

ESTIMATION OF SEASONAL CHANGES OF POPULATION FEEDING
ACTIVITY OF THE ORIBATID MITE *GALUMNA ELIMATA*
(ACARI: ORIBATIDA)

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ORIBATIDA,
GALUMNA,
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SEASONAL CHANGES,
ABUNDANCE,
DECOMPOSITION,
MEADOW

SUMMARY: The abundance of oribatids in natural biotopes in the temperate region is characterised by two peaks, in spring and in autumn. We tested, whether these abundance peaks are accompanied by high feeding activity of *Galumna elimata* population. The defecation was used as an indirect estimation of the feeding activity. The model of seasonal changes of population defecation activity was constructed. Temperature dependence of defecation measured previously in laboratory and *Galumna* abundance data from 4 meadow plots in Central Bohemia were used for the model. The mites were sampled monthly from 1992 to 1993. The monthly defecation per *Galumna* population on each plot was adjusted to mean monthly temperatures and to mean monthly abundance. The estimated maximal population faecal pellets production was not correlated to the abundance peaks on three from four plots. The model showed that mites defecated particularly from May to September. In the autumn, when abundance was high, negligible defecation was found. The model of seasonal changes indicates that oribatid defecation may influence activity of microorganisms mainly in late spring and in summer.

ORIBATIDA,
GALUMNA,
DÉFÉCATION,
VARIATIONS SAISONNIÈRES,
ABONDANCE,
DÉCOMPOSITION,
PRAIRIES

RÉSUMÉ: L'abondance des oribates des biotopes naturels des régions tempérées est caractérisée par les deux pics de printemps et d'automne. Nous avons testé l'hypothèse qu'une activité alimentaire importante accompagne les pics d'abondance des populations de *Galumna elimata*. La défécation est utilisée pour estimer indirectement l'activité alimentaire. Le modèle des changements saisonniers de l'activité de défécation a été construit. La relation de dépendance de la défécation et de la température a été mesurée préalablement en laboratoire, et les données d'abondance de *Galumna* dans 4 sites de prairie en Bohême centrale ont été utilisées dans le modèle. Les acariens sont échantillonnés mensuellement de 1992 à 1993. La défécation mensuelle a été ajustée aux moyennes mensuelles de températures et aux moyennes mensuelles d'abondance. Le taux maximal estimé de production de boulettes fécales n'est pas corrélé aux abondances dans 3 sur 4 des sites expérimentaux. Le modèle montre que la défécation des acariens

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est importante de mai à septembre. À l'automne, en période de haute abondance, la défécation est négligeable. Le modèle des variations saisonnières montre que la défécation des oribatides est susceptible d'influencer l'activité des microorganismes principalement à la fin du printemps et en été.

INTRODUCTION

Soil oribatids are well known to influence plant litter decomposition. They affect decomposers community by grazing and dispersion of microorganisms (PETERSEN & LUXTON 1982, LUSSENHOP 1992) and their faeces represent an important nutrient source for microorganisms (WEBB 1977, HANLON 1981, TEUBEN & VERHOEF 1992). The complex of interaction between the soil microorganisms and the oribatids affect carbon cycling, mineralization, the physical properties of the soil and its biological environment. The understanding of this relationship is a formidable task, but it is necessary for an understanding of the soil system (MITCHELL & PARKINSON 1976).

In temperate zones, the population density of oribatid mites fluctuates during a year (CURRY 1971). There are two peaks, one in spring and the other in autumn, which are believed to be a result of suitable abiotic conditions (temperature and humidity), the autumn peak is, furthermore, a result of litter addition to the soils in temperate forests (LUXTON 1981a).

