



SHORT NOTE

Body Size of Wood Ant Workers Affects their Work Division

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Abstract

The division of functions among ant workers and their mutual cooperation is one of the reasons for ants' success. The activities that workers perform in the nest can be divided by age or morphology. We studied the body size of workers of the wood ant *Formica polyctena* as a function of their activity. Our results show that workers exploiting protein baits were larger than workers attracted to carbohydrate baits. The biggest of all were workers located at the upper parts of the nest, which shows the importance of nest defense and maintenance. It also points that the distribution of functions does not have to be given only by workers age. Work division based on several mechanisms may be advantageous for colony functioning.

The ants taxon is characterized by great variability in body size, which plays an important role for their survival (Bugrova, 2010; Bernadou et al., 2016; Bishop et al., 2016; Kramer et al., 2016; Wills et al., 2018). Ants' body sizes are conditioned upon factors both intrinsic (evolutionary constraints, genetic factors, social environment, colony age, need in colony defense and foragers) and extrinsic (physical environment, food availability and nutrition, anthropogenic disturbances and environmental pollution) (Kaspári, 2005; Johansson & Gibb, 2012; Grześ et al., 2015; Bernadou et al., 2016; Kramer et al., 2016; Purcell et al., 2016; Wills et al., 2018). These factors interact with one another (Wills et al., 2018).

Significant differences in ant sizes exist between castes within a given nest. In the case of polymorphic species, it often occurs that the workers, too, differ greatly and can be designated as minor and major workers. Each type of such workers performs different activities (Hölldobler & Wilson, 1990). Smaller differences in size can be found also in workers of monomorphic species (Grześ et al., 2016). Physiological differentiation of workers can be the reason for a specific division of labor (Fénéron et al., 1996), and this division is one of the bases for ants' successful organization (Hölldobler & Wilson, 1990).

The European red wood ant *Formica polyctena* Förster, 1850 is a monomorphic wood ant species with North-Palaearctic distribution. The colonies are generally polygynous, frequently with more than 1 million workers. They collect honeydew, forage for arthropod prey and scavenge (Horstmann, 1972; Czechowski et al., 2002). *F. polyctena* is listed on the Red List of Threatened Species, but also it is used for biological protection against forest pests (Adlung, 1966; IUCN, 1996)

We examine the question as to whether body size in workers of the *F. polyctena* is a determinant of the activities that they perform. Specifically, we investigate whether there are differences among hunting workers, workers that collect honeydew, and workers laboring in the upper parts of the nest.

Our study was conducted in a forest in the north of the Czech Republic (50°58'30.02"N, 15°13'09.34"E) at an altitude of 440 m a.s.l. The forest is dominated by Norway spruce (*Picea abies*). The research was conducted in August 2016. We randomly selected 20 separately located nests. The smallest distance between the nests was 50 m and nests belonged to different colonies. We placed baits consisting of sugar (honey) and protein-rich (tuna fish) foods on paper plates at a distance of 5 m from each nest. Each bait contained



1 cm³ of each type of food. After 10 min, we collected five workers from each type of bait and five workers from the upper parts of the nests (15 individuals per nest). For all captured workers, we measured the dimensions: eye length, head width, pronotum width, mandible width, and hind femur length (Fig 1). The measurement was performed using a binocular magnifier with 45× magnification.

The differences between the measured parameters according to work division were determined using one-way ANOVA nested within the nest. In a statistically significant morphological parameter, the significance of differences by work division was also compared using treatment contrasts (Crawley, 2013; Pekár & Brabec 2009). All analyses were performed in the R 3.3.2 environment (R Core Team 2016).

