WINTER ACTIVITY OF ANTS IN SCOTS PINE CANOPIES IN BORSKÁ NÍŽINA LOWLAND (SW SLOVAKIA)

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Abstract: During the non-growing period (from mid-November 2014 to mid-March 2015), we studied epigeic activity of ants in Scots pine canopies. Ants were collected using pitfall traps situated at seven study plots in the Borská nížina lowland. A total of 12 species belonging to seven genera and two subfamilies were found. Two to six ant species were cumulatively recorded at the examined pine canopies during the non-growing period. The oligotope *Formica polyctena* was the only species with epigeic activity during the whole study period. Low air temperatures and, consequently, the low soil temperatures combined with a weak insolation and strong shadowing inhibit the epigeic activity of ants.

Key words: epigeic activity, non-growing period, ants, Scots pine forests, SW Slovakia.

INTRODUCTION

Temperature is considered to be one of the most important factors affecting foraging activity in ants. In the temperate regions, the majority of ant species are thermophilic and their forage activity optimum is at temperatures ranging from 10 to 45°C (Hölldobler & Wilson 1990). The extreme thermophily has been documented in many ant species (Bernstein 1979, Marsh 1985, Christian & Morton 1992, Bestelmeyer 1997, Cerdá et al. 1998, etc.), while cold conditions inhibit their activity (Hölldobler & Wilson 1990). Cryophily, on the other hand, is a poorly known and rarely recorded phenomenon in ants. So far, only a few species, such as *Prenolepis imparis* (Say, 1836), *Camponotus vicinus* Mayr, 1870, *Nothomyrmecia macrops* Clark, 1934, and *Prenolepis nitens* (Mayr, 1853) have their peak activity when temperatures are relatively low for most ants, i.e., from freezing to ca. 15–20°C (Talbot 1943a, 1943b, Bernstein 1979, Hölldobler & Taylor 1983, Lőrinczi 2016).

The winter activity of ants associated with coniferous canopies has not yet been studied in Slovakia. Likewise, there are only a few data from Slovakia about overwintering leaf-eating insects dwelling on branches of coniferous trees (e.g. Dvořáčková & Kulfan 2009, Parák et al. 2015, Šebestová et al. 2015, J. Kulfan et al. 2016, M. Kulfan et al. 2016, Holecová et al. 2016).

The aims of the present study are to (1) characterize the winter activity of ants in Scots pine canopies at the territory of the Borská nížina lowland; (2) analyze epigeic activity of ants in forest stands

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of different age, canopy and fragmentation as well as to (3) find out whether there are differences in species richness and cumulative abundance of ants between individual forest stands and in individual samplings during the non-growing period.

MATERIAL AND METHODS

Area description

Ants were studied in Scots pine forests of different age and structure, growing on the sandy soils in the Borská nížina lowland, southwestern Slovakia. In total, seven study plots were investigated. They belong to the biotope of managed pine forests and semi-native pine-oak forests. The study area is warm with moderately dry climate and mild winters, whereby the average temperature in January is usually above -3°C. The average annual temperature is 9°C and annual rainfalls are about 550 mm (Lapin et al. 2002). Study plots were visited from the part of November 2014 to the middle part of March 2015. The non-growing period of the study area was warmer when compared to the long-term average (1971–2000). The average air temperature increased by about 2.8°C (from 3.5°C in November 2014 to 2.2°C in March 2015). The highest number of days with average temperature below freezing occurred in February 2015 (9 days). In December 2014 and January 2015, there were 6 days with freezing, while there were no days with temperatures below freezing in November 2014 and March 2015. Meteorological data, as measured at the station Moravský Svätý Ján, were provided by the Slovak Hydrometeorological Institute in Bratislava (Figure 1).

Our field study was carried out at seven study plots (SP 1–7). Four of them were situated near the Lakšárska Nová Ves village and the other three plots near the Studienka village. All study sites were located in Scots pine forests of different age, canopy and fragmentation.

SP 1 (Lakšárska Nová Ves), 48°34'56" N, 17°10'33" E, 222 m a.s.l.: about 25-year old pines solitarily growing on sand dunes that gradually reach the adjacent stand about 100-year old.

SP 2 (Lakšárska Nová Ves), 48°34'54" N, 17°10'34" E, 218 m a.s.l.: about 10-year old pines forming a dense forest stand close to a canopied stand.

SP 3 (Lakšárska Nová Ves), 48°34'51" N, 17°10'22" E, 218 m a.s.l.: about 25-year old pines forming a forest stand wall adjacent to a meadow.

SP 4 (Lakšárska Nová Ves), 48°34'55" N, 17°09'52" E, 218 m a.s.l.: a dense forest stand of 15-year old pines, strongly canopied and without contact with open landscape.

