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Seasonal dynamics of geobiont arthropods in mountainous spruce forests with a special emphasis on beetles (Coleoptera)

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Abstract

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Eclosion phenology of beetles (Coleoptera) was studied using soil photoeclectors (POT) at 3 study sites along the Tichá dolina valley, the Vysoké Tatry Mts (Slovakia). In the vegetation period 2008 (144 days), the average abundance of arthropods reached the value of 2,763 ex. m^{-2}. Arthropods were represented by 24 orders, including dominant Diptera (30.0%), Hymenoptera (11.5%) and Araneae (11.7%). The community of Coleoptera (7.6%) included 145 species of 29 families and culminated in June at all the study sites, varying between 181 and 1,016 ex. m^{-2}. The main goal of the project was to analyse changes in seasonal dynamics of geobiont arthropods, particularly beetles (Coleoptera).

Key words

beetles, macrofauna, phenology, soil ecology, the Tatra Mts

Introduction

Research on geobiont (soil-dwelling) arthropods always brings a challenge to analyse and understand the whole soil complex and even ecosystem. An analysis of their dynamics, structure and diversity may mean an important potential for bioindication studies aimed to identify interactions among the species and their environmental conditions. This is undisputedly emphasized if the system is impacted by various types (natural, anthropogenic) of disturbances.

A soil photoeclector method (POT) is usually applied to observe eclosion phenology in various geobiont insects. There were published numerous papers on this matter in Slovakia (e.g. Majzlan and Fedor, 2005, 2009). In the Austrian Alps the trap was applied to monitor the area of 0.5 m^2 (Troger et al., 1994).

One of the scientific schools dealing with geobiont arthropod dynamics has been established by Funke (1997). Consequentially, plenty of papers have been published, e.g. Durmek et al. (1993).

Study sites

The whole study area, situated along the Tichá dolina valley (DFS grid square 6885 b), the Vysoké Tatry Mts, included the 3 following sites:

- Site A: coordinates: 49°08´ N, 19°53´ E, altitude: 965 m a.s.l, Alnetum incanae carpathicum – wetland with *Alnus incana*, *Salix* sp., *Betula pendula, Caltha palustris*, located by the Belá creek just under a forest road in the locality of Podbanské (Fig. 1).
- Site B: coordinates: 49°09´ N, 19°55´ E, altitude: 1,001 m a.s.l., Lariceto-Piceetum on podzolic cambisol, sparse forest stand of *Picea abies* with a cover density of 60%, surrounded by fallen Norway spruces and European larches (standing : fallen trees 60 : 40 at the area of 300 × 300 m), mouth of the Tichá dolina valley close to a arboriculture (Fig. 2).
- Site C: coordinates: 49°10´ N, 19°55´ E, altitude: 1,086 m a.s.l, Lariceto-Piceetum on podzolic cambisol, just in the valley centre in a totally disturbed area (standing : fallen trees 10 : 90 at the site of 300 × 300 m) (Fig. 3).

Fig. 1. The POT traps at the site A, a wetland with *Sorbus, Betula, Alnus* trees, with a Malaise trap in background.

Fig. 2. 3 POT traps at the site B (Larici-Piceetum).

Fig. 3. The POT and Malaise traps at the site C with a high degree of damaged stands.

Material and methods

A soil photoeclector (POT) records eclosion abundance and other dynamic activities of insects over a certain soil area. Arthropods are captured in a collecting jar with monoethylenglycol as a conservation medium. In the past, picric acid was used (Majzlan and Fedor, 2005).

Three soil photoeclector traps (POT) were installed at each study site situated along the Tichá dolina valley, for a period of 144 days (May 9, 2008 – September 29, 2008). Each non-stationary trap, covering an area of 0.125 m^2 (3 = 0.375 m^2), was moved onto another area once a month, and the material was sampled at 1-week intervals. The research was accompanied by exposition of Malaise traps, managed once a week.

Some of the captured taxa were identified by: P. Průdek – Latridiidae and Cryptophagidae, T. Jászay – Staphylinidae, O. Šauša – Elateridae, E. Jendek – Buprestidae.

