
研究資料 (Research record)

Aculeate wasp assemblages in naturally regenerating broad-leaved forests and conifer plantations in temperate Japan (Insecta, Hymenoptera)

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Abstract

We collected aculeate wasps in ten naturally regenerating broad-leaved stands (1–178 years old) and eight *Cryptomeria japonica* conifer plantations (3–76 years old) using Malaise traps through the wasp flight season (April–November) in Ibaraki Prefecture, Japan. There were 167, 12, and 3605 species, families, and individuals collected, respectively, in the broad-leaved stands and 136, 11, and 2645 in the conifer plantation stands. The most speciose family was Crabronidae, followed by Pompilidae, while in terms of the number of individuals, Pompilidae dominated in every stand. Species richness and abundance were the highest in young stands, decreasing as the stands grew older. Although most collected wasp species preferred young stands, some species characteristically occurred in older stands.

Key words : hunting wasps, monitoring, Malaise trap, parasitoid, forest age, biodiversity, ecosystem services

1. Introduction

Aculeates make up a group of hymenopterous stinging insects; this group includes bees, ants, and stinging wasps. Most aculeate wasps hunt insects or spiders and store captured prey as food in their brood nests. However, some aculeate wasps are parasitoids or kleptoparasites rather than hunters (O'Neill 2001). Prey or host insects of aculeate wasps include Homoptera, Lepidoptera, and Diptera (Iwata 1976, Bohart and Menke 1976, O'Neill 2001), which contain several potential agricultural, forestry, or animal husbandry pests. Thus, these wasps possibly contribute to regulating ecosystem services. In contrast, spiders, which are generally recognized as natural enemies of various pests, are important prey for some hunting wasps. For these reasons, hunting wasps may influence ecosystem services in a positive (as natural enemies of pests) or adverse (as predators of beneficial spiders) ways.

Aculeate wasps are also diverse in terms of nesting substrates: some wasps nest in subterranean sites (fossorial nesters), while others favor aboveground sites, including wood burrows and herbaceous stem piths (tube nesters) (Iwata 1976, O'Neill 2001). Given these diversities in food and

nesting sites, we can naturally expect their assemblages to significantly change with forest conditions, even in a single geological region. To manage forests from an ecosystem service perspective, we need, at the very least, exhaustive lists of agents that potentially affect these services. However, limited information is available on aculeate wasp assemblages in various conditions or forest types (Shlyakhtenok and Agunovich 2001, Arnan et al. 2011, Wenninger et al. 2019).

In this study, we present a working list of aculeate wasps collected with Malaise traps in broad-leaved and conifer stands in a region situated in temperate Japan. The broad-leaved stands were naturally regenerated after clear-cutting, whereas the conifer stands were monoculture Japanese cedar (*Cryptomeria japonica*) plantations. Both stand types varied in age from very young to mature or old ages. Sampling was regularly performed in these stands through the wasp flight season. This extensive list will explain how aculeate wasp species richness and abundance vary with forest type and age, thus contributing as preliminary information on which forest ecosystem approach strategies should be implemented.

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2. Materials and methods

The wasp samplings were conducted in two areas, Ogawa (36°56'N, 140°35'E; 580–800 m a.s.l.) and Satomi (36°50'N, 140°34'E; 700–800 m a.s.l.), approximately 10 km apart from each other, in northern regions of Ibaraki Prefecture, Japan. We selected study plots in ten naturally regenerating broad-leaved stands (stand area varying from 2.5 to 32 ha) within an approximately 30 km² area in Ogawa and eight conifer (*C. japonica*) plantation plots (2.6–14.3 ha) within an approximately 10 km² area in Satomi. The ages of the broad-leaved stands ranged from 1 to 178 years (1, 4, 12, 24, 51, 54, 71, 128, 174, and 178) after clear-cutting and that of the conifer stands ranged from 3 to 76 years (3, 7, 9, 20, 29, 31, 75, and 76) after planting. The dominant large trees in the broad-leaved stands were *Quercus serrata*, *Q. mongolica*, and *Fagus crenata*, whereas planted *C. japonica* naturally dominated the conifer stands. The broad-leaved stands in Ogawa and the conifer stands in Satomi, respectively, correspond to plot codes O1–O178 and S3–S76 in Makino et al. (2007). The same codes are used in the present paper. For more details on the plots, see Makino et al. (2007) and Taki et al. (2013), who studied longhorn beetles and wild bees, respectively, in the same series of plots as above.