SP 5 (Studienka), 48°32'25" N, 17°08'29" E, 218 m a.s.l.: about 100-year old pines forming a stand with grassy undergrowth and surrounded by a meadow.

SP 6 (Studienka), 48°32'16" N, 17°08'15" E, 218 m a.s.l.: about 15-year old pines growing in irregular clusters with grassy undergrowth.

SP 7 (Studienka), 48°32'30" N, 17°08'13" E, 219 m a.s.l.: the youngest forest with 5-year old pine trees, canopied and strongly insolated.

Methods

Ant workers were pitfall-trapped. At each study plot, five formaldehyde traps were installed every 10 m in a line. The traps consisted of plastic cups with a diameter of 8 cm and a volume of 200 ml. They were buried at a level of the soil surface and filled with about 80 ml of 4% formaldehyde. The traps were exposed from the middle part of November 2014 to the middle part of March 2015, and were emptied monthly. After separation, ant workers were preserved in 70% ethanol and examined in the laboratory, using a stereomicroscope Leica MZ 9. Ant workers were identified to species level using the keys of Seifert (2007) and Czechowski et al. (2012). Characteristics of zoogeographic distribution and ecological groups of ant species is according to Czechowski et al. (2012). Voucher specimens of all ant species detected in the present study are deposited at the Department of Zoology, Comenius University in Bratislava.

Data analysis

Ant fauna of individual study sites was compared by non-metric multidimensional scaling (nMDS) using the computer programs NCLAS (Podani 1993) and STATISTICA (StatSoft Inc 2001). Analyses were based on the Bray-Curtis dissimilarity index (Bray & Curtis 1957, Faith et al. 1987).

RESULTS AND DISCUSSION

A total of 776 ant workers belonging to 12 species and 7 genera were collected at the seven study plots. Oligotopic species predominated in the examined material. The highest species richness was observed at study sites with solitarily growing (non-canopied) pines and/or weakly canopied pines, i.e., SP 1 harboured six species and SP 6 five species. Only two taxa have been active in young and middle-aged, strongly canopied forest stands without any contact to open landscape (SP 2 and 4). This phenomenon may be caused by worse microclimatic conditions, that is, weaker warming of soil surface due to the reduced insolation and shadowing (Table 1).

Formica polyctena predominated in the examined material and accounted for 94.34% of all collected

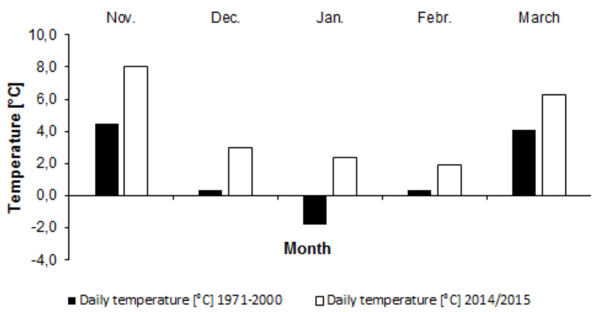

Figure 1. Long-term average monthly temperatures (1971–2000) and average monthly temperatures in examined months and years of the research (according to the measurements of the meteorological station in Moravský Svätý Ján).

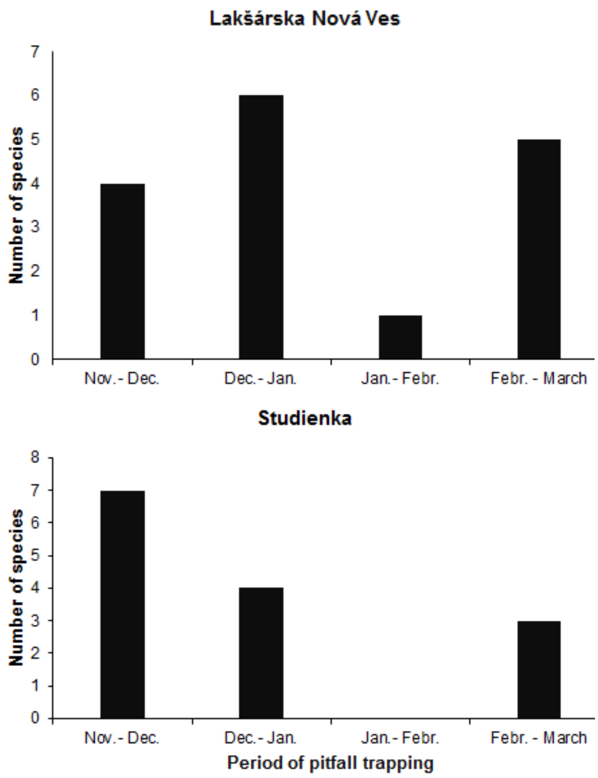

Figure 2. Species richness recorded in individual samplings of two examined localities - Lakšárska Nová Ves (together SP 1 – SP4) and Studienka (together SP 5 – SP 7) during the non-growing season.