Results and discussion

Arthropoda

Abundance of arthropods reached the values of 2,062 ex. m^{-2} (site A), 3,453 ex. m^{-2} (site B), 2,773 ex. m^{-2} (site C), with an average of 2,763 ex. m^{-2} for the whole study area (Table 1). In the period of 144 days the daily values were recorded as 14 ex. m^{-2} (site A), 24 ex. m^{-2} (site B), 19 ex. m^{-2} (site C). In 2007 analysing dynamics of arthropods in the area impacted by wind calamity and fire as well as intensive management we observed a significantly lower value of 1,661 ex. m^{-2} (Majzlan and Fedor, 2009).

Diversity of soil macrofauna appears identical for both years.

Dipterans, especially those of Nematocera, may be generally classified as dominant in the whole study area (in total: A 800, B 1,054, C 1,514 ex. m^{-2}, in daily values: A 5.5, B 7.3 and C 10.5 ex. m^{-2}) (Table 2). Comparing Diptera in our older research in 2007 (Straka and Majzlan, 2009), the daily abundance ranged between 0.7 (at the site damaged by wind and fire) and 4.0 (reference site).

Analysing dynamics of arthropods, their abundance reach its culmination point in June (838 ex. m^{-2} in average) for the whole study area (Table 2). At the site A with no impact the values continuously increase from May to June when they decline gradually (Fig. 4).

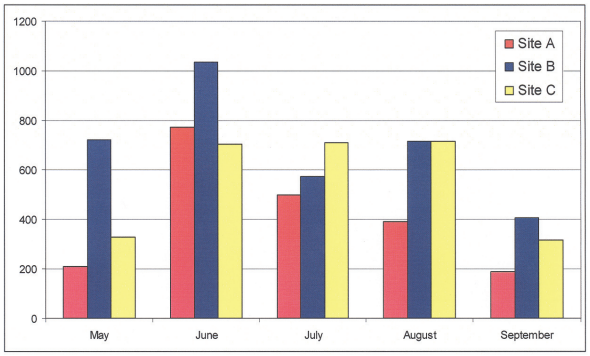

Fig. 4. Abundance dynamics of the arthropods sampled in 2008.

Coleoptera

The total abundance of beetles for the whole period (144 days) varied between 181 and 1,016 ex. m^{-2}, with the daily values of 1.2 (A), 7.0 (B) and 3.0 (C) ex./days/m^2. For the sites A and C, the values correspond with our previous analyses in the area impacted by the wind calamity and fire in 2007. The higher abundance at the site B refers to eclosion of *Cryphalus piceae* (300 ex. m^{-2}).

In 2007, an average abundance of beetles per 1 m^2 ranged between 0.9 ex./days at the site impacted by the wind calamity and 3.2 ex. day^{-1} at the reference site (Majzlan and Fedor, 2009).

The beetle species diversity (richness: A 44, B 78, C 75) appears similar at the sites B and C, in accordance with their similar ecological conditions (Lariceto-Piceetum) and with 29 species occurring at both sites. There are only 10 species occurring at all 3 study sites.

Site A

At the site A, a wetland with more dynamic upper soil horizon, the beetles are predominantly represented by predacious Staphylindae and phytophagous Curculionidae (Table 3). The analyses declare the lowest abundance (290.6 ex. m^{-2}), but the highest values obtained by applying Malaise traps with massive eclosion of *Bytturus tomentosus* in May (1,000 ex. per week).

Site B

The community may be determined by the dominant (28.8%) *Cryphalus piceae* (Scolytidae), eclosing in the 20th week between May 9–19, and subdominant representatives of Curculionidae and Staphylinidae (Table 3). At the site B, the abundance reached the highest values (997.3 ex. m^{-2}) within the whole study area, supported particularly by 6 species of Scolytidae (*Cryphalus piceae, Hylastes ater, Hylastes cunicularius, Ips typographus, Pityogenes chalcographus* and *Xyloterus lineatus*). Even 4 years after the calamity, eclosion of Scolytidae and their invasion to the nearby stands is evident, when 626.6 specimens were eclosed per 1 m^2 in the period of 144 days. This quantity was predominantly due to *Ips typographus* (29.3 ex. m^{-2}) and *Pityogenes chalcographus* (90.6 ex. m^{-2}).

