

## 論文 (Original article)

# Species compositions of vespine wasps collected with bait traps in recreation forests in northern and central Japan (Insecta, Hymenoptera, Vespidae)

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### Abstract

In order to monitor social wasp abundance for sting risk assessment, vespine wasps were collected with bait (mixture of orange juice and liquor) traps during two flight seasons in two forest parks in Sapporo and another two in Ushiku, respectively located in northern and central Japan. We collected nine vespine species in Sapporo and six in Ushiku. Nearly all of these species were represented by overwintered females (potential queens), workers and males. In Sapporo, *Vespa simillima* and *Vespula shidai* dominated in the trapped wasps, while *Vespa mandarinia* and *Vespa analis* were most frequent in Ushiku. In Sapporo, the social parasite *Vespa dybowskii* accounted for 12% of the total catch. In Ushiku, there were two peaks per year in trap catch of most species, one composed of overwintered females and another of workers, while in Sapporo, overwintered females were collected much less frequently than in Ushiku. The seasonal change in the number of trapped workers of *V. analis* paralleled that of worker populations in colonies in both Sapporo and Ushiku. The discussion focuses on possible causes of differences in species and caste compositions of trapped wasps between the two regions and on the possibility of assessing sting risk with the bait traps.

**Key words :** social wasp, *Vespa*, *Vespula*, *Dolichovespula*, sting accidents, recreation forest, monitoring

### Introduction

Many people have increasingly visited suburban and exurban forest parks for recreation in Japan. For example, Ushiku Nature Sanctuary, which is situated in an exurban area in the Kanto region of central Japan, accommodated about 35,000 visitors in 2003 (2004 Annual Report of Ushiku Nature Sanctuary). Although there are no statistics of incidents, visitors to these recreation forests potentially run the risk of being stung by hornets (*Vespa* spp.) or yellow jackets (*Vespula* spp. and *Dolichovespula* spp.). This is because those areas abound in potential nest sites (shrubs, trees, subterranean hollows, etc.) and food (insects or spiders for protein, nectar or tree sap for carbohydrates) for the vespine wasps, and because most people visit them without taking precautions against stings. In order to prevent stinging incidents, we need to make a risk assessment of stings in the forest parks.

One of the possible causes of stinging incidents in forest parks is an inadvertent disturbance of vespine nests by people, because it is the most frequently reported cause of stings in residential areas (Matsuura & Yamane, 1990) and in national man-made forests (National Forest Safety Management Working Group, 1996). As wasps' reaction to disturbance varies during the season as well as among species (Matsuura, 1998), we need information on species

compositions and their seasonal changes for sting risk assessment in those areas. Although the number or density of nests in an area is the most reliable index of sting risk, it is difficult, if not impossible, to locate all nests in an expansive recreation forest.

As an estimate of wasp density, we monitored the number of wasps with bait traps in four forest parks in Sapporo and Ushiku, respectively located in northern and central Japan. The discussion focuses on geographical and seasonal differences in species or caste composition of trapped wasps and on assessment of sting risk based on the trap catch.

### Materials and Methods

**Study sites:** We monitored vespine wasps in two forest parks in each of two cities, Sapporo, northern Japan, and Ushiku, central Japan, in 2001 and 2002 (Table 1). Shiraikawa Citizen's Forest (SCF) and Nishioka Reservoir Park (NRP) in Sapporo are about 10 km away from the center of Sapporo, which has a population of about 1.9 million. Ushiku Nature Sanctuary (UNS) and Takasaki Nature Park (TNP) are situated about 4 km from the center of Ushiku with a population of about 80,000.

