J. Entomol. Res. Soc., 15(3): 1-7, 2013 *ISSN:1302-0250*

Some Structural Features of Nest Materials of *Polistes nimpha* (Christ, 1791) in Several Ecological Conditions (Hymenoptera: Vespidae)

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ABSTRACT

The aim of this study is to determine the nest materials and some physical features and elemental composition of the nests of *Polistes nimpha* (Christ) collected in different ecological conditions. The nests were collected in Aksaray, Adana, Konya, Niğde, Malatya, Uşak provinces of Turkey. The nest surface was observed, the thickness of plant fibers was measured and an Energy Dispersive X-Ray Analysis was carried out by Scanning Electron Microscope. The percentage of the nest materials and the water absorption capacity were calculated.

The results indicate that the nest architectures of the samples and the nest surface are similar. The colors of the nests are beige and grey along dark grey lines. There are differences in respect to the fiber thickness, the elemental composition and their amount, the percentage of fiber and saliva, and the water absorbency. Amounts of plant materials and oral secretions, the nitrogen concentrations in the nest walls, the nest wall's absorption capacity of *P. nimpha* were calculated between 37-61% and 39-63%, 25.82% and 30.22%, 217% and 764%, respectively. These differences may be related to choosing of fiber, the environment of the colonies and the production of paper.

Key words: Hymenoptera, *Polistes nimpha,* ecology, nest material.

INTRODUCTION

The architecture of nests made by animals provides information about behavioral evolution. The diversity and some structural features of social wasps nest serve as useful taxonomic characters. Taxonomy of social wasps relies on architecture as much as on morphology (Wenzel, 1991). The nests of *Polistes* are arboreal, sometimes in cavities, and consists of a single resinous pedicel and a comb not covered by envelope. Carton supple of long fiver, usually glossy only near pedicel but sometimes extensively over comb back. Comb planar or recurved, rarely as a long string of cells (Wenzel, 1998). Usually the nests are made of chewed plant fibers from weathered wood and other sources (Jeanne, 1975). The species of Polistinae use paper pulps that are obtained from a mixture of oral secretions and plant fibers, to construct their nests (Evans and West Eberhard, 1970). They build up their nest in nature by using various organic and inorganic materials (Spradbery, 1973; Edwards, 1980). The choosing of nest site and plant fibers and the duration of chewing of nest materials by wasp affect physical features of the nest paper (Cole *et al.*, 2001). The oral secretion

is used to physically maintain their nest from rain and weathering (Kudô *et al.*, 2001). The processing of pulp affects the sticking ability of the fibers, the absorbency of nest paper and its durability (Biermann, 1993).

The physical properties, water absorbency, toughness and protein concentration of nest paper were studied in *Dolichovespula sylvestris, Dolichovespula norwegica, Vespula vulgaris, Polistes fuscatus* and *Polistes dominulus* (Cole *et al.*, 2001; Curtis *et al.*, 2005). The chemical composition of oral secretion and the amino acid composition of protein were examined in *Polistes annularis* (Espelie and Himmelbach, 1990), *Polistes metricus* (Singer *et al.*, 1992), *Polistes riparius* (Kudô *et al.*, 2000), *Polistes chinensis* (Kudô *et al*., 1998; Kudô, 2000) and *Polybia paulista* (Kudô *et al*., 2001). Some structural features of the nest paper of *Vespa orientalis* and *Vespa crabro* were determined in Turkey (Bagrıaçık, 2011).

Nine species of Polistinae are known in Turkey (Yildirim and Kojima, 1999); however, the kind of nest material has not been studied in detail. Turkey has variable geographical and ecological factors play role on nesting behaviour of *Polistes*. In this study, the nest materials of *Polistes nimpha* (Christ) collected from various districts of Turkey were studied to identify whether there were differences in the nest material choosing and the features of the nest material in different ecological conditions. The aim of this study is the determination of similarity and diversity of their nests in terms of physical and chemical features. The kind of nest materials, their chemical components and some, physical properties were determined and compared.

MATERIALS AND METHODS

Nest collection and material examined

Nests materials were collected from the provinces of Adana (1), Aksaray (2), Konya (3), Malatya (4), Niğde (5), Uşak (6) in August 2009. Aksaray, Konya, Niğde, Uşak and Malatya are located in inner part of Anatolia. In these provinces, winters are cold and snowy, while summers are usually hot and dry and, steppe vegetation prevails. Uşak is close to Aegean Sea. Malatya is isolated from Central Anatolia by Anatolian Diagonal. Adana is located in the southern part of Turkey with Mediterranean climate and vegetation (Atalay, 1994).