Site C

Dominated by Chrysomelidae, Curculionidae and Scolytidae, the beetle abundance reached the value of 474.6 ex. m^{-2}, with a special portion of Scolytidae (72 ex. m^{-2}), including *Ips typographus* (56 ex. m^{-2}). Consequentially, the results declare that in the deforested area 4 years after the calamity, the populations of Scolytidae have been significantly declined (Table 3).

Acknowledgement

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Table 3. Survey of beetles sampled at 3 study sites (month/specimens) in 2008

Taxone	Site A	Site B	Site C
Carabidae			
Cychrus caraboides (Linnaeus, 1758)			8/1
Carabus linnaei Panzer, 1810			8/1
Pterostichus aterrimus (Herbst, 1784)	6/1		
Ptiliidae			
Acrotrichis intermedia (Gillmeister, 1845)		6/1,7/2	
Pteryx suturalis (Heer, 1841)	7/2	8/1	
Staphylinidae			
Acidota crenata (Fabricius, 1792)			8/1
Alevonota egregia (Rye, 1876)			5/1
Alevonota rufotestacea (Kraatz, 1856)		6/1	
Amischa analis (Gravenhorst, 1802)	8/1		6/2,7/2
Amphichroum canaliculatum (Erichson, 1840)		6/1	6/3
Anotylus tetracarinatus (Block, 1799)	7/12		8/1
Anthophagus alpestris Heer, 1839		6/5,8/2	8/4
Anthophagus bicornis (Block, 1799)			8/1
Anthophagus omalinus arrowi Koch, 1933		8/1	
Atheta fungi (Gravenhorst, 1806)		6/1	
Atheta fungivora (Thomson, 1867)			5/1
A*theta episcopalis* Bernhauer, 1910	9/1		
Atheta pilicornis (Thomson, 1852)		6/1	
Atheta procera (Kraatz, 1856)		6/2	6/1
Eusphalerum limbatum (Erichson, 1840)		5/2,6/1	
Eusphalerum luteum (Marsham, 1802)		5/1	
Eusphalerum rectangulum (Fauvel, 1869)	6/1	6/6,7/1,9/1	
Liogluta wuesthoffi (Benick, 1938)	7/1	8/1	9/1
Lordithon exoletus (Erichson, 1839)		9/1	
Omalium caesum Gravenhorst, 1806		6/1	
Othius angustus Stephens, 1833			8/1
Philonthus decorus (Gravenhorst, 1802)			9/1
Phloeoporus corticalis (Gravenhorst, 1802)			7/1
Phloeoporus scribae (Eppelsheim, 1884)			7/2
Placusa depressa Mäklin, 1845		7/1	6/1,7/1
Placusa tachyporoides (Waltl, 1839)		8/1	
Proteinus brachypterus (Fabricius, 1792)		8/3,9/1	9/1
Quedius paradisianus (Heer, 1839)			9/1
Rugilus rufipes Germar, 1836	6/1		
Tachinus laticollis Gravenhorst, 1802	6/2		
Tachinus signatus (Gravenhorst, 1802)	5/1		
Tachyporus chrysomelinus (Linnaeus, 1758)			7/1
Xantholinus laevigatus Jacobsen, 1847			5/1
Pselaphidae			
Trimium brevicorne (Reichenbach, 1813)			8/1
Bibloporus bicolor (Denny, 1825)			6/1

