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Nationwide survey of social wasps (Vespinae) in Finland

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Global change affects species distribution and abundance. To monitor changes in the distribution and abundance of social wasps (Vespinae), reliable baseline data are needed. We established a network of study sites (n = 16) to study vespine abundance throughout Finland, ranging a 1 100 km south to north distance, during 2019–2024. Similar beer traps were used in all sites. Altogether 4 099 individuals and nine species were captured. The most abundant and frequent species was *Vespula vulgaris* (60% of individuals and 92% site-year occupancy) followed by *Dolichovespula media* (31% and 81%) and *Vespa crabro* (3% and 4%). *Vespa crabro* was only trapped in Åland Islands, but abundantly. Variation in the abundance of *V. vulgaris* and *D. media* was great among sites and years. Our study suggests great spatio-temporal variation and species-specificity in beer trap catches of social vespine wasps, which should be considered in designing monitoring protocols.

Introduction

Global change affects species distribution and abundance, and social wasps (Hymenoptera: Vespinae) are no exception. Social vespine wasps are ubiquitous organisms, abundant in anthropogenic environments, and often considered a nuisance (Archer 2012, Sumner et al. 2018, Santaoja et al. 2023). Large-scale surveys of species distribution and abundance provide important baselines for evaluating species responses to environmental change.

In Finland, there are 12 species of social vespine wasps (Pekkarinen & Huldén 1995, Paukkunen 2024). Most species have a nation-wide distribution, while *Vespula germanica* (Fabricius)

and *Vespa crabro* L., for example, have a southern distribution; both species are extending their range northwards, probably due to climate change (Teräs et al. 2003, Sorvari 2013, 2018, Komonen et al. 2020). Vespines have yearly variation in abundance (Akre & Reed 1981, Sorvari 2013, Lester et al. 2017, Komonen et al. 2025). There is also considerable variation across geographical locations but the underlying causes for this variation are not fully understood (Sorvari 2018, Komonen et al. 2025). Given the increase in colony size over summer, wasp abundance in Finland reaches its peak in late July to mid-September, depending on the species and year (Pekkarinen & Huldén 1995, Archer 2012, Sorvari 2013, Komonen et al. 2025). In favorable years, however, the peak abundance of *Dolichovespula* can occur already in mid-July (Komonen et al. 2020, 2025).

Our overall goal was to explore the distribution and abundance of social wasp (Vespinae) workers across a 1 100 km south to north gradient across Finland using standardized sampling with beer traps. Trapping was conducted for one to six years in each location. We asked 1) are there interspecific differences in species abundances overall and among locations, and 2) are there differences in species frequencies of occurrence among locations.

Fig. 1. The study was conducted in sixteen sites across Finland.

Material and methods

The study was conducted in sixteen sites across Finland (Fig. 1, Appendix). One site was sampled for six years (2019–2024), two sites for four years (2019–2022), one site for three years (2019–2021), seven sites for two years (2019–2020), and five sites for one year (2019). The southernmost sites were on the archipelago of Gulf of Finland and the northernmost in Lapland (ca. 1 100 km north – south gradient). Most sites were either research stations or university cities. Traps were hung in trees or bushes 1 to 2 m (2 to 4 m in Kuopio) from the ground in different habitat types. Each trap (model Sorvari 2013; Fig. 2) was filled with 2 dl of beer and a hint of brown sugar and dry yeast. Most sites had three traps (min. – max. = 3–22), and the traps were set for somewhat variable periods, mostly for ca. two months (mid-July to late August) but, in some cases, from mid-

Fig. 2. The beer trap used in the study.

May to early August (Appendix). The overall cumulative number of trap days totaled 13,516. In sites that were sampled over several years, the traps were kept in the same locations with two exceptions: in Jyväskylä, two traps were moved 80 m and 100 m, and in Kevo, two traps were moved 200 m and 5 km. The frequency of occupancy was calculated across 16 sites and 1–6 years, i.e. 42 site-year combinations (Appendix). Individuals were identified to species using Douwes et al. (2012). Data are available on request.

