

Original paper

Changes in bait-trapped numbers of hornet by species (Vespinae) from summer to autumn on Okayama University of Science campus

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Abstract: Vespinae, a subfamily of wasps or "hornets", was studied on the Okayama campus of Okayama University of Science. We investigated the hornet fauna and its change with the samples collected by bait traps from early August to early December 2019. The results showed that all the seven species (*Vespa analis*, *V. crabro*, *V. ducalis*, *V. dybowskii*, *V. mandarinia*, *V. simillima*, and *Vespula flaviceps*) recorded in southern Okayama Prefecture were collected in the study area, and that the period of activity of each species varied. *Vespa mandarinia* was the most dominant hornet species in the area. *Vespa simillima* remained active until the end of the study period in December.

I. Introduction

Japan has a rich hornet fauna as Terayama & Suda (2016) list 17 species in three genera (*Dolichovespula*, *Vespa*, and *Vespula*; Vespinae, Vespidae) in total, in their guide to the aculeate wasps in Japan, including the non-native *Vespa velutina*. In the country, 10-20 fatal cases due to wasp stings have been reported every year (http://www2u.biglobe.ne.jp/~vespa/vespa0562.htm; retrieved 7 September 2020). In addition, damage to apiaries, in particular due to mass-attack by *Vespa mandarinia*, has been problematical since the introduction of the domesticated European honeybee *Apis mellifera* (Matsuura 1969, 1984, 1988, Matsuura & Sakagami 1973, Matsuura & Yamane 1990), whereas the native Asian honeybee *A. cerana* shows behavioral adaptations (Ono et al. 1987, 1995). On the other hand, the hornets preside among the top predators in the food chain of insects in their habitats, and they play an indispensable role in the local ecosystem. In other words, short-sighted extermination of them will result in imbalance of the system. As their habitation is inevitable, we need to know them better for desirable coexistence with them.

Many hornet species are seen on the Okayama campus of Okayama University of Science in southwestern Honshu, Japan, and some students and staff, though only a few, are stung by hornets every year. Although it is desirable, therefore, to collect detailed information on them to reduce such accidents on the campus, no report on them is available so far. In this study, we investigated the seasonal changes in number of each hornet species using bait traps from the summer to autumn in 2019 on the campus.

II. Materials and Methods

In the bait trap used, an H-shaped cut of about 4 cm was placed in the center of the upper halves of the pair of parallel sides of a 2 liter plastic (polyethylene terephthalate) bottle for beverages, and the cuts on the sides were half folded insides to form anti-escape valves (Fig. 1). As social wasps have profound association with yeast (Stefanini et al. 2012), dry yeast was added to the attractant fluid to hasten fermentation compensating for the frequent trap changes. One teaspoonful of dry yeast was added to about 250 mL of a 5-fold dilution of the commercially available grape and fermented milk flavored sour-sweet beverage "Calpis Kyohô grape" (CALPIS Co. Ltd., Japan). "Calpis Kyohô grape" was chosen because grape juice, which easily gets fermented, is liked by hornets in nature. The commercial beverage was also suitable for constant reproducibility of the bait throughout the trapping period. A string was passed through a hole bored just below the cap for hanging the plastic bottle trap from a tree branch (Fig. 1). In case many hornets gathered, the string was replaced with a piece of wire to bear the weight.

The survey period was from August 9 to December 12 in 2019 at 10 points on the Okayama campus of Okayama University of Science (OUS; 34.7°E, 133.9°N) in southwestern Honshu, Japan. The trapping points were named after the block names on OUS campus (A1, A2, A3, B1,

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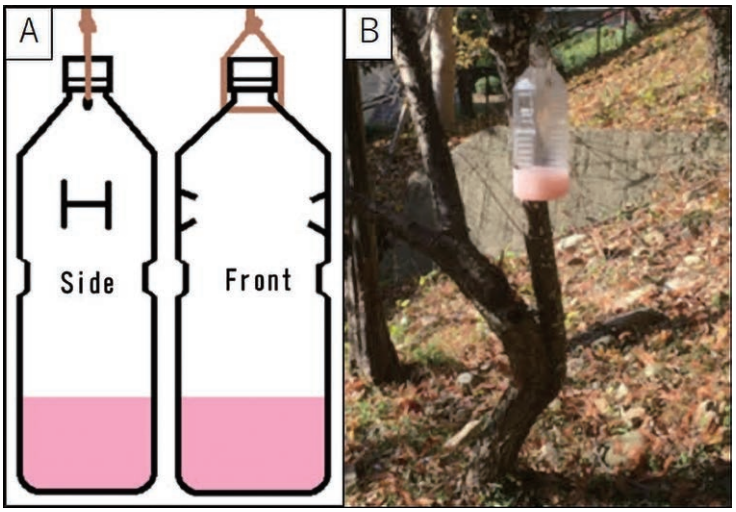

Fig. 1. Bait trap used in this study. A: design, B: setting example.