Table 3. Continued

Taxone	Site A	Site B	Site C
Helodidae			
Elodes elongata Tournier, 1868	6/1		
Scarabaeidae			
Aphodius abdominalis Bonelli, 1812			7/1
Byrrhidae			
Byrrhus glabratus Heer, 1841		6/1	5/1,6/1,7/2
Elateridae			
Agriotes obscurus (Linnaeus, 1758)			7/1
Ampedus aethiops (Lacordaire, 1835)	5/1	6/3	6/2
Ampedus balteatus (Linnaeus, 1758)	6/1		
Ampedus nigrinus (Herbst, 1784)	5/5	5/1,6/2,7/1	5/1,6/1,7/2
Ampedus sanguineus (Linnaeus, 1758)			6/1
Anostirus castaneus Linnaeus, 1758	6/1		
Athous subfuscus (Müller, 1767)		5/2,6/8	5/2,6/11
Ctenicera cuprea (Fabricius, 1781)		6/1	
Hemicrepidius niger (Linnaeus, 1758)	6/1	7/2	
Hypnoidus riparius (Fabricius, 1792)			6/1
Liotrichus affinis (Paykull, 1800)	5/5	6/1	
Melanotus castanipes (Paykull, 1800)	6/1		
Prosternon tesselatum (Linnaeus, 1758)			8/1
Lycidae			
Pyropterus nigrojuber (De Geer, 1774)		7/3	
Cantharidae			
Absidia pilosa (Paykull, 1798)		6/1	
Absidia rufotestacea (Letzner, 1845)		6/1,7/1	7/1
Cantharis obscura Linnaeus, 1758	6/2		6/1
Cantharis pagana Rosenhauer, 1846		6/1	
Cratosilis denticollis (Schummel, 1844)			7/1
Malthodes minimus (Linnaeus, 1758)			7/1
Malthodes hexacanthus Kiesenwetter, 1852		7/2	
Malthodes pumilus (Brébisson, 1835)		7/2	
Rhagonycha nigripes Redtenbacher, 1842		7/1	
Anobiidae			
Ernobius angusticollis (Ratzeburg, 1847)		5/1	
Cleridae			
Thanasimus femoralis (Zetterstedt, 1828)			6/1,8/1
Nitidulidae			
Meligethes aeneus (Fabricius, 1775)		5/1,9/1	
Epuraea pygmaea (Gyllenhal, 1808)	7/1	6/1	6/1
Epuraea boreella (Zetterstedt, 1828)		5/1	
Epuraea marseuli Reitter, 1827		9/1	
Epuraea binotata Reitter, 1827		6/1	
Epuraea rufomarginata (Stephens, 1830)			8/1
Rhizophagidae			
Rhizophagus dispar (Paykull, 1800)			6/1,8/1

Table 3. Continued

Taxone	Site A	Site B	Site C
Silvanidae			
Dendrophagus crenatus (Paykull, 1799)	6/1		
Cucujidae			
Leptophloeus alternans (Erichson, 1845)		8/1	
Cryptophagidae			
Atomaria umbrina (Gyllenhal, 1827)	6/1		
Atomaria nigripennis (Kugelann, 1792)	6/1	7/1	
Byturidae			
Byturus tomentosus (De Geer, 1774)			
Coccinellidae			
Coccinella septempunctata (Linnaeus, 1758)			7/3
Aphidecta obliterata (Linnaeus, 1758)		8/1	
Corylophidae			
Corylophus casssidoides (Marsham, 1802)		6/1	
Orthoperus atomus (Gyllenhal, 1808)	6/1	6/1,7/1	
Latridiidae			
Aridius nodifer (Westwood, 1839)	8/2,9/1		
Corticaria longicornis (Herbst, 1793)		7/1	5/1,8/1
Corticaria obscura Brisout, 1863		7/1	
Corticaria rubripes Mannerheim, 1844		7/1	6/1
Corticarina minuta (Fabricius, 1792)	6/1,7/1	6/2,7/2	6/1
Corticarina parvula Mannerheim, 1844			6/1
Cortinicara gibbosa (Herbst, 1793)			6/1,7/4,8/1
Enicmus fungicola Thomson, 1868		7/1	
Stephostethus angusticollis (Gyllenhal, 1827)		8/1	
Melandryidae			
Xylita laevigata (Hellenius, 1786)	6/1		
Oedemeridae			
Oedemera virescens (Linnaeus, 1767)	7/1		
Tenebrionidae			
Corticeus suberis (Lucas, 1846)		7/1	
Cerambycidae			
Isarthron castaneus (Linnaeus, 1758)		6/1	6/1
Monochamus sutor (Linnaeus, 1758)			6/1,7/1 8/1
Chrysomelidae			
Altica oleracea (Linnaeus, 1758)	5/2,6/4	6/2	
Batophila rubi (Paykull, 1790)	5/1,6/3		
Galeruca tanaceti (Linnaeus, 1758)			8/1
Chaetocnema hortensis (Geoffroy, 1785)			6/1
Chrysolina cuprina (Duftschmid, 1825)			9/4
Chrysolina rufa Duftschmid, 1825			6/2
Chrysolina varians (Schaller, 1783)		6/1	5/1 6/11 7/3 8/3
Longitarsus luridus (Scopoli, 1763)		6/1,7/1	6/1
Longitarsus suturellus (Duftschmid, 1825)	9/1		5/4,6/8,7/2,8/1
Luperus viridipennis (Germar, 1824)		7/1	