**Traps:** The traps we used were of the same type as that described by Makino et al. (1999). Bait was comprised

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Table 1. Forest parks where vespine wasps were monitored

Study site	Dominant tree species	% area forested (total area)
Shiraikawa Citizen's Forest (SCF; Sapporo) 42°58'N141°18'E, ca.160 m a.s.l.	<i>Quercus crispula</i> Blume; <i>Betula platyphylla</i> var. <i>japonica</i> (Miq.) Hara; <i>Acer mono</i> Maxim.	98% (133 ha)
Nishioka Reservoir Park (NRP; Sapporo) 42°59'N141°22'E, ca.140 m a.s.l.	<i>Quercus crispula</i> Blume; <i>Betula platyphylla</i> var. <i>japonica</i> (Miq.) Hara; <i>Acer mono</i> Maxim.	65% (38 ha)
Ushiku Nature Sanctuary (UNS; Ushiku) 35°57'N140°10'E, ca.15 m a.s.l.	<i>Quercus serrata</i> Thunb.; <i>Quercus acutissima</i> Carruthers; <i>Castanea crenata</i> Sieb. et Zucc.	80% (16 ha)
Takasaki Nature Park (TNP; Ushiku) 35°59'N140°07'E, ca.15 m a.s.l.	<i>Pinus densiflora</i> Sieb. et Zucc.; <i>Quercus serrata</i> Thunb.	70% (16 ha)

of 100 to 200 ml of clear liquor and an equal amount of orange juice, and beverage bottles of clear plastic (2000 ml in capacity) with a small square hole (3 × 3 cm) were used as bait containers. These bait traps emit an odor similar to that of fermented tree sap or fruits, which are attractive to vespines (Ono, 1997). The traps were strung from or tied to trees at 1.0 to 1.5 m above the ground. We installed 10 traps at each study site at intervals of 10 to 50 m mainly along walking trails in the parks. Installation was made on April 12 in Ushiku in 2001 and 2002, and on May 13, 2001 and May 2, 2002 in Sapporo. Trapped insects were collected every week as a rule, and bait was replenished every two weeks from April or May through October or November. We stopped the monitoring when no wasps were found in the traps on two consecutive visits.

**Nest collection:** In order to learn if seasonal changes in trap catch reflect those in worker populations in nests, we collected nests of *V. analis* Fabricius in Sapporo and Ushiku, and counted the number of contained workers. For the other species, the comparison was not possible, because only small numbers of nests were collected in either or both of the two localities. Nests were collected at night or

in the daytime. We can exactly determine the number of workers for nests collected at night, because no foragers went outside. When collecting nests in the daytime, we collected returning foragers for at least 30 minutes after the nest entrance was plugged with ether-soaked cotton to anesthetize the adults inside.

## Results

### Species composition of trapped vespines

We collected a total of 4,080 vespine wasps of nine species in the two parks in Sapporo, and 1,640 of six species in the two parks in Ushiku in the 2 years (Table 2). *Vespa analis*, *V. crabro* Linnaeus, *V. mandarinia* Smith, *V. simillima* Smith and *Vespula flaviceps* Smith were collected in both Sapporo and Ushiku, while *Vespa ducalis* Smith was collected only in Ushiku, and *Vespula shidai* Ishikawa, Sk. Yamane et Wagner, *Vespula rufa* (Linnaeus), and *Dolichovespula media* (Retzius) were collected only in Sapporo. In Ushiku, the six species were collected in both parks and in both years, while in Sapporo, *Vl. flaviceps* was collected only in 2002, and only a single *Vl. rufa* was trapped in SCF in 2002 (Table 2).

Table 2. The number of wasps collected with bait traps in forest parks in Sapporo (SCF and NRP) and Ushiku (UNS and TNP). The letters F, W, and M stand for overwintered females, workers and males, respectively