We collected aculeate wasps in 2002 and 2003 in the broad-leaved and conifer plantation plots, respectively. The wasps were collected with Townes-style Malaise traps (Golden Owl Publishers; 180 cm long, 120 cm wide, and 200 cm high) with a collection bottle containing 70% ethanol and propylene glycol as preservatives. We placed five traps, approximately 10 m apart from each other, on the ground inside each stand to avoid possible edge effects. The traps were visited every two weeks from late April to early November to cover the wasp flight season, and trapped insects were brought back to the laboratory of the Forestry and Forest Products Institute, Tsukuba, Japan, for identification. We used the collections of aculeate wasps from one of the five traps in each plot for subsequent analysis.

Because the relationships between plot age and species richness or abundance were nonlinear, they were approximated with logarithmic regression. Cluster analyses were separately performed for the broad-leaved plots and conifer plantation plots to examine similarities of wasp assemblages among them. We used the Bray-Curtiss index as the dissimilarity index and Ward's method for clustering. The number of clusters to divide was determined based on the Silhouette coefficient. The indicator values (IndVals) were then calculated to find wasp species that characterized the clusters. All calculations were made with R4.0.2 (R core Team, 2020) using the following libraries: "vegan" (Oksanen et al. 2018) to calculate dissimilarity indices, "cluster" (Maechler et al. 2018) for

clustering, and "labdsv" (Roberts 2016) to calculate IndVals.

The identification of collected wasps was mainly made by SM. The classificatory system of families and higher taxa follows Terayama and Suda (2016). All specimens are deposited into the collection of the Forestry and Forest Products Research Institute, Tsukuba, Japan.

3. Results and discussion

Table S1 presents the list of all collected aculeate wasps. A total of 3605 individuals of 167 species (12 families) were collected in the ten naturally regenerating broad-leaved plots and 2645 individuals of 136 species (11 families) in the eight conifer plantation plots (Appendix Table 1). All families of the broad-leaved plots were also collected in the conifer plots, except for Dryinidae, and 114 species were collected in both broad-leaved and conifer plots. The biweekly capture peaked in early to mid-August in both series of plots. The most speciose family was Crabronidae, accounting for 42% of the total number of species in the broad-leaved plots and 43% in the conifer plots. Second to Crabronidae was Pompilidae, which accounted for 23% and 28% in the broad-leaved and conifer plots, respectively. The other ten families, namely, Vespidae, Chrysididae, Bethyridae, Tiphiidae, Mutillidae, Scoliidae, Dryinidae (in broad-leaved plots only), Sphecidae, Myrmosidae, and Thynnidae, contributed to, at most, 10% to the total species richness in either series of plots. Females of some or all the collected species of Mutillidae, Myrmosidae, Chrysididae, and Dryinidae are apterous, whereas males are fully winged (Terayama and Suda 2016). For these species, the collected specimens were almost always males, which is expected as Malaise traps are principally designed to capture flying insects.

The proportion of individuals of the families was slightly different from the species richness results (Appendix Table 1). The most abundant family was Pompilidae, accounting for 61% of all collected individuals in the broad-leaved plots and 52% in the conifer plots, followed by Crabronidae, which accounted for 20% of collected insects in both stand types. The numerical dominance of Pompilidae in forests has also been reported through monitoring using trap nests (Makino and Okabe 2019). The abundance of other families, as in species richness, was much smaller compared to these two dominant families, although a single species of Myrmosidae, *Taimyrmosa nigrofasciata* (Yasumatsu), showed disproportionately large contributions to the total abundance in both plot series (8% in the broad-leaved and 12% in the conifer plots).

