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&
International Society of Arachnology**



Book of Abstracts

Editor: Marek Żabka

Siedlce 2010

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ISBN: 978-83-7051-575-1

The publication co-financed by the Polish Ministry for Science and Higher Education (grant for the University of Podlasie), the International Society of Arachnology and the City of Siedlce

Akademia Podlaska
ul. Konarskiego 2, 08-110 Siedlce
Format B-5
Druk: ELPIL, Siedlce

Harvestmen (Opiliones) thermo-preference reactions under industrial pollution

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Introduction

An ecosystem transformation under industrial pollution is one of classic issues in contemporary ecology. At the same time much attention is focused on functional or taxonomic/population changes in communities. The physiological reactions are important basic components in population adaptation. The preference reactions may be used as the indicator of ecological features of species or populations. The long-term emissions of a copper-smelting factory changes plant cover and temperature conditions and should affect thermo-preference reactions of epigeic invertebrates. Harvestmen have a short range of individual activity (approximately 200 m), cannot move over long distances by air like insects or spiders so they are convenient research subject. Our goal in this study is to test the assumption that harvestmen dwelling in close vicinity of the copper-smelting factory have specific thermo-preference reactions.

Methods

The investigation was carried out in Pervouralsk district of Sverdlovsk region (Middle Urals, Russia) near the Revda town during two summers (2007, 2008). The native biotopes in this region are fir forests with admixture of birch, aspen and pine. Two sites located at the different distances from the Sredneuralsk copper-smelting factory (SUMZ) were used: *background zone* (30 km) where pollution is at the average regional level and *impact zone* (2 km) where the amplitude of daily temperature fluctuations in forest litter is higher than on the unpolluted area. The most numerous three species of harvestmen has been chosen for study: *Nemastoma lugubre*, *Oligolophus tridens* and *Lacinius ephippiatus*. Harvestmen were caught by soil traps (2 days exposition). Live individuals were delivered to a laboratory and placed inside experimental device with temperature gradient from +8°C to +30°C. Six rounds of measurements during day and night with 3 hours intervals were taken. The experiments have been executed on August, 14th, 17th, 21st, 23rd, 29th and on September, 7th in 2007 (evaluation units (*n*) is individual): 25 *L. ephippiatus*, 89 *N. lugubre* and 5 *O. tridens* from the background population and 5 *O. tridens* from the impact population. Eleven rounds have been executed in 2008: on July, 14th, 17th, 22nd, 25th, 28th, on August, 10th, 13th, 17th, 21st, 26th and on September, 3rd (47 *L. ephippiatus*, 70 *N. lugubre* and 57 *O. tridens* from the background and 5 *O. tridens* from the impact population). For the temperature registration in litter top horizon (depth 1 cm) during the period of laboratory research in 2007 we installed the wireless sensors THERMOCHRON DS 1921 GF50. The statistical

analyses were carried out using Generalized Regression Models in Statistica© program (StatSoft, Inc. 2001). The mean daily temperature (meteorological data), time within a day and a species (or pollution zone for two *O. tridens* population) were used as continuous or categorical predictors for explanation of variability in harvestmen preference temperature.

Results

Litter temperature

The temperature in forest litter where harvestmen spend many time at their early stages has considerable influence on their activity. The similar average temperature of the litter top horizon (registration unit (n) is sensor) in the background zone ($16.0 \pm 0.3^\circ\text{C}$, $sd=1.4$, $n=6$) and in the impact zone ($16.2 \pm 0.5^\circ\text{C}$, $sd=2.4$, $n=4$) was observed ($F(1; 648)=0.2$) but the variability of daily (time*zone $F(23; 648)=6.3$) and seasonal (season*zone: $F(4; 648)=20.8$) temperatures is higher in the impact zone.

