



Determination of The Copper Accumulation in The Nest Materials of *Polistes dominulus* and *Polistes nimpha* (Hymenoptera: Vespidae: Polistinae)

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Abstract: Social insects can be used as bioindicators of environmental quality. The trace metals, heavy metals, radioactivity, pesticides, environmental pollutants have been monitored by using social wasps. The species of Polistinae build up their nest in nature by collecting various organic and inorganic materials from surrounding areas. The idea of this study was to detect the accumulation of copper as environmental pollutant on native species. The nest materials belonging to two species *Polistes nimpha* and *Polistes dominulus* were collected from Adana in Çukurova Region that is one of the very important agriculture areas in Turkey and analyzed through flame atomic absorption spectrometric methods. The amount of copper was found in the nests of *P. nimpha* and *P. dominulus* which was changed from 2.03 to 6.68 $\mu\text{g.g}^{-1}$. It is believed that this accumulation is due to applications of copper-containing pesticides. Overall analyses of findings indicated that composition of the nests of *Polistes* might be evaluated as biomonitor for copper pollution.

Polistes dominulus ve *Polistes nimpha*'nın Yuva Materyalinde Bakır Birikiminin Tespiti (Hymenoptera: Vespidae: Polistinae)

Anahtar Kelimeler

Bakır birikimi,
Polistes dominulus,
Polistes nimpha

Özet: Sosyal böcekler çevre kalitesinin biyoindikatörleri olarak kullanılabilirler. İz elementleri, ağır metaller, radyoaktivite, pestisitler, çevre kirleticiler sosyal arılar kullanılarak tespit edilebilir. Polistinae türleri doğada yuvalarını civardan topladıkları çeşitli organik ve inorganik materyaller ile inşa ederler. Bu çalışmanın amacı doğal türlerde çevre kirleticisi olan bakır birikiminin tespit edilmesidir. Türkiye'nin en önemli tarım bölgesi olan Çukurova'nın Adana ilinden toplanan *Polistes nimpha* ve *Polistes dominulus* türlerine ait yuvalar alevli atomik absorpsiyon spektrometresi metodu ile analiz edildi. *P. nimpha* ve *P. dominulus* yuvalarında bakır miktarının 2.03 – 6.68 $\mu\text{g.g}^{-1}$ arasında değiştiği tespit edildi. Bu birikimin bakır içeren pestisit uygulamalarından kaynaklanabileceği düşünülmektedir. *Polistes* türlerinin yuvaları bakır kirliliğinin biyomonitörü olarak kullanılabilir.

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1. INTRODUCTION

Insects, occupy different position in food chain, are the important part of the ecosystem. It

is reported that some insects accumulate large amount of metals in their

bodies and result in physiological toxicity (Heliövaara and Väisänen, 1990; Diener et al. 2015). Some predatory insects are used as bioindicators because of high abilities of accumulating metals from the ambient environment (Nummelin et al., 2007). The heavy metal accumulation and their biogeochemical transport in the soil-plant-insect system were clarified (Zhang et al., 2009).

Diptera (Hare and Tessier, 1998), Odonata (Hardersen, 2000) can be used as bioindicators of environmental quality. Metal concentrations in some insects belonging to Orthoptera, Odonata and Lepidoptera collected from industrial areas were evaluated (Azam et al., 2015). The presence of heavy metals in larvae, pupae and adults of the social wasps were examined (Kowalczyk and Watala, 1989; Urbini et al., 2006; Magalhaes de Souza et al., 2010). Possible adverse effects of heavy metal pollution to host plant-aphid relationships were indicated (Gorur, 2006). Hymenoptera species can be successfully used as bioindicators. The honey bee and its products are considered most versatile and efficient biomarkers for environmental pollution (Pohl, 2009; Balestra et al., 1992; Kevan, 1999; Zhelyazkova, 2012). Ants have been used to indicate pollutant concentrations (Andersen and Müller, 2000).

The wasps of the genus *Polistes*, commonly known as paper wasps, have a worldwide distribution in temperate and tropical zones. In temperate zones they are characterized by annual colonies (Cervo, 2000). The *Polistes* colonies in Turkey are univoltin. Their colonies are small with less than 100 workers per colony usually (Bagriacik, 2013). The nests of *Polistes* are arboreal, sometimes in cavities, and consist of a single resinous pedicel and a comb not covered by envelope. The species of *Polistes* prefer long vegetative fibers and plant hairs as nest material (Wenzel, 1998). 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). Usually the nests are made of chewed plant fibers from weathered wood and other sources (Jeanne, 1975). Nests occur in or on vegetation, and on manmade structures such as the roofs and eaves of buildings. There are interspecific variations in preferred nesting sites (Evans and West Eberhard, 1970).

The concentration of copper in soils ranges from 2 ppm to 100 ppm (on dry weight basis) with a mean value of 20 ppm. Metals are absorbed by plants from contaminated soil (Naqvil et al., 2014). Copper is an essential micronutrient for normal plant growth and development, although it is also potentially toxic (Yruela, 2005). Cu concentrations in cells need to be maintained at low levels since this element is extremely toxic in view of its high redox properties. Excessive Cu can interfere with numerous physiological processes such as enzyme activity, protein oxidation (Işlek and Türkyılmaz Ünal, 2015).

