but was the most common bumblebee species in the afternoon. *B. jonellus*, however, was significantly more common in the morning than in the afternoon.

On 3.VII.2023, a double inspection of the transect in the morning and in the afternoon also revealed changes in the abundance of the bumblebee species (Figure 6). All species were represented by more individuals in the afternoon than in the morning (only *B. lapponicus* remained the same), although the weather conditions were

FIGURE 5. Frequency of bumblebee (*Bombus*) species on Ekkerøy on two different daysFIGURE 6. Frequency of bumblebee (*Bombus*) species on Ekkerøy in the morning and afternoon of the same day.

better in the morning (13 °C and windless in the morning, 11 °C and light wind in the afternoon). *B. balteatus* was the most common bumblebee species at both times of day.

Forage plants

The sandy dunes of the isthmus, the edges of the only tarmac access road and the few side streets proved to be the best places to find bumblebees. A total of 280 observations of bumblebees on

flowers were made during the study period (Table 2). The animals visited 11 species from 11 different genera of forage plants. The Alpine Milkvetch *Astragalus alpinus* received by far the most visits from bumblebees with 88,9 % (n = 248). It was also the only forage plant visited by all 9 bumblebee species. Of the remaining 10 plant species (11,1 %, n = 31), the Blue Honeysuckle *Lonicera caerulea* had the most flower visits with 5,4 % (n = 15). Only one bumblebee was observed foraging on each of 6 forage plants. For most

TABLE 2. Early season forage plants on Ekkerøy and their visit by bumblebees. Abbreviations: Bal = *B. alpinus* (Linnaeus, 1758), Bba = *B. balteatus* Dahlbom, 1832, Bbo = *B. bohemicus* Seidl, 1837, Bcr = *B. cryptarum* (Fabricius, 1775), Bho = *B. hortorum* (Linnaeus, 1761), Bjo = *B. jonellus* (Kirby, 1802), Bla = *B. lapponicus* (Fabricius, 1793), Bmo = *B. monticola* Smith, 1849, Bpr = *B. pratorum* (Linnaeus, 1761).

	Bal	Bba	Bbo	Bcr	Bho	Bjo	Bla	Bmo	Bpr
<i>Astragalus alpinus</i>	13	43	1	11	11	65	86	16	2
<i>Dryas octopetala</i>	-	1	-	-	-	-	-	-	-
<i>Geranium sylvaticum</i>	-	1	-	-	-	-	-	-	-
<i>Lathyrus japonicus</i>	-	2	-	-	1	-	-	-	-
<i>Lonicera caerulea</i>	-	-	-	2	4	1	-	-	8
<i>Oxytropis campestris</i>	1	1	-	-	4	-	-	-	-
<i>Papaver radiculatum</i>	-	-	-	-	-	-	1	-	-
<i>Salix</i> sp.	-	-	-	-	-	-	2	-	-
<i>Silene dioica</i>	-	-	-	-	1	-	-	-	-
<i>Taraxacum officinale</i>	-	-	-	-	-	-	-	-	1
<i>Trifolium</i> sp.	-	-	-	-	1	-	-	-	-

bumblebee species, *A. alpinus* was by far the most important food source. Only *B. pratorum* showed a preference for *L. caerulea*. The latter, together with the Field Locoweed *Oxytropis campestris*, was still a real alternative to *A. alpinus*, at least for *B. hortorum*.

The bumblebee species *B. hortorum* (6) and *B. balteatus* (5) showed the greatest variety of forage plants visited (Figure 8). *B. lapponicus* was found on 4, *B. pratorum* on 3 and *B. alpinus*, *B. cryptarum* and *B. jonellus* on 2 different plant species. *B. bohemicus* and *B. monticola* were only found on *A. alpinus*.

During the observation period, there was a small-scale shift of the bumblebee hotspot to the isthmus. When the Alpine Milkvetch *A. alpinus* faded and the Beach Pea *Lathyrus japonicus* began to bloom, the most frequent observations were made in a small fenced garden behind a residential building.

Comparison of 1990 and 2023

After partial revision and re-determination of the specimens from 1990, 6 species of the genus *Bombus* were found on the Ekkerøy peninsula in contrast to 9 species 33 years later (Figure 9). *B. lapponicus* (36,0 % / 31,8 %) proved to be the only constant and common species in both

