FOLIA OECOLOGICA – vol. 36, no. 2 (2009). ISSN 1336-5266

Caterpillars overwintering on spruce roost near their food

Katarína Dvořáčková[1], Ján Kulfan[2]

Institute of Forest Ecology of the Slovak Academy of Sciences, Štúrova 2, 960 53, Zvolen, Slovak Republic,
[1]E-mail: vargova@savzv.sk, [2]E-mail: kulfan@savzv.sk

Abstract

Dvořáčková, K., Kulfan, J. 2009. Caterpillars overwintering on spruce roost near their food. *Folia oecol.*, 36: 75–78.

We studied roosting positions of caterpillars of five cryptically coloured moth species (Lepidoptera, Geometridae: *Thera variata, Pungeleria capreolaria, Peribatodes secundarius, Hylaea fasciaria* and *Alcis repandata*) during winter 2006/2007 (November–April). The separate caterpillars were bred in outdoor conditions, placed in transparent plastic vials (60 ml), each containing a dry and a green spruce twig. We observed the place where the caterpillars roosted during the day. We found caterpillars of all species roosting on green twigs of their host plant, in most cases stretched along a single needle (in direct contact with the source of food). This position allowed them to use effectively short periods in winter, with favourable conditions for feeding, and it also allowed them to use their cryptic colouring and shape in avoiding the predators.

Key words

behaviour, caterpillars, Lepidoptera, Norway spruce, roosting positions, winter

Introduction

In most insect species is supposed that they are inactive during winter and that they spend adverse weather periods in specific shelters. During winter are the predators limited only to visually orientating insectivorous birds noticeably reducing insect populations on spruce branches (Jansson and von Bromssen, 1981).

Some of the insect species are able to feed during warmer winter periods (Tauber et al., 1986; Majerus, 2002). This was also proved in some species of spruce caterpillars (Vargová and Kulfan, 2007).

The aim of our study was to find where roosted caterpillars of selected Lepidoptera species feeding on spruce that are active during the winter (Vargová and Kulfan, 2007).

Material and methods

Our observations were focused on cryptic caterpillars of five Lepidoptera species of the family Geometridae. These caterpillars are free-living, feeding on spruce needles, and they overwinter in larval stage (Patočka et al., 1960; Kulfan, 1995).

The caterpillars of *Thera variata* (Den. & Schiff., 1775) (Fig 1) and *Pungeleria capreolaria* (Den. & Schiff., 1775) (Fig 2) are green-coloured with bright-white longitudinal stripes. We made 138 observations of caterpillars of *T. variata* (n = 4) and 322 observations of *P. capreolaria* (n = 12). The initial size of the observed individuals of both species was about 9 mm, whereas in their last instar they reached a length of 20–25 mm and 25–28 mm, respectively (Patočka et al., 1960).

The caterpillars of *Peribatodes secundarius* (Den. & Schiff., 1775) (Fig 3), *Hylaea fasciaria* (Linnaeus, 1758) (Fig 4) and *Alcis repandata* (Linnaeus, 1758) (Fig 5) are brown-coloured. We made 331 observations of *P. secundarius* (n = 12), 33 observations of *H. fasciaria* (n = 1) and 166 observations of *A. repandata* (n = 4). The initial size of *P. secundarius* and *A. repandata* was about 11 mm, whereas both species are in the last instar 25−30 mm long (Patočka et al., 1960). The initial length of *H. fasciaria* was 14 mm. In the last instar this species reached 25−30 mm (Patočka et al., 1960).

The caterpillars used in our study were obtained by beating spruce branches in the Veporské vrchy hills and Poľana Mts (central Slovakia, 800–950 m asl), in autumn 2006. After being transported to the laboratory, they were identified and put into glass jars with fresh food. At the beginning of November, we measured the length of caterpillars. Then the separate caterpillars were placed in transparent plastic vials (60 ml). Each vial was provided with a fresh green spruce twig and a dry spruce twig without needles. The vials were put in the external environment (natural conditions – temperature and photoperiod). The place was shaded from direct solar radiation. The temperature inside the vials was the same the air temperature.