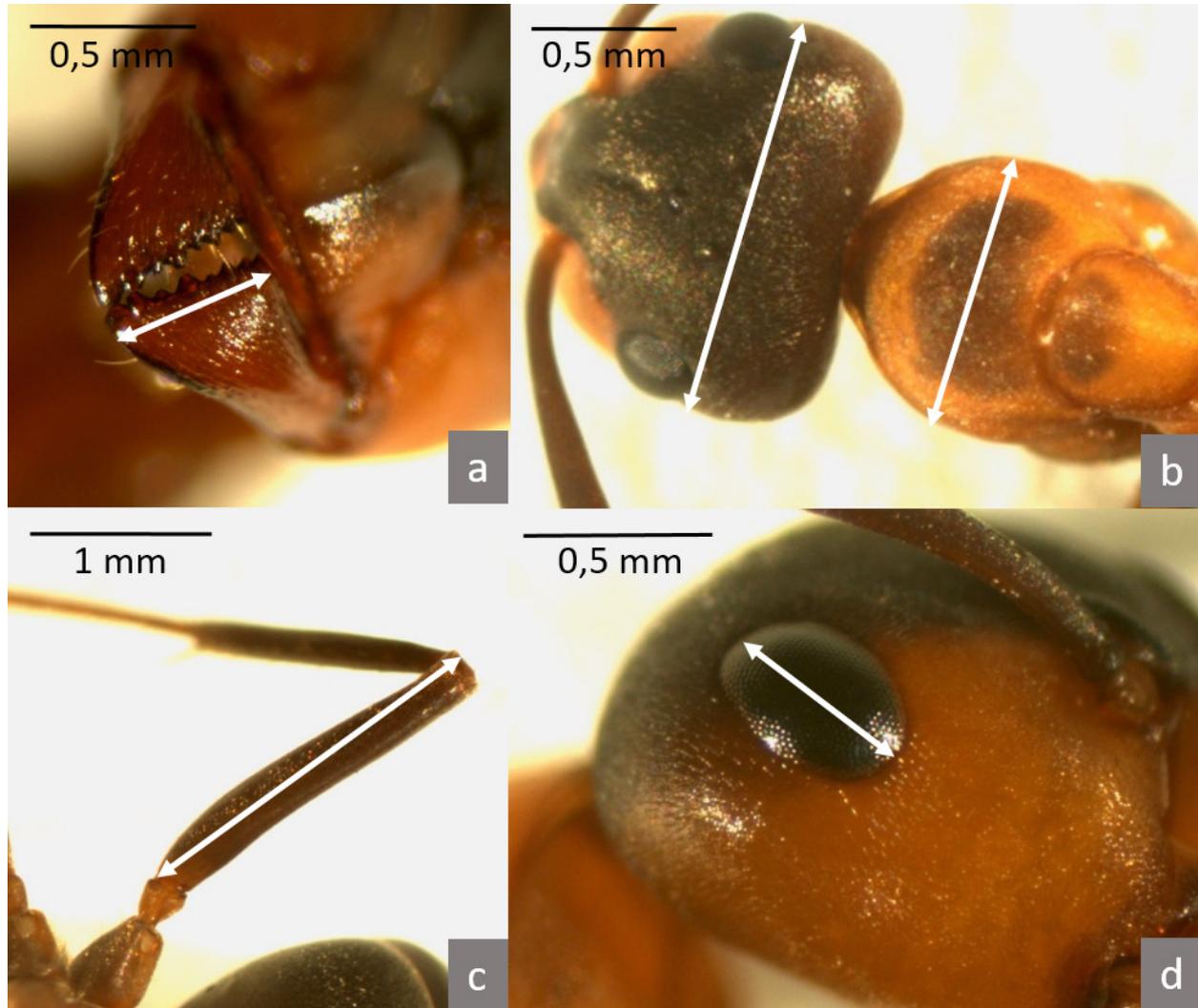


Fig 1. Measured parts of the bodies of *Formica polyctena* workers: a) mandible width, b) head and pronotum width, c) femur length, d) eye length.

All morphological parameters measured in ants acquired at different capture points (tuna, honey, nest) were statistically significantly different (ANOVA: $df = 2$, $p < 0.001$). Body size values were highest at the nest, and individuals of somewhat smaller sizes were found on the tuna. The smallest parameters were those of individuals on the honey bait. These differences were statistically significant in all cases (contrast: $p < 0.001$, Fig 2).

Our results may be explained by the degree of specialization, which differs between worker individuals (Otto, 1958; Horstmann, 1973). The larger body size of wood ant workers gathering protein food vis-à-vis those collecting honeydew has been described by Rosengren & Sundström (1987). There may be several possible causes for this fact. Larger workers are able to catch and transfer

large prey (Batchelor, 2012), they move faster and further from the nest (Rissing, 1982; Wright et al., 2000), they have better orientation ability (Bernstein & Bernstein, 1969), they are more resistant against unfavourable meteorological conditions (Kay & Rissing, 2005), and more aggressive and better fighters (Batchelor et al., 2012). All these features are advantage, because the occurrence of prey at the territory is random and may not be in places, where there are numerous ants (Sundström, 1993; Yao, 2012). Workers at low-density sites may more commonly meet up with competing ants, which leads to a reduction in the number of the smaller workers employed for foraging (Savolainen & Vepsäläinen, 1989; Kay & Rissing, 2005). Conversely, the sources of honeydew are stable and well attended (Del-Claro & Oliveira, 1993).

