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SHORT NOTE

Formica rufa ants have a limited effect on the abundance of the parasitic fly *Ernestia rudis* in Scots pine plantations

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Abstract
Red wood ants (the *Formica rufa* group) are important predators which affect animal communities in their territory. Therefore, they are useful in forest protection. On the other hand, they also prey on beneficial organisms. We have asked whether *Formica rufa* L. affects the abundance of the parasitic fly *Ernestia rudis* (Fallén). Ten anthills situated in about 40-year- old pine plantations were used for the study. The presence of *E. rudis* cocoons was assessed in eight soil samples excavated in the surrounding of each nest at a distance of 2–17 m. Our results show a considerably lower abundance of *E. rudis* only to 4.5 m from the nests. The occurrence of *Formica rufa* ants therefore had no significant effect on the beneficial *E. rudis* population in plantation forests, where ants populations are low.

Red wood ants (the *Formica rufa* group) are polyphagous predators (Laakso, 1999). Although captured prey only constitutes about 20% of their diet, they strongly affect the abundance and behaviors of many arthropod taxa in the temporal and boreal forests of Europe (Skinner, 1980; Laakso, 1999; Reznikova & Doroshea, 2004). In addition to direct predation, they may influence other animals through resource competition or non-consumptive interactions (Hawes et al., 2002, Maňák et al., 2013). Several studies describe the predatory capacity of wood ants to reduce the population densities of forest pests, e.g., *Pristiphora abietina* (Christ.), *Bupalus piniarius* (L.), *Panolis flammea* (Denis & Schiffermüller), *Dendrolimus pini* (L.), *Lymantria dispar* (L.), *Operophtera brumata* (L.), and *Oporinia autumnata* (Bkh.) (Otto, 1967; Laine & Niemelä, 1980; Weseloh, 1994, Nielsen et al., 2018). In defoliated plantations, the effect of ant predation can be observed as "green islands" of undefoliated trees around their nests (Karhu & Neuvonen, 1998). Adlung (1969) points out that as a result of their foraging opportunism, ants also prey on nonharmful and beneficial species, thereby hindering the contribution of the latter to forest protection.

In our study, we have asked whether *Formica rufa* L. affects the abundance of *Ernestia rudis*. This species of parasitic fly of the family Tachinidae is an important population regulator of the moth *Panolis flammea*, which causes extensive damage in pine plantations. One *E. rudis* larva can parasitize one *Panolis flammea* caterpillar and subsequently crawl to the ground, where it pupates (Křístek & Urban, 2013). *Formica rufa* is a typical representative of wood ants. In central Europe, it is common from lowlands to mountains, where it inhabits mainly coniferous and mixed forests, preferring lighter areas (Czechowski et al., 2002; Bezděčka & Bezděčková, 2011).

The study area was a large (ca 35 km^2) plantation forest of *Pinus sylvestris* L. in South Moravia, Czech Republic (48°57′27.516″ N, 17°12′46.611″ E). Three hundred ha of

this area were equally and severely damaged by *P. flammea* in 2018 and 2019. In line with this, the abundance of the parasitic *E. rudis* increased in 2019. For the study, ten anthills situated in about 40-year-old forests were chosen. All nests were isolated, i.e., their territories did not overlap. Eight soil samples were dug up in the surrounding of each nest. The centers of the soil sampling patches (25 × 25 cm) were situated at a regular distance of 2.1, 4.3, 6.5, 8.7, 10.9, 13.1, 15.3, and 17.5 m from the nests. A distance of 17.5 m is roughly equivalent to an average wood ant territory (Horstmann, 1974; Skinner, 1980). All samples were collected on November 15, 2019, and transported to the laboratory, where cocoons were separated. To determine the predictors (mound volume, distance from nest) explaining the *E. rudis* cocoon number, a generalized linear model with log-normal distribution was used. Analyses were done in Statistica 13.0.