The roosting positions of individuals were observed always at 10 am, 3 times a week (intervals of 2–3 days), from November 2006 to April 2007. We recorded the background preferred by the caterpillars for roosting: either green (1) or dry (2) twig of Norway spruce. When they roosted on the green twig, we recorded whether they were (a) stretched along a single needle, (b) stretched from one needle to another, (c) stretched from a needle to the sprig or (d) stretched on the sprig. During our experiment, the caterpillars of the observed species were active for most of the days. Their feeding activity was deduced from presence of their droppings.

Data analysis

We supposed that if the caterpillars select places for roosting randomly, the number of the observed situations in each category should be the same. It means that the number of cases when caterpillars roost on green twigs should be the same as on dry twigs. The same should also hold for the four positions of caterpillars roosting on green twigs. We tested this hypothesis by using χ^2 test (Zar, 1984) comparing between the expected number of events and the number of the events observed.

Results

We made a total of 990 observations on 33 individuals belonging to 5 species of the family Geometridae.

Caterpillars of all five species roosted on green twigs exclusively, that means very close to their food source. We did not observed roosting on dry twigs. The

Fig 1. *Thera variata*

Fig 2. *Pungeleria capreolaria*

Fig 3. *Peribatodes secundarius*

Fig 4. *Hylaea fasciaria*

Fig 5. *Alcis repandata*

caterpillars did not select their roosting places on green twigs randomly (*P. capreolaria*: $\chi^2 = 329.1$, *T. variata*: $\chi^2 = 271.4$, *P. secundarius*: $\chi^2 = 30.1$, *H. fasciaria*: $\chi^2 = 22.2$, *A. repandata*: 166.7; $p < 0.001$ for each species).

Both green-coloured caterpillar species mimicking spruce needles (*P. capreolaria* and *T. variata*) roosted in most cases stretched along a single green needle (in 68.3% or 85.5%, respectively).

The brown-coloured caterpillars of *A. repandata* and *H. fasciaria* roosted stretched on a single needle in 66.3% and 57.6% of observations, respectively. Caterpillars of *H. fasciaria* often roosted also on the brown central sprigs (27.2% of observations) that they imitated by the colour of their body and also by the structure of their skin. *P. secundarius* did not manifest such differences among roosting positions as the other species. The caterpillars of this species usually roosted stretched between two green needles (34.7% of observations) (Fig 6). Interesting was also their roosting position, recorded in 16% of our observations: the caterpillars roosted fastened with their prolegs to the terminal parts of needles, making an angle of 45° with the needle axis. In other species, we did not notice such a case.

Discussion

Spruce, as a host plant, provides caterpillars (and also other herbivores) with an important advantage: the needles represent an available source of food also during the winter. Caterpillars feeding on assimilatory organs of deciduous trees also overwinter in litter (Patočka et al., 1999). The spruce caterpillars observed in this study fed on needles also during warmer periods in winter (Vargová and Kulfan, 2007), which allowed them to shorten their spring development and, consequently, to avoid the pressure of predators elevated during their last instar (Vargová and Kulfan, 2008).

We observed that caterpillars of the five studied species of the family Geometridae roosted during the winter period on the green spruce twigs with sufficient food supply. This behaviour has the following benefits: (1) caterpillars do not have to waste energy for moving to the food, (2) reduced risk of predation during moving between the roosting place and the place where they feed (Betts, 1955; Bergelson and Lawton, 1988; Heinrich, 1993; Bernays, 1997).

The caterpillars of the studied species in winter generally do not reach the needle length. The caterpillars that we studied often roosted stretched along a single needle. This position has some advantages: (1) the caterpillar is in direct contact with the food source, (2) the whole abdominal part of caterpillar is mechanically protected by the needle, (3) contact with the needle inhibits sudden fluctuation of body temperature in the caterpillar.

Caterpillars associated with spruce have been adapted to the environment in which their host plant grows naturally, that means an environment with occurrence short periods suitable for the insect development. It these conditions, the caterpillars take advantage from roosting near the food source (on green spruce twigs). They also make use of their crypticity (mimicking a green needle, dry needle or a brown sprig) as a defence against predators.

