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Comparative Analysis on the Nest Structures of the Korean Yellowjacket, *Vespula koreensis* and the Yellow Hornet, *Vespa simillima simillima*

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Abstract

This study compared the nest structure of the Korean yellowjacket, *Vespula koreensis* and the yellow hornet, *Vespa simillima simillima*, both belonging to the subfamily Vespinae which contains the largest and best-known eusocial wasps. *Vespula* and *Vespa* are considered as same category in major design of nest architecture among eusocial wasps. Four nests of *V. koreensis* and three nests of *V. simillima simillima* were examined. The nest of *V. simillima simillima* was 3.26 times bigger than that of *V. koreensis,* and nest envelope of *V. simillima simillima* was 1.3 times thicker than that of *V. koreensis*. The comb of *V. koreensis* contained 2.4 times more cells than that of *V. simillima simillima*: on average 647 cells vs. 269 cells within a comb. On the whole, mean diameter of the cell was almost two times greater in *V. simillima simillima*: 4.7mm vs. 8.9mm. In *V. simillima simillima*, cell size was bigger in larger comb. More vigorous researches should be done on life history traits of *V. koreensis*, a Korean endemic species which is almost unknown, while social wasp population seems to be dramatically increasing in temperate regions.

Key words: Nest structure, Korean yellowjacket, *Vespula koreensis*, Yellow hornet, *Vespa simillima simillima*

INTRODUCTION

The architecture of nest made by animals is an important source of information about behavioral evolution. Unlike most behavior, construction leaves behind a physical trace that can be measured, stored and later reexamined (Wenzel, 1991). In social wasps, nest construction is probably the most complex task of the workers. From collecting materials to the structural architecture, simple things done by each individual with presumably limited intelligence gather and interact, and finally show great structural architectures (Jeanne, 1975).

The subfamily Vespinae contains the largest and best-known eusocial wasps, including true hornets (the genus *Vespa*), and the yellowjackets (*genera Dolichovespula* and *Vespula*). *Vespa* and *Vespula* are most often observed eusocial wasps in East Asia, with recently increasing population densities in residential sections on the outskirts of cities (Jeanne, 1975; Matsuura and Yamane, 1984; Choi and Moon, 2005; Choi *et al*., 2012). Out of 18 species of Vespinae found in South Korea, 10 species belong to the genus *Vespa*, 6 species to the genus *Vespula* and 2 species to the genus *Dolichovespula* (Choi *et al*., 2013). Using same nest materials and food source the genus *Vespula* and *Vespa* show a similar ecological niche and life history traits (Ross and Matthews, 1991).

The nest sites preferred by *Vespa* wasps are above the ground in the open or in an enclosed space, below the

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ground in a cavity, or some combination of these feature depending on the species (Matsuura and Yamane, 1984). *Vespa simillima* is the only *Vespa* species known that shows adaptability to a wide range of nest site in both and enclosed situations aboveground and underground (Matsuura, 1991). *Vespula* species, in contrast, mainly nest in cavities underground. Wenzel (1991) classified the *Vespula* and *Vespa* as same category in major design of nest architecture among eusocial wasps. The queens make an ordinary pedicellate first comb, but later worker-initiated combs may be built directly from the substrate without pedicels (Matsuura and Yamane, 1984; Jung and Burgett, 2009). Both of *Vespula* and *Vespa* construct their nests using wood pulp. Brood cells are constructed, arranged in a honeycombed pattern, and surrounded by a multi-layered envelope.

In this study I conducted comparative analysis on the nest structure of the yellow hornet, *Vespa simillima simillima* and the Korean yellowjacket, *Vespula koreensis*, a Korean native species. Volume of the nests, thickness of nest envelope, the number of cells within combs, cell diameter etc. were compared between species.

MATERIALS AND METHODS

Building behaviors of *Vespa simillima simillima* and *Vespula koreensis*

Queens of both species initially builds a series of cells. The cells are arranged in horizontal layers named combs, an egg is then laid in each cell. As the colonies grow new combs are added by the workers and the nest envelop is enlarged so that it covers the comb entirely. In *Vespula* species the bottom part of the nest is opened to serve as a nest entrance. But the envelope of *V. simillima simillima* completely covers the comb whether nesting occurs in an open or an enclosed situation (Matsuura, 1991). On the basis of this characteristic it seems probable that this species evolved from ancestors that nested exclusively in the open environment (Matsuura, 1991).

The pulp, nest material, is either collected from external sources of fibers or taken from the nest inner envelop, which must be continually removed in many places to accommodate comb expansion. Cells are built almost entirely from the recycled paper, while incoming pulp from the field is usually applied to the outer envelope (Duncan, 1939; Akre *et al*., 1976).

Nest collection and analysis

Nests of *V. simillima simillima* measured in this study were obtained under roofs of buildings during summer season. Nests of *V. koreensis* were carefully collected to dig up from underground as much as possible so as not to damage the envelope. Four nests of *V. koreensis* and three nests of *V. simillima simillima* were collected and studied. Measurements on the nest components were conducted under laboratory conditions.