Species richness and abundance were greatest in the very young stands in both broad-leaved and conifer plots and declined as the stands became older (Fig. 1). They showed steep declines until broad-leaved plots became approximately

50 years old and until conifer plantation stands become 30 years old while remaining relatively stable thereafter in both. The changes in species richness and abundance with the stand age did not evenly occur among the families: Pompilidae and Crabronidae shrunk as the plots grew older but persisted through the oldest plots. However, most of the other families became extraordinarily rare or completely disappeared in older plots, particularly in the conifer plantation plots (Appendix Table 1).

The cluster analyses grouped the broad-leaved plots into two clusters, (O1, O4) and (O12, O24, O51, O54, O71, O128, O174, O178), and the conifer plots into three, (S3, S7, S9), (S20, S29, S31), and (S75, S76). Based on the ages of plots contained, the two clusters of the broad-leaved plots were referred to as young (Y) and old (O), which respectively had 41 and six species with statistically significant IndVals (Tables 1, 2). Likewise, the three clusters of conifer plots were young (Y), middle-aged (M), and old (O); the “young” and “middle-aged” clusters had 16 and five species with significant IndVals, respectively, while the “old” cluster had none.

Of all Japanese aculeate wasp species ever recorded (846 spp.), Crabronidae, and Pompilidae are the two most speciose families, accounting for 32% (274 spp.) and 16% (134 spp.), respectively (Terayama and Suda 2016). The dominance of these two families was also represented in our samples, but more markedly, as the two families together contributed 60–70% in both series of broad-leaved and conifer plots (Appendix Table 1). Additionally, in terms of abundance, the contribution of Pompilidae is remarkable in that more than half of the collected aculeate wasps belonged to that family. This suggests that these forests are diverse and abundant sources of spiders that the wasps hunt.

The generally declining trends of species richness and abundance of aculeate wasps are similar to those found in the results for bees collected in the same plots and with the same methods as this study (Taki et al., 2013). The open habitats in

young regenerating or plantation stands seem to provide many hunting wasps with suitable habitats and prey because those stands abound in diverse nest substrates. Wasps with high IndVals (Tables 1, 2) included some fossorial species of such genera as *Tiphia* (Tiphidae), *Cerceris*, *Oxybelus* (Crabronidae), or *Episyron* (Pompilidae) that nest in bare soil, or of *Dipogon* (Pompilidae) or *Psenulus* (Crabronidae) that use dead stems or pith of herbaceous plants as nesting sites. These young stands are also rich in forest floor vegetation (Tanaka et al., 2008), which seems to result in an increase in various groups of phytophagous insects (Inoue 2003, Maleque et al. 2010), as well as some spiders that feed on them, thus providing the wasps with diverse and abundant prey. Further, rich forest floor vegetation means suitable nectar resources, on which many aculeate wasp adults depend as energy sources (O'Neill 2001). Greater species richness and abundance in very young stands have also been reported in various insect groups examined in the same study plots (Makino et al. 2006, Taki 2013).

However, our resulting IndVals also show that, although much smaller in number, a part of aculeate wasps occurred more frequently in older (>10 years old) or middle-aged (20 to 31 years old) stands compared to younger ones in broad-leaved and conifer stands, respectively (Tables 1, 2). It is also notable that such a genus as *Dipogon* had a wide habitat range because it contained species with different preferences in terms of stand ages, as exemplified by *D. nipponicus* and *D. bifasciatus* that were mainly collected in younger stands, and *D. romankovae*, which was found in older stands.

Finally, the presence of aculeate wasps that characterize middle-aged to old stands in broad-leaved stands, but not in conifer stands, is an important finding from a forest management viewpoint since a mosaic-like landscape composed of various stand types or ages is preferable in terms of conservation of diversity and abundance of these wasps, at least part of which are excellent hunters of insect pests.