Acknowledgement

We would like to appreciate P. Zach for revision of the manuscript, and D. Kúdelová for editing the English text. The study was supported by the grants Vega 2/0130/08, 2/0110/09 and APVV 0456-07.

References

Bergelson, J.M., Lawton, J.H. 1988. Does foliage damage influence predation on the insect herbivores of birch? *Ecology*, 69: 434−445.

Bernays, E.A. 1997. Feeding by lepidopteran larvae is dangerous. *Ecol. Ent.*, 22: 131−123.

Betts, M.M. 1955. The food of titmice in oak woodland. *J. Anim. Ecol.*, 24: 283−323.

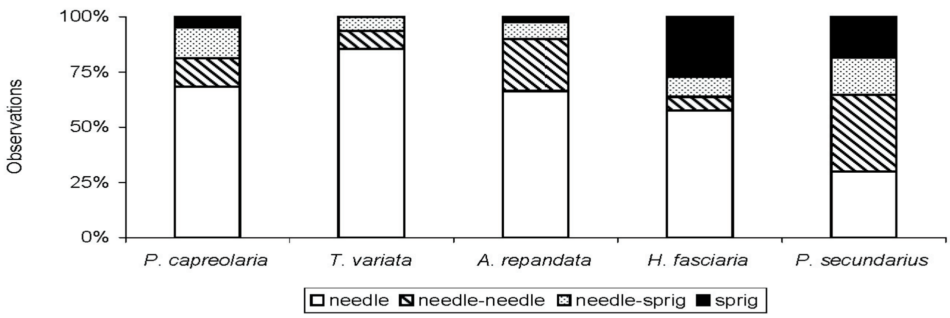


Fig 6. Position of five overwintering species of caterpillars on green spruce twigs during their roosting

Heinrich, B. 1993. How avian predators constrain caterpillar foraging. In Stamp, N.E., Casey, T.M. (eds). *Caterpillars. Ecological and evolutionary constrains on foraging*. London: Chapman and Hall, p. 224–247.

Jansson, C., Bromssen, A. von 1981. Winter decline of spiders and insects in spruce Picea abies and relation to predation by birds. *Holarctic Ecol.*, 4: 82–93.

Kulfan, J. 1995. Piadivky rodu Boarmia s.lat. na smreku obyčajnom (Lepidoptera, Geometridae) [Geometrid moths of genus Boarmia s. lat. on Norway spruce (Lepidoptera, Geomteridae)]. *Entomofauna carpath.*, 7: 105–109.

Majerus, M.E.N. 2002. *Moths*. The New Naturalist. London: Harper Collins Publishers. 310 p.

Patočka, J., Burgan, J., Čapek, M., Stolina, M. 1960. *Die Tannenschmetterlinge der Slowakei.* Bratislava: Vydavateľstvo Slovenskej akadémie vied. 216 p.

Patočka, J., Krištín, A., Kulfan, J., Zach, P. 1999. *Die Eichenschädlinge und ihre Feinde.* Zvolen: Institut für Waldőkologie der Slowakischen Akademie der Wissenschaften. 396 p.

Tauber M.J., Tauber C.A., Masaki S. 1986. *Seasonal adaptations of insects*. New York: Oxford University Press. 426 p.

Vargová, K., Kulfan, J. 2007. Potravová aktivita smrekových húseníc v zimnom období [Feeding activity of spruce caterpillars during winter]. In *Študentská vedecká konferencia, 18. apríl 2007. Zborník recenzovaných príspevkov, 1. zväzok, biologická a environmentálna sekcia*. Bratislava: Kartprint, p. 223–225.

Vargová, K., Kulfan, J. 2008. Pôsobí globálne otepleníe na húsenice v horských smrečinách? [Does the global warming influence caterpillars in mountain spruce forests?] In *Študentská vedecká konferencia, 23. apríl 2008. Zborník príspevkov, 1. zväzok, biologická sekcia*. Bratislava: IRIS, p. 341–343.

Zar, J.H. 1984. *Biostatistical analysis*. New Jersey: Prentice-Hall. 736 p.