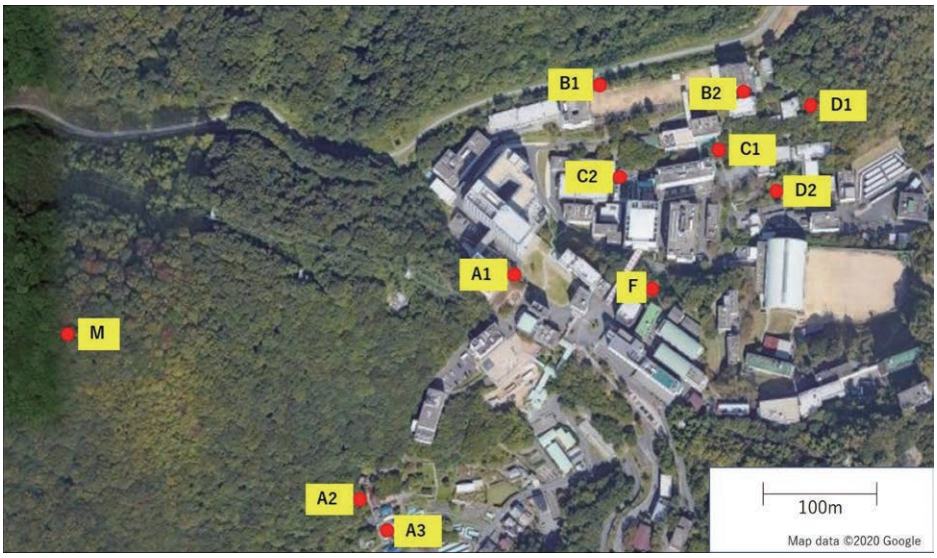

Fig. 2. Trap setting location map.

Fig. 3. Specimens of "hornets" trapped on OUS campus. Top from left: *Vespa analis* (♀), *V. crabro* (♀), *V. ducalis* (♀), *V. dybowskii* (♀). Bottom from left: *V. mandarinia* (♀), *V. mandarinia* (♂), *V. simillima* (♀), *Vespula flaviceps* (♀), *Vespula flaviceps* (♂) (stored in K. Suzuki's private collection).

Table 1. Weekly captured species and numbers (graphed in Fig. 4).

Species \ retrieval date	Aug. 16	24	Sep. 2	9	16	23	30	Oct. 7	14	21	28	Nov. 4	11	18	25	Dec. 5	12	Total
Vespa analis	6	1	15	6	20	7	13	14	12	8	8	2	0	0	1	0	0	113
Vespa crabro	5	4	33	48	57	74	30	4	7	4	0	0	0	0	0	0	0	266
Vespa ducalis	7	1	4	0	12	5	1	2	1	0	0	0	0	0	0	0	0	33
Vespa dybowskii	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Vespa mandarinia	29	5	44	61	71	179	87	65	75	79(♂1)	18(♂2)	8(♂2)	0	0	0	0	0	721(♂5)
Vespa simillima	2	2	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	8
Vespula flaviceps	0	0	3	0	1	0	1	0	3	1	2	0	0	1	1(♂1)	0	0	13(♂1)
Total	49	13	100	115	161	265	132	85	100	94	28	10	0	1	2	0	0	1155

B2, C1, C2, D1, D2, and F; Fig. 2). The lowest altitude among all the points is about 23 m a.s.l. and the radius of the smallest circle enclosing all the points (A1-F) was 250 m, covering an area about 20 ha. In addition, after August 26, an additional trap (M) was set near the triangulation point (about 160 m a.s.l.) of Mt. Daimi-sen near OUS campus (Fig. 2). The campus is surrounded by secondary forest vegetation of the deciduous oaks (*Quercus variabilis* and *Q. serrata*) and the evergreen oak (*Q. glauca*) on the slopes. The locations for setting traps were chosen to avoid human passage. The trapped hornets were retrieved, and traps were replaced once a week from August 9 to August 24; thereafter, twice a week on Mondays and Thursdays. The species, number and sex of the trapped hornets were recorded for each point. The species identification was made by visual observation with reference to literature (e.g. Terayama & Suda 2016). The collected hornets were dried to make specimens, one male and one female each per species when available. For sexing the specimens, antennae were checked. However, the trapped specimens were drowned in the attractant fluid, and distinction between worker and reproductive females was impracticable due to the swollen forms. Therefore, they were counted altogether as "females".

