

The phenology of geobiont beetles (Coleoptera) and other arthropods (Arthropoda) in the Vysoké Tatry Mts

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Abstract

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Soil photoelectors as a method to observe phenology of hypogaeous adults hatching have been tested and discussed in the Vysoké Tatry (High Tatras) Mts (N Slovakia). In total, 5,028 arthropods were collected in traps installed at 3 sampling sites. The average daily abundance declares an intensive impact of fire destruction on the activity of soil arthropods, particularly geobionts such as springtails (Collembola). The wind calamity has led to changes in dynamics as well; in this case, dipterans (Diptera) have been affected especially. Springtails (Collembola), beetles (Coleoptera) and 2 other insect orders (Diptera and Hymenoptera) generally dominated at all sampled sites. The forest fire has damaged the upper soil horizon, including the mass of decaying leaves and needles. The affected assemblage shows lower values of arthropod abundance. Revitalization of the sites depends on pressure of bacteria and fungi mineralizing vegetation biomass after the fire. Within these biochemical processes, mycetophagous beetles of Lathridiidae, Cryptophagidae and Staphylinidae have found their position. The analysed assemblage even includes *Sericoda quadripunctata* (Carabidae), a pyrophilous beetle, which is bionomically interacted to burnt wood and ash just after forest fires.

Key words

beetles, forests, impact, photoelectors, soil fauna

Introduction

Soil photoelectors as a method to observe phenology of hypogaeous adults hatching have been tested and discussed in detail. The approach itself was introduced to practical ecology by FUNKE (1971, 1983) in Germany. A lot of relevant papers have been published in the field of soil zoology (eg HOLSTEIN et al., 1994; REICH et al., 1984). TROGER et al. (1994) led their research by exposing photoelectors in the Austrian Alps Mts. Modified traps constructed on the principle of positive phototaxy were used by ANDRZEWSKA and KAJAK (1956). Even in Slovakia, the method of photoelectors was frequently applied to analyse the structure and dynamics of soil macrofauna (DURMEK et al., 1993; MAJZLAN, 1986; MAJ-

ZLAN and HOLECOVÁ, 1993; MAJZLAN and KOŽÍŠEK, 1995; MAJZLAN and FEDOR, 2005, etc.).

Recently there has been published a wide spectrum of papers dealing with impact of wind calamity and fire on forest communities. Recurrent wildfires represent the most important natural disturbance in forests of N Canada (ROWE and SCOTTER, 1973). Fire significantly contributes to the forest landscape modelling and to floristic diversity (JOHNSON, 1992; PAYETTE, 1992). ANGELSTAM (1998) presents a conceptual model as a guide to the maintenance and restoration of an ecologically sustainable boreal forest. According to the author, the model is based on the hypothesis that self-sustained forest ecosystems can be created, and their biodiversity developed, if the forest management can simulate the

composition and structure of boreal forest landscapes by introducing and maintaining disturbances leading to naturally dynamic spatial and temporal patterns of forest regeneration. The fire suppression policies implemented in the early 1900's have resulted in profound changes to the forest species composition and structure (McCULLOUGH et al., 1998). Thus information about the roles played by both fire and insects is needed in many northern forests to increase our understanding of the ecology of these systems.

Material and methods

Three study plots for sampling the hypogaeous macrofauna in natural and in disturbed habitats were established in forest and forest-derived ecosystems in the Vysoké Tatry Mts in 2007, all of them covered by *Larici-Piceetum* (Table 1):

- o Site 1 (Tatranská Lomnica – Start station): a reference plot (REF) with a relatively natural degree of

homeostasis – to compare with wind-calamity-affected sites

- o Site 2 (Tatranské Zruby): influenced by the post-fire succession (FIRE) following the large-sized fire in 2005
- o Site 3 (Daniel's house, Nová Polianka): the wood biomass broken and blown down has been exploited (EXP).

In the area of the Vysoké Tatry Mts, photoelectors were installed for the first time (Fig 1). The equipment enables to study adults' hatching activity calculated as their abundance on 1 m². A photoelector (PhOT) is constructed of two collecting jars to sample invertebrates, one situated on the top (upper jar), the other in the substrate, on the principle of a groundtrap. Monoethylenglycole was applied as a conservation medium, because it is actually declared as a better chemical than picric acid used in the past (MAJZLAN and FEDOR, 2005). The traps were installed in the period of April 30, 2007–October 8, 2007, and the material was regularly sampled at 2 weeks interval.