Table 3. Continued

Taxone	Site A	Site B	Site C
Chrysomelidae			
Minota carpathica Heikertinger, 1911			5/1,6/2
Mniophila muscorum (Koch, 1831)		5/1	
Oreina intricata (Germar, 1824)			5/1
Phyllotreta nigripes (Fabricius, 1775)		9/1	6/5,7/3
Phyllotreta nigripes (Fabricius, 1775)	5/1		
Phyllotreta vittula (Redtenbacher, 1849)			8/1
Anthribidae			
Brachytarsus nebulosus (Forster, 1771)			9/1
Curculionidae			
Anthonomus rubi (Herbst, 1758)	7/1		
Curculio pellitus (Boheman, 1843)	9/1		
Donus oxalidis (Herbst, 1795)			7/1,8/1
Hylobius abietis (Linnaeus, 1758)	6/3	5/3,6/3,7/2	6/2,7/2
Magdalis punctulata (Mulsant et Rey, 1859)			6/1
Otiorhynchus equestris (Richter, 1821)			6/1
Otiorhynchus multipunctatus (Fabricius, 1792)		6/1	
Otiorhynchus niger (Fabricius, 1775)		5/3,6/23,7/8,8/2	6/1,7/1
Otiorhynchus lepidopterus (Fabricius, 1794)		6/1	
Phyllobius alpinus Stierlin, 1859	6/3		
Phyllobius arborator (Herbst, 1797)		7/3	
Polydrusus amoenus (Germar, 1824)		7/1	
Polydrusus pallidus Gyllenhal, 1834	6/1	6/2,7/1	7/1
Polydrusus impar Des Gozis, 1882		7/2,8/7,9/4	7/1,8/3
Rhamphus pulicarius (Herbst, 1795)	6/2,8/2		
Rhyncolus ater (Linnaeus, 1758)		7/1	
Rutidosoma fallax (Otto, 1897)			6/1
Sitona sulcifrons (Thunberg, 1798)		9/1	
Trachodes hispidus (Linnaeus, 1758)	7/1		
Scolytidae			
Ips typographus (Linnaeus, 1758)	6/1	7/1,8/3	
Crypturgus pusillus (Gyllenhal, 1813)	6/1		
Dryocoetes autographus (Ratzeburg, 1867)		6/2	6/2,8/1
Hylurgops glabratus (Zetterstedt, 1828)		7/1	6/2
Cryphalus piceae (Ratzeburg, 1837)		5/110,6/5,7/4,8/3	
Hylurgops palliatus (Gyllenhal, 1813)	6/5,8/1	6/1	6/4,
Pityogenes chalcographus (Linnaeus, 1761)	5/1,6/2,7/4,8/2	5/11,6/24,7/3,8/1,9/1	5/5,6/13
Hylastes ater (Paykull, 1800)		6/5	
Hylastes cunicularius Erichson, 1836		5/7,6/7	
Polygraphus poligraphus (Linnaeus, 1758)			8/3
Xyloterus lineatus (Olivier, 1795)		5/20,6/2	