The gut contents analysis showed that the food is present in the gut of many oribatid species during the whole year (LUXTON 1991, SMRŽ & MATERNA 2000, HUBERT 2000). An energetical study also showed that oribatids may feed continuously during the whole year receiving low but continuous supply of energy which is utilized immediately and completely (WALLWORK 1975, NORTON 1994). In spite of continual feeding, the rate of individual use of energy (i. e. consumption, production, defecation) depends on temperature and is assumed to be the greatest in warm summer months (LUXTON 1981b). Thus the maximal metabolic activity of the whole population does not correspond to the maximum abundance (BERTHET 1964, MITCHELL & PARKINSON 1976, LUXTON 1979, MITCHELL 1979, THOMAS 1979). The feeding activity of mites shall be the highest in summer

(when abundance of oribatids is low), whereas population density of mites are highest during colder months in autumn and winter (when feeding rate shall be low).

In this study we combine data on abundance and monthly average temperatures with the data on metabolic activity in order to model the seasonal metabolic activity of mites in the condition of seminatural meadows in temperate (central European) climate. Almost all of the population-energetic studies were done in conditions of West European maritime climate and in forest biotopes (BERTHET 1964, LUXTON 1979, LUXTON 1981b, THOMAS 1979), where the microclimate is more stable than in central European open habitats. We used data on abundance of a model species, *Galumna elimata* (C. L. Koch, 1841), which is a dominant species in meadow habitats (HUBERT & TUČKOVÁ 2003). As a measure of its metabolic activity we used data on production of faecal pellets gained under various temperatures in the laboratory. The defecation is an indirect estimation of feeding rate (LUXTON 1972, HUBERT *et al.* 1999).

MATERIAL AND METHODS

Abundance data

We observed monthly abundances of *G. elimata* on four study plots. The plots were situated on two meadows near Říčany town (Central Bohemia, Czech Republic), 406 m. a. s. l. (see HUBERT 2000 for detail description). The meadows were visited once per month from September 1992 to September 1993. Each plot was ca. 1.5 × 2 m large. From each plot 12 samples, arranged in a lattice of 4 × 3 points, 45 cm distant from each other, were taken using Kopecky cylinder (diameter 5 cm, height 5 cm). Altogether 624 soil samples were collected during our study. Mites were extracted in Berlese-Tullgren funnels and identified to species level (see HUBERT 2002).