Parameters on the structure and composition of the nests were determined as follows: After measuring a longer diameter and shorter diameter of the nest, volume of the nest was calculated by $4\pi((R+r)/2)^3/3$. 'R' is longer radius and 'r' is shorter radius. Number of combs was considered as the order of construction. Number of cells within each comb was counted. Diameter of the cell was considered as a longer diameter of cells. The measurements were carried out with a vernier caliper and ruler.

The relationship between the number of cells within comb and diameter of cells in the comb was estimated by regression analysis using SigmaPlot 12.3 (Systat, 2012).

RESULTS

Nests of the two species measured in this study were all right globular shape. *V. simillima simillima* had a nest 3.26 times larger than that of *V. koreensis*: 1782±6974 mm^3 on average in *V. koreensis* vs. 2156±7036 mm^3 in *V. simillima simillima*. Nest envelope of *V. simillima simillima* was 1.3 times thicker than that of *V. koreensis*: 27.1 ±2.8 mm in *V. simillima simillima* vs. 20.7±2.5 mm in *V. koreensis*.

Table 1 presents the nest volume, and the number and diameter of cells in each comb in *V. koreensis* and *V. simillima simillima*. The number of cells within comb varied strongly from the first comb to the last one. For both

Table 1. Comparison of the nest volume, and the number and diameter of cells in each comb between *Vespula koreensis* and *Vespa simillima simillima*

	Nest volume* (cm^3)	Number and diameter (mm; mean ± SD) of cells in each comb							
		Comb 1	Comb 2	Comb 3	Comb 4	Comb 5	Comb 6	Comb 7	Total number
Vespula koreensis									
1	2,266.4	420	551	281					1252
		4.73±0.24	4.84±0.18	4.87±0.30					
2	-	517	1130	1441	1279	994	100		5461
		3.74±0.24	3.88±0.20	4.02±0.24	4.02±0.20	4.11±0.16	3.94±0.32		
3	321.4	192	266	254	106				818
		4.15±0.24	4.75±0.30	4.68±0.29	4.70±0.25				
4	3,880.5	448	894	1333	1211	1555	1283	661	7385
		4.48±0.20	5.38±0.28	5.43±0.34	5.35±0.33	5.40±0.26	5.38±0.28	5.53±0.34	
Vespa simillima simillima									
1	6,791.8	296	269	220	129				914
		8.26±0.48	9.05±0.37	9.26±0.37	9.34±0.59				
2	14,130.0	345	548	615	602	526	217		2853
		8.45±0.46	9.35±0.65	9.55±0.39	9.98±0.41	9.88±0.32	9.93±0.59		
3	187.3	99	104						203
		7.87±0.36	8.25±0.34						

*: nest volume was calculated by $4\pi((R+r)/2)^3/3$. R: longer radius, r: shorter radius.

of the species the number of cells was constantly higher in second comb than in the first comb, and the last comb had less cells than previous combs except the first comb.

Nest of *V. koreensis* contained 2.4 times more cells than that of *V. simillima simillima*: on average 647 cells within a comb in the nest of *V. koreensis* vs. 269 cells within a comb of *V. simillima simillima* (Table 1). Mean of the cell diameter was constantly smaller in the first comb than that of the second comb in the two species. On the whole, mean diameter of the cell was almost two times greater in *V. simillima simillima*: 4.7mm in *V. koreensis* vs. 8.9mm in *V. simillima simillima* (Table 1; Fig. 1).

In *V. simillima simillima* the number of cells within comb showed a positive relationship with mean diameter of cells in the comb (Anova test for regression analysis, R^2 =0.5888, y=0.0022x+8.3710, $F_{1,10}$=5.3075, P=0.0440), while there was no relationship found in *V. koreensis* in this case (Fig. 2).

DISCUSSION

There is few quantitative data on life history traits of *V. koreensis* which is a Korean endemic species. This study provides limited information on the nest structure of *V. koreensis* comparing to *V. simillima simillima* which shows similar ecological niche and eusociality.

Within the genus *Vespula*, 2 species groups have been recognized: the *V. vulgaris* group, the members of which exist in large colonies, build large nests and whose workers scavenge for meat in addition to capturing live prey to feed their larvae; and the *V. rufa* group, the members of which exist in much smaller colonies, build small nests and whose workers are strictly predacious (MacDonald *et al*., 1976). Carpenter (1987) made the cladogram based on analysis of 39 characters (Matsuura and Yamane, 1984), and established *Vespula* species groups as *V. koreensis* and *V. vulgaris* groups are sister-taxa. The nest size of *V. koreensis* seems to be smaller than *V. vulgaris* which shows 3,000 up to 15,000 workers within a nest. The cell diameter of *V. koreensis* appeared also smaller than that of *V. vulgaris*: 4.7mm in this study vs. 6mm in *V. vulgaris* (Jung and Burgett, 2009).