Results

In total, we recorded nine species and 4 099 individuals (Table 1). *Vespula vulgaris* L. was the most abundant species (n = 2 460 individuals; 60% of all individuals 2019–2024; Fig. 3), followed by *Dolichovespula media* (Retzius) (n = 1 253; 31%) and *Vespa crabro* (n = 136; 3%). *Vespula vulgaris* was present in 91% of the site-year combinations, *D. media* in 79% and *V. crabro* in 5% (Fig. 4). *V. crabro* was only trapped in Husö, Åland Islands, but rather abundantly throughout the season (Fig. 5): the average number of individuals per trap day was 0.46 in 2019 and 0.36 in 2020. The peak abundance was reached during weeks 34 and 35. *Dolichovespula saxonica* (Fabricius) was rather frequent (57% of site-year occupancy), although very few individuals were trapped (Figs. 3 & 4). Only 44 individuals of *V. germanica* were trapped.

Discussion

In Finland, there are 12 species of social vespine, of which nine occurred in our survey material. The three parasitic vespine species were missing, which is logical since the parasitic vespines do not have workers and thus occur in low numbers.

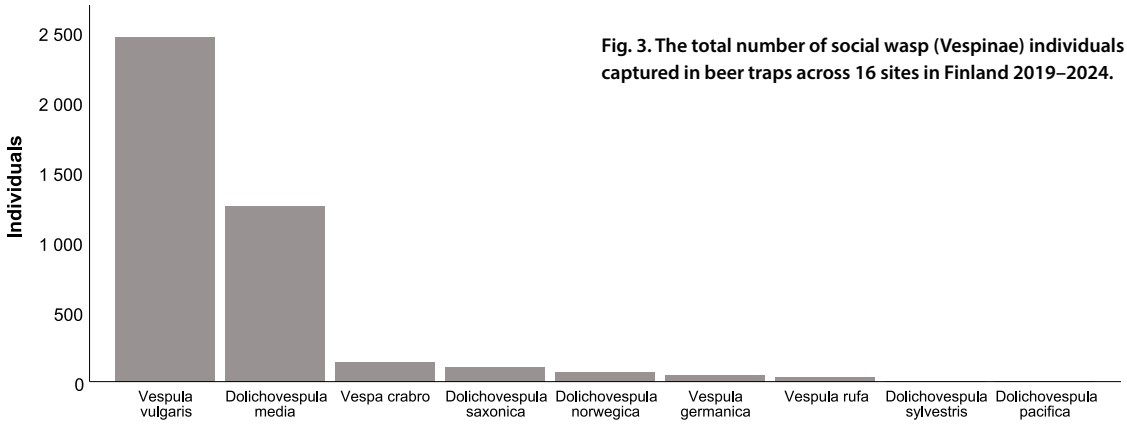

Fig. 3. The total number of social wasp (Vespinae) individuals captured in beer traps across 16 sites in Finland 2019–2024.

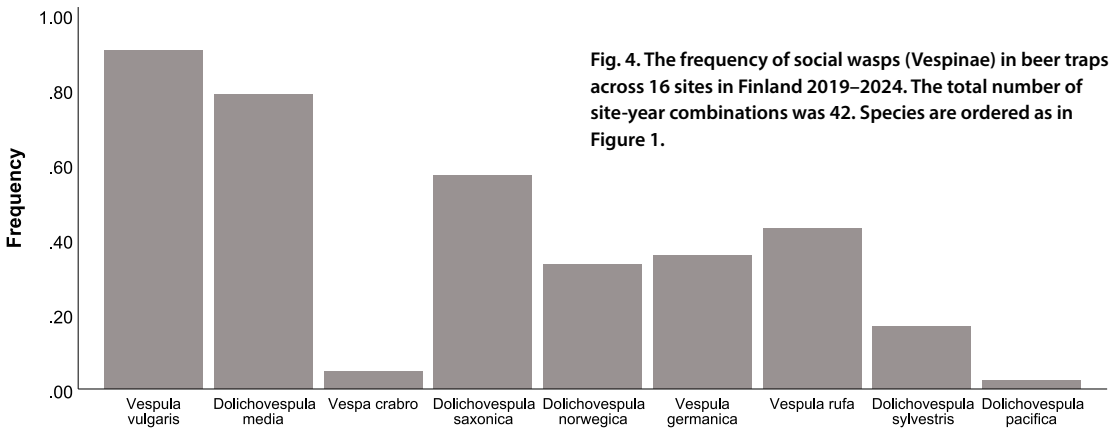

Fig. 4. The frequency of social wasps (Vespinae) in beer traps across 16 sites in Finland 2019–2024. The total number of site-year combinations was 42. Species are ordered as in Figure 1.

