Extraction and Elemental Composition of Meconium in Polistes dominulus (Hymenoptera: Vespidae)

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Extraction and elemental composition of meconium in *Polistes dominulus* (Hymenoptera: Vespidae)

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Abstract

In the social wasps, meconium is the fecal waste of the last larval instar before pupation. Meconium is ejected from fifth (last) instar larvae after their last feeding period as a fecal mass in *Polistes* species. The ejection of the meconium is important for the completion of metamorphosis. The aim of this study was to determine the elemental composition of meconium from *Polistes dominulus* (Christ) (Hymenoptera: Vespidae). Meconia were analyzed with an energy dispersive x-ray scanning electron microscope where the average atomic percentage of C, N, O, P, K, Si, Fe, Mg, S, Al, Ca, Na, and Cl were determined. We also found that the percentage of elements in the meconia in our study were variable and probably attributable to larval diet.

Key Words: Vespoidea; Polistinae; fecal waste

Resumen

En las avispas sociales, el meconio es el desperdicio fecal del último estadio larval antes de la pupación. El meconio se expulsa de las larvas del quinto (último) estadio (instar) después de su último período de alimentación como una masa fecal en las especies de *Polistes*. La expulsión del meconio es importante para completar la metamorfosis. El objetivo de este estudio fue determinar la composición elemental del meconio de *Polistes dominulus* (Christ) (Hymenoptera: Euminidae). Se analizó el meconio con un microscopio electrónico de barrido de rayos X de dispersión de energía donde se determinó el porcentaje atómico promedio de C, N, O, P, K, Si, Fe, Mg, S, Al, Ca, Na, y Cl. También encontramos que el porcentaje de elementos en el meconio en nuestro estudio fue variable y probablemente atribuible a la dieta larval.

Palabras Claves: Vespoidea; Polistinae; desechos fecales

In most apocritan larval Hymenoptera, the end of the midgut is closed, characteristic of a blind digestive system (Peters 2012). Therefore, at the completion of the last larval instar the midgut and hindgut will accumulate wastes that must be ejected before complete metamorphosis can take place. This waste package is termed a meconium (Sharkey 2007).

Meconium extraction is a behavioral quality of Old World Polistinae. In social wasps, the meconium is left at the brood cell, but in *Belanogaster*, *Polybioides*, *Parapolybia*, and *Ropalidia* (all Hymenoptera: Vespidae), a small hole is chewed at the bottom of the cell and the meconium is removed from the chamber by adults. The behavioral differences of meconial extraction suggest a phylogeny of social wasps (Gadagkar 1991).

Among the social wasps, the fifth-stage larva (last instar) continues feeding for a period, but soon begins preparation for spinning the cocoon. Fifth instar larvae of Vespinae and Polistinae eject the meconium after the cocoon is spun, and compress it to the bottom of their cell just before pupation. This fecal mass is surrounded by a peritrophic membrane that forms a sac in which all food residues accumulate. If the last larval instar fails to eject the meconium, it will die (Piccioli 1968; Kojima 1983). Nutrient-rich waste in the nest has ecological advantage in terms of reducing risk of fungal damage and predation by scavenging insects (Jeanne 1975). Indeed, important information on adult production from a colony standpoint can be inferred from the number of meconia and cocoons present. Generally, total abundance of all caste and sexually reproducing individuals in each nest are equal to that of the number of meconia present (Makino & Yamane 1997).

Nutrition plays a major role in caste determination in many social insects (Hunt et al. 2003). Different castes have different metabolic and nutritional requirements (Judd & Fasnacht 2017). Therefore, the composition and dry weight of meconium are indices of food consumption and energy balance within the colony (Marian et al. 1982). In our study,