III. Results

Seven hornet species of two genera were shown to occur in this small area of OUS campus (Fig. 3). In total, 1155 hornets were collected (Table 1); 113 of *Vespa analis*, 266 of *V. crabro* (European hornet), 33 of *V. ducalis*, one of *V. dybowskii*, 721 (including five males) of *V. mandarinia* (Asian giant hornet), eight of *V. simillima* (Japanese yellow hornet), and 13 (including one male) of *Vespula flaviceps*. Provided the numbers of trapped males, as males tend to emerge earlier than reproductive females, which are much fewer than males, the number of trapped reproductive females, if any, would have been further fewer. The seasonal changes of the captures were lumped altogether in Figure 4 and Table 1. From August 9 to September 15, captures were recorded only at points A2, A3, B2, and D2, followed by B1 and D1, C1 and C2, and finally including points A1 and F (Fig. 4, graphed from Table 1 in numbers). The results obtained for Mt. Daimi-sen hilltop point M did not differ greatly.

Among the top four species for which more than 30 insects were trapped, *V. analis* and *V. ducalis* reached their maxima in traps on September 16 (hereinafter, the retrieval date given), whereas *V. crabro* and *V. mandarinia* reached their maxima on September 23. *Vespa ducalis*

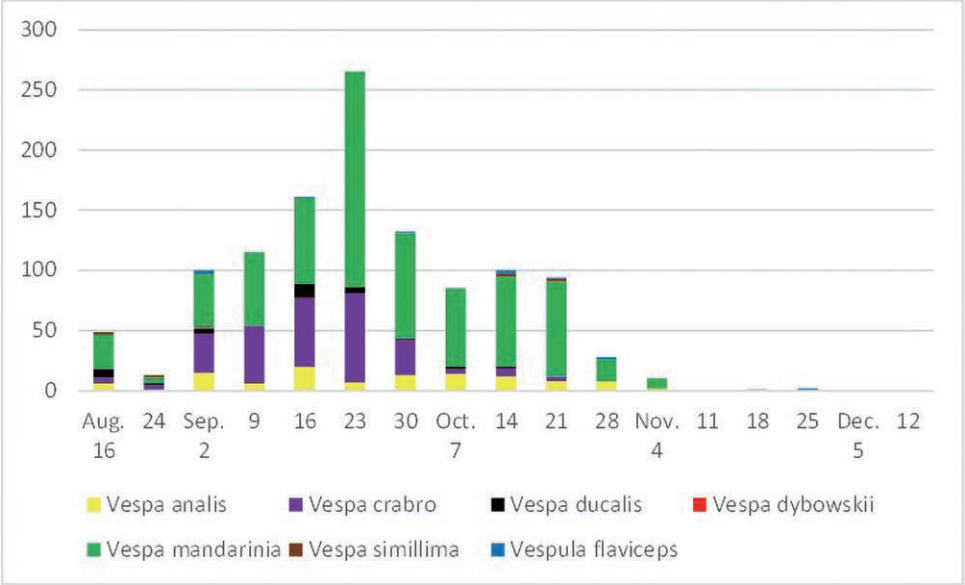

Fig. 4. Seasonal changes of the species and numbers of hornets trapped on OUS campus.