Table 1. Study plots characteristics

Site	REF	FIRE	EXP
Altitude [m asl]	1,310	1,065	1,260
Exposition	SE	SE	S
Slope [%]	5	5–10	10
Vegetation unit	Lariceto-Piceetum	Lariceto-Piceetum	Lariceto-Piceetum
Age of the stand (before the disaster)	120 years	80 years	80 years
Soil type	Cambisol, Podzol Soil	Cambisol, Podzol Soil	Cambisol, Podzol Soil
Tree composition [%]	Picea 80, Larix 20	Picea 70, Larix 30	Picea 90, Larix 10
GPS coordinates	49°07', 20°06'	49°07', 20°11'	N 49°07', E 20°09'
pH	4.2–3.3	4.8–3.5	4.–3.6
% humus (average)	5–11	7	4–8
Cellulosis decay [%]	43–54	64	39–45



Fig 1. The photoelector used for sampling

On July 25, 2007 the trap in Tatranská Lomnica (Štart) was damaged by a bear. The material has been stored in 75% ethylalcohol and analysed by experts.

Results and discussion

In total 5,028 arthropods (Tables 2, 3) were collected in the traps installed at 3 sampling sites (REF: 1,708 – 91 days, FIRE: 1,448 – 147 days, EXP: 1,827 – 147 days). The values of average daily abundance (REF 24.3, EXP 12.7, FIRE 9.8) declare an intensive impact of fire destruction on activity of soil arthropods, particularly geobionts such as springtails (Collembola). Wind calamity led

to changes in dynamics as well, in this case Diptera were affected especially (REF: 284 individuals per m², FIRE: 117 individuals per m², EXP: 99 individuals per m²).

A relatively low quantity at the reference site reflects a remarkably shorter exposition period of 71 days (1,708 individuals). Under optimum conditions, the value would have increased considerably. General quantitative variables (total or average abundance) hint at any impact (natural or anthropogenous) as a negative determinant in natural geobiont fauna dynamics.

Springtails (Collembola), beetles (Coleoptera) and 2 other insect orders (Diptera and Hymenoptera) generally dominated at all the sampling sites. The results correspond with the data published by TROGER et al. (1994).

Table 2. Abundance (total values) of arthropods sampled (upper jar/lower jar)

Site	15. 5.	28. 5.	15. 6.	28. 6.	16. 7.	
REF	248/22	278/ 95	236/ 64	270/22	236/38	
FIRE	160/63	178/131	59/135	36/70	40/82	
EXP	190/29	245/ 53	257/ 48	160/42	189/37	
Site	24. 7.	2. 8.	21. 8.	13. 9.	8. 10.	Total
REF	206/13	–	–	–	–	1,708
FIRE	37/54	38/38	96/38	111/56	72/24	1,448
EXP	81/24	60/36	89/19	86/28	119/74	1,872

Table 3. Total abundance of arthropod groups sampled

	REF	FIRE	EXP
Diplopoda	1	1	2
Chilopoda	2	1	2
Acarina	3	22	14
Araneae	15	177	66
Collembola	619	119	984
Plecocoptera	–	–	2
Heteroptera	2	23	78
Caelifera	1	2	
Aphidoidea	8	2	2
Auchenorrhyncha	5	21	40
Psocoptera	3	19	
Thysanoptera	188	92	69
Hymenoptera	139	80	264
Coleoptera	229	398	135
Neuroptera	3	8	
Lepidoptera	3	5	3
Diptera	484	418	211
Larvae diversae	3	60	
Total	1,708	1,448	1,872
Average daily abundance	24.3	9.8	12.7
Days of exposition	71	147	147

According to the author, the abundance on managed meadows in Alps reached the value of 2,400–3,700 individuals per m². At upper altitudes (1900 m asl) it dropped to 1,500–1,800 individuals per m². Comparing both analyses (in the Tatry Mts and the Alps Mts) we can see that the abundance correlates with the similar ecological conditions.