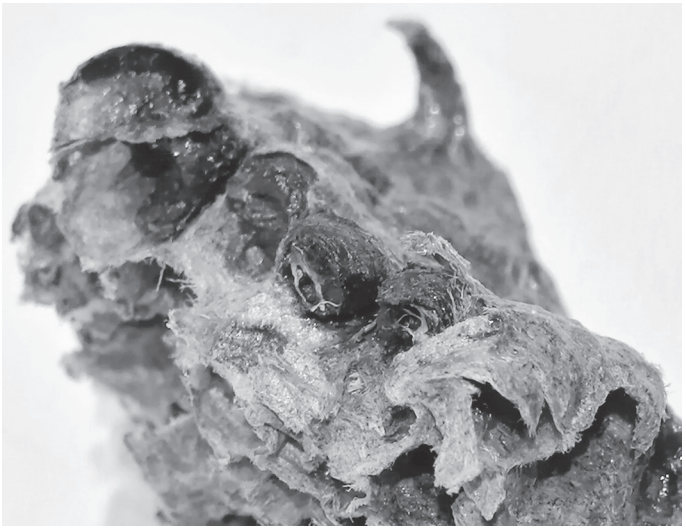

Fig. 1. Meconia in the bottom of the cells of a *Polistes dominulus* nest.

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we compared the elemental components of meconium collected from several *Polistes dominulus* (Christ) (Hymenoptera: Vespidae) nests under similar ecological conditions in the southern provinces of Turkey.

Materials and Methods

Meconium from *P. dominulus* nests were collected in Adana, İçel, Osmaniye, and Hatay provinces in southern Turkey during Jun 2017. Mediterranean climate and flora prevails in this province. Twelve nests from foundress colonies were collected from the following localities: (1) Hatay, Payas, 79 masl; (2) Hatay, Erzin, Yeşiltepe, 33 masl; (3) İçel, Mezitli, 68 masl; (4) İçel, Tarsus, Kaleburcu, 115 masl; (5) İçel, Tarsus, Çamtepe, 81 masl; (6) Osmaniye, Kadirli, 66 masl; (7) Osmaniye, Toprakkale, 68 masl; (8) Adana, Yüreğir, 32 masl; (9) Adana, Sarıçam, 101 masl; (10) Adana, Kozan, Anavarza, 177 masl; (11) Adana, Ceyhan, 18 masl; (12) Adana, İmamoglu, 110 masl.

Meconium composition of the 12 samples were determined with energy dispersive x-ray analysis using a scanning electron microscopy (Carl Zeiss AG-Evo 40, Oberkochen, Germany) at the Central Research Laboratory of Niğde Omer Halisdemir University, Nigde, Turkey. Full area analyses were conducted instead of spot analyses. Energy dispersive x-ray analysis is an x-ray technique used to identify elemental composition. Data generated by energy dispersive x-ray analyses consist of spectral peaks that correspond to the specific elements present within the sample.

Results

Figure 1 shows the meconia of *P. dominulus* embedded in the bottom of the comb after defecation and separated with a membrane from the brood cell. Overall average dry weight of meconia was 0.097 ± 0.036 mg, and measured 2 to 3 mm long and 1 to 2 mm thick (Fig. 2).

Meconia composition collected from nests of *P. dominulus* are presented in Table 1. Energy dispersive x-ray analysis spectra are shown in Figure 3. Carbon, oxygen, and nitrogen were major components of the fecal waste in all meconia. The amount of carbon and oxygen in each of those samples were greater than nitrogen. Phosphorus and potassium also were found in every sample. Sulphur and magnesium each were recovered from 9 nests, whereas aluminum was present in 6 nests. Calcium, chloride, and silicon were found in 4 nests, sodium in 3 nests, and iron in 2 nests. The overall average atomic percent of the amounts of C, N, O, P, K, Si, Fe, Mg, S, Al, Ca, Na, and Cl in samples from each nest are listed in Table 1.