The mean mound volume was 0.11 ± 0.08 m^3. The number of *E. rudis* cocoons increased with distance from nests ($p \leq 0.01$), independently of mound volume ($p = 0.4$). A considerably lower abundance of *E. rudis* was determined up to a distance of 4.5 m (Fig 1).

The short distance found in this study is probably a consequence of the low volume of mounds (Sorvari, 2009). The mound volume is correlated with the size of the nest population (Skinner, 1980). It follows that a larger colony consumes more prey (Trainello, 1989; Domisch et al., 2009). Mound volumes measured in this study are lower than the size commonly reported for *F. rufa* and the closely related species *F. polyctena* Först., hence the all examined anthills fall into the category of small nests (Cezchowski, 2002; Mabelis, 1979; Frouz, 1996; Kadochová & Frouz, 2014; Rybnikova & Kuznetsov, 2015). This may be the reason why mound volume was found to be insignificant in this study and why other authors describe strong predatory abilities of ants up to a distance of 17-35 m (Koehler, 1976; Laine & Niemelä, 1980; Oloffson, 1992).

Another explanation may be that the above studies primarily focus on prey on trees. However, only 25% of the foraging activity of wood ants takes place on the forest floor (Sudd & Lodhi, 1981). The caterpillars in the vicinity of the anthill may have been carried by the wind from more distant trees, as described by Edland (1971) on the example of the larvae of *O. brumata*. Wellenstein (1954), who counted cocoons of *Diprion pini* (L.), found within 7 m of the nest only 32% of pupae occurring in the vicinity, which roughly confirms our results. Also Reznikova and Dorosheva (2004) found a similar distance when studying the dynamic density of carabids around ant nests. This may be explained by the number of workers, which decreases with increasing distance from the nest (Mabelis, 1979).

Our study provides the first data that suggest the marginal influence of wood ants on the occurrence of the cocoons of *E. rudis*. Outbreaks of *P. flammea* (and subsequently *E. rudis*) are rare in central Europe, as evidenced by the fact that the previous outbreak at the study site occurred more than 100 years ago. The onset of *P. flammea* outbreaks was related to a combination of sufficient temperature and precipitation (Haynes et al., 2014; Véle & Liška, 2019). In the future, shorter gradation cycles can be expected due to climate change (Haynes et al.. 2014). In light of our findings, future studies should be carried out to describe and evaluate the number of predated *E. rudis* larvae or compare it with the number of *P. flammea* caterpillars carried to the nest.

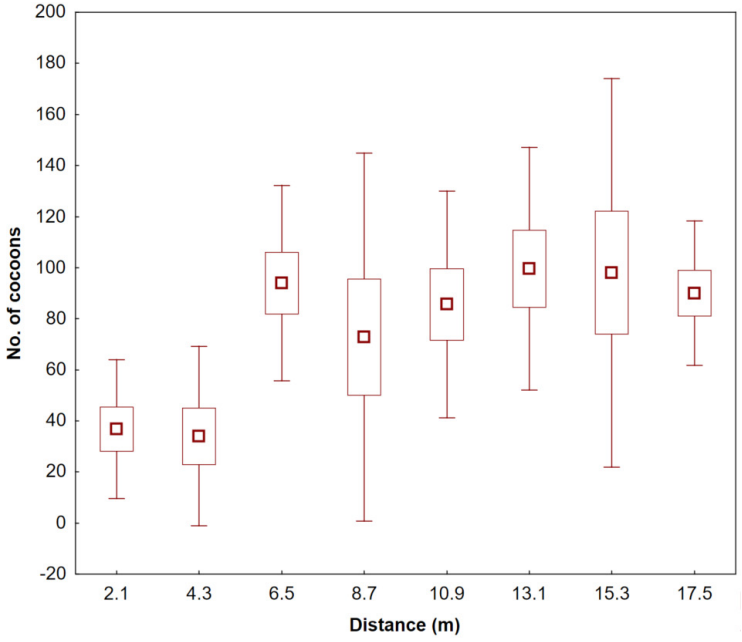

Fig 1. Box plots despicts mean, standard error (box) and standard deviation (whiskers) of the number of *E. rudis* cocoons according to distance from wood ant nests.