Húsenice zimujúce na smreku odpočívajú v blízkosti svojej potravy

Súhrn

Húsenice viazané svojim vývinom na smrek sú adaptované na podmienky, v ktorých sa táto drevina prirodzene vyskytuje, t. j. na miesta s krátkymi časovými periódami vhodnými pre vývin hmyzu. Niektoré druhy húseníc aktívne prijímajú potravu aj počas zimného obdobia, preto je miesto ich odpočívania pre ne strategicky dôležité. Počas zimného obdobia (november 2006 – Apríl 2007) sme chovali húsenice 5 druhov motýľov (Lepidoptera, Geometridae: *Thera variata, Pungeleria capreolaria, Peribatodes secundarius*, *Hylaea fasciaria* a *Alcis repandata*) vo vonkajšom prostredí v prirodzených teplotných a svetelných (fotoperióda) podmienkach. Húsenice boli umiestnené individuálne v 60 ml plastových transparentných nádobkách, kde mali k dispozícii suchú (bez ihlíc) a čerstvú (so zelenými ihlicami) vetvičku smreka. Zaznamenávali sme miesto, kde húsenice počas dňa odpočívali. Zistili sme, že húsenice všetkých druhov odpočívali na zelenej vetvičke hostiteľskej rastliny, t.j. priamo pri zdroji svojej potravy. Táto stratégia im umožňuje efektívne využívať obdobia s vhodnými podmienkami pre príjem potravy a zároveň využívať svoje kryptické sfarbenie a tvar (napodobňovanie zelenej ihlice, suchej ihlice alebo hnedého konárika) na ochranu pred predátormi.

Received June 18, 2009
Accepted August 10, 2009

Needle disease on English yew caused by the parasitic fungus *Cryptocline taxicola* (All.) Petr. noticed in Nitra town

Helena Ivanová[1], Slávka Bernadovičová[2]

Branch for Woody Plants Biology, Institute of Forest Ecology of the Slovak Academy of Sciences, Akademická 2, 949 01 Nitra, Slovak Republic,
[1]E-mail: helena.ivanova@savzv.sk, [2]E-mail: slavka.bernadovicova@savzv.sk

Abstract

Ivanová, H., Bernadovičová, S. 2009. Needle disease on English yew caused by the parasitic fungus *Cryptocline taxicola* (All.) Petr. noticed in Nitra town. *Folia oecol*., 36: 79–85.

This study reports the occurrence of the fungus *Cryptocline taxicola* (All.) Petr. on needles of *Taxus baccata* L. Symptoms of fungal infection, irregular necrotic spots and lesions, followed by turning brown of infected needles and whole shoots, were observed on *Taxus baccata* var. *fastigiata* (Lindl.) Loudon and *Taxus baccata* var. *fastigiata Robusta* in private gardens of the town of Nitra. Some important characteristics and distinctive morphological features were described. Black, subcircular fruiting bodies (acervuli) were observed on the upper, but more massed on the lower side of necrotic needles. Conidia were ellipsoidal to ovoid, smooth-walled, brownish to hyaline, nonseptate, grainy inside, rarely with two oil drops, average size 5–15 × 4–5 µm. The fungus formed on PDA aerial, pale brown to greyish colonies with olive-brown shade and hyaline, branched, septate mycelium. Average growth rate of mycelium in culture reached 3.02 mm day^{-1}. Experimental spraying with fungicide Dithane M45 showed to be effective. Because the English yew is affected by only a few serious fungal diseases, so the isolation and identification of *C. taxicola* – a fungal pathogen with sporadical incidence causing damage to needles of this woody plant was relatively uncommon. From this aspect the fungus *Cryptocline taxicola* seems to be important pathogen on needles of the English yew in Europa, including Slovakia.

Key words

Coelomycetes, Cryptocline damage, fungal disease, *Taxus baccata* L.

Introduction

Taxus is a genus of yews, small coniferous trees or shrubs in the yew family Taxaceae. *Taxus baccata* L. is a conifer native to western, central and southern Europe, northwest Africa, northern Iran and southwest Asia. This extraordinally long-lived and relatively slow growing tree known as common yew, European or English yew is the predominant yew species in all Europe. It is one of the oldest species in the world.

English yews are widely used in landscaping and ornamental horticulture, and thanks to their low site requirements and relatively high tolerance to harmful agents, they often belong to favourable evergreen tree species used especially for formal hedges and topiary in parks and gardens (Fig 1).