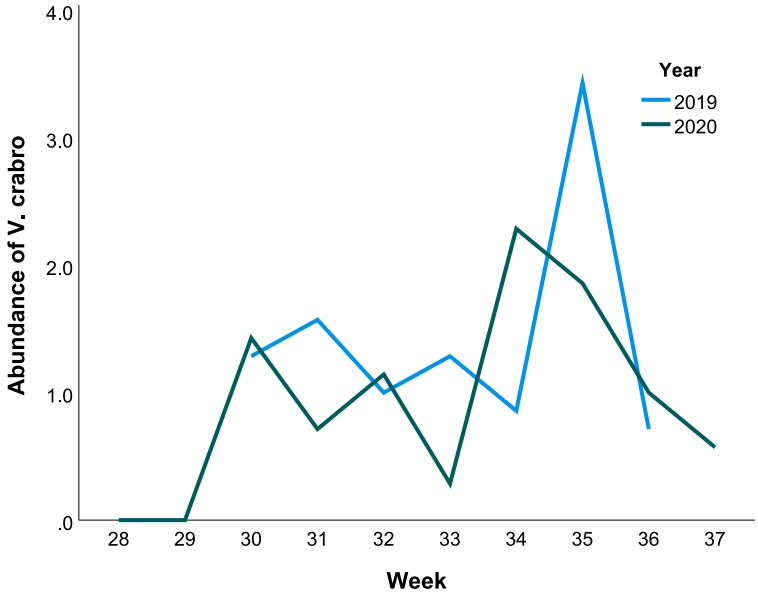

Fig 5. The mean number of *Vespa crabro* individuals per trap day in beer traps (n = 3) in Husö, Åland Island, Finland 2019–2020.

Our results corroborate previous studies in that the abundance of the trapped vespine species was highly variable. This was expected as beer traps mainly attract *V. vulgaris*, *V. germanica*, *D. media* and *V. crabro* (Dvořak 2007, Sorvari 2013, 2018, Demichelis et al. 2014). *Vespula vulgaris* was the most abundant species and present in almost all sites. Interestingly, the species was scarce in the archipelago sites. *Dolichovespula media* was locally very abundant in South-Central Finland but very rare in northern and eastern Finland. A potential reason for the large spatial variability is that the habitat types in which trapping was conducted varied even within locations (see Pawlikowski et al. 2016). The rarity of *D. media* in Kuopio may result from unfavorable habitat types in which trapping was conducted (pers. obs.), and August sampling, as the species often reaches its seasonal peak abundance already in July (Komonen et al. 2025). Furthermore, we want to pinpoint that also *V. vulgaris* was trapped in very low numbers in northern Finland, so *D. media* does not necessarily become rarer there in comparison with *V. vulgaris*.

Vespa crabro and *Vespula germanica* both have a southern distribution in Finland, but both are expanding their range northwards. *Vespa crabro* was recorded only from the Åland Islands but rather abundantly. This suggests that the ongoing increase in distribution and abundance of *V. crabro* in Finland could be monitored with beer traps (see also Dvořak 2007, Demichelis et al. 2014). The species reached its peak abundance in the latter half of August, which resembles more the seasonal abundance pattern of *Vespula* than *Dolichovespula* (Komonen et al. 2025). We also recorded *Vespula germanica* in several sites but in low numbers, although the species is readily trapped with beer traps (Sorvari 2013, 2018). The species had occurred in the Åland Islands for decades, became common in the mainland Finland in the early 2000s, and the first potential breeding colony was reported in 2006 (laji.fi, Eeva et al. 2006). In the turn of the decade 2000 to 2010, *V. germanica* was locally more abundant than *V. vulgaris* in urban areas in southern Finland (Sorvari 2013, 2018). Our study supports the northward range expansion but suggests that the species is not yet very abundant outside the southernmost coastal Finland.