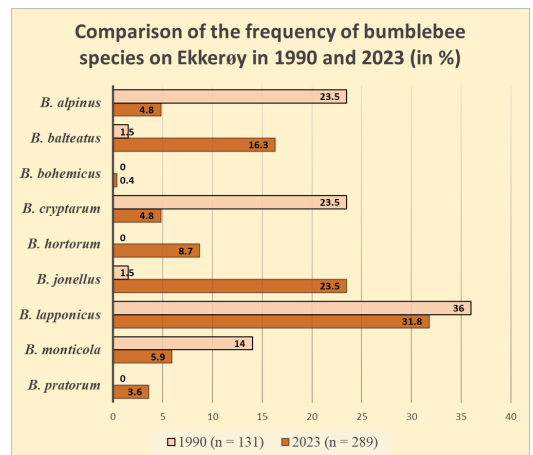


FIGURE 7. Comparison of bumblebee frequency on Ekkerøy in 1990 and 2023.

periods. 5 bumblebee species showed extreme differences in their abundance. *B. jonellus* (1,5 % / 23,5 %) and *B. balteatus* (1,5 % / 16,3 %) were significantly less common 33 years ago. *B. alpinus* (23,5 % / 4,8 %), *B. cryptarum* (23,4 % / 4,8 %) and *B. monticola* (14,0 % / 5,9 %), on the other hand, were each strikingly more common in 1990 than in 2023. *B. hortorum*, *B. pratorum* and *B. bohemicus* were detected for the first time in contrast to 1990.

Discussion

The year 2023

Species and their abundance. The occurrence of 9 bumblebee species on such a small subarctic peninsula is remarkable. Of the 4 purely arctic species (Potapov et al. 2014), *B. balteatus* and *B. lapponicus* were two of the more common representatives. According to Ødegaard et al. (2015), Bollingmo (2012) and Rasmont et al. (2021), *B. polaris* (*B. pyrrhopygus* according to Williams et al. 2015, 2016, 2019, Martinet et al. 2018, Potapov et al. 2019) might have been expected on Ekkerøy. According to Rasmont et al. (2021), *B. hyperboreus* was only found before 1990. According to earlier (Løken 1973) and more recent findings (Bollingmo 2012), *B. hyperboreus* can only be found in the Sør-Varanger Commune or further East in the Murmansk region (Paukkunen & Kozlov 2015). Ødegaard et al. (2015), on the other hand, had no records in the entire Varanger region. In any case, the host species *B. balteatus* (Gjershaug 2009) is represented with a considerable occurrence on Ekkerøy. *B. polaris* could be detected in larger-scale studies in the entire Varanger region in 2023 in Sandfjord (Hallmen in prep.), *B. hyperboreus* Schönherr, 1809, on the other hand, does not. All 4 arctic bumblebee species are extremely endangered as polar relicts from the Pleistocene due to global warming (Potapov et al. 2021). According to the climate risk index by Rasmont et al. (2015), *B. balteatus* and *B. lapponicus* are subject to a very high climate change risk (HHR). In the Norwegian Red List of Threatened Bumblebee Species (Bengtson et al. 2019, Ødegaard et al. 2021) they are listed as Least Concern (LC).

The alpine-boreal bumblebee species *B. jonellus*, *B. alpinus* and *B. monticola* can also be considered typical for the subarctic tundra. They were (Løken 1973) and are found here regularly, but with varying frequencies (Bollingmo et al. 2012, Ødegaard et al. 2015, Bengtson 2021, Rasmont et al. 2012). But according to Zoller et al. (2013), a decline in populations has already been recorded for *B. jonellus*. On Ekkerøy, all 3 species occurred at different frequencies, but regularly.

According to Rasmont et al. (2015), *B. alpinus* is subject to a very high climate change risk (HHR) and *B. jonellus* and *B. monticola* to a high climate change risk (HR).

The occurrence of *B. pratorum* on Ekkerøy, as one of the generalist bumblebee species, is consistent with the distribution data of Løken (1973), Bollingmo (2012), Ødegaard et al. (2015), Bengtson (2021) and Rasmont et al. (2021). The evaluation of the results for *B. cryptarum* is not easy due to the problems with species identification, especially in the field (Wolf et al. 2010, Carolan et al. 2012). According to Rasmont et al. (2021), it is a common species in the Varanger region, which is confirmed by records from the European part of Russia (Potapov et al. 2022). Ødegaard et al. (2015), on the other hand, record only one specimen at Ekkerøy, but no others in the entire Varanger region, and Bollingmo (2012) only lists specimens from a few localities. The available specimens, especially of the queens that are somewhat easier to categorise (Bertsch et al. 2004), identify all the animals found in the *B. terrestris-lucorum*-complex as *B. cryptarum*.

The findings of *B. hortorum* on the Ekkerøy peninsula are consistent with the recent records in Varangerbotn and Vadsø, which are listed in Ødegaard et al. (2021). Previously, the Varanger Peninsula was considered free of *B. hortorum*. The number of individuals found on Ekkerøy and other records on Varangeshalvøya (Hallmen 2024a in prep.) show that the species has become established on the northern shore of the Varanger fjord. More recent records show that *B. hortorum* has reached the Arctic Ocean (Hallmen 2024c in prep.).