In contrast to other European tree species, English yew has a conspicuously low affinity for fungi. However, several authors reported infection of *Taxus* by several species of fungi (Brandenburger, 1985; Ellis and Ellis, 1997; Thomas and Polwart, 2003). From fungal disorders, parasitic fungi *Dotchichiza* sp. (syn. *Cytospora taxifolia* Cke. & Mass.), *Stagonospora* sp. (syn. *Hendersonia taxi* Hollós) and *Phyllosticta concentrica* Sacc. (syn. *Phyllosticta taxi* (Fr.) Wr. & Hoch.) are known commonly.

For the first time, *Cryptocline* fungus on yew needles was noticed in 1973 (Morgan and Jones, 1973). The fungus has been for long accounted as a weak pathogen but at present, strains with a higher degree of parasitism are occuring on various yew species and varieties. Towards the end of the 20th century, the disease occurrence was confirmed on Pacific yew (*Taxus brevifolia* Nuttall) in Canada (Vujanovic and St-Arnaud, 2001). In Europe, the disease was observed in 2001 on *Taxus baccata* var. *fastigiata* in Norway (Talgø et al., 2003), later in Germany on *Taxus baccata* L. (Wulf and Pehl, 2002). The first incidence in Slovakia on *Taxus baccata* was recently noticed in 2007 by Bukvayová (2007). In the Czech Republic, Šafránková (2008) recorded the disease on living and necrotic needles of *Taxus baccata* L. and its cultivars 'Adpressa', 'Fastigiata Aurea', 'Fastigiata Robusta', 'Nissens Praesident', 'Nissens Regent', also on *T. cuspidata* S. & Z and *Taxus* × *media* Rehd. 'Thayerae'.

Fig 1. *Taxus baccata* var. *fastigiata Robusta* often planted as a hedge in public greenery

Cryptocline taxicola (Allesch.) Petr. (Coelomycetes), teleomorph *Anthostomella taxi* Grove, current name *Anthostomella formosa* var. *taxi* (Grove) S.M. Francis (Xylariaceae, Xylariales) was described as *Gloeosporium taxicola* (All.) in 1896. In 1925, Petrak (1925) put the fungus – on the base of morphological features, into a new genus *Cryptocline* with characteristic subcuticular or intraepidermal development of acervuli. Later Von Arx (1957), by revision of genus *Gloeosporium,* classified the *Cryptocline taxicola* into the genus *Cryptocline.* Morgan-Jones (1973) categorized 14 species, including *Cryptocline taxicola* to the *Cryptocline* genus. Next revision of the genus *Cryptocline* was accomplished by Sutton (1980).

This study aims to describe the characteristic disease symptoms according to the previous diagnostic data and based on examination of cultural and morphological attributes, the distinctive morphological features of the fungus *Cryptocline taxicola* (All.) Petr. on *Taxus baccata* L. For this purpose, several important characteristics as cultural growth, conidial formation and size differences in microscopic structures were studied in pure hyphal cultures of *Cryptocline taxicola* isolated from symptomatic yew trees.

Material and methods

In the spring 2009, damaged twigs of yew (*Taxus baccata* var. *fastigiata* and *Taxus baccata* var. *fastigiata Robusta*) were delivered to the laboratory of the Institute of Forest Ecology of the Slovak Academy of Sciences in Nitra. The plant material had been taken from infected trees growing in private gardens of the town of Nitra – part Zobor. Visual characteristics of necrotic and chlorotic needles with fruiting bodies on the upper and lower surface were examined with a stereomicroscope SZ51 (Olympus). Investigation of fungal structures (conidia, conidiophores) immersed in water was performed with a clinical microscope BX41 (Olympus) under a 400× magnification.