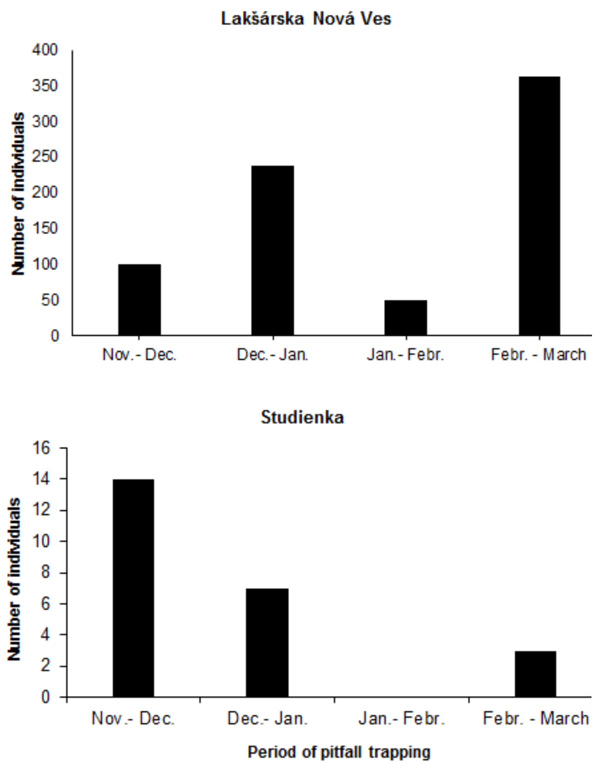

Figure 3. Cumulative abundance of ants in individual samplings of two examined localities during the non-growing season.

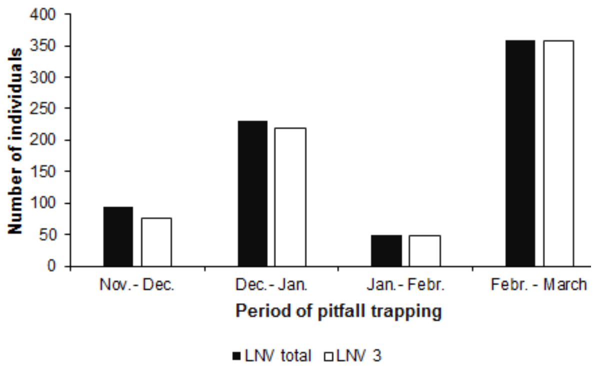

Figure 4. Cumulative abundance of *Formica polyctena* in Lakšárska Nová Ves (together SP1–SP4) and in SP 3 (Lakšárska Nová Ves, the middle-aged forest stand in contact with open landscape).

individuals. This oligotopic species prefers coniferous and partly mixed forests. Its epigeic activity was recorded at three pine canopies near the Lakšárska Nova Ves village. The predominance of *Formica polyctena* was noticed in the middle-aged dense canopy adjacent to an open landscape (SP 3). Highly polygynous colonies of this species form a polycalic (multi-nest) system that sometimes covers large areas of forests (Czechowski et al. 2012). *Formica polyctena* is characterized by an enormous thermoregulation ability allowing its development even during winter under continuous snow cover in mountain forests and in the far north of Europe (Seifert 2007).

One to nine species were found in individual periods of pitfall trapping. In the second half of January and first half of February, we also recorded the lowest cumulative number of active individuals, all belonging only to one species, *Formica polyctena* (Table 2, Figures 2, 3, 4). Low epigeic activity in the winter months (mid-January to mid-February) is due to the greater number of days with low

Table 1. List of the recorded ant species at individual study plots and their ecological characteristics.

ZG – zoogeographical elements: NP – North-Palaearctic, EC – Euro-Caucasian, SP – South-Palaearctic, MD – Mediterranean; ECOL – ecological plasticity: P – polytopic, O – oligotopic, HUM – humidity preference: hyg-mes – hygro-mesohygrophile, mes – mesohygrophile, mes-xer – mesohygro-xerophile; TEMP – temperature requirements: oli-mte – oligo-mesothermophile, mte – mesothermophile, mte-ter – mesothermo-thermophile, ter – thermophile.