The unique record of the parasitic bumblebee *B. bohemicus* on Ekkerøy is a rarity. The observation confirms the more recent records at the southern part of the Nordkinn peninsula west of the Varanger peninsula near Eastojavri (Ødegaard et al. 2021). The record probably corresponds to the current northern distribution border of *B. bohemicus*. This is the first record of *B. bohemicus* in the Varanger region and is discussed in more details in Hallmen (2024d).

Comparison of days. The observations on a transect on two consecutive days or at intervals of

7 days showed large differences in the occurrence of almost all bumblebee species. Even common species such as *B. lapponicus*, *B. jonellus* or *B. balteatus* occurred only with a few specimens. Even the results from morning and afternoon observations on the same day and under otherwise comparable conditions do not provide a uniform picture of bumblebee abundance at the main site on Ekkerøy. The abundance of bumblebees and the composition of their communities show clear fluctuations in shorter as well as in medium and longer periods. Only a large number of observations on numerous different days, preferably spread over the entire bumblebee season, can provide an approximately realistic picture of the distribution and abundance of bumblebees, at least for the respective study year. The results may look completely different the following year (Zoller et al. 2020, Hallmen 2023). Continuous long-term studies are necessary to make statements about trends within bumblebee populations.

Comparison of 1990 and 2023

Species and their abundance. The sometimes very different composition of the biodiversity of bumblebee species on Ekkerøy between 1990 and 2023 is less likely to be due to the different time periods of the surveys within the bumblebee season (1990 the second half of the season, 2023 from the beginning of the season to around the middle), because the life cycle for the bumblebee colonies is short and all species have to use the short arctic summer almost simultaneously. One possible explanation would be the proven fluctuations within different years (Zoller et al. 2020) or the changes within short periods of days or weeks shown in this study.

However, the difference also could be the effect of climate change, which has been taking place for some time, particularly in the Arctic Region (Pekkarinen & Teräs 1993, Martinet et al. 2015, Potapov et al. 2014). A warmer climate led to a short-term increase in biodiversity in the subpolar and polar zones due to the invasion of new species (Zoller et al. 2023). An example of this could be *B. hortorum* on Ekkerøy. The species is only known from the Sør-Varanger Municipality (Løken

1973, Bollingmo 2012, Rasmont et al. 2021). On the Varanghalvøya and thus also on Ekkerøy, no records have been done so far. However, the species is quite common in the neighbouring Russian part of the Arctic (Potapov et al. 2022). The findings of *B. hortorum* on Ekkerøy can possibly be explained by an immigration of the species from the European part of Russia bordering Finland via Sør-Varanger Municipality to the Varanghalvøya, which it is possibly just beginning to colonise. But colonisation from the south would also be possible.

Forage plants

With the observations made later in the bumblebee season in 1990 and the early records from 2023, an almost complete overall picture of the vegetation development of the forage plants for bumblebees on Ekkerøy emerged. At the beginning of the season, around 5 willow species of the genus *Salix* were found to be the mainstays of the bumblebee population, serving as a food source for the first queens. They are replaced for several weeks by the Alpine Milkvetch *A. alpinus* (Figure 10), whose importance is also emphasised by Stenström & Bergmann (1998) and Potapov et al. (2019). In the middle of the season, it is mainly the Beach Pea *L. japonicus*, which is replaced towards the end by Fireweed *Epilobium* sp. All other types of forage plants are utilised, but are not of central importance, at least on Ekkerøy.

On Ekkerøy, as in many other regions of Norway, roadsides play an important role in insect feeding (Bruholt et al. 2020). As on Ekkerøy, *A. alpinus* in particular was found along many roadsides in the entire Varanger region like a purple band. The few road casualties found among the bumblebees do not appear to diminish the positive effect of the forage plants on the bumblebees' diet. The range of forage plants for bumblebees does not appear to have changed in the last 33 years.

Outlook for the future

The available results show the ongoing change. Particularly in the far north of Europe, where many European bumblebee species are predicted to seek



FIGURE 8. By far the most frequently visited forage plant by the bumblebees on Ekkerøy was the Alpine Milkvetch *Astragalus alpinus*. Photo: M. Hallmen.

refuge (Lenoir & Svenning 2015, Kerr et al. 2015, Rasmont et al. 2015, Martinet et al. 2018), the diversity of species is expected to change rapidly. The pure arctic and alpine bumblebee species are the most threatened in their populations (Potapov et al. 2021, Liu et al. 2023, Zoller et al. 2023). For Ekkerøy and the entire Varanger region, newly immigrating and extinct bumblebee species are also expected.

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