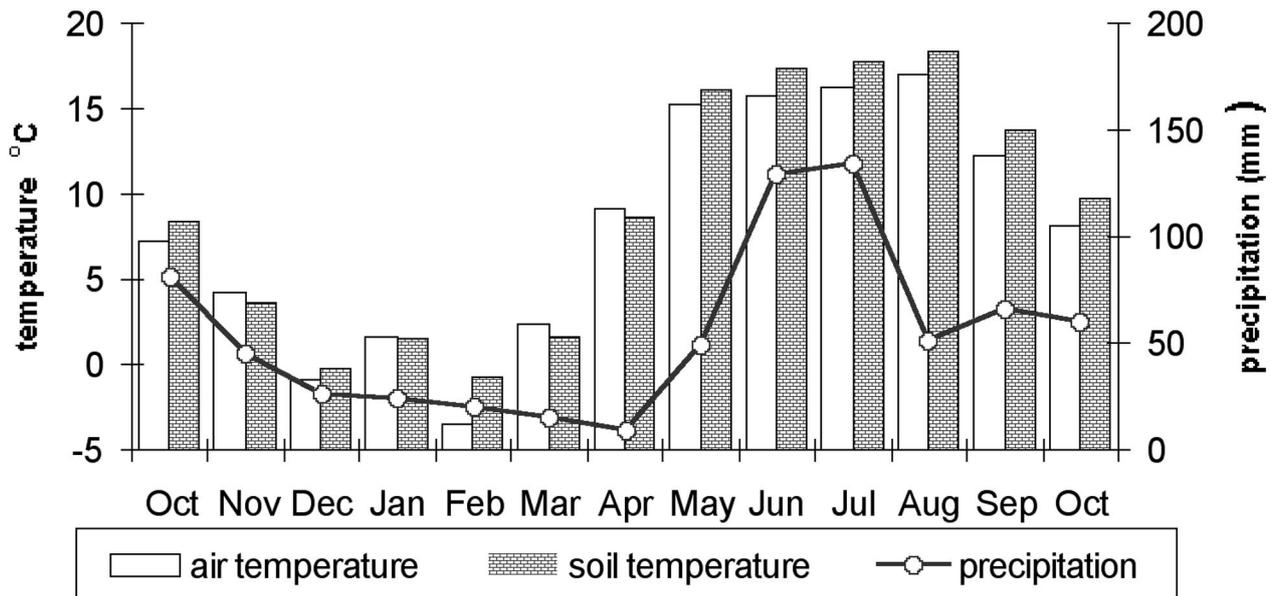


FIG. 1: Climatic conditions during the observed season (values represent monthly averages).

Meteorological data

The distance between the meadows is approximately 500 m, so the same temperature records were used for all study sites. The meteorological data were obtained from the local Meteorological station that provided us with monthly average temperatures (FIG. 1) measured in the air (2 m above ground) and in the soil (5 cm deep).

Physiological data

The mites were extracted from soil samples using modified Berlese-Tullgren funnels at 35 °C using water as collecting fluid that was replaced daily for 3 days. The adults were kept in vials (volume 250 ml) containing plaster of Paris mixed with charcoal (ratio 9: 1) covered by a mesh. Pieces of bark with the green bark alga *Desmococcus vulgaris* (syn. *Protococcus viridis*) were offered as food. The vials were stored in a refrigerator at 8 °C for one week before the experiments. The bark pieces were removed 24 hours before the start of experiments.

For the defecation observations mites were reared individually in boxes with the green bark alga and filter paper on the bottom (HUBERT et al. 1999). The boxes were placed into a container and moistened at the start of the experiments in a 3-day interval. The containers were placed into experimental temperatures 5, 8, 15, 20, 25 and 30 °C. The number of faecal pellets was counted after three days in twelve replicates per one experimental temperature. After another 18 days of acclimatisation the mites were moved to new boxes and faecal pellets were counted again for another three days. The defecation was expressed as a number of faecal pellets per three days.

Model

The defecation data were used to model the change of faecal pellets production with temperature. To model the seasonal metabolic activity of a single mite the model on defecation was combined with monthly average temperatures observed on the study sites. Obtained monthly values were multiplied by the