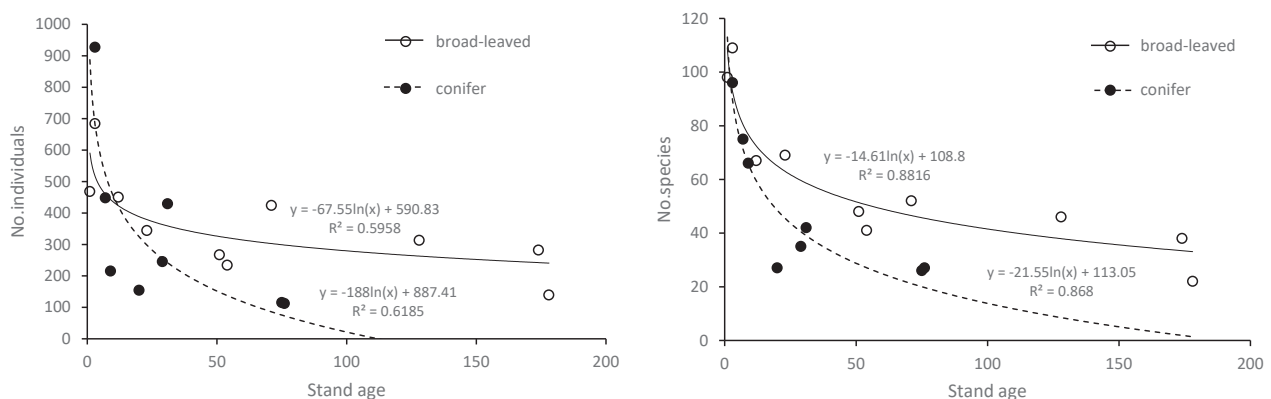


Fig. 1. Responses of the number of individuals (left) and species (right) of aculeate wasps to the stand age of naturally regenerating broad-leaved stands and conifer plantation stands.

Table 1. Aculeate wasps with significant index values (IndVals) characterizing the clusters of regenerating broad-leaved stands. For further information on the cluster components, see text.