Site	Year	<i>V. analis</i>			<i>V. crabro</i>			<i>V. dybowskii</i>			<i>V. mandarinia</i>			<i>V. simillima</i>			<i>V. ducalis</i>			<i>D. media</i>			<i>Vl. shidai</i>			<i>Vl. flaviceps</i>			<i>Vl. rufa</i>			
		F	W	M	F	W	M	F	W	M	F	W	M	F	W	M	F	W	M	F	W	M	F	W	M	F	W	M				
SCF	2001	3	65	25	0	28	4	1	3	2	1	25	15	3	144	24	0	0	0	0	1	0	0	461	1	0	0	0	0	0	0	0
SCF	2002	19	89	40	2	166	47	2	35	7	3	68	15	3	137	37	0	0	0	0	1	0	0	310	1	0	4	0	0	1	0	
NRF	2001	0	137	15	0	58	1	0	66	7	0	33	15	2	438	20	0	0	0	0	3	0	0	338	0	0	0	0	0	0	0	0
NRF	2002	7	75	6	2	8	3	8	309	31	5	18	5	33	453	19	0	0	0	0	2	1	0	161	1	0	7	0	0	0	0	
UNS	2001	44	12	5	13	4	2	0	0	0	68	15	2	11	0	0	31	51	11	0	0	0	0	0	0	0	20	0	0	0	0	
UNS	2002	51	6	1	22	5	0	0	0	0	100	49	4	2	1	0	46	24	3	0	0	0	0	0	0	100	0	0	0	0	0	
TNP	2001	32	60	18	8	1	0	0	0	0	54	106	1	3	7	5	0	31	45	2	11	0	0	0	0	0	93	0	0	0	0	0
TNP	2002	66	15	5	3	8	3	0	0	0	91	102	9	3	3	0	37	23	8	0	0	0	0	0	0	87	0	0	0	0	0	

1) Including two probable new queens. 2) Including six probable new queens.

In Sapporo, the most frequently collected species in the 2 years was *V. simillima* (32.2%), followed by *Vl. shidai* (31.2), and *V. analis* (11.8) (Table 2). In Ushiku, *V. mandarinia* (29.8%) was the most dominant, followed by *V. analis* (23.7) and *V. ducalis* (20.9) (Table 2). The two parks in Ushiku significantly differed in species composition in 2001 ( $\chi^2$  test;  $p < 0.0001$ ) and 2002 ( $p = 0.0077$ ). In Sapporo, the difference in species composition between the two parks was highly significant ( $p < 0.0001$ ) in both years. The two parks in Sapporo and those in Ushiku significantly differed in species composition between the 2 years ( $p < 0.0001$  for SCF, NRP and UNS,  $p = 0.0275$  for TNP). For Sapporo, catches of the least frequent three species, i.e. *D. media*, *Vl. rufa* and *Vl. flaviceps*, were combined before the tests.

### Seasonal changes

Seasonal changes in the number of trapped wasps are shown in Figs. 1 and 2, where the catches in the two parks in Sapporo and those in Ushiku are combined biweekly for each year. The first individuals were trapped in mid to late May in Sapporo, and in mid to late April in Ushiku. These were all overwintered females.

In Sapporo, about 90% of the annual catch was obtained in and after August for all dominant species, resulting in an essentially single peak of catch in both years (Fig. 1). Among the species with annual catch of more than 50 wasps, *V. analis*, *V. crabro*, *V. dybowskii*, and *V. simillima* showed the peak in late August to early September, *V. mandarinia* in late September to early