Preference reactions

The daily average air temperature during the capture set in 2007 was less by 1.3°C than that in 2008 ($F(1; 2422)=59.4$). It is remarkable that in 2007 the preference values of *O. tridens* (hereinafter $M \pm se$: 16.8 ± 0.9) and *N. lugubre* ($17.8 \pm 0.3^\circ\text{C}$) were a little lower (18.1 ± 0.4 , $18.2 \pm 0.2^\circ\text{C}$ in 2008 accordingly). On the contrary *L. ephippiatus* in 2007 chose higher temperatures ($20.1 \pm 0.5^\circ\text{C}$) than in 2008 ($18.7 \pm 0.4^\circ\text{C}$). The thermo-preference of all three species varied slightly among two years ($F(1; 2309)=2.66$). Significant interspecies differences in thermo-preference were observed ($F(2; 2310)=16.1$). *L. ephippiatus* is more thermophilic species ($19.2 \pm 0.3^\circ\text{C}$). *O. tridens* and *N. lugubre* showed similar reactions ($18.0 \pm 0.4^\circ\text{C}$ and $18.0 \pm 0.2^\circ\text{C}$ accordingly). Contrary to expectations thermo-preference of *O. tridens* inhabiting impact and background zone was similar ($18.4 \pm 0.7^\circ\text{C}$, $F(1; 532)=0.0002$). The influence of average daily air temperature on harvestmen thermo-preference is revealed ($F(1; 2310)=8.58$), with decrease air temperature it decrease too.

Circadian dynamics in harvestmen preference temperature

All three species show similar circadian dynamics of preferred temperatures (time: $F(7; 2310)=4.9$): the harvestmen chose high values at night but low values at day, such feature is peculiar to crepuscular and nocturnal invertebrates. There is only one coherent peak in all three species preference temperature dynamics within 3 a.m. and 6 a.m. *L. ephippiatus* chose minimum temperatures within the period since 12 a.m. till 3 p.m., background population of *N. lugubre* and *O. tridens* – since 3 p.m. till 6 p.m. *O. tridens* inhabiting impact territory displayed maximum width daily range thermo-preference (5.1°C). The thermo-preference circadian dynamics in both populations of *O. tridens* are similar (zone: $F(1; 532)=0.0002$; time zone: $F(7; 532)=1.28$).

Harvestmen's norm of reaction to temperature

Thermal preference reactions allow characterized organism as eury- or stenothermic and we used a standard deviation as evaluation for it. *N. lugubre* has a lowest standard deviation (2.0°C), impact population of *O. tridens* (2.3°C)

and *L. ephippiatus* (2.6°C) characterized by intermediate value, background population of *O. tridens* has a largest standard deviation (2.8°C).

Discussion and conclusions

According to effects relative importance in explanation of thermo-preference variability, mean daily air temperatures and its seasonal dynamics has the greatest relevance ($p=0.004$), the circadian rhythm ($p=0.014$) and interspecies differences ($p=0.013$) are significant too. Thus the influence of daily average air temperature evidences the harvestmen acclimation to environmental temperature dynamics and it is similar to reactions in insects. There is a point of view that the temperature mode in early ontogenesis, average summer temperature, physiological condition, age, gender etc affects on thermo-preference. Because of the standard deviations of all three species are similar (Hartley statistic $F_{\max}=1.9$), it is possible to say about narrow/wide species norm of reaction only as a weak tendency. The distribution of the three species somehow corresponds to its presence in polluted zones: *N. lugubre* has not been catch in the impact area while *L. ephippiatus* and *O. tridens* has been found in the odds 1:10. *L. ephippiatus* is larger than *O. tridens* and its distribution possibly more depends on food supply and spatial restrictions (favourable places for oviposition and young development). The relative narrow norm of reaction in *O. tridens* impact population may be partially explained by its low abundance and genetic diversity. Local microclimate differences in two habitats are not enough for induced strong harvestmen physiological response. Nevertheless some weak tendency exists, and it is possible that under more contrast environmental conditions the difference will be stronger.

Acknowledgements

This work was supported by the program "Biological diversity". We are grateful to A.B. Kohan for his help in experiment execution and to K.V. Maklakov for manuscript translation improvement.