The larvaes, pupas and eggs were removed from the nest. The nests were stored in the Laboratory of Entomology at Department of Biology, Niğde University, Turkey. Nest localities are shown as numbers in text.

Observation of surface and analysis

Small fragments of nests' outer wall were cut from the combs and observed with Scanning Electron Microscope (LEO 440). Thickness of plant fibers were measured (n=10 for each nest) and elemental composition analysis (EDX analysis) was made at SEM. The measurements were given as mean ± standard error.

Percentage of plant material and oral secretion

The dried nests' fragments were weighed. Fragment of wall was immersed in 0.5N KOH solutions and kept at 70°C for 4-5 hours. After oral secretion has melted and fibers unbound, fibrous components were filtrated and separated from secretion. The fibrous material was washed with water and dried in an electric oven. It was weighed with filter paper. Then percentage proportion of plant material and oral secretion were estimated as in the following formula: Fiber (Cellulose) (%) = (k_1/ k_2) x 100, (where k_1= dried weight of sample before process, k_2 = dried weight of sample after process) (Yamane *et al.*, 1999).

Absorbency

Small fragments were weighed (n=10 for each nest). Each fragment was reweighed after all were sunk in water for 30 sec. (Curtis *et al*., 2005). The absorption capacity was estimated in percentage by the following formula: Absorption capacity (%) = [(m_2-m_1)/ m_1] x 100, (m_1= dried weight of sample before process, m_2 = dried weight of sample after 30 sec).

RESULTS

The nest colors of the samples were beige and grey along dark grey linings. The fundamental structures of the nests' surfaces at SEM were similar. The fibers bound together with the oral secretion. The fibers were fine and long. The oral secretions were seen as a thin membrane at SEM micrographs. Some inorganic particles were seen at SEM micrographs (Fig. 1). Fiber thicknesses, percentages amounts of the fiber and saliva, absorption capacity of the nest of *P. nimpha* are given on Table 1. Nest sizes were measured as 7.9x8.1cm (1), 3.8x5cm (2), 5.6x7.2cm (3), 8.5x9.6cm (4), 4.8x6.4cm (5), 5.4x4.3cm (6).

The elemental composition of the nest wall was analyzed with EDX analysis. Nitrogen used for the production of the oral secretion by wasp was an important component of the nest. Oxygen, carbon and nitrogen were major elements of the nests' fragments of each nest. Silisium, calcium, aluminum, potassium, iron were found in the fragment of the nest walls. The concentrations of elements and EDX spectra are shown in Table 2 and Fig. 2.

Table 1. The measurements of *P. nimpha*'s nests (locality numbers 1-6).

Locality no	Percentage amount of fiber and saliva (%)		Thickness of fiber (µm)	Absorption capacity (%)
	fiber	saliva		
1	41	59	11.21±2.11	740±23.44
2	49	51	10.77±2.76	764±29.08
3	61	39	9.78±2.72	408±23.22
4	37	63	9.91±1.15	217±8.23
5	42	58	9.05±1.58	634±10.11
6	53	47	8.09±1.65	673±8.95