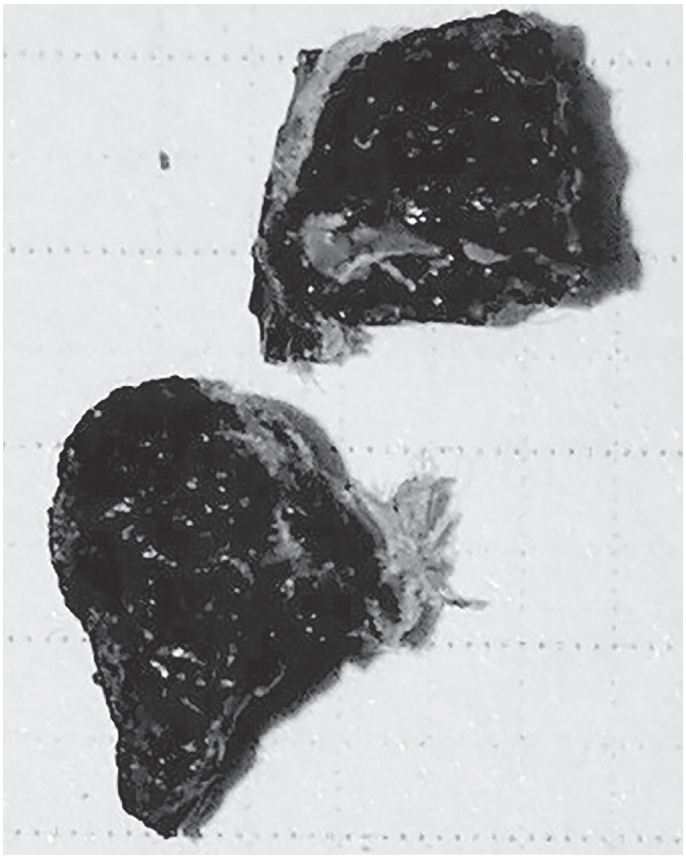

Fig. 2. Meconia of *Polistes dominulus*.

Discussion

Meconial extraction behavior of *P. dominulus* in nesting cells was similar to previously reported information (Bergmann et al. 1966). Meconia of this wasp species was considerably less in length and weight than that reported for other Hymenoptera. *Ropalidia fasciata* were 3 to 4 mm long and 1 mm thick (Kojima 1983). Suzuki (1983) and Bergmann et al. (1966) reported that the dry weights of *P. chinensis antennalis* meconia were 7.073 ± 0.889 mg, and 80 mg for *Vespa orientalis*, whereas meconial weights of 1.3 to 4.6 mg were found for *Speliphron violaceum* (Marian et al. 1982).

Table 1. Micronutrient content of meconia collected from 12 localities in Turkey during June 2017; atomic percentage of elements are according to energy dispersive x-ray analyses.

	Atomic percentage												
Locality	C	N	O	P	K	Si	Fe	Mg	S	Al	Ca	Na	Cl
1	36.4	13.4	39.2	1.6	0.9	–	5.5	1.5	0.2	–	1	–	–
2	30.0	16.1	41.8	2.4	1.2	–	0.3	3.2	–	3.5	0.8	–	–
3	47.2	13.2	38.2	0.2	0.8	–	–	–	0.06	–	–	–	0.08
4	36.5	12.4	46.3	0.6	0.7	0.2	–	0.9	0.07	0.9	–	1.0	–
5	39.3	14.2	45.5	0.07	0.2	0.1	–	0.05	–	0.4	–	–	–
6	43.4	15.9	38.2	0.5	1.1	0.02	–	–	–	0.5	0.3	–	–
7	43.1	14.8	39.2	0.4	1	–	–	0.3	0.3	0.1	–	–	–
8	41.2	17.1	35.7	1.3	1.2	–	–	0.7	0.2	0.01	–	2.1	0.1
9	41.6	15.2	39.9	0.9	1.7	–	–	–	0.3	–	–	–	0.2
10	37.7	14.0	43.9	0.8	1.8	0.07	–	0.8	0.3	–	–	0.3	0.1
11	37.1	12.4	42.8	2.9	1	–	–	0.7	0.3	–	2.5	–	–
12	42.2	15.8	39.6	0.3	0.8	–	–	0.4	0.4	–	–	–	–