Our results are roughly consistent with Karhu, Neuvonen (1998), who generally determined the border of the ecological importance of wood ants to a distance of 8 m and do not support Adlung's (1969) claim of a negative effect of ants on beneficial insects. This may be because plantation forests are not conducive to ants, so that their nest densities and population sizes are low here (Sorvari & Hakkarainen 2005, 2007).

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Conflict of interest

The authors declare no conflicts of interest.

References

Adlung, K.G. (1966). A Critical Evaluation of the European Research on Use of Red Wood Ants (*Formica rufa* Group) for the Protection of Forests against Harmful Insects. Zeitschrift für Angewandte Entomologie, 57: 167-189. doi: 10.1111/j. 1439- 0418.1966.tb03822.x

Bězděčka, P. & Bezděčková, K. (2011). Mravenci ve sbírkách českých, moravských a slezských muzeí. Jihlava: Muzeum Vysočiny Jihlava, 147p

Czechowski, W.; Radchenko, A.; Czechowska, W. (2002). The ants (Hymenoptera, Formicidae) of Poland. Warsaw: Museum and Institute of Zoology, Polish Academy of Sciences, 200 p

Domisch, T., Finer, L., Neuvonen, S., Niemelä, P., Risch, A.C., Kilpeläinen, J., Ohashi, M. & Jurgensen, M.F. (2009). Foraging activity and dietary spectrum of wood ants (*Formica rufa* group) and their role in nutrient fluxes in boreal forests. Ecological Entomology, 34: 369-377. doi: 10.1111/j.1365-2311.2009.01086.x

Edland, T. (1971). Wind dispersal of the winter moth larvae *Operophtera brumata* L. (Lep., Geometridae) and its relevance to control measures. Norwegian Journal of Entomology, 18: 103-105.

Frouz, J. (1996). The role of nest moisture in thermoregulation of ant *(Formica polyctena*, Hymenoptera, Formicidae) nests. Biologia, 51: 541-547.

Hawes, C., Stewart, A.J.A. & Evans, H.F. (2002). The impact of wood ants (Formica rufa) on the distribution and abundance of ground beetles (Coleoptera: Carabidae) in a Scots pine plantation. Oecologia, 131: 612-619. doi: 10.1007/s00442-002-0916-6

Haynes, K.J., Allstadt, A.J., Klimetzek, D. (2014). Forest defoliator outbreaks under climate change: effects on the frequency and severity of outbreaks of five pine insect pests. Global Change Biology, 20: 2004-2018. doi: 10.1111/gcb.12506

Horstmann, K. (1974). Untersuchungen über den Nahrungswerb der Waldameisen (Formica polyctena Foerster) im Eichenwald. III. Jahresbilanz. Oecologia, 15: 187-204.

Kadochová, S. & Frouz, J. (2014). Red wood ants *Formica polyctena* switch off active thermoregulation of the nest in autumn. Insectes Sociaux, 61: 297-306. doi: 10.1007/s00040-014-0356-4

Karhu, K. & Neuvonen, S. (1998). Wood ants and geometrid defoliators of birch: predation outweighs beneficial effects through the host plant. Oecologia 113: 509-516.

Koehler, W. (1976). Ksztaltowanie sie stosunkow trofobiotycznych przy sztucnej kolonizacii *Formica polyctena*. Prace Instytutu Badawczego lesnictva, 499 p.