Species / study plot	SP 1	SP 2	SP 3	SP 4	SP 5	SP 6	SP 7	Σ	%	ZG	ECOL	HUM	TEMP
Myrmica ruginodis (Nylander, 1846)	0	0	0	0	2	2	0	4	0.52	NP	P	hyg-mes	oli-mte
Myrmica sabuleti (Meinert, 1861)	1	0	3	3	4	6	0	17	2.19	EC	O	mes-xer	mte-ter
Temnothorax unifasciatus (Latreille, 1798)	1	0	0	0	0	0	0	1	0.13	EC	O	mes-xer	mte-ter
Tetramorium cf. *caespitum* (Linnaeus, 1758)	1	0	0	0	0	0	0	1	0.13	SP	P	mes-xer	mte-ter
Prenolepis nitens (Mayr, 1853)	3	0	0	0	0	0	0	3	0.39	MD	O	mes-xer	ter
Lasius alienus (Förster, 1850)	0	0	0	1	0	0	1	2	0.26	SP	O	mes	mte
Lasius niger (Linnaeus, 1758)	2	0	1	0	0	0	1	4	0.52	NP	P	mes	mte
Camponotus ligniperda (Latreille, 1802)	0	0	0	0	0	1	1	2	0.26	EC	O	mes	mte
Formica polyctena (Förster, 1850)	24	7	702	0	0	0	0	733	94.46	NP	O	mes	mte
Formica pratensis (Retzius, 1783)	0	0	0	0	2	1	0	3	0.39	SP	P	mes-xer	mte-ter
Formica rufa (Linnaeus, 1761)	0	0	0	0	0	0	2	2	0.26	NP	O	mes	mte
Formica sanguinea (Latreille, 1798)	0	3	0	0	0	1	0	4	0.52	SP	P	mes-xer	mte-ter
Σ individuals	32	10	706	4	8	11	5	776					
Σ species	6	2	3	2	3	5	4	12					

Table 2. Distribution of ant species in individual sampling periods during the non-growing season.

Black patch means over 50 individuals collected in relevant sampling period together, yellow patch means from 5 to 50 individuals, red patch means up to 5 individuals.

Species / sampling period	Nov.-Dec.	Dec.-Jan.	Jan.-Feb.	Feb.-Mar.
Myrmica ruginodis				
Myrmica sabuleti				
Temnothorax unifasciatus				
Tetramorium cf. *caespitum*				
Prenolepis nitens				
Lasius alienus				
Lasius niger				
Camponotus ligniperda				
Formica polyctena				
Formica pratensis				
Formica rufa				
Formica sanguinea				
Σ individuals	114	244	50	368
Σ species	9	9	1	7

temperatures that often fell below freezing. At the end of winter and in the early spring, we recorded an increase in the number of species and their epigeic activity.

The ant fauna of individual study plots was compared by non-metric multidimensional scaling (nMDS) based on Bray-Curtis dissimilarity. The scatter shows a strong difference between ant faunas at SP 1 and SP 3, both characterized by a higher epigeic activity of *Formica polyctena* workers, and fauna of the remaining study sites (SP 2, SP 4, SP 5, SP 6, SP 7) where the epigeic activity of ants was very low during the non-growing period (Figure 5).

Low air temperatures and consequently low temperatures of the soil surface combined with weak insolation and strong shadowing significantly inhibit the epigeic activity of ants in temperate regions of the word (Hölldobler & Wilson 1990, Seifert 1996). On the other hand, even in the winter months, local climatic conditions (southern exposure, insolation, heating of the soil substrate) and especially the increased air and soil temperatures may stimulate the foraging activity of some species that are tolerant to cooler conditions and

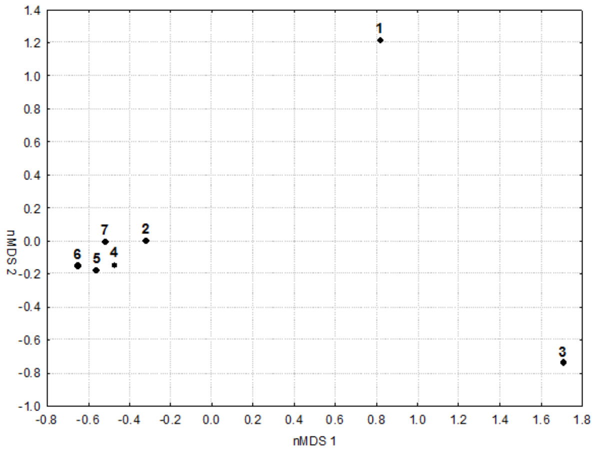

Figure 5. Results of nMDS analysis based on Bray-Curtis distance showing dissimilarity of ant fauna in individual study plots during the non-growing season. For numbers of study plots, see Material and methods.

have a greater ability of thermoregulation inside their nests (Talbot 1943a, b). This phenomenon has been observed and further confirmed also by our preliminary research.

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