The high variability in vespine abundance, even within sites or among nearby traps, suggests that systematic as well as extensive and intensive trapping is needed to get comparable national or regional data over years. Due to latitude- and weather-related variation in peak flight time, the timing of monitoring should be modified accordingly, if the flight season cannot be adequately covered. Although reliable monitoring of vespine abundance requires standardized trapping,

citizen science data can be more effective in documenting vespine distribution at regional or national scales (see also Sumner et al. 2019). Despite its limitations, long-term standardized monitoring of social vespine wasps is easy to conduct, and it increases our knowledge about insect population fluctuations.

Table 1. Study locations 2019–2024, and the number of wasps trapped each year. 'Jyväskylä A' refers to traps that were continuously operated, 'Jyväskylä B' to traps that operated 12 days in July and 12 days in August. Vesvul = Vespula vulgaris, Vesger = V. germanica, Vesruf = V. rufa, Vescra = Vespa crabro, Dolmed = Dolichovespula media, Dolsax = D. saxonica, Dolnor = D. norwegica, Dolsyl = D. sylvestris, Dolpac = D. pacifica. Exx. = individuals and Spp. = species.

Sites	Vesvul	Dolmed	Vescra	Dolsax	Dolnor	Vesger	Vesruf	Dolsyl	Dolpac	Exx.	Spp.
Tvärminne 2019	0	1	0	1	0	0	0	0	0	2	2
Tvärminne 2020	0	0	0	1	0	0	1	0	0	2	2
Husö 2019	4	4	71	1	0	6	0	0	0	86	5
Husö 2020	7	1	65	2	0	5	2	0	0	82	6
Helsinki 2019	28	1	0	1	0	3	0	0	0	33	4
Seili 2019	1	3	0	0	0	0	1	0	0	5	3
Seili 2020	0	9	0	0	0	0	0	0	0	9	1
Lammi 2019	59	30	0	1	0	1	1	1	0	93	6
Lammi 2020	18	36	0	0	0	0	1	0	0	55	3
Lammi 2021	58	90	0	3	1	2	0	0	0	154	5
Lammi 2022	84	50	0	2	0	0	0	0	0	136	3
Etelä-Karjala 2019	14	7	0	13	0	0	1	0	0	35	4
Hyytiälä 2019	24	23	0	2	6	0	1	0	0	56	5
Hyytiälä 2020	7	13	0	0	3	0	2	0	0	25	4
Hyytiälä 2021	22	63	0	0	0	0	0	0	0	85	2
Hyytiälä 2022	7	66	0	1	0	0	1	0	0	75	4
Jyväskylä A 2019	223	16	0	5	1	4	0	1	0	250	6
Jyväskylä A 2020	188	37	0	6	3	0	2	1	0	237	6
Jyväskylä A 2021	229	129	0	11	4	2	1	1	0	377	7
Jyväskylä A 2022	154	210	0	0	0	0	0	0	0	364	2
Jyväskylä A 2023	162	150	0	4	0	6	0	0	0	322	4
Jyväskylä A 2024	67	25	0	0	2	3	0	0	0	97	4
Jyväskylä B 2019	196	16	0	6	7	0	0	1	0	226	5
Jyväskylä B 2020	61	6	0	1	1	1	0	1	0	71	6
Jyväskylä B 2021	247	103	0	11	0	3	1	1	0	366	6
Jyväskylä B 2022	43	75	0	4	0	1	0	0	0	123	4
Jyväskylä B 2023	114	45	0	4	0	4	0	0	0	167	4
Jyväskylä B 2024	115	16	0	7	0	1	1	0	0	140	5
Konnevesi 2019	39	4	0	10	0	0	2	0	0	55	4
Konnevesi 2020	6	0	0	0	0	0	0	0	0	6	1
Kuopio 2019	57	6	0	0	0	0	0	0	0	63	2
Kuopio 2020	131	1	0	2	0	0	0	0	0	134	3
Kuopio 2021	48	12	0	0	0	2	0	0	0	62	3
Kuhmo 2019	9	3	0	0	2	0	0	0	0	14	3
Oulanka 2019	2	2	0	0	0	0	0	0	0	4	2
Oulanka 2020	2	0	0	0	0	0	3	0	0	5	2
Rovaniemi 2019	21	0	0	2	3	0	2	0	1	29	5
Värriö 2020	8	0	0	0	0	0	0	0	0	8	1
Kilpisjärvi 2019	0	0	0	0	11	0	0	0	0	11	1
Kilpisjärvi 2020	1	0	0	0	16	0	1	0	0	18	3
Kevo 2019	1	0	0	0	0	0	0	0	0	1	1
Kevo 2020	3	0	0	0	8	0	5	0	0	16	3
Total	2460	1253	136	101	68	44	29	7	1	4099	9

