

UNIVERSITY OF SZEGED
Faculty of Science and Informatics
Department of Ecology
Doctoral School of Environmental Sciences

**Nest complex organisation in territorial *Formica*
species**

Abstract of Ph.D. thesis

BENEDEK KLÁRA

Supervisor: Prof. Dr. Gallé László, University of Szeged
Advisor: dr. Markó Bálint, Babeş - Bolyai University

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1. Introduction

Ant colonies are exposed to severe competition by conspecific and alien colonies, as a rule. In order to eliminate intruders it is essential to distinguish colony mates and non-colony mates. The clue to nestmate recognition is the cuticular hydrocarbon profile of specimens in many ant species. The hydrocarbon profile has genetically and environmentally determined components. Aggressive interactions occur when workers detect chemical recognition clues that do not conform to a familiar template or chemical distance affects the level of aggression in ants. Differences in the level of aggression with the variations of spatial distance are also described. Some ant species avoid the aggression encounters with close neighbours in order to reduce the costs of territoriality. The opposite phenomenon is also known, that is, the level of aggression is growing with the increasing spatial distance between colonies.

The interspecific relations influence the functions and success of ant colonies. Ant species are hierarchically arranged on the basis of social organization of their colonies and this hierarchy contains three main competition levels. These are: (1) submissive species which protect only their nests, (2) encounter species which defend their nests and food sources too and (3) territorial species which defend their whole foraging areas.

Territorial species play a major role in the formation of ant communities. Their presence usually excludes the appearance of other dominant species. Submissive species can live together with territorial ants, but their activity is modified or inhibited by dominants.

2. Aims

In the present work, aggressive ant species with large territory were studied. The two selected species were *Formica exsecta* Nylander, 1846 and *Formica pratensis* Retzius, 1783. The aims of my study were to detect the effect of spatial distance of colonies in the level of between-colony aggression and to study the impact of territorial species on the other members of the ant community living in their territory.

The following questions were addressed:

- (1) Is there any difference in the level of aggression among ants from nest complexes situated in different spatial distances?
- (2) Could the territorial species' foragers cover the whole area of their territory?
- (3) Which other ant species could colonize and survive in the domain of the territorial species?
- (4) What is the impact of territorial species on other, coexistent ant species?

(5) What is the relation between the populations of other species domain of the territorial species?

3. Material and methods

3.1. Study site

The fieldwork was carried out from 2004 August to 2007 July in three different study sites.

(1) Clearing in Hoia (Hója) Forest (Cluj/Kolozs County, Romania). This site is situated to the West from the city of Cluj-Napoca (Kolozsvár). During the period of the study, more than twenty *Formica pratensis* nests were living here. The number of nests decreased within the three years of the study probably because of the human disturbance by hikers.

(2) Fânațele Clujului (Kolozsvári Szénafüvek) Nature Reserve is situated in the North of Cluj-Napoca, 5 km away from the city. The area is formed by landslide. The human impact is present here too, in spite of the area's protected status. More than 100 *Formica pratensis* nest were living here, however the number of nests decreased dramatically from autumn 2004 to spring 2005. The exact reasons of the nest extinction are still unknown.

(3) Wet meadows near the După Luncă (Fenek) Marsh (Harghita/Hargita County, Romania). The area is situated between Voşlobeni (Vasláb) and Joseni (Gyergyóalfalu) in the

southern part of the Giurgeului (Gyergyói) Depression. *Formica exsecta* nest-complexes of different sizes were observed here. The largest has more than 3000 nests, whereas smaller aggregations contain around 10 nests.

3.2. Applied methods

Aggressiveness tests were carried out with ants from colonies situated in various distances in order to detect the effect of spatial distance on the level of aggression. Nests from Fânațele Clujului were categorized into three groups: first neighbours (the distance was less than 20 meters), second neighbours (the distance was more than 30 meters and between the tested colonies there was one or more other colonies) and non-neighbours (at more than 300 meters distance). As no other *Formica pratensis* population was found in the neighbourhood, only the first two categories were set up in the Hoia forest. There are more *Formica exsecta* nest complexes near După Luncă Marsh, it was possible to analyse the relation between the spatial distance on the one side and the conflict intensity of polydomous colonies on the other. Aggressiveness tests were made in this study site within nest complexes, between neighbouring nest complexes and between nest complexes situated far from one another.