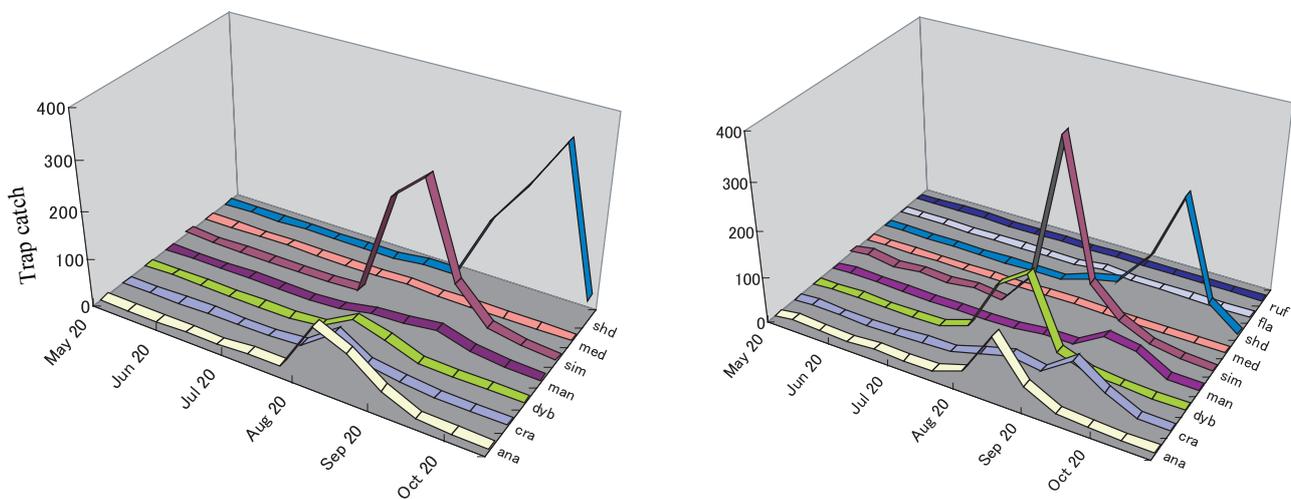


Fig. 1. Seasonal changes in the number of wasps collected with bait traps in two forest parks in Sapporo (Table 1) in 2001 (left) and 2002 (right). The first catch occurred in mid to late May in both years. ana: *V. analis*; cra: *V. crabro*; dyb: *V. dybowskii*; fla: *Vl. flaviceps*; man: *V. mandarinia*; med: *D. media*; ruf: *Vl. rufa*; shd: *Vl. shidai*; sim: *V. simillima*

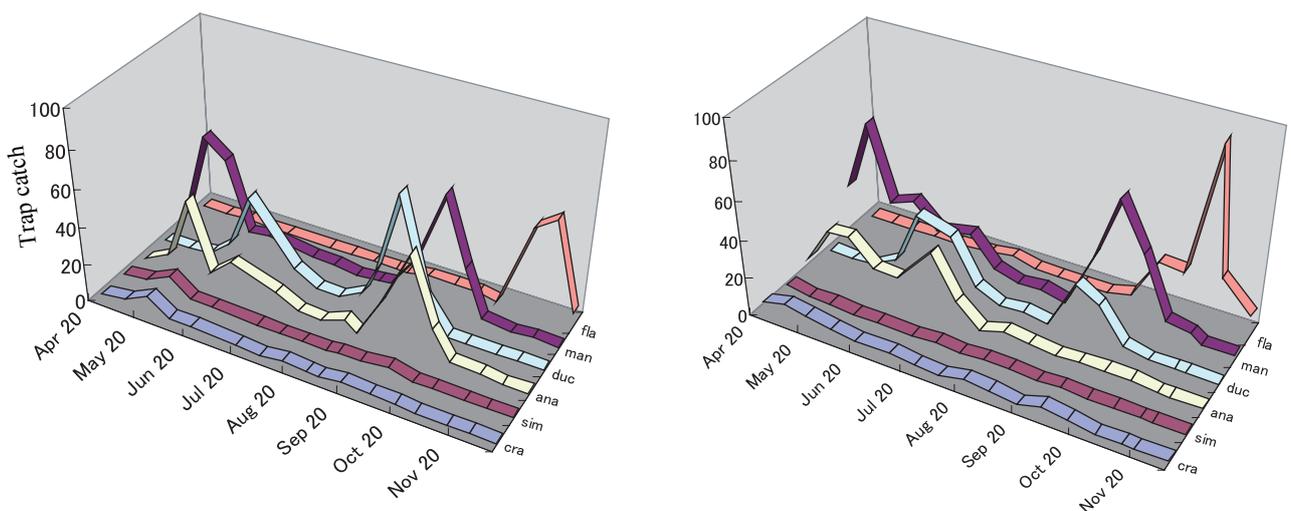


Fig. 2. Seasonal changes in the number of wasps collected with bait traps in two forest parks in Ushiku (Table 1) in 2001 (left) and 2002 (right). ana: *V. analis*; cra: *V. crabro*; duc: *V. ducalis*; fla: *Vl. flaviceps*; man: *V. mandarinia*; sim: *V. simillima*

October, and *Vl. shidai* in mid October. *Vl. shidai* was the last species to remain active in the flight season.

In Ushiku, on the other hand, most species showed two peaks (Fig. 2). The catch peaked in early May and in early October for *V. mandarinia*, and in late June and mid September for *V. ducalis*. *V. analis* also had one peak each in late May and in early October, though the second peak was not clear in 2002. In contrast to these bimodal distributions of annual catch, *Vl. flaviceps* showed a single peak in mid to late November, similar to *Vl. shidai* in Sapporo.