Species	Family	Cluster	IndVal*	No. wasps in cluster:	
				Y	O
<i>Dipogon nipponicus</i> (Yasumatsu)	Pompilidae	Y	93.4	81	23
<i>Dipogon bifasciatus</i> (Geoffroy)	Pompilidae	Y	94.8	69	15
<i>Tiphia popilliavora</i> Rohwer	Tiphiidae	Y	99.6	71	1
<i>Cerceris nipponensis</i> Tsuneki	Crabronidae	Y	97.2	43	5
<i>Episyron arrogans</i> (Smith)	Pompilidae	Y	99.0	25	1
<i>Oxybelus strandi</i> Yasumatsu	Crabronidae	Y	100.0	25	0
<i>Psen dzimm</i> Tsuneki	Crabronidae	Y	99.0	24	1
<i>Psenulus laevigatus</i> (Schenck)	Crabronidae	Y	92.3	15	5
<i>Ectemnius iridifrons</i> (Pérez)	Crabronidae	Y	91.2	13	5
<i>Cerceris hortivaga</i> Kohl	Crabronidae	Y	100.0	17	0
<i>Crossocerus cetratus</i> (Shuckard)	Crabronidae	Y	96.6	14	2
<i>Dipogon sperconsus</i> Shimizu & Ishikawa	Pompilidae	Y	83.7	9	7
<i>Pseno exaratus</i> (Eversmann)	Crabronidae	Y	96.3	13	2
<i>Tiphia punctata</i> Smith	Tiphiidae	Y	100.0	14	0
<i>Hedychrum japonicum</i> Cameron	Chrysididae	Y	100.0	12	0
<i>Pemphredon lethifer</i> (Shuckard)	Crabronidae	Y	97.6	10	1
<i>Arachnospila</i> sp.	Pompilidae	Y	100.0	9	0
<i>Eumenes micado</i> Cameron	Vespidae	Y	100.0	9	0
<i>Scolia fascinata</i> Smith	Scoliidae	Y	100.0	9	0
<i>Methocha japonica</i> (Yasumatsu)	Thynnidae	Y	96.6	7	1
<i>Gorytes aino</i> Tsuneki	Crabronidae	Y	92.3	6	2
<i>Priocnemis ishikawai</i> Lelej	Pompilidae	Y	96.0	6	1
<i>Ammophila infesta</i> Smith	Sphecidae	Y	100.0	6	0
<i>Chrysis fasciata</i> Olivier	Chrysididae	Y	100.0	6	0
<i>Ectemnius continuus</i> (Fabricius)	Crabronidae	Y	100.0	6	0
<i>Pemphredon diervillae</i> Iwata	Crabronidae	Y	95.2	5	1
<i>Pseudomalus punctatus</i> (Uchida)	Chrysididae	Y	95.2	5	1
<i>Cerceris carinalis</i> Pérez	Crabronidae	Y	100.0	5	0
<i>Polistes snelleni</i> de Saussure	Vespidae	Y	100.0	5	0
<i>Tachytes latifrons</i> Tsuneki	Crabronidae	Y	100.0	5	0
<i>Discoelius zonalis</i> (Panzer)	Vespidae	Y	94.1	4	1
<i>Tiphia magnoliae</i> Tsuneki	Tiphiidae	Y	100.0	4	0
<i>Trypoxylon fronticorne</i> Gussakovskij	Crabronidae	Y	100.0	4	0
<i>Chrysis syrinx</i> Tsuneki	Chrysididae	Y	92.3	3	1
<i>Crossocerus nikkoensis</i> Tsuneki	Crabronidae	Y	100.0	3	0
<i>Hedychrum okai</i> Tsuneki	Chrysididae	Y	100.0	3	0
<i>Pemphredon krombeini</i> Tsuneki	Crabronidae	Y	100.0	3	0
<i>Priocnemis kunashirensis</i> Lelej	Pompilidae	Y	100.0	3	0
<i>Stenodynerus chinensis</i> (de Saussure)	Vespidae	Y	100.0	3	0
<i>Trypoxylon nipponicum</i> Tsuneki	Crabronidae	Y	100.0	3	0
<i>Ancistrocerus japonicus</i> (Schulthess)	Vespidae	Y	100.0	2	0
<i>Clistoderes futabae</i> (Ishikawa)	Pompilidae	O	91.2	7	289
<i>Poecilagenia maruyamai</i> (Ishikawa)	Pompilidae	O	93.2	4	219
<i>Ctenopriocnemis filicornis</i> Ishikawa	Pompilidae	O	86.5	5	128
<i>Priocnemis cyphonata</i> Pérez	Pompilidae	O	100.0	0	90
<i>Carinostigmus filippovi</i> (Gussakovskij)	Crabronidae	O	95.5	1	85
<i>Dipogon romankovae</i> Lelej	Pompilidae	O	100.0	0	22

*p<0.05 for all

Table 2. Aculeate wasps with significant index values (IndVals) characterizing the clusters of conifer plantation stands. For further information on the cluster components, see text.