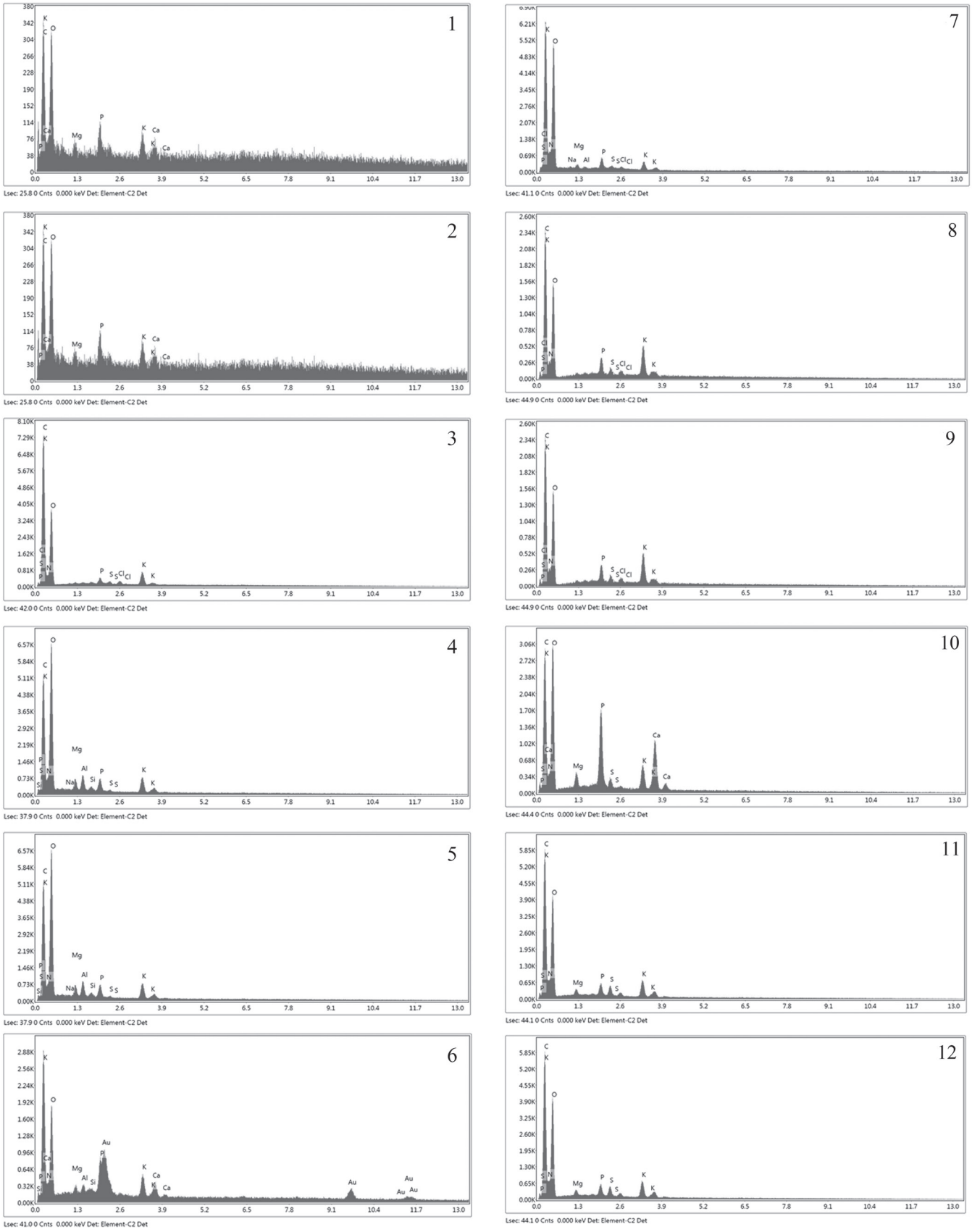

Fig. 3. Energy dispersive x-ray spectra of *Polistes dominulus* meconia samples according to locality number: (1) Hatay, Payas; (2) Hatay, Erzin, Yeşiltepe; (3) İçel, Mezitli; (4) İçel, Tarsus, Kaleburcu; (5) İçel, Tarsus, Çamtepe; (6) Osmaniye, Kadirli; (7) Osmaniye, Toprakkale; (8) Adana, Yüreğir; (9) Adana, Sarıçam; (10) Adana, Kozan, Anavarza; (11) Adana, Ceyhan; (12) Adana, İmamoglu.