The lowest abundance of arthropods appeared at the site FIRE, corresponding with a damage to the upper soil horizon by fire.

The forest fire has even affected the soil assemblages at the site EXP, with a total abundance of 1,827 individuals per m² and a daily average of 12.87 individuals per m² (half of the value at the reference plot).

The abundance reached the maximum at the end of May at all study sites, later it was gently declining with 2 smaller peaks in July and September.

In the Carpathians Mts the abundance of arthropods in the submountainous zone varies between 1,700–3,000 individuals per m² (MAJZLAN and KOŽÍŠEK, 1995). Near Bratislava (an abandoned garden), we observed a value of 3,854 individuals per m² (MAJZLAN and HOLECOVÁ, 1993).

Springtails (Collembola), particularly represented by *Lepidocyrtus lanuginosus*, *L. lignorum*, *Ceratophysella armata* and *Choreuntinela inermis*, significantly dominated at all the sampled sites (119–984 individuals per m²).

The analysis has brought a reference on 126 beetle species (Table 4), 65 of them at REF, 75 at FIRE and 49 at EXP site.

The reference site (REF) with its vegetation has not been affected by the wind calamity. The forest stand with no damage spreads out from Tatranská Lomnica

Table 4. Abundance of beetles (Coleoptera) sampled (upper jar/lower jar)

	REF	FIR	EXT
Family/species			
Carabidae			
<i>Amara eurynota</i> (PANZER, 1797)		0/1	
<i>Amara lunicollis</i> SCHIOEDTE, 1837			0/1
<i>Amara plebeja</i> (GYLLENHAL, 1810)		0/3	
<i>Amara familiaris</i> (DUFTSCHMID, 1812)		0/7	
<i>Bembidion lampros</i> (HERBST, 1784)		0/1	
<i>Molops piceus</i> (PANZER, 1793)	0/1		
<i>Notiophilus biguttatus</i> (FABRICIUS, 1779)		0/1	
<i>Pterostichus burmeisteri</i> HEER, 1841	0/2		
<i>Pterostichus foveolatus</i> (DUFTSCHMID, 1812)	0/1		0/2
<i>Pterostichus rufitarsis</i> (DEJEAN, 1828)			0/1
<i>Pterostichus unctulatus</i> (DUFTSCHMID, 1812)	0/1	0/1	0/2
<i>Sericoda quadripunctata</i> (DE GEER, 1774)		1/0	
<i>Trichotichnus laevicollis</i> (DUFTSCHMID, 1812)	1/0		
Dytiscidae			
<i>Agabus melanarius</i> AUBÉ, 1836	1/0		
<i>Hydroporus palustris</i> (LINNAEUS, 1761)	2/0		
Histeridae			
<i>Margarinotus striola</i> (THOMSON, 1862)	0/1		
Ptiliidae			
<i>Acrotichis intermedia</i> (GILLMEISTER, 1845)	3/1		
<i>Ptenidium laevigatum</i> ERICHSON, 1845	1/0		
<i>Ptilium caesum</i> ERICHSON, 1845			1/0
Leiodidae			
<i>Agathidium mandibulare</i> STURM, 1807			1/0
Scydmaenidae			
<i>Stenichnus collaris</i> (MÜLLER et KUNZE, 1822)			2/0
<i>Neuraphes elongatulus</i> (MÜLLER et KUNZE, 1822)	0/1		