Species	Family	Cluster	IndVal*	No. wasps in cluster:		
				Y	M	O
<i>Taimyrmosa nigrofasciata</i> (Yasumatsu)	Myrmosidae	Y	53.2	184	108	36
<i>Tiphia popilliavora</i> Rohwer	Tiphiidae	Y	100.0	184	0	3
<i>Eopompilus internalis</i> (Matsumura)	Pompilidae	Y	77.1	79	7	11
<i>Dipogon nipponicus</i> (Yasumatsu)	Pompilidae	Y	97.4	76	2	0
<i>Anoplius petiolaris</i> Gussakovskij	Pompilidae	Y	97.2	52	0	1
<i>Tiphia sternata</i> Parker	Tiphiidae	Y	100.0	45	0	0
<i>Episyron arrogans</i> (Smith)	Pompilidae	Y	100.0	37	0	0
<i>Priocnemis shidai</i> Ishikawa	Pompilidae	Y	100.0	25	0	0
<i>Caliadurgus ussuriensis</i> (Gussakovskij)	Pompilidae	Y	95.8	23	1	0
<i>Dipogon bifasciatus</i> (Geoffroy)	Pompilidae	Y	100.0	19	0	0
<i>Psenulus laevigatus</i> (Schenck)	Crabronidae	Y	100.0	12	0	0
<i>Anoplius samariensis</i> (Pallas)	Pompilidae	Y	100.0	10	0	0
<i>Bischoffitilla ardescens</i> (Smith)	Mutillidae	Y	100.0	10	0	0
<i>Stenodynerus chinensis</i> (de Saussure)	Vespidae	Y	100.0	6	0	0
<i>Arachnospila</i> sp.	Pompilidae	Y	100.0	3	0	0
<i>Trypoxylon imayoshii</i> Yasumatsu	Crabronidae	Y	100.0	3	0	0
<i>Priocnemis cyphonata</i> Pérez	Pompilidae	M	88.6	4	124	8
<i>Irenangelus nambui</i> Shimizu	Pompilidae	M	90.8	6	89	2
<i>Poecilagenia maruyamai</i> (Ishikawa)	Pompilidae	M	86.1	1	71	7
<i>Trypoxylon varipes</i> Pérez	Crabronidae	M	83.0	0	22	3
<i>Rhopalum venustum</i> Tsuneki	Crabronidae	M	73.5	2	18	3

*p<0.05 for all

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Supplementary data

Supplementary data can be found at

<https://www.ffpri.affrc.go.jp/pubs/bulletin/458/index.html>

Table S1. Numbers of aculeate wasps collected with Malaise traps at ten naturally regenerating stands (O1–O178) and eight conifer plantation stands (S3–S76) arranged by collection date. Trapped insects were collected every two weeks from April to November in 2002 (O1– O128) and 2003 (S3–S76).

Appendix Table 1. Numbers of species (A, C) and individuals (B, D) of aculeate wasps collected in ten naturally regenerating stand plots (O1–O178) and eight conifer plantation plots (S3–S76). Values in parentheses denote percentages to the total of each plot.

A	Number of species in naturally regenerating broad-leaved plots (% in parenthesis)										
	O1	O4	O12	O24	O51	O54	O71	O128	O174	O178	Pooled
Sphecidae	2(2.0)	1(0.9)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(1.2)
Crabronidae	39(39.8)	40(37.0)	28(41.8)	28(41.8)	19(39.6)	17(39.5)	27(54.0)	13(28.3)	14(36.8)	9(40.9)	70(41.9)
Mutillidae	1(1.0)	3(2.8)	1(1.5)	1(1.5)	1(2.1)	0(0.0)	0(0.0)	1(2.2)	1(2.6)	0(0.0)	3(1.8)
Myrmosidae	1(1.0)	1(0.9)	1(1.5)	1(1.5)	1(2.1)	1(2.3)	1(2.0)	1(2.2)	1(2.6)	1(4.6)	1(0.6)
Pompilidae	26(26.5)	29(26.9)	24(35.8)	29(43.3)	20(41.7)	19(44.2)	20(40.0)	23(50.0)	14(36.8)	10(45.5)	38(22.8)
Scoliidae	3(3.1)	3(2.8)	2(3.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	5(3.0)
Thynnidae	1(1.0)	1(0.9)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(2.2)	0(0.0)	0(0.0)	1(0.6)
Tiphiidae	5(5.1)	5(4.6)	2(3.0)	1(1.5)	1(2.1)	1(2.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	6(3.6)
Vespidae	11(11.2)	14(13.0)	5(7.5)	4(6.0)	4(8.3)	3(7.0)	1(2.0)	4(8.7)	4(10.5)	1(4.6)	17(10.2)
Bethylidae	1(1.0)	3(2.8)	1(1.5)	0(0.0)	1(2.1)	0(0.0)	1(2.0)	2(4.4)	4(10.5)	1(4.6)	9(5.4)
Chrysididae	7(7.1)	8(7.4)	3(4.5)	2(3.0)	1(2.1)	2(4.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	13(7.8)
Dryinidae	1(1.0)	0(0.0)	0(0.0)	1(1.5)	0(0.0)	0(0.0)	0(0.0)	1(2.2)	0(0.0)	0(0.0)	2(1.2)
Total	98(100)	108(100)	67(100)	67(100)	48(100)	43(100)	50(100)	46(100)	38(100)	22(100)	167(100)