Including true hornets (the genus *Vespa*), and the yellowjackets (genera *Dolichovespula* and *Vespula*), the

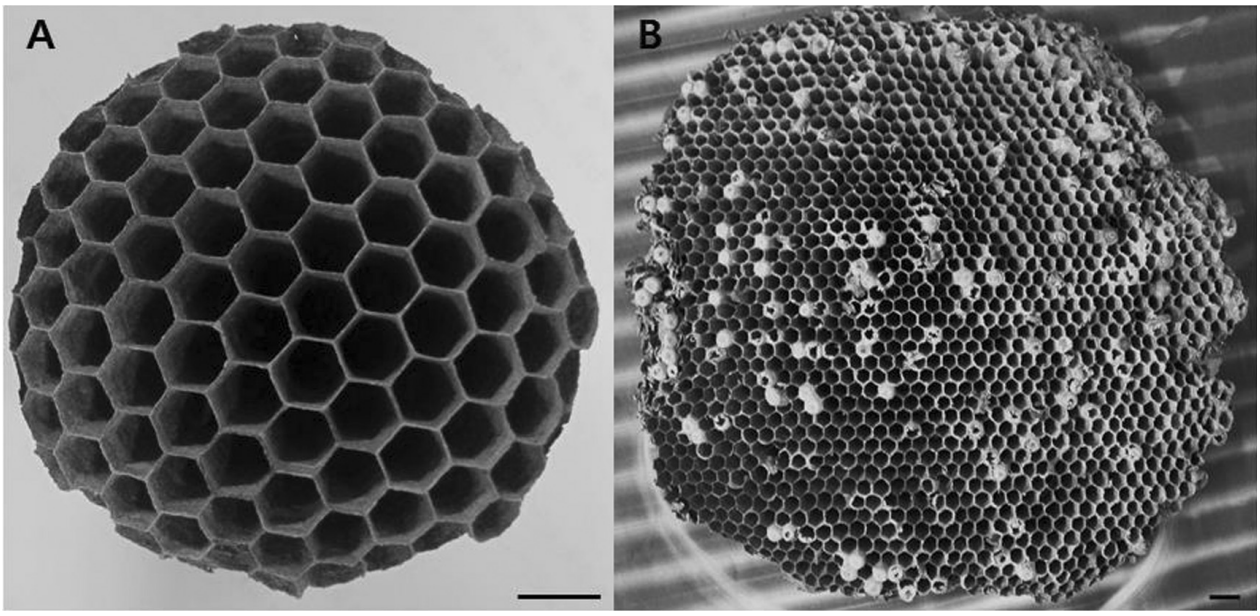

Fig. 1. Combs of *Vespa simillima simillima* (A) and *Vespula koreensis* (B). The figures shows an example of the second comb in the nest, and the black bar on each figure corresponds to 1cm of length.

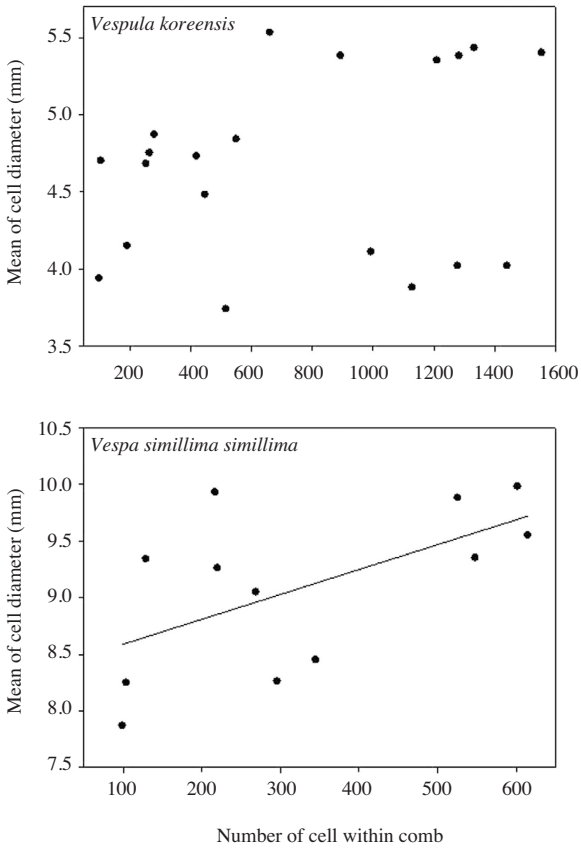

Fig. 2. Relationship between the number of cells within comb and mean diameter of cells in the comb of the nest in *Vespula koreensis* and *Vespa simillima simillima*.

subfamily Vespinae are the dominant social wasps in temperate areas and have profound effects on the ecology of vast regions (Jeanne, 1975; Akre, 1991; Dejean *et al*., 2011). These wasps have been introduced into many areas of the world where they do not naturally occur, and the population seems to be dramatically increasing in temperate regions (Choi and Moon, 2005; Masciocchi, 2010; Choi *et al*., 2012). It might need more robust studies on the Korea endemic species.

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