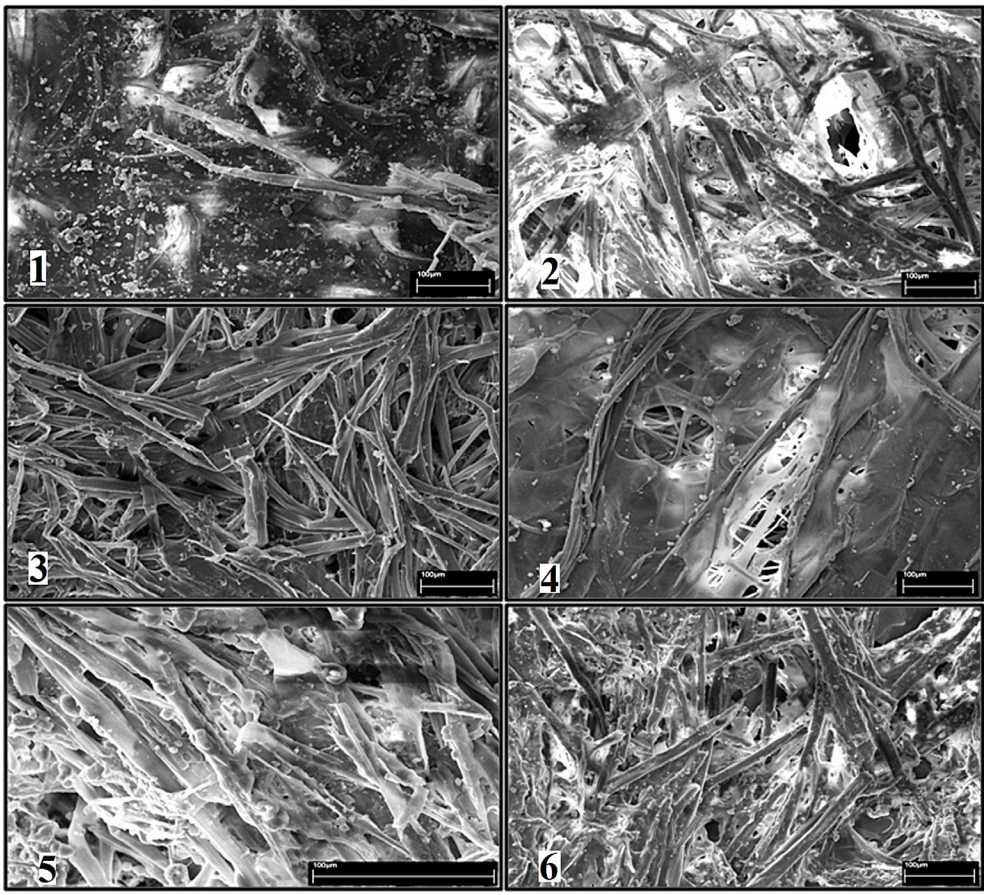

Fig. 1 (1-6). Surfaces of the nest's walls of *Polistes nimpha* in SEM (each scale show 100µm, locality numbers 1-6).

Table 2. Elements and their concentrations in a fragment according to EDX analysis (locality numbers 1-6).

Element	Concentration (%)					
	1	2	3	4	5	6
C	31.70	32.11	34.27	34.60	31.73	33.97
N	**27.60**	**26.95**	**27.52**	**30.22**	**25.82**	**28.39**
O	34.23	38.66	33.84	31.68	36.98	34.45
Al	0.72	0.13	0.45	0.29	0.60	0.43
Si	2.20	0.64	1.80	0.98	2.53	1.14
K	0.85	0.29	0.41	0.47	0.60	0.34
Ca	1.62	0.52	0.97	1.06	0.96	0.63
Fe	1.07	0.72	0.73	0.71	0.80	0.64

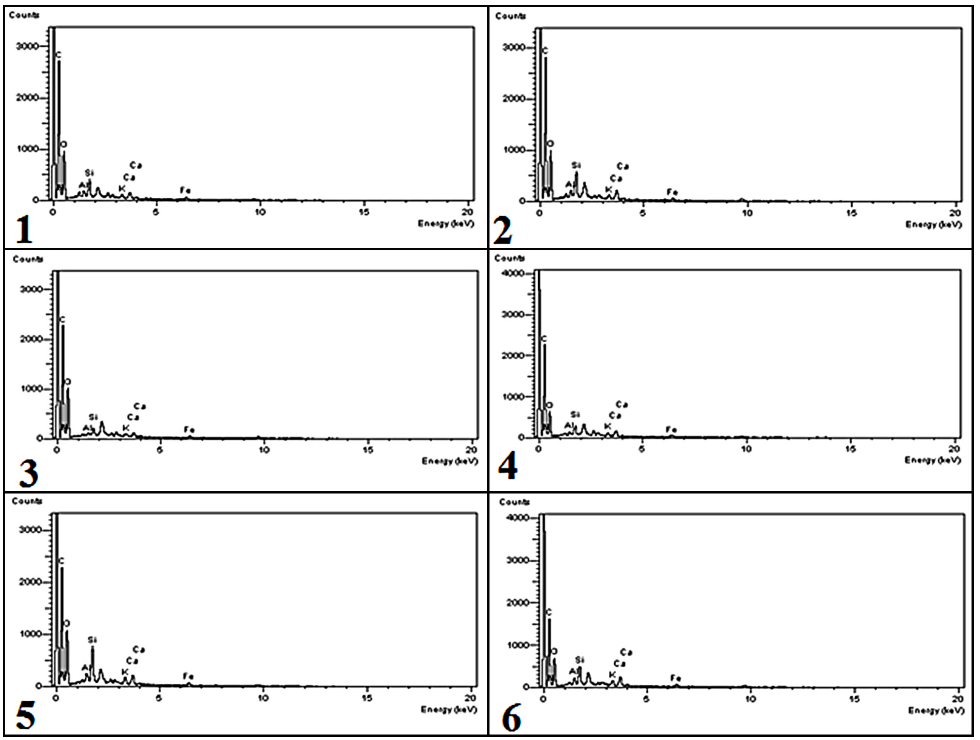

Fig. 2. (1-6) EDX spectra of elements embedded in the wall of the comb: Polistes nimpha (locality numbers 1-6).