B	Number of individuals in naturally regenerating broad-leaved plots (% in parenthesis)										
	O1	O4	O12	O24	O51	O54	O71	O128	O174	O178	Pooled
Sphecidae	4(0.9)	3(0.4)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	7(0.2)
Crabronidae	139(29.7)	174(25.4)	81(18.0)	78(22.7)	45(16.9)	35(15.0)	64(15.1)	26(8.3)	43(15.3)	23(16.6)	708(19.6)
Mutillidae	3(0.6)	14(2.1)	19(4.2)	15(4.4)	2(0.8)	0(0.0)	0(0.0)	1(0.3)	3(1.1)	0(0.0)	57(1.6)
Myrmosidae	31(6.6)	31(4.5)	50(11.1)	21(6.1)	10(3.8)	40(17.1)	33(7.8)	19(6.1)	37(13.1)	9(6.5)	281(7.8)
Pompilidae	230(49.2)	290(42.4)	272(60.4)	218(63.4)	189(70.8)	137(58.6)	323(76.2)	247(78.9)	186(66.0)	105(75.5)	2197(60.9)
Scoliidae	5(1.1)	10(1.5)	3(0.7)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	18(0.5)
Thynnidae	1(0.2)	6(0.9)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.3)	0(0.0)	0(0.0)	8(0.2)
Tiphiidae	14(3.0)	97(14.2)	7(1.6)	2(0.6)	1(0.4)	1(0.4)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	122(3.4)
Vespidae	22(4.7)	37(5.4)	11(2.4)	4(1.2)	18(6.7)	21(9.0)	1(0.2)	15(4.8)	9(3.2)	1(0.7)	139(3.9)
Bethylidae	1(0.2)	3(0.4)	1(0.2)	0(0.0)	1(0.4)	0(0.0)	1(0.2)	3(1.0)	4(1.4)	1(0.7)	15(0.4)
Chrysididae	18(3.9)	18(2.6)	6(1.3)	5(1.5)	1(0.4)	0(0.0)	2(0.5)	0(0.0)	0(0.0)	0(0.0)	50(1.4)
Dryinidae	0(0.0)	1(0.2)	0(0.0)	1(0.3)	0(0.0)	0(0.0)	0(0.0)	1(0.3)	0(0.0)	0(0.0)	3(0.1)
Total	468(100)	684(100)	450(100)	344(100)	267(100)	234(100)	424(100)	313(100)	282(100)	139(100)	3605(100)