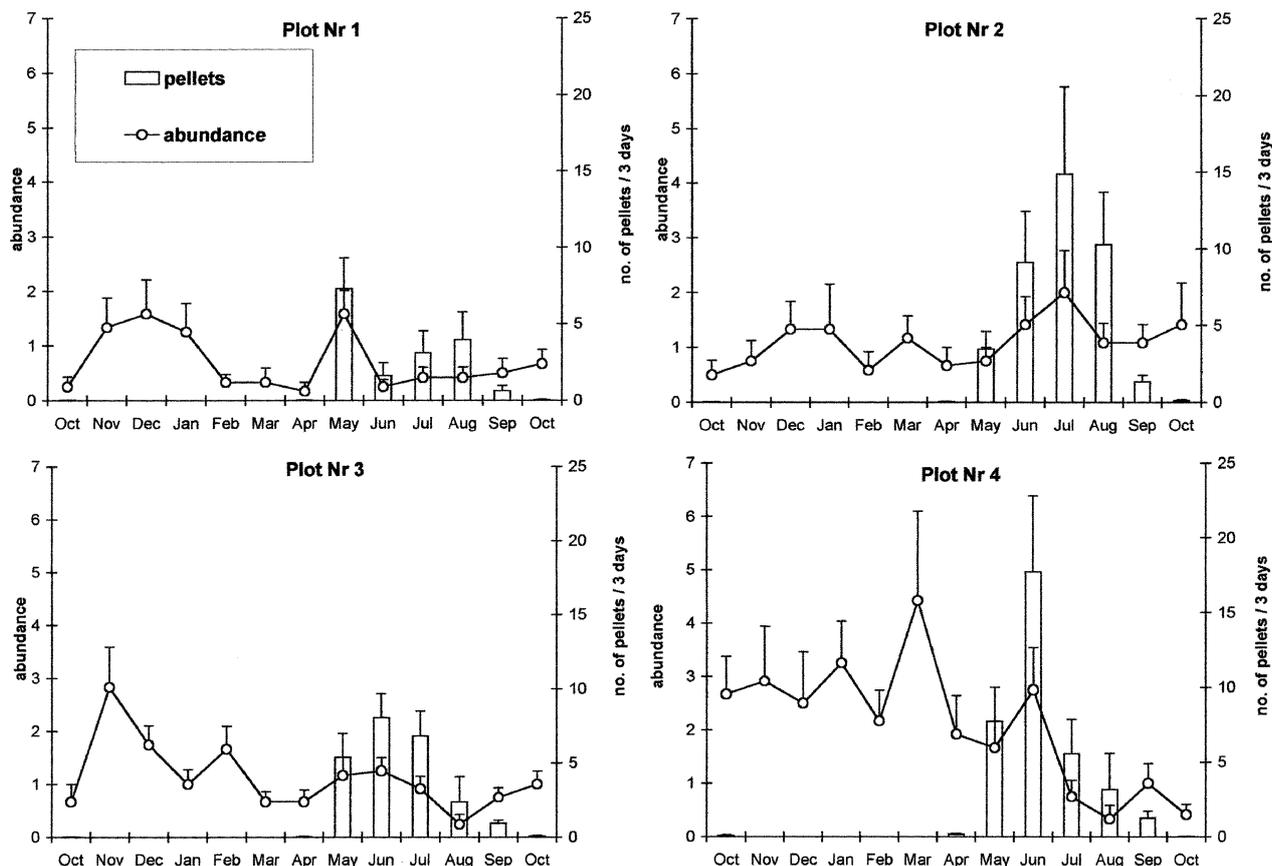


FIG. 2: Abundance of *Galumna elimata* and the estimated number of produced pellets in three days in the particular month on four meadow plots. Points and bars are means + SE.

number of *Galumna elimata* individuals and all oribatid mite individuals (given that all species have similar metabolic activity as *G. elimata*) collected per sampling date.

RESULTS

The abundance of *Galumna elimata* fluctuated in the course of the year in the soil on the four study plots. Two peaks of abundance, one in winter and the other in summer, were recognised. The winter peak was clearer than the summer one (FIG. 2).

The faecal pellets production of *G. elimata* specimens depend on the experimental temperature under laboratory experiments (FIG. 3). For description defecation and temperature correlations, several non-

linear models were tested. The best fit ($R^2=0.81$) was obtained with the exponential polynomial model, $y = \exp(a + bx + cx^2)$ after France & Thorney (1984). The parameters are given in TABLE 1. At 5 and 8 °C no defecation was observed. The faecal pellets production increased from 10 °C reaching its maximum between 20 and 25 °C.

The modelled production of pellets, however, followed a different pattern than the seasonal change of abundance (FIG. 2). Defecation occurred only from April to October, with peaks between May and July. The abundance was not correlated with the production of pellets on the study plots (Pearson correlation, $r < 0.25$, NS), except for the plot no. 2 (Pearson correlation, $r = 0.6$, $P = 0.03$).