### Caste and sex of trapped wasps

The bait trap attracted overwintered females, workers and males of almost all species in Sapporo and Ushiku (Table 2). In most cases, the overwintered females were potential queens that had emerged and been fertilized in the previous year. In *V. analis*, however, overwintered females were often workers that had been parasitized by *Xenos moutoni* du Buysson (Strepsiptera, Stylopidae), as reported by Makino (2001) and Tatsuta & Makino (2003). In both Sapporo and Ushiku, wasps caught from April to July were mostly overwintered females, whereas those collected in and after August were workers and males. Because the catch before August was small in Sapporo as stated above (Fig. 1), much smaller numbers of overwintered females were collected in Sapporo than in Ushiku. In the two species of *Vespula*, almost no overwintered females or males were collected in Sapporo (*Vl. shidai*) and Ushiku (*Vl. flaviceps*); almost all individuals collected were workers (Table 1).

In annual social wasps, reproductives (males and new

queens) are generally produced late in the nesting season. Males were mainly collected from late August to September for all species in both Sapporo and Ushiku, though in much fewer numbers than workers (Table 2). New queens were rarely trapped: the only obvious new queens collected were six individuals of *V. ducalis* and two of *V. mandarinia* in TNP in Ushiku (Table 2).

### Worker populations in collected nests

Figure 3 shows the number of workers contained in the nests of *V. analis* collected in Sapporo and Ushiku. We add several data points of Sapporo based on Yamane & Makino (1977: Table 1) in order to augment data from nests that we collected. The number of workers peaked in mid to late September in Ushiku, and in late August to early September in Sapporo.

### Discussion

Our study showed that species compositions of vespines attracted to bait traps were different between Sapporo and Ushiku. This was partly due to different geographical distributions of the species. For example, *V. ducalis*, which was only collected in Ushiku, is not distributed in Hokkaido (Matsuura, 1995). Likewise, *D. media*, which is known to prefer cooler locations (Matsuura, 1995), was only collected in Sapporo and not in Ibaraki Prefecture (also see Hisamatsu, 2004).

The bait traps in Sapporo caught nine of the 14 vespine species recorded in Hokkaido (Matsuura, 1995), and those in Ushiku caught six of the nine species ever recorded in Ibaraki Prefecture (Hisamatsu, 2004). The vespine species that have been recorded in Hokkaido (Matsuura,