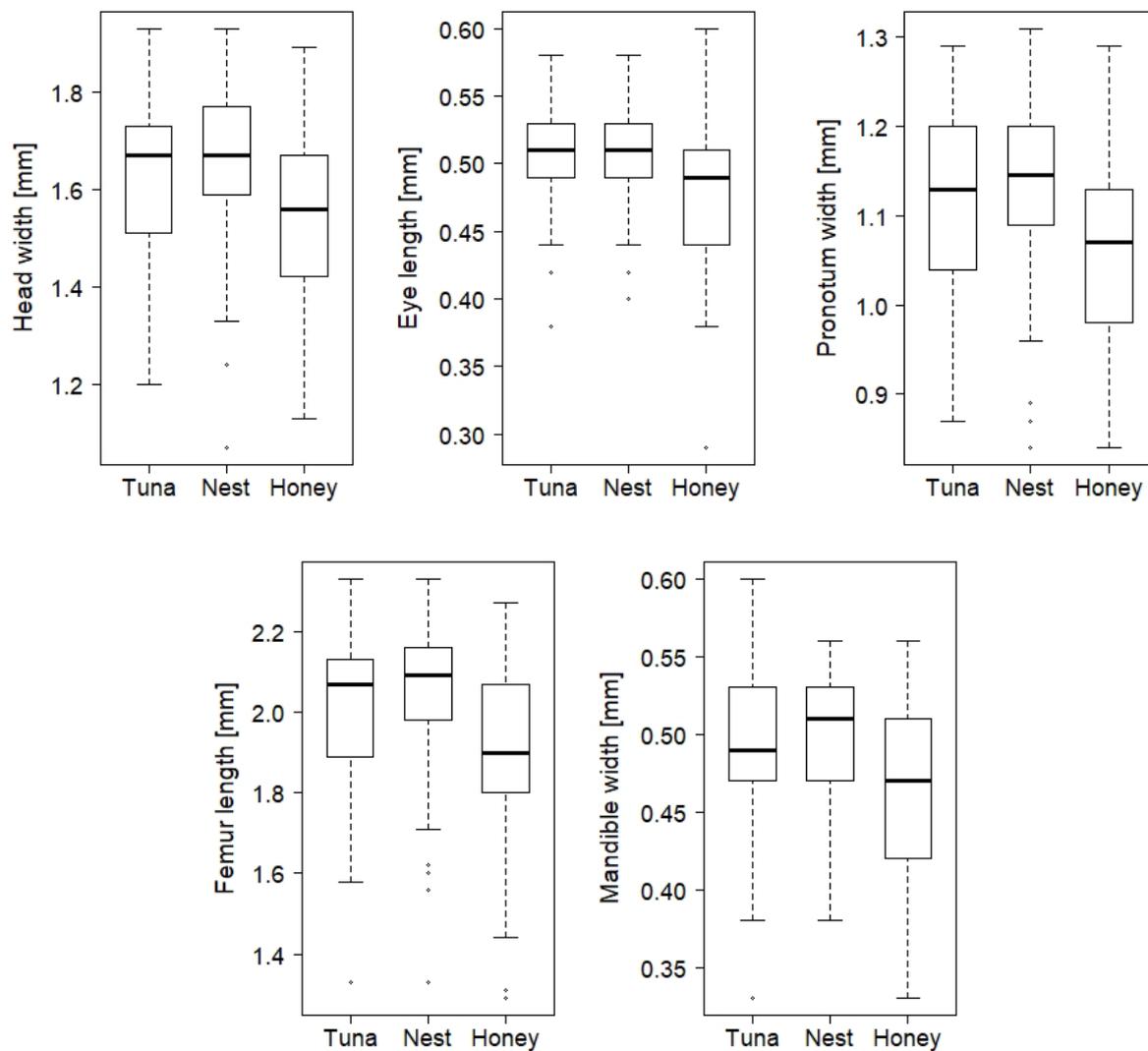


Fig 2. Overview of measured dimensions (head, pronotum and mandible width, femur and eye length) of *Formica polyctena* workers in dependence on their work division (tuna – workers gathering protein food, honey - workers collecting honeydew, nest – workers at the upper parts of nests). Horizontal line in the middle of the box is median, whiskers represent 1.5 times the inter-quartile range. One hundred workers were used for measurement in every group.

A unique finding is that wood ant workers working outside the nest are smaller than workers on the nest. It is known that the wood ants are divided into groups working inside and outside the nests and that these groups differ in age, physiology, and behaviour (Rosengren, 1977). The higher aggression of large workers is advantageous in defending the nest (Kay & Rissing, 2005; Batchelor, 2012). A loss of large workers is more costly for the colony (Kay & Rissing, 2005). The probability of loss is high when ants are moving on the territory, and especially at its edges (Wilson, 1971).

To date, however, work division, as a life history trait of wood ants, has been regarded as a typical example of age polytheism (younger workers are found in nests, older individuals work outside the nest) (see Rosengren, 1977). Our results on specific data prove the presumption of Otto (1958) that the division of functions need not be given only by age polytheism.

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Authors' Contribution

A Vélé contributed to fieldwork, conception and design. R Modlinger performed the statistical analyses. Both authors contributed to interpretation and to revisions of the manuscript.

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