Křístek, J. & Urban, J. (2013). Lesnická entomologie. Praha: Academia, 445 p

Laakso, J. (1999). Short-term effects of wood ants (*Formica aquilonia* Yarr.) on soil animal community structure. Soil Biology and Biochemistry, 31: 337-343. doi: 10.1016/S0038-0717(98)00131-X

Laine, K. & Niemelä, P. (1980). The Influence of Ants on the Survival of Mountain Birches during an *Oporinia autumnata* (Lep., Geometridae) Outbreak. Oecologia, 47: 39-42.

Mabelis, A. A. (1979). Wood ant wars. The relationship between aggression and predation in the red wood ant (*Formica polyctena* Foerst.). Netherlands Journal of Zoology, 29: 451-620.

Maňák, V., Nordenhem, H., Björklund, N., Lenoir, L., & Nordlander, G. (2013). Ants protect conifer seedlings from feeding damage by the pine weevil *Hylobius abietis*. Agricultural and Forest Entomology, 15: 98-105. doi: 10.1111/j.1461-9563.2012.00597.x

Nielsen, J.S., Nielsen M.G., Damgaard, C. & Offenberg, J. (2018). Experiences in Transplanting Wood Ants into Plantations for Integrated Pest Management. Sociobiology, 65: 403-414. doi: 10.13102/sociobiology.v65i3.2872

Olofsson, E. (1992). Predation by *Formica polyctena* Förster (Hym., formicidae) on newly emerged larvae of *Neodiprion sertifer* (Geoffroy) (Hym., Diprionidae). Journal of Applied Entomology, 114: 315-319. doi: 10.1111/j.1439-0418.1992.tb01132.x

Otto, D. (1967). Die Bedeutung der Formica-Völker für die Dezimierung der wichtigsten Schadinsekten–Ein Literaturbericht. Waldhygiene, 7: 65-90.

Reznikova, Z. & Dorosheva, H. (2004): Impacts of red wood ants *Formica polyctena* on the spatial distribution and behavioural patterns of ground beetles (Carabidae). Pedobiologia, 48: 15-21. doi: 10.1016/j.pedobi.2003.06.002

Rybnikova, I.A. & Kuznetsov, A.V. (2015). Complexes of Formica s. str. nests in the Darwin Nature Reserve and causes of their degradation. Entmological Review, 95: 947-952. doi: 10.1134/S0013873815080023

Skinner, G.J. (1980). Territory, trail structure and activity patterns in the woodant, *Formica rufa* (Hymenoptera: Formicidae) in Limestone woodland in northwest England. Journal of Animal Ecology, 49: 381-394.

Sorvari, J. & Hakkarainen, H. (2005). Deforestation reduces nest mound size and decreases the production of sexual offspring in the wood ant *Formica aquilonia*, Annales. Zoological Fennici, 42: 259-267

Sorvari, J. & Hakkarainen, H. (2007). Wood ants are wood ants: deforestation causes population declines in the polydomous wood ant *Formica aquilonia*. Ecological Entomology, 32: 707-71. doi: 10.1111/j.1365-2311.2007.00921.x

Sudd, J.H. & Lodhi, Q.K. (1981). The distribution of foraging workers of the wood-ant *Formica lugubris* Zetterstedt (Hym.: Formicidae) and their effect on the numbers and diversity of other Arthropoda. Biological Conservation, 20: 133-145.

Traniello, J.F.A. (1989). Foraging strategies of ants. Annual Review of Entomology, 34: 191-210.

Véle, A. & Liška, J. (2019). Sosnokaz borový na jihovýchodní Moravě v roce 2019. Lesnická práce, 9: 46-47.

Wellenstein, G. (1954): What can we expect from the red wood ant for the forest protection? Beiträge zur Entomologie, 4: 117-138.

Weseloh, R.M. (1994). Forest Ant (Hymenoptera: Formicidae) Effect on Gypsy Moth (Lepidoptera: Lymantriidae) Larval Numbers in a Mature Forest. Environmental Entomology, 23: 870-877. doi: 10.1093/ee/23.4.870