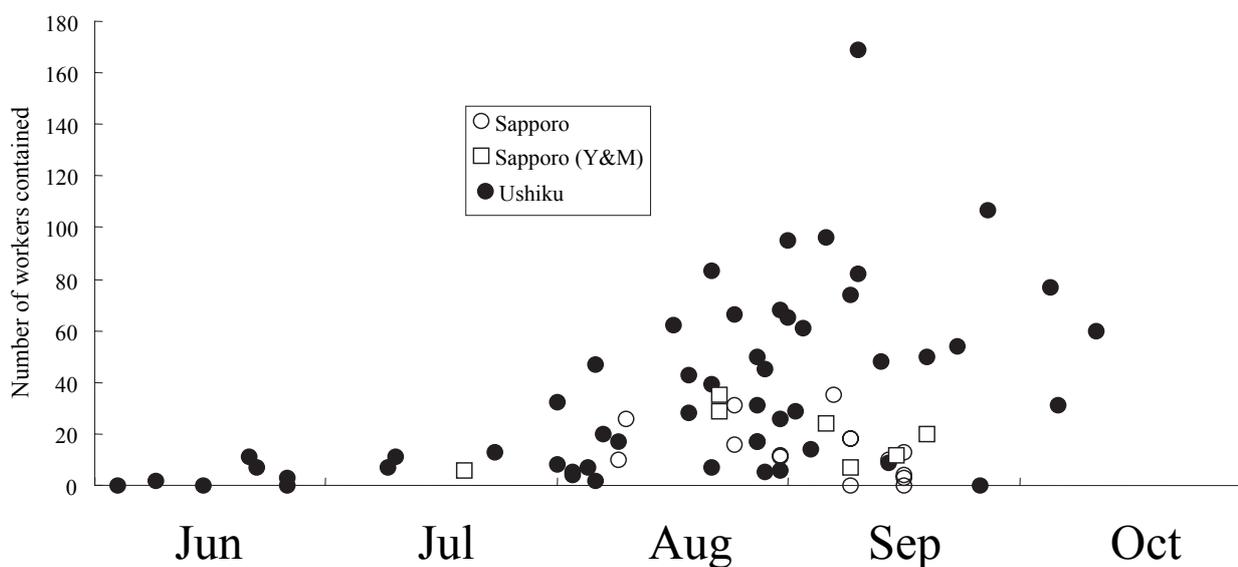


Fig. 3. The number of workers contained in nests of *V. analis* collected in Sapporo and Ushiku. Data points denoted as "Sapporo (Y&M)" are based on Yamane and Makino (1977)

1995) but were not collected with our traps in Sapporo are *Dolichovespula saxonica* (Fabricius), *D. pacifica* (Birula), *D. adulterina* (du Buysson), *Vespula vulgaris* (Linnaeus) and *Vespula austriaca* (Panzer); those that have been recorded in Ibarki Prefecture (Hisamatsu, 2004) but were not collected in Ushiku in this study are *V. dybowskii*, *Vl. rufa* and *Vl. shidai*. Except for *D. saxonica* in Sapporo (Makino, 1982), these species occur much less frequently than the collected species do in the study regions. For instance, based on a list of Hymenoptera of Ibaraki Prefecture (Hisamatsu, 2004), *V. dybowskii*, *Vl. rufa* and *Vl. shidai* have only one or a few collection records, presenting a sharp contrast with the other six species which have many records. The results of the bait trap thus seem to reflect the relative abundance of the vespine species in the two regions. Therefore, we suggest that the trap is a useful tool to monitor common vespine species.

The total catch at Sapporo was more than twice as much as at Ushiku. The species that contributed most to this difference was *V. simillima*, whose workers made up 32% of the total catch in Sapporo, but only 1% in Ushiku. Although *V. simillima* is one of the commonest vespine species in Japan (Matsuura & Yamane, 1990), its nest density may differ among regions. In Sapporo, nests of *V. simillima* made up the largest part (37%) of 2,150 vespine nests that were destroyed over a 5-year period at the request of citizens (Takahashi, 1994). The prevalence of *V. simillima* is also clear in Otaru, a neighboring city of Sapporo, as about 70% of the 490 nests destroyed over 4 years were of this species (Makino et al., 1981).

In Ushiku, we have no published statistics of vespine nests destroyed. Of the 111 nests collected by one of the authors (SM) for 7 years in and around Ushiku, however, *V. simillima* only accounted for 17%, while *V. analis* accounted for 74%. These facts suggest that the bait catches of *V. simillima* in Sapporo and Ushiku reflect different nest densities in the two cities.

A notable difference in seasonal change in trap catch between Sapporo and Ushiku is that there was only a single peak of catch in the former (Fig. 1), but there were two peaks in the latter (Fig. 2). In Sapporo, the 1st (and only) peak was mostly composed of workers, while the 1st and 2nd peaks in Ushiku were mostly composed of overwintered females and workers, respectively. This is because far fewer overwintered females were caught than workers in Sapporo as compared with Ushiku. For *V. analis*, for example, the proportion of overwintered queens to workers was only 0.08 in Sapporo, whereas it was 2.08 in Ushiku in the total catch of the 2 years. Similarly, for *V. mandarinia*, the proportion was 0.06 in Sapporo, but 1.15 in Ushiku.

Tsuchiya (2005), using the same type of bait trap as ours, also shows a single peak composed of workers in *V. crabro*, *V. simillima*, *Vl. shidai*, *V. rufa*, *D. media* in Kushiro, eastern Hokkaido, located at a similar latitude (43°05'N) to Sapporo. The reason why much fewer overwintered females were attracted to the trap in Sapporo than in Ushiku is unclear. Responses of overwintered females to odors of the bait may be different between northern and central Japan. Odors themselves may geographically differ because of the possibly different fungal florae that are involved in the fermentation of the bait.