Regarding the meconia found in *P. dominulus* nest cells, potassium is primarily involved in the storage capacity of fat body and may regulate protein levels (Bhattacharya & Kaliwal 2005). Magnesium is important for glycolysis and the formation of trehalose (Murphy & Wyatt 1965); sodium regulates cold tolerance in insects (Kristiansen & Zachariassen 2001). Calcium has been found to be important for ovarian development (Pszczolowski et al. 2008), and Judd et al. (2010) found that all wasp castes lose this micronutrient during metamorphosis. Interestingly, some of the micronutrients we recovered from meconia were found in several (but not all) of the nests that were sampled in our study, even though collections were from similar ecological conditions. The main components (carbon, oxygen, and nitrogen) were present in all nests, but a few components were not recovered from others nor were they found at equal levels. The differences of amount and presence of some elements in those samples may have been influenced by the larval foods presented by adult wasps during immature development.

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References Cited

Bergmann F, Ishay I, Kidman M. 1966. Pharmacologically active substances in the faeces of the oriental wasps *Vespa orientalis* F. British Journal of Pharmacology 26: 229–236.

Bhattacharya A, Kaliwal BB. 2005. The biochemical effects of potassium chloride on the silkworm (*Bombyx mori* L.). Insect Science 12: 95–100.

Gadagkar R. 1991. Belonogaster, Mischocyttarus, Parapolybia and independent-founding Ropalidia, pp. 149–190 *In* Ross KG, Matthews RW [eds.], The Social Biology of Wasps. Cornell University Press, Ithaca, New York, USA.

Hunt JH, Buck NA, Wheeler DE. 2003. Storage proteins in Vespid wasps: characterization, developmental pattern and occurrence in adults. Journal of Insect Physiology 49: 785–794.

Jeanne RL. 1975. The adaptiveness of social wasp nest architecture. Quarterly Review of Biology 50: 267–286.

Judd TM, Fasnacht MP. 2017. A nutritional profile of the trap-nesting wasp *Trypoxylon lactitarse* (Hymenoptera: Crabronidae): comparison of sexes and overwintering and non-overwintering generations. Insects 8: 1–8.

Judd TM, Magnun RM, Fasnacht MP. 2010. A nutritional profile of the social wasps *Polistes metricus*: differences in nutrient levels between castes and changes within castes during the annual life cycle. Journal of Insect Physiology 56: 42–56.

Kojima J. 1983. Peritrophic sac extraction in *Ropalidia fasciata* (Hymenoptera: Vespidae). Kontyû 51: 502–508.

Kristiansen E, Zachariassen KE. 2001. Effect of freezing on the transmembrane distribution of ions in freeze-tolerant larvae of the wood fly *Xylophagus cinctus* (Diptera, Xylophagidae). Journal of Insect Physiology 147: 585–592.

Makino S, Yamane S. 1997. Nest content and colonial adults' productivity in a common hornet, *Vespa simillima simillima* Smith, in northern Japan (Hymenoptera: Vespidae). Japanese Journal of Entomology 65: 47–54.

Marian PM, Pandian TJ, Muthukrishnan J. 1982. Energy balance in *Speliphron violaceum* (Hymenoptera) and use of meconium weight as an index of bioenergetics components. Oecologia (Berlin) 55: 264–267.

Murphy TA, Wyatt GR. 1965. The enzymes of glycogen and trehalose synthesis in silk moth fat body. Journal of Biological Chemistry 240: 1500–1508.

Peters W. 2012. Peritrophic Membranes. Springer Verlag, Heidelberg, Germany.

Piccioli MTM. 1968. The extraction of the larval peritrophic sac by adults in *Belonogaster* (Hymenoptera: Vespoidea). Monitore Zoologico Italiano (N.S.) 2: 203–206.

Pszczolowski MA, Olsen E, Rhine C, Ramaswamy SB. 2008. Role forcalcium in the development of ovarial patency in *Heliothis virenscens*. Journal of Insect Physiology 54: 358–366.

Sharkey JM. 2007. Phylogeny and classification of Hymenoptera. Zootaxa 1668: 521–548.

Suzuki T. 1983. Amount of flesh intake by successful colonies *Polistes chinensis antennalis* (Hymenoptera, Vespidae) in southern Japan. Japanese Journal of Ecology 33: 481–482.