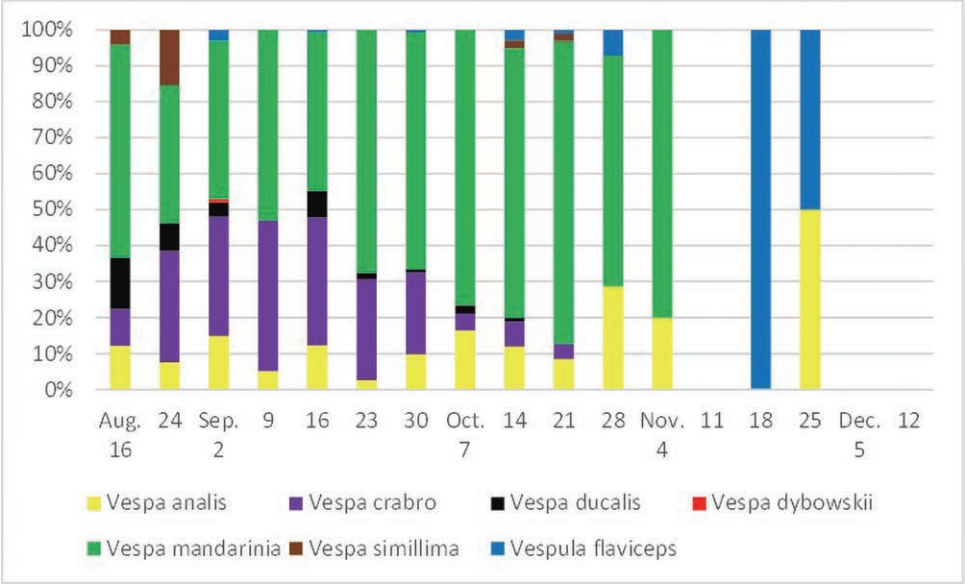

Fig. 5. Weekly trapped hornet species composition.

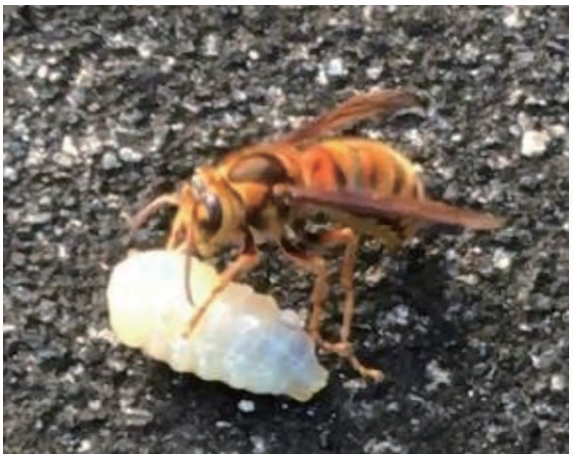

Fig. 6. A larva is abandoned by *Vespa simillima* late in the season. (December 5, 2019, photo by K. Suzuki).

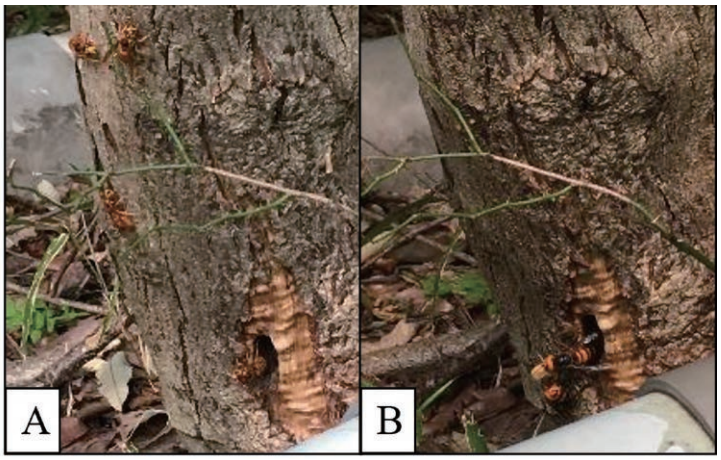

Fig. 7. A nest entrance of *Vespa simillima* made on the trunk of a dead tree (A) and raid by *Vespa mandarinia* (Giant Asian hornet) (B). (A: August 22, 2019, photo by K. Suzuki, B: August 26, photo by K. Suzuki).

was obtained last on October 14, *V. crabro* on October 21, *V. mandarinia* on November 4, and *V. analis* on November 25. Males were trapped for *V. mandarinia* (five specimens in total) from October 21 to November 4, and for *Vespula flaviceps* (one specimen only) on November 25, although no males were trapped for the other species. The species composition of the bait-trapped hornets changed greatly with the seasons (Fig. 5; Fig. 4 rearranged in proportions). On the other hand, the attractant fluid was exhausted (all sucked up) on the retrieval day in 19 traps from September 12 to October 7, and in such cases no insects were trapped despite the evidenced too many visitors.