In both Sapporo and Ushiku, almost no overwintered females of *Vl. shidai* or *Vl. flaviceps* were collected. Overwintered females, or potential queens, of the genus *Vespula* depend on tree sap as a carbohydrate source to a much smaller extent than those of *Vespa*: main energy sources of *Vespula* are flower nectar or honeydew of aphids (Matsuura & Yamane, 1990). In contrast, workers of *Vespula* have been observed to ingest tree sap, damaged fruits, and various sweet beverages (Matsuura & Yamane, 1990). These biological features seem responsible for the different catches between overwintered females and workers of *Vespula*.

An interesting finding in this study is the prevalence of *V. dybowskii* in Sapporo, particularly at NRP, where about 30% of the annual catch was comprised of *V. dybowskii* in 2002. This species, a social parasite of *V. simillima* or *V. crabro* (Matsuura, 1995), had long been quite rare in Hokkaido: a single adult specimen collected in the Jozankei district of Sapporo (Sakagami & Fukushima, 1957), was the only reliable record in Hokkaido before the early 1980's (Matsuura & Yamane, 1990). However, the number of collected specimens and nests has increased since the 1990's in Hokkaido, mainly in the western and central parts (Matsuura, 1995; Yamamoto & Sayama, 2003). Our result shows that *V. dybowskii* has become firmly established in Sapporo. It is simply unknown why the species with specialized biological characteristics of obligate social parasitism has spread so quickly in Hokkaido. Future studies, including those focused on its further expansion of distribution, would help us understand this interesting phenomenon. Because the bait trap effectively attracts *V. dybowskii*, as shown here, we can use it to monitor how the species is expanding its distribution in Hokkaido. It is interesting to note that Tsuchiya (2005) did not collect a single individual of *V. dybowskii* in Kushiro, eastern Hokkaido, with the same trap and bait as we used here.

We assume that the number of workers attracted to bait traps is proportional to the average worker population in

colonies that inhabit the monitored area. It is reasonable to assume that the number of foraging workers of a colony is proportional to the worker force. If this relationship is established, it will help us determine the season when we have to be prepared for stings. For *V. analis*, the peak of catch of workers occurred in early September in Sapporo, but in early October in Ushiku, at least in 2001. The number of workers in collected nests peaked in mid to late September in Ushiku, but in late August to early September in Sapporo (Fig. 1), roughly coinciding with the changes in trap catch. This shows that the monitoring of vespines with bait traps is a useful method to monitor both colony and flying worker activity.

The bait trap may be also useful to estimate abundance of nests in a particular area, because Archer (1980) reported in England that the annual catch of *Vespula vulgaris* workers with bait (diluted fruits jam) traps in an area well correlated with the number of nests found there. It would be interesting to relate trap catches of various vespine species with the number of nests destroyed by local authorities in Japan.

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# 北海道と関東のレクリエーション林においてベイトトラップで捕獲されたスズメバチ類の種構成

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## 要旨

刺傷事故の危険性評価のために、札幌市と牛久市それぞれ2カ所のレクリエーション林でベイトトラップ（オレンジジュースと焼酎の混合物）を用いて2年間にわたってスズメバチ類を捕獲したところ、札幌と牛久それぞれで9種と6種が得られた。ほとんどの種で越冬明けメス、ワーカーおよびオスが得られた。札幌ではキイロスズメバチとシダクロスズメバチが最も多く捕獲され、牛久ではオオスズメバチとコガタスズメバチが優占した。また札幌では社会寄生種であるチャイロスズメバチが全体の12%を占めた。牛久では多くの種で捕獲消長には年間2つのピークがあり、それぞれ越冬明けメスとワーカーに対応したが、札幌では越冬明けメスの捕獲数が非常に少なかったため、年間の捕獲ピークは1つだった。コガタスズメバチのワーカーの捕獲数の季節変化は、札幌、牛久とも、同じ地域で採集された巣内のワーカー数の変化と平行していた。本研究で捕獲されたスズメバチ類について、その種構成やカースト構成の地域間での違いを議論するとともに、刺傷事故のリスク評価をベイトトラップで行う可能性についても論じた。

キーワード：社会性カリバチ、スズメバチ属、クロスズメバチ属、ホオナガスズメバチ属、刺傷事故、レクリエーション林、モニタリング

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