Table 2. Abundance of arthropods in the period May–September 2008

Arthropoda	Month (site, abundance per 1 m2)
Diplopoda	5.(A 5, B 5), 7.(A 4, B 4, C 5), 8.(A 5, B 4)
Chilopoda	7.(A 4), 8.(C 4)
Acarina	5.(A 29), 6.(B 16), 7(A 29, C 13)
Araneae	5.(A 53, B 8, C 4), 6.(A 99, B 53, C 40), 7.(A 43, B 27, C 5), 8.(A 56, B 29, C 53), 9.(A 32, B 13, C 27)
Opiliones	6.(C 8), 7.(B 5, C 4), 9.(B 4)
Collembola	5.(A 16, B 53, C 72), 6.(A 99 ,B 53, C 40), 7.(A 8, B 75, C 45) 8.(A 48, B 107), 9.(A 27, B 155, C 69)
Plecoptera	5.(A 11, C 4), 6.(A 40, B 21), 7.(A 24, B 53, C 13), 8.(A 4, B 8, C 5), 9.(B 11, C 4)
Isopoda	6.(A 4), 8.(A 4), 9.(A 4)
Pseudoscropiones	8.(B 4), 9.(B 5)
Dermaptera	7.(A 4)
Blattodea	6.(C 5), 8.(B 4, C 4)
Heteroptera	5.(A 4, C 4), 6.(C 57), 7.(C 43), 8.(A 4, B 8, C 13), 9.(A 4, C 11)
Caelifera	6.(C 4), 7.(C 11), 8.(C 21), 9(C 8)
Aphidoidea	5.(A 4, B 40, C 27), 6.(B 72, C 13), 8.(B 13), 9(C 5)
Auchennorhyncha	5.(A 4, C 4), 6.(A 5, B 5, C 11), 7.(A 165, B 45, C 19), 8.(A 64, B 91, C 69), 9.(A 5, B 13, C 13)
Psocoptera	7.(C 4), 8.(B 5, C 4), 9.(A 4, B 27)
Thysanoptera	5.(A 4, B 4, C 24), 6.(A 8, B 43, C 45), 7.(A 5, B 67, C 35), 8.(A 13, B 109, C 72), 9.(A 4, B 8, C 4)
Hymenoptera	5.(A 11, B 32, C 4), 6.(A 99, B 171, C 240), 7.(A 40, B 75, C 43), 8.(A 61, B 56, C 203), 9.(A 8, B 91, C 45)
Coleoptera	5.(A 19, B 430, C 56), 6.(A 113, B 379, C 258), 7.(A 15, B 117, C 75), 8.(A 21, B 59, C 64), 9.(A 13, B 31)
Neuroptera	7.(C 4), 8.(B 8), 9.(B 4)
Raphidioptera	7.(C 4)
Mecoptera	7.(C 4)
Lepidoptera	6.(A 11, B 8, C 13), 7.(B 5, C 21), 8.(A 4, C 16), 9.(C 5)
Trichoptera	7.(B 4)
Diptera	5.(A 56, B 208, C 216), 6.(A 376, B 432, C 792), 7.(A 155, B 128, C 275), 8.(A 117, B 227, C 114), 9.(A 96, B 59, C 117)
Larvae div.	5.(C 5), 6.(A 5), 9.(A 4, C 8)

Table 1. Abundance (specimens per 1 m^2) of arthropods in the study area in 2008

	May	June	July	August	September	In total
Site A	210	774	499	391	188	2,062
Site B	722	1037	572	716	406	3,453
Site C	328	703	709	717	316	2,773

Sezónna dynamika pôdnych článkonožcov so zameraním na chrobáky (Coleoptera)

Súhrn

Dynamiku abundancie pôdnych článkonožcov je možné sledovať metódou pôdnych fotoeklektorov. Na troch študijných plochách v profile Tichej doliny vo Vysokých Tatrách sme takýto výskum uskutočnili v roku 2008. Počas vegetačnej sezóny (144) dní sme získali bohatý študijný materiál článkonožcov a najmä hmyzu, ktorý sa liahne z pôdy. Priemerná abundancia počas sledovaného obdobia bola 2,763 ex. m^{-2}. V spoločenstve článkonožcov (zástupcovia 24 radov) dominovali Diptera 30,0 %, Hymenoptera 11,5 % a Araneae 11,7 %. Chrobáky (Coleoptera) dosiahli najvyššiu hodnotu dominancie 7,6 % v mesiaci jún.

Abundancia chrobákov s 145 druhmi (29 čeľadí) sa pohybovala v hodnotách 181 a 1,016 ex. m^{-2}. Priemerná hodnota fenológie (liahnutia a aktivity) imág chrobákov má hodnotu 3,7 ex. Druh *Cryphalus piceae* dosiahol najvyššiu hodnotu abundancie 300 ex. m^{-2} na ploche B.

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