In this study, the nests of two species *Polistes dominulus* and *Polistes nimpha* collected from Adana province which is one of important agricultural areas in southern part of Turkey were analyzed in respect to copper accumulation. Many chemicals are applied for preventing of pests and plant diseases in this region. The aim of the study was determination of the level of copper as environmental pollutant in the nests as natural structure made by *Polistes* wasps. The copper was analyzed because it is essential microelement for plants and also can accumulate in tissues.

2. MATERIAL AND METHODS

The nests of *Polistes nimpha* and *Polistes dominulus* were collected around Adana province of Turkey in the summer season of 2016. The samples were randomly collected from various areas which represent different habitats and altitudes of Adana province. The nests were mechanically dried in oven at 70°C for 48 h., weighed on microbalance (1g. for each

part of the nests), and digested in a mixture of five milliliters of nitric acid 0.1 M (6:1). Then, 10 ml of the same acid was added and the mixture was made up to 25 ml with distilled water. Four measurements were made for each nest. Each concentration datum is the average of the measurements. 13 nests were analyzed at the laboratory of the Department of Chemistry in Niğde Ömer Halisdemir University through flame atomic absorption spectrometric methods by Shimadzu AA7000.

3. RESULTS AND DISCUSSION

In this study, the nest materials established using the natural materials by wasps were analyzed. The average amounts of copper in the nests of *Polistes* species were determined $5.20 \pm 1.45 \mu\text{g.g}^{-1}$ varying from a minimum of $2.03 \mu\text{g.g}^{-1}$ to a maximum of $6.68 \mu\text{g.g}^{-1}$ (Table 1). The average amount of copper of the nests of *P. dominulus* and *P. nimpha* were determined $6.05 \pm 0.37 \mu\text{g.g}^{-1}$ and $4.96 \pm 2.21 \mu\text{g.g}^{-1}$, respectively.

The analysis of measurements was shown that the nest materials including plant fibers contain higher concentrations of copper. Also, copper accumulated in fibrous materials of *P. nimpha* and *P. dominulus* nests. According to Bağriacik (2012) *Polistes nimpha*, *P. gallicus* and *P. dominulus* in Turkey were similar in terms of nest material preference and nest architecture. Long vegetable fibers, plant hairs and inorganic particles were observed in the nests of *Polistes* species. The nest materials of *P. dominulus* and *P. nimpha* collected for this study are similar.

The reason of the accumulation of copper of the nests of *P. nimpha* and *P. dominulus* in this study may be due to the applications of chemical drugs including copper for pest control and plant diseases in collecting areas. Approximately %40 of agricultural chemicals used in Turkey are applied in Adana province (Zeren and Eren, 2000). In this region, cupreous preparations are density used against plant disease (Mirik et al., 2005). Copper

hydroxide, copper sulphate (Bordeaux mixture), copper sulphatepenta hydrate, copper oxychlorid are some of the chemicals that were applied against plant diseases in Adana (DPPP, 2017).

Table 1. Data on the collecting localities and the amounts of copper in the nests

Locality number	Locality name	Altitude	Coordinates	Speices	Mean±SD ($\mu\text{g.g}^{-1}$)
1	Karaisalı	240m.	35°25' N, 35°05' E	<i>P. dominulus</i>	5.42±2.32
2	Sarıçam, Menekşe	160m.	37°08' N, 35°35' E	<i>P. dominulus</i>	3.45±1.84
3	Ceyhan, Toktamış	25m.	36°99' N, 35°76' E	<i>P. dominulus</i>	2.03±1.13
4	Yüregir, Solaklı	23m.	36°80' N, 35°33' E	<i>P. dominulus</i>	4.12±3.11
5	İmamoglu	84m.	37°25' N, 35°66' E	<i>P. dominulus</i>	3.55±2.24
6	Cukurova, Topalak	150m.	37°09' N, 35°27' E	<i>P. dominulus</i>	6.34±2.4
7	Yumurtalık	20m.	36°81' N, 35°75' E	<i>P. dominulus</i>	6.68±1.74
8	Feke, Merkez	620m.	38°81' N, 35°91' E	<i>P. dominulus</i>	5.79±4.36
9	Aladag, Kabasakal	700m.	37°55' N, 35°35' E	<i>P. nimpha</i>	5.58±1.87
10	Karatas	10m.	36°56' N, 35°38' E	<i>P. dominulus</i>	6.68±1.12
11	Pozantı, Eskikonacık	995m.	32°38' N, 34°86' E	<i>P. nimpha</i>	5.75±1.68
12	Saimbeyli, Güseren	1050m.	37°90' N, 36°08' E	<i>P. nimpha</i>	6.44±1.97
13	Kozan, Anavarza	200m.	37°25' N, 35°90' E	<i>P. dominulus</i>	5.85±1.94

There are a few studies on social wasps as biomonitor of environmental quality. *Polistes dominulus* seem to be a good candidate species for biomonitoring lead pollution in Florence (Italy) according to the results of analysis of the larval fecal masses (Urbini et al., 2006). *Pseudopolybia vespiceps*, *Polybia fastidiosuscula* and *Mischocyttarus drewseni* can be suggested to be used in monitoring programs of environmental quality of Riparian Forests in Southeast Brazil (Magalhaes de Souza et al., 2010). According to results of this study, the compositions of the nest materials of *Polistes dominulus* and *Polistes nimpha* may be a biomonitor for copper accumulation and environmental pollution. As chemicals with different composition heavily applied against pest species in agricultural lands in Turkey, conducting these types of studies are going to be important to detect side effects of chemical pollutions effects.

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