The competitive behaviour of ant species was observed in the absence and in the presence of artificial food source, i.e. baits. The observation plots were put up at different distances from the nests. Tuna fish and honey were used as baits. The individual observations lasted not longer than three hours. During the observations, the individual number of different species and the negative interactions were recorded every 20 minutes for 1 minute.

4. Results and discussion

4.1. Changes in the level of aggression at *Formica pratensis* and *Formica exsecta* ant species

(1). The *Formica pratensis* population from Fânațele Clujului is formed by monodomous colonies. The behaviour of workers from adjacent nests was more aggressive than of those from non-adjacent colonies. One reason for this could be the encounter-induced hostility mentioned by Sanada-Morimura *et al.* in 2003 and van Wilgenburg *et al.* in 2007. According to this theory, individuals from different territorial social insect colonies of stable habitats can learn the colony odour of non-nestmate conspecifics when they meet one another at food sources. Those colonies situated in the neighbourhood are 'well known' by the

workers and as a result they behave more aggressively with them like with specimens from longer distances.

(2) During our study, the population in the Hoia Forest was a supercolony. The hostility of workers was higher towards conspecifics from second neighbour nests during spring observations. Contrary to this, no aggressive reactions between the individuals were found in summer. One possible reason for this could be the higher energy necessity caused by intensive larva breeding in spring, but the phenomenon might also be explained by the lack of intermixing of individuals during hibernation period.

(3) *Formica exsecta* population is also formed by polydomous colonies. The level of aggression was very low among non-nestmates belonging to the same nest-complex. The level of aggression between individuals from neighbouring supercolonies was lower than between those from distant supercolonies. On the one hand, this could mean that the relation between the neighbouring supercolonies is stronger. On the other hand, it is also possible that our two nest complexes situated close to each other have a common origin and they were both part of one bigger supercolony.

4.2. Impact of territorial *Formica* species to the ant community

(1) The research areas in the Hoia Forest and Fânațele Clujului were covered and the ant community was highly dominated by *Formica pratensis*. This species was present in almost every observation plot and no other ant species were really successful here. No other aggressive territorial ant species was detected in these two study areas.

(2) *Formica exsecta* could not cover the whole territory in the small supercolonies and at the border side of the large supercolony. It was present in slightly less observation plots than expected, both with and without artificial food source. In the border side of the large supercolony no bait monopolized by *Formica exsecta* was observed. Despite the fact that in the literature *Formica exsecta* is mentioned as a territorial species, *Formica pratensis* nests were found, and the similarly territorial *Formica sanguinea* monopolised bait in the area dominated by the studied species. Other ant species also became unexpectedly successful. Submissive species were present in almost as many plots and they monopolised more baits in two territories as did the *Formica exsecta*, despite the fact that the latter always reacted aggressively to intruders and won all aggressive interactions. It

might well be that the forager number of these supercolonies is too low to equally dominate the whole territory.

The situation was completely different in the centre of the large supercolony. *Formica exsecta* was observed in all observation plots and only a very low number of other species appeared in a few plots. It is likely that the forager number is enough to allow the absolute dominance upon the territory.

(3) Species appearing in the areas dominated by the two territorial species showed a different behaviour.

Those species that appeared on the territories dominated by the *Formica pratensis* at Fânațele Clujului showed some kind of 'peaceful living together', thanks to the impact of the dominant species' strong superiority. The results of the General Linear Mixed Model analysis show that, in the absence of baits, the forager number of different appearing species had a negative influence upon the distribution of other species in only one case, whereas the forager number of some species had a positive influence upon the distribution of other species. In the presence of baits the forager number of different appearing species did not influence the distribution of other species. In Hoia forest, only *Formica cunicularia* was permanently present in the observation points, other species were only occasionally detected.

Intensive competition was found between the species that appeared on the area dominated by *Formica exsecta*: the General

Linear Mixed Model shows that, in the presence of baits, the distribution of all detected species was negatively affected by the forager number of almost all other species.