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Appendix

Study sites and trapping 2019–2024. 'Jyväskylä A' refers to traps that operated continuously, 'Jyväskylä B' to traps that operated 12 days in July and 12 days in August.

	Trapping period	Traps	Cumulative trapping days
Tvärminne 2019	**1.7–2.9**	**3**	**192**
Tvärminne 2020	**6.7–14.9**	**3**	**213**
Husö 2019	**23.7–9.9**	**3**	**147**
Husö 2020	**6.7–14.9**	**3**	**213**
Helsinki 2019	**1.8–29.8**	**4**	**116**
Seili 2019	**1.7–26.8**	**3**	**171**
Seili 2020	**6.7–14.9**	**3**	**213**
Lammi 2019	**16.5–26.9**	**3**	**405**
Lammi 2020	**6.7–14.9**	**3**	**213**
Lammi 2021	**15.7–16.9**	**3**	**192**
Lammi 2022	**11.7–12.9**	**3**	**192**

Appendix cont.

	Trapping period	Traps	Cumulative trapping days
Etelä-Karjala 2019	15.7–2.9	8	400
Hyytiälä 2019	1.7–2.9	3	192
Hyytiälä 2020	6.7–14.9	3	213
Hyytiälä 2021	12.7–13.9	3	192
Hyytiälä 2022	11.7–12.9	3	192
Jyväskylä A 2019	13.5–30.9	6	846
Jyväskylä A 2020	11.5–4.10 (7.10)	6	891
Jyväskylä A 2021	13.5 (17.5)–30.9	6	815
Jyväskylä A 2022	11.7–2.10 (3.10)	6	507
Jyväskylä A 2023	12.7 (13.7)–31.8 (4.10)	6	405
Jyväskylä A 2024	12.7–27.9	6	462
Jyväskylä B 2019	15.–26.7 & 12.–23.8	22	517
Jyväskylä B 2020	13.–24.7 & 13.–24.8	22	473
Jyväskylä B 2021	12.–23.7 & 9.–20.8	22	528
Jyväskylä B 2022	11.–22.7 & 8.–19.8	22	484
Jyväskylä B 2023	13.–24.7 & 11.–22.8	22	506
Jyväskylä B 2024	12.–23.7 & 12.–23.8	22	528
Konnevesi 2019	13.5–16.9	3	381
Konnevesi 2020	13.7–14.9	3	192
Kuopio 2019	12.8–19.8	20	160
Kuopio 2020	9.8–16.8	20	160
Kuopio 2021	9.8–16.8	20	160
Kuhmo 2019	23.7–19.8	4	112
Oulanka 2019	20.5–16.9	3	360
Oulanka 2020	6.7–14.9	3	213
Rovaniemi 2019	29.7–12.8	7	105
Värriö 2020	6.7–14.9	3	213
Kilpisjärvi 2019	24.6–26.8	4	256
Kilpisjärvi 2020	6.7–14.9	3	213
Kevo 2019	20.5–16.9	3	360
Kevo 2020	6.7–14.9	3	213