DISCUSSION AND CONCLUSIONS

The nests' architectures of *P. nimpha* collected from different area of Turkey are similar to the previous findings (Jeanne, 1975; Evans and West Eberhard, 1970; Wenzel, 1998). The *Polistes* colonies in Turkey are univoltin. Their colonies are small with less than 100 workers per colony usually. The nest size variations are observed depending on nest site. Nest size of Malatya sample is larger than other samples.

Species of *Polybia* utilize a great variety of nest materials (Wenzel, 1991). *Polybia paulista* uses minute vegetable chips, plant hairs and a small amount of mud or inorganic materials (Kudô *et al.*, 2001), while the species of *Polistes* prefer long vegetative fibers and plant hairs as nest material (Wenzel,1998). The nest materials of *Polistes chinensis* (Kudô *et al.*, 1998) and *Polistes riparius* (Yamane *et al*., 1999) are long woody fibers and inorganic particles, as also seen in this work (see Fig 1).

Nitrogen content is an index to indicate the amount of oral secretion. According to Kudô *et al.* (2000), oral secretion also protects the nest from rainfalls. The nitrogen content in *Polistes* nest varies considerably (Espelie and Himmelbach, 1990; Singer *et al*., 1992). *Polybia paulista* uses a small amount of oral secretion and nitrogen contents

was very low (1.59-2.14%) (Kudô *et al*., 2001). The nitrogen concentration of *Polistes fuscatus* (McGovern *et al*., 1988), *Polistes annularis* (Espelie and Himmelbach, 1990) and *Polistes metricus* (Singer *et al*., 1992) were found 6.6%, 2.8% and 1.4-8.0%, respectively. The nitrogen concentrations in the nest walls of *Polistes nimpha* were found to be between 25.82% and 30.22%. The nitrogen contents of *P. nimpha*'s nests are variable. The oral secretion on the surface of *P. nimpha*'s nest from Malatya is the richest among all samples. The nitrogen contents of *P. nimpha* are higher than previously mentioned studies. So, *P. nimpha* use more oral secretion for nest building than other species.

Amount of plant materials and oral secretion of *Polistes riparius* nests were calculated 43-48% and 52-57%, respectively. Amount of plant materials and oral secretion of *Polistes chinensis* were calculated 35-40% and 60-65%, respectively (Yamane *et al*., 1999). Amounts of plant materials and oral secretions of *P. nimpha* were calculated 37-61% and 39-63%, respectively. Amount of plant materials of *P. nimpha'*s nest in Malatya is lower and oral secretion higher than other samples. So plant diversity of Malatya differs from that of other provinces and plant source of *P. nimpha* in Malatya is different than other samples.

The amount of protein used for nest construction may depend on environmental conditions. The amount of oral secretion added to nest paper is positively correlated with exposure to rainfall (Kudô *et al*., 1998; Kudô, 2000). The protein concentration and absorbency of *Polistes fuscatus*'s nest were negatively correlated, but for *Polistes dominulus* the correlation was positive. Nest of *P. dominulus* are more absorbent than nests of *P. fuscatus* (Curtis *et al*., 2005). There is a relationship between the water absorbency and low moisture content of the nest (Biermann, 1993). There was a positive correlation between the amount of saliva and absorbency of *P. nimpha*'s nest from Malatya. While the absorbency was low, the amount of saliva was high in the sample found in Malatya. The absorbency capacity was higher at other samples. Amount and low moisture content of fibers may affect absorbency.

There were no differences among the nest samples of *P. nimpha* collected in the different ecological conditions in terms of nest material preference and nest architecture. There were diversities for the measurements (amount of saliva and fiber, fiber thicknesses, nitrogen concentration, absorbency of nest paper). These differences may depend on environmental conditions. The fibers are collected from near surroundings of their nests. If the nests include many dry fibers, the saliva may be not effective on water permeability of paper. The duration of chewing affects the absorbency of nest paper. The chewing duration of pulps may be different for each colony.

The result of the study showed that there are variations in respect to chemical and physical features of nest materials of *Polistes nimpha* in various ecological conditions. But, Malatya's sample is different from the others according to the measurements. Malatya is at the south-east of the Anatolian Diagonal, which is one of the main endemism centres in Turkey. Anatolian Diagonal is very impotant geographical and ecological barrier between Western and Eastern Anatolia.

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Received: April 26, 2012 *Accepted: August 06, 2013*