C	Number of species in conifer plantation plots (% in parenthesis)								
	S3	S7	S9	S20	S29	S31	S75	S76	Pooled
Sphecidae	0(0.0)	1(1.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.7)
Crabronidae	36(37.5)	31(41.3)	26(40.0)	14(51.9)	14(40.0)	19(45.2)	11(42.3)	10(37.0)	59(43.4)
Mutillidae	3(3.1)	1(1.3)	1(1.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(2.2)
Myrmosidae	1(1.0)	1(1.3)	1(1.5)	1(3.7)	1(2.9)	1(2.4)	1(3.9)	1(3.7)	1(0.7)
Pompilidae	31(32.3)	26(34.7)	23(35.4)	11(40.7)	17(48.6)	19(45.2)	9(34.6)	15(55.6)	38(27.9)
Scoliidae	1(1.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.7)
Thynnidae	1(1.0)	1(1.3)	0(0.0)	0(0.0)	0(0.0)	1(2.4)	0(0.0)	0(0.0)	1(0.7)
Tiphiidae	3(3.1)	2(2.7)	2(3.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	3(2.2)
Vespidae	7(7.3)	8(10.7)	8(12.3)	0(0.0)	1(2.9)	0(0.0)	3(11.5)	0(0.0)	13(9.6)
Bethylidae	1(1.0)	0(0.0)	1(1.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(1.5)
Chrysididae	12(12.5)	4(5.3)	3(4.6)	1(3.7)	2(5.7)	2(4.8)	2(7.7)	1(3.7)	14(10.3)
Drylidae	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.7)
Total	96(100)	75(100)	65(100)	27(100)	35(100)	42(100)	26(100)	27(100)	136(100)

D	Number of individuals in conifer plantation plots (% in parenthesis)								
	S3	S7	S9	S20	S29	S31	S75	S76	Pooled
Sphecidae	0(0.0)	1(0.2)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.0)
Crabronidae	151(16.3)	136(30.4)	50(23.3)	27(17.5)	44(18.0)	78(18.2)	27(23.5)	22(19.6)	535(20.2)
Mutillidae	10(1.1)	1(0.2)	3(1.4)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	14(0.5)
Myrmosidae	84(9.1)	56(12.5)	44(20.5)	30(19.5)	31(12.7)	47(11.0)	20(17.4)	16(14.3)	328(12.4)
Pompilidae	400(43.2)	199(44.4)	89(41.4)	96(62.3)	167(68.2)	301(70.2)	58(50.4)	68(60.7)	1378(52.1)
Scolidae	2(0.2)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2(0.1)
Thynnidae	3(0.3)	6(1.3)	0(0.0)	0(0.0)	0(0.0)	1(0.2)	0(0.0)	0(0.0)	10(0.4)
Tiphiidae	217(23.4)	12(2.7)	5(2.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	234(8.9)
Vespidae	24(2.6)	19(4.2)	14(6.5)	0(0.0)	1(0.4)	0(0.0)	4(3.5)	0(0.0)	62(2.3)
Bethylidae	3(0.3)	0(0.0)	1(0.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	4(0.2)
Chrysididae	33(3.6)	18(4.0)	9(4.2)	1(0.7)	2(0.8)	2(0.5)	6(5.2)	6(5.4)	77(2.9)
Drylidae	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.7)
Total	927(100)	448(100)	215(100)	154(100)	245(100)	429(100)	115(100)	112(100)	2645(100)

温帯地域の天然広葉樹二次林とスギ人工林における有剣ハチ類群集

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要旨

茨城県北部の、林齢が異なる天然広葉樹二次林 10 か所（林齢 1~178 年）と、スギ人工林 8 か所（3~76 年）においてマレーズトラップを用いた有剣ハチ類の採集を 4~11 月に行った。広葉樹二次林系列では 1 年間で合計 12 科 167 種 3605 個体、スギ林系列では 11 科 136 種 2645 個体が得られた。種数が最も多かったのはギングチバチ科で、クモバチ科がそれに次いだが、個体数ではクモバチ科がどの林分でも最も多かった。有剣ハチ類全体の種数と個体数は、広葉樹二次林系列、スギ人工林系列ともに林齢 3~4 年の林分で最多で、いずれにおいても林齢とともに減少した。有剣ハチ類の多くは若齢林分を好んで出現したが、より林齢の高い林分に偏って出現する種も見られた。

キーワード：カリバチ、モニタリング、マレーズトラップ、捕食寄生者、林齢、生物多様性、生態系サービス

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