Table 4. Continued

	REF	FIR	EXT
Family/species			
Staphylinidae			
<i>Acrulia inflata</i> (GYLLENHAL, 1813)			1/0
<i>Amischa analis</i> (GRAVENHORST, 1802)		5/0	
<i>Amphichroum canaliculatum</i> (ERICHSON, 1840)			1/0
<i>Anthophagus alpestris</i> HEER, 1839	4/0		
<i>Anthophagus omalinus</i> KOCH, 1933	1/0		
<i>Atheta contristata</i> (KRAATZ, 1856)			2/0
<i>Atheta fungi</i> (GRAVENHORST, 1806)			0/3
<i>Atheta picipes</i> (THOMSON, 1856)	4/1	6/7	1/3
<i>Atheta sodalis</i> (ERICHSON, 1837)	8/0		
<i>Bolitobius castaneus</i> (STEPHENS, 1832)	1/0		
<i>Bryoporus rufus</i> (ERICHSON, 1839)			1/0
<i>Carpelimus corticinus</i> (GRAVENHORST, 1806)			1/0
<i>Encephalus complicans</i> KIRBY, 1832			0/1
<i>Eusphalerum sorbi</i> (GYLLENHAL, 1810)			0/1
<i>Gabrius subnigritulus</i> (GRAVENHORST, 1802)		0/2	2/0
<i>Geostiba circellaris</i> (GRAVENHORST, 1806)	1/0	8/5	1/7
<i>Liogluta granigera</i> (KIESENWETTER, 1850)			1/0
<i>Liogluta microptera</i> THOMSON, 1867			1/0
<i>Mycetoporus lepidus</i> (GRAVENHORST, 1802)		0/25	5/5
<i>Mycetoporus nigricollis</i> STEPHENS, 1835	2/0		
<i>Omalium caesum</i> GRAVENHORST, 1806	0/1		
<i>Omalium rivulare</i> (PAYKULL, 1789)	1/0		
<i>Oxypoda alternans</i> (GRAVENHORST, 1802)			1/0
<i>Oxypoda annularis</i> (MANNERHEIM, 1830)	3/0		
<i>Phloeocharis subtilissima</i> MANNERHEIM, 1830	3/0		
<i>Quedius fuliginosus</i> (GRAVENHORST, 1802)	1/0		
<i>Quedius mesomelinus</i> (MARSHAM, 1802)	1/0		
<i>Quedius punctatellus</i> (HEER, 1839)	2/0		
<i>Stenus fossulatus</i> ERICHSON, 1840	1/0		
<i>Tachinus laticollis</i> GRAVENHORST, 1802	1/0	1/1	
<i>Tachyporus chrysomelinus</i> (LINNAEUS, 1758)		1/3	
<i>Tachyporus tersus</i> ERICHSON, 1839		1/0	
<i>Xantholinus tricolor</i> (FABRICIUS, 1787)		0/1	
Pselaphidae			
<i>Trimium brevicorne</i> (REICHENBACH, 1813)	1/0		
Scarabaeidae			
<i>Aphodius depressus</i> (KUGELANN, 1792)	0/1		
<i>Aphodius abdominalis</i> BONELLI, 1812	0/1		
Elateridae			
<i>Athous subfuscus</i> (MÜLLER, 1767)		2/2	16/0
<i>Ctenicera cuprea</i> (FABRICIUS, 1781)	1/0		
<i>Dalopius marginatus</i> (LINNAEUS, 1758)			1/0
<i>Mesotalesus impressus</i> (FABRICIUS, 1792)		0/1	