The mean annual abundance of *Galumna elimata* was not correlated with the estimated annual produc-

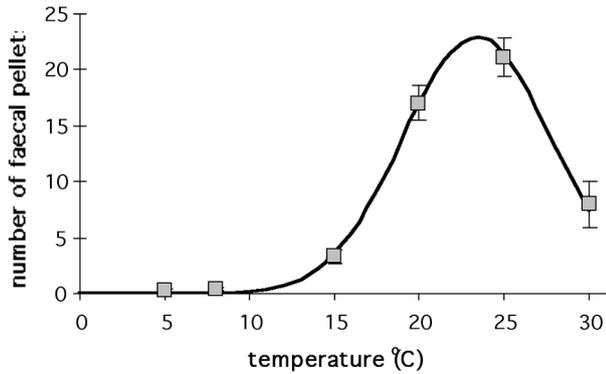


FIG. 3: Change of faecal pellets production of *Galumna elimata* with the experimental temperature. Data are means \pm SE. The line represents fitted exponential polynomial model.

	parameter	SE	P
a	-7.22	0.05	<0.0001
b	0.82	0.01	<0.0001
c	-0.02	0.01	<0.0001

TABLE 1. Values of parameters of the model ($y = \exp(a + bx + cx^2)$), their standard errors and probability of difference from '0'.

	plot			
	Nr.1	Nr.2	Nr.3	Nr.4
Dominance %	1.14	2.37	1.81	3.90
Frequency %	38	49	63	63
Mean annual abundance	9.08	14.08	14.58	26.75

TABLE 2. Population characteristics of *G. elimata* at the study plots.

	plot			
	Nr. 1	Nr. 2	Nr. 3	Nr. 4
<i>Desmococcus</i>	171	401	241	362
<i>Hypericum</i>	97	227	136	205
<i>Acetosella</i>	84	198	119	179
<i>Holcus</i>	27	63	38	57
filter paper	51	119	71	107

TABLE 3. Estimated number of annual faecal pellet production in *Galumna elimata* on various food sources.

plot	Mean annual abundance	Annual number of faecal pellets
Nr. 1	735	14028
Nr. 2	533	8963
Nr. 3	790	9045
Nr. 4	635	6795

TABLE 4. Total abundance of all oribatid mites and estimated number of annual faecal pellet production.

tion of faecal pellets (Pearson correlation, $r=0.38$, NS). The highest abundance was on the plot Nr. 4, while the highest defecation was on the plot Nr. 2 (TABLE 2, Figs 2 and 3).

DISCUSSION

The observed results indicate that the faecal pellets production does not correlate with the abundance of mites in the conditions of temperate seminatural meadow soils. This trend is even more apparent when the model of *G. elimata* faecal production was used to simulate faecal pellets production of all oribatid mites found on the study plots (FIG. 4). The total number of sampled mites was not correlated with the annual estimates of the pellets production (TABLE 4).

The absence of compensation mechanism at low temperatures (Šustr, unpublished) shows that at low temperature the feeding activity of *G. elimata* is low. In our experiments the mites almost did not produce any pellets at low temperatures which suggest that the feeding activity is negligible. The model shows that the studied mites in the condition of mentioned above are metabolically inactive during more than eight months, from April to October.

However during “metabolically inactive period”, the oribatids store the food in their guts (SMRŽ 1996). The highest proportion of mites with full guts actually occurs in December (LUXTON 1991). SMRŽ & MATERNA (2000) found the highest amount of glyco-genous granulae in the mesenchym tissue of *Melanozetes meridianus* Sellnick, 1929 in autumn and early winter. These storage deposits indicate that mites did not starve (HUBERT & ŠUSTR 2001) during metabolically inactive period. In fact, the metabolic cost is very low due to low temperature in this period (ŠUSTR, unpublished).

The presented model is based on feeding behaviour observed at (1) constant temperature, (2) using one type of diet, and (3) monthly average temperatures. The feeding behaviour may be different under fluctuating temperature, but such data are missing. Direct observation on defaecation under fluctuating temperature would improve the model. The defecation changes with the type of food. We observed that *G. elimata* has its highest defecation rate when feeding on *Desmococcus vulgaris* in comparison with *Hypericum*