For *V. dybowskii*, *V. simillima*, and *Vespula flaviceps*, the trapped numbers were too small to elucidate their summer-autumn seasonal changes. Of them, *V. simillima* was not trapped in number but was often seen in this study area. Nests of *V. simillima* were found on the rooftop of the OUS student clubhouse building near the trapping points (November 14, 2019) and near B2 (August 22, 2019). In the former, larvae were discarded out of the nest after December 5 (Fig. 6) and the last worker was recorded on December 24. The latter nest was raided and destroyed by *V. mandarinia* on August 26 (Fig. 7).

IV. Discussion

In this study area, differences by species in the maturation cycle of the nest seem to have existed, as trapped workers declined in number in the order of *Vespa ducalis*, *V. crabro*, *V. mandarinia*, and *V. analis*, and also as the species composition of those trapped greatly changed from summer to autumn (Figs. 4 & 5, Table 1). The order of decline coincided with that reported elsewhere (Matsuura 1984, Matsuura & Yamane 1990). In this study area, differences by species in the maturation cycle of the nest seem to have existed, as trapped workers declined in number in the order of *V. ducalis*, *V. crabro*, *V. mandarinia*, and *V. analis*, and also as the species composition of those trapped greatly changed from summer to autumn. The order of decline coincided with that reported elsewhere (Matsuura 1984, Matsuura & Yamane 1990).

The hornets trapped on OUS campus constitute all the species occurring in the southern part of Okayama Prefecture as recorded in the prefectural checklist of species of wildlife (Okayama Prefectural Wild Fauna and Flora Research Council 2020). In the checklist, *V. crabro*, *V. ducalis*, and *V. dybowskii* are relatively rare in the prefecture. The hornet fauna and ecosystem of the present study area are concluded to be particularly rich by the following three facts. (1) The top predator *V. mandarinia*, which also raids the other hornet species' nests for larvae, was the overwhelming majority of the trapped hornets, particularly in the latter half of the season. (2) *V. crabro* and *V. ducalis*, which prey on rather limited groups of insects (the former on cicadas, odonates, and orthopterans, whereas the latter on paper wasps; Matsuura 1984, Terayama & Suda 2016), were recorded. (3) The rare *V. dybowskii*, a social parasite on *V. crabro* and *V. simillima* (presumably present in much greater numbers), was recorded. Incidentally, the richness of the hymenopteran fauna in the area is also evidenced by the occurrence of a cleptoparasitic bee *Thyreus decorus* (Suzuki et al. 2019).

Vespa simillima continued to be present on the campus area until the end of the study period. Oyaizu & Kudô (2013) reported that the same type of bait attracted *V. dybowskii* and *V. simillima* very well in northern Honshu, Japan. In general, the dominance of *V. mandarinia* over *V. simillima* as well as the other hornets is evident (Matsuura 1969, 1984). On OUS campus, *V. simillima* was not trapped as expected from their abundance, likely due to the overwhelming number of the aggressive *V. mandarinia* in the latter half of the study period in the area. Once the bait traps were totally occupied by them, the other hornets hardly dared to near them. Besides, small patches of sugar sources on vitaceous flowers (e.g. *Cayratia japonica* and *Ampelopsis glandulosa* var. *heterophylla*) were available for *V. simillima* throughout the period.

Development of traps using baits usable as protein sources for larval growth remains a challenge in the future. If the seasonal changes in consumption of protein sources for larval growth are elucidated, differences in the nest maturation cycle of each species will be better understood. The number of insects varies greatly from year to year, and 2019 had a record warm winter as observed in the seasonal temperature data of Okayama City (https://www.data.jma.go.jp/obd/stats/etrn/view/10daily_s1.php?prec_no=66&block_no=47768&year=2019&month=&day=&view=a2; retrieved 18 March 2020). For enhancing the reliability of the conclusion reached in this study, similar studies are desired to be repeated in the area for several years.

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鈴木浩太・高崎浩幸：岡山理科大学構内におけるスズメバチ類のベイトトラップによる種別捕獲数の夏から秋の変化

要約

岡山理科大学岡山キャンパス構内におけるスズメバチ亜科について，2019年の８月上旬から12月上旬の期間にベイトトラップで採集したサンプルを元に，種相と夏から秋にかけての出現変化を調べた．その結果，岡山県南部から記録されている全７種（コガタスズメバチ，モンスズメバチ，ヒメスズメバチ，チャイロスズメバチ，オオスズメバチ，キイロスズメバチ，クロスズメバチ）が生息していること，種ごとに活動期間のずれがあることが分かった．オオスズメバチが最優位種であり，また12月上旬の最後まで活動していたのはキイロスズメバチであった．

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