Table 4. Continued

	REF	FIR	EXT
Family/species			
Cantharidae			
<i>Malthodes brevicollis</i> (PAYKULL, 1798)	1/0		
<i>Malthodes fuscus</i> (WALTL, 1838)		1/0	
<i>Malthodes guttifer</i> KIESENWETTER, 1852			2/0
<i>Malthodes hexacanthus</i> KIESENWETTER, 1852	12/0		1/0
<i>Malthodes pumilus</i> (BRÉBISSON, 1835)			10/0
<i>Absidia rufostacea</i> (LETZNER, 1845)	7/0		
Anobiidae			
<i>Ernobius abietis</i> (FABRICIUS, 1792)	1/0		
Cleridae			
<i>Thanasimus femoralis</i> (ZETTERSTEDT, 1828)			1/0
Dasytidae			
<i>Danacea pallipes</i> (PANZER, 1793)	0/1		
Nitidulidae			
<i>Epuraea pygmaea</i> (GYLLENHAL, 1808)	3/0		
<i>Epuraea rufomarginata</i> (STEPHENS, 1830)	1/0	0/1	
<i>Epuraea variegata</i> (HERBST, 1793)		1/0	
<i>Meligethes aeneus</i> (FABRICIUS, 1775)	1/0		
<i>Pityophagus ferrugineus</i> (LINNAEUS, 1761)		1/0	
Rhizophagidae			
<i>Rhizophagus dispar</i> (PAYKULL, 1800)	2/0	1/1	0/1
<i>Rhizophagus ferrugineus</i> (PAYKULL, 1800)			1/0
Sphindidae			
<i>Aspidiphorus orbicularis</i> (GYLLENHAL, 1808)		1/0	
Cryptophagidae			
<i>Atomaria analis</i> ERICHSON, 1846	4/5	0/3	
<i>Atomaria bella</i> REITTER, 1875			0/1
<i>Atomaria fusata</i> (SCHONHERR, 1808)		3/0	
<i>Atomaria ruficornis</i> (MARSHAM, 1802)		2/1	
<i>Curelius exiguus</i> (ERICHSON, 1846)		1/0	
<i>Micrambe abietis</i> (PAYKULL, 1798)	1/1		
Coccinellidae			
<i>Ceratomegilla alpina</i> redt. (CAPRA, 1928)			1/0
<i>Adonia variegata</i> (GOEZE, 1777)	1/0	3/1	
Corylophidae			
<i>Sericoderus lateralis</i> (GYLLENHAL, 1827)		0/1	
Lathridiidae			
<i>Aridius nodifer</i> (WESTWOOD, 1839)		5/1	0/1
<i>Corticaria abietorum</i> MOTSCHULSKY, 1867	1/5		1/0
<i>Corticaria ferruginea</i> MARSHAM, 1802			0/1
<i>Corticaria impressa</i> (OLIVIER, 1790)		1/1	
<i>Corticaria rubripes</i> MANNERHEIM, 1844	1/0	48/3	4/3
<i>Corticarina fuscula</i> (GYLLENHAL, 1827)		38/22	1/0
<i>Cortinicara gibbosa</i> (HERBST, 1793)		8/0	
<i>Dienerella elongata</i> (CURTIS, 1830)			2/1

Table 4. Continued

	REF	FIR	EXT
Family/species			
Lathridiidae			
<i>Enicmus fungicola</i> THOMSON, 1868		0/19	
<i>Enicmus transversus</i> (OLIVIER, 1790)		5/1	
<i>Lathridius anthracinus</i> MANNERHEIM, 1844			4/1
<i>Lathridius brevicollis</i> (THOMSON, 1868)		4/8	
<i>Lathridius minutus</i> (LINNAEUS, 1767)	0/1		
<i>Melanophthalma distinguenda</i> (COMOLLI, 1837)		0/1	
<i>Stephostethus rugicollis</i> (OLIVIER, 1790)			1/0
Ciidae			
<i>Orthocis alni</i> (GYLLENHAL, 1813)			1/0
Chrysomelidae			
<i>Altica oleracea</i> (LINNAEUS, 1758)		15/3	
<i>Cryptocephalus carpathicus</i> FRIVALDSZKY,	2/0		1/0
<i>Gastroidea polygona</i> (LINNAEUS, 1758)	0/1		
<i>Chaetocnema concinna</i> (MARSHAM, 1802)		1/0	
<i>Chaetocnema confusa</i> (BOHEMAN, 1851)	1/0	1/0	
<i>Chrysolina varinas</i> (SCHALLER, 1783)	2/0		
<i>Luperus viridipennis</i> (GERMAR, 1824)	6/0		
<i>Phyllotreta nemorum</i> (LINNAEUS, 1758)	1/0		
Curculionidae			
<i>Hylobius abietis</i> (LINNAEUS, 1758)	2/0	0/1	2/3
<i>Notaris aterrimus</i> (HAMPE, 1850)	0/1		
<i>Otiorhynchus lepidopterus</i> (FABRICIUS, 1794)	1/0	1/0	
<i>Otiorhynchus niger</i> (FABRICIUS, 1775)	5/0	6/0	
<i>Otiorhynchus scaber</i> (LINNAEUS, 1758)	3/1		0/3
<i>Polydrusus amoenus</i> (GERMAR, 1824)	9/0		
<i>Polydrusus pallidus</i> GYLLENHAL, 1834	1/0		
<i>Rhinomias forticornis</i> (BOHEMAN, 1843)	0/1		
Scolytidae			
<i>Crypturgus cinereus</i> (HERBST, 1793)			2/0
<i>Dryocoetus autographus</i> (RATZEBURG, 1837)			7/7
<i>Hylastes ater</i> (PAYKULL, 1800)		2/3	
<i>Hylastes cunicularius</i> ERICHSON, 1836	2/1	1/0	
<i>Phthorophloeus spinulosus</i> REY, 1883			1/0
<i>Pityogenes chalcographus</i> (LINNAEUS, 1761)			2/0