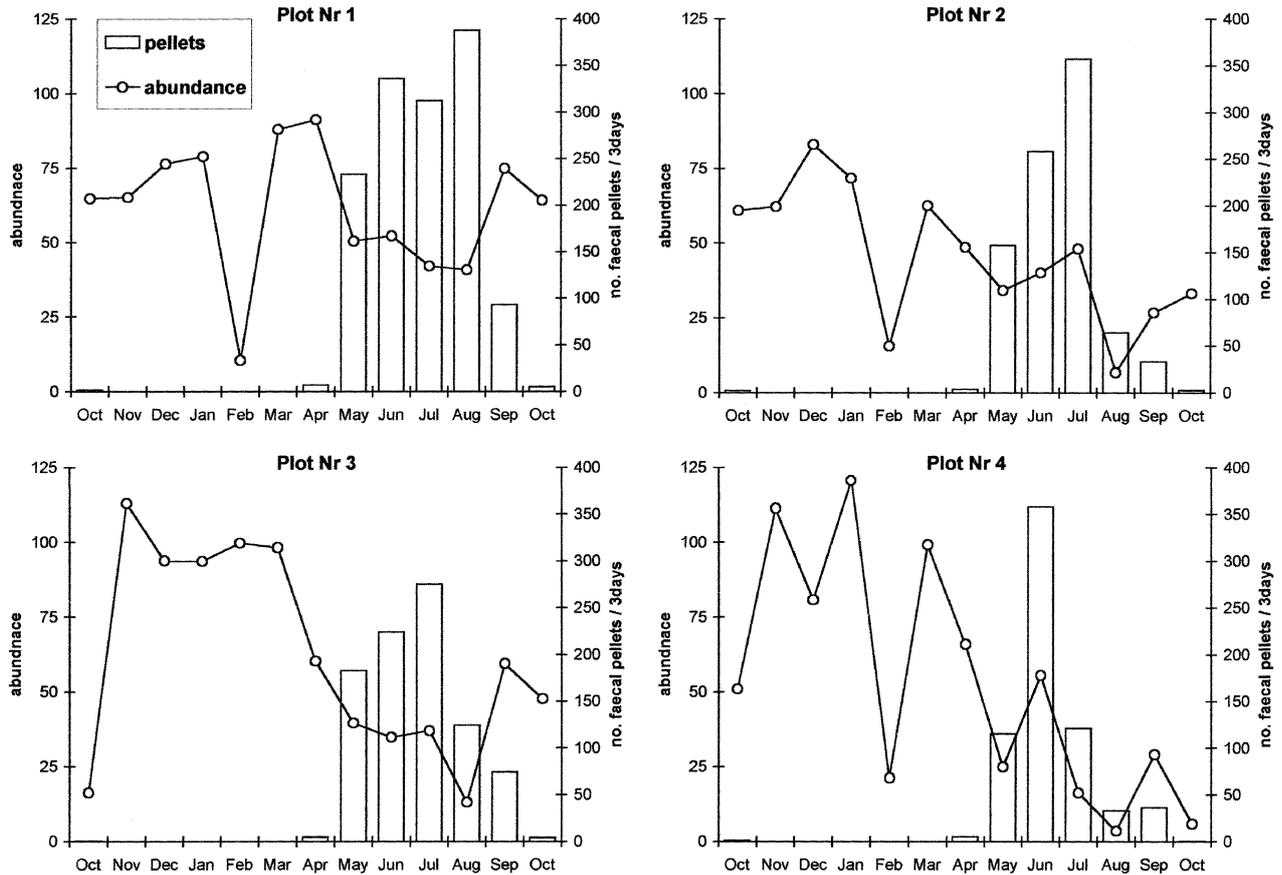


FIG. 4: — Abundance of all oribatid mites and estimated number of produced pellets in three days in the particular month on four meadow plots.

cum maculatum, *Acetosella vulgaris*, filter paper, and *Holcus lanatus* (data presented in Hubert et al. 2001). For more precise estimations of the defecation activity daily temperature reading would be necessary.

Our results show that the faeces produced by mites may affect population dynamic of microorganisms particularly in summer months in the condition of central European meadows.

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