to Podbanské. At the sample plot (1 m²), 229 beetles were captured in the trap what should actually correspond with an untouched and natural ecosystem. The species spectrum includes the dominant *Ctenicera cuprea* (10 individuals per m²), *Malthodes hexacanthus* (12 individuals per m²), *Corticaria abietorum* (14 individuals per m²), *Luperus viridipennis* (16 individuals per m²) and *Polydrusus amoenus* (19 individuals per m²). The whole assemblage is defined and determined

by *Polydrusus amoenus*, an oligophagous species on *Alnus incana*, *Sorbus aucuparia* and *Picea abies*. The soil underground provides suitable conditions for its development, including hatching. At the reference site was recorded the highest value of daily arthropod abundance.

The forest fire at the site FIRE damaged the upper soil horizon including the mass of decaying leaves and needles. Thus, the affected assemblage had the lowest

value of arthropod abundance (1,448 individuals per m²); however, the surprisingly highest abundance of beetles (418 individuals per m²). Amongst the recorded species, *Mycetoporus lepidus* (25 individuals per m²), *Athous subfuscus* (14 individuals per m²), *Corticaria rubripes* (56 individuals per m²), *Corticaria fuscula* (50 individuals per m²) and *Altica oleracea* (18 individuals per m²) may be classified as dominant. *Mycetoporus lepidus* represents a zoophagous species feeding on eggs of mycetophilous dipterans. Two species of Lathridiidae, *Corticaria rubripes* and *Corticaria fuscula* are mycetophagous, sometimes feeding on decaying matter. Revitalization of the site depends on pressure of bacteria and fungi mineralizing vegetation biomass after the fire. Within these biochemical processes, mycetophagous beetles of Lathridiidae, Cryptophagidae and Staphylinidae found their position.

Altica oleracea, an oligophagous species on *Lythrum*, *Chamaenerium* and *Epilobium* plants occurred massively, following the succession stage of *Chamaenerium angustifolium* shortly after the fire. Our parallel analyses (MAJZLAN, 2008) using Malaise traps have proved the r-strategy behaviour of this species, an intensive increase in the population abundance from 56 (2006) to 374 (2007) specimens captured (the sample period of 80 days a year). Similarly *Corticaria rubripes*, *Corticaria fuscula*, *Aridius nodifer* and *Lathridius minutus*, mycetophagous species, may be considered as r-strategists in initial stages of a succession process.

The analysed assemblage even includes *Sericoda quadripunctata* (Carabidae), a pyrophilous beetle, which is bionomically interacting with burnt wood and ash immediately after the forest fire. Thus, the species belongs to rare insects practically dependent on a specific microhabitat affected by fire.

The lowest value of beetle abundance (135 individuals per m²) was observed at the site EXP. The species spectrum includes the dominant *Athous subfuscus* (16 individuals per m²) and *Dryocoetus autographus* (14 individuals per m²).

In our research, the method of photoelectors was applied for the first time in the Vysoké Tatry Mts. The analyses have brought interesting data on phenology of geobiont arthropods with a special emphasis on beetles. The soil assemblages may indicate changes in structure and dynamics of the forest ecosystem affected by fire and wind calamity.

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Fenológia pôdnych bezstavovcov (Coleoptera) a iných článkonožcov (Arthropoda) v podmienkach Vysokých Tatier

Súhrn

Výskum fenológie pôdnych bezstavovcov v podmienkach Vysokých Tatier bol zrealizovaný po prvýkrát v roku 2007. Pre sledovanie pôdnej makrofauny (eklektorfauna) sme použili pôdny fotoeklektor, založený na pozitívnej fototaxii liahnucich sa imág z pôdy. Na dvoch študijných plochách (kalamitné plochy) a jednej kontrolnej sme získali celkovo 5028 jedincov článkonožcov z plochy 3 m². Dominantné hodnoty abundancie dosahovali Collembola, Diptera, Coleoptera a Hymenoptera.

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