The fungus *Cryptocline taxicola* was isolated from symptomatic needles and twigs with characteristic spots and lesions sampled during the growing season from the affected host trees of *Taxus baccata* var. *fastigiata*. The samples were surface-sterilized in 70% ethanol, then immersed for 15 minutes in sodium hypochlorite, rinsed in sterile distilled water (2–3 times) and dried carefully with filter paper. After the surface sterilization, the tissue samples were cut to small pieces (4–5 mm), placed on potato dextrose agar (PDA) and subsequently incubated in Petri dishes. Then followed cultivation in a versatile environmental test chamber MLR-351H (Sanyo) at 24 ± 1 °C temperature, 45% humidity and photoperiod 12/12 hours and isolation on potato-dextrose agar (PDA). Pure fungal cultures were obtained after multiple purification.

The collections from the town of Nitra (25 April, 8 May, 12 May and 15 May 2009, leg. H. Ivanová) were identified. The samples of material have been deposed at the Institute of Forest Ecology of the Slovak Academy of Sciences, Branch for Woody Plant Biology in Nitra.

The growth rate of the examined fungus was assessed on 10-day-old pure cultures grown on PDA in Petri dishes at 24 ± 1 °C and photoperiod 12/12 hours, based on the daily records of mycelium growth (mm day^{-1}; with precision of 0.5 mm) made during seven days. Agar columns with about 0.5 × 0.5 mm of the parent mycelium were used for inoculation of plates. Altogether 30 repetitions were made, and two dishes with fungal colonies were examined in each replication.

Results and discussion

Symptoms and morphology

In our observations, the first symptoms of damage caused by fungus *Cryptocline taxicola* (Allesch.) Petr. appeared on needles of new shoots as irregular necrotic lesions (Fig 2). They progressively increased in size, and finally affected the whole needles. According to Lawrence and Moltzan (2007), the symptoms include a browning of needles and the signs include black „pepper grains“ on the needles. Strong infection can lead to dying of whole shoots. Affected needles and whole shoots turn greeny up to brown, and they wither and fall off as the disease develops (Fig 3). Black circular or subcircular fruiting bodies (acervuli) are formed under epidermis on the both – upper and lower side of the needles. Acervuli reach 150–370 µm in diameter. According to Bukvayová (2007), the acervuli of the fungus observed with a stereomicroscope were circular to subcircular, black, surrounded by brown circles and 150–350 µm in diameter. Vujanovic and St-Arnaud (2001) observed circular to subcircular acervuli which were yellowish, surrounded by brown circles, subcuticular to intraepidermal, at first full covered, later having a fissure in the cuticule, and 150 to 350 µm wide. The fruiting bodies, sometimes more than 400 per a needle were observed on the upper surface. According to Talgø et al. (2003) acervuli are formed on the upper as well as lower side of the needles, and the epidermis breaks through. Acervuli are visible to the naked eye on green needles and shoots but a good stereomicroscope is needed to see them properly. The epidermis of the needle was first pushed upwards and then ruptured irregularly when the fruiting bodies became ripe and broke through.

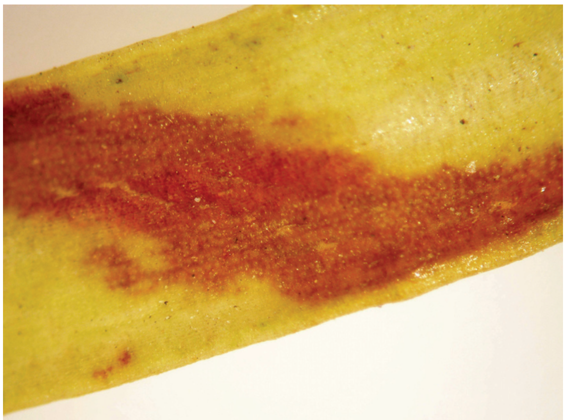


Fig 2. Detail of damaged needle of *Taxus baccata* var. *fastigiata Robusta* with irregular lesion

With an above normal precipitation, the epidermis arched and rupted, a creamy coloured spore (conidia) mass oozed out from the acervuli. During dry season, the needles manifested ocurrence of well visible rumpled and shrivelled, circular to oval or irregular fruiting bodies of the fungus (Fig 4a). When the infected material was incubated in saturated air at room temperature, a cream coloured spore mass of conidia oozed out from the acervuli (Fig 4b).

Fig 3. Necrotic needles and whole shoots of English yew affected by *Cryptocline taxicola* turn brown as the disease develops

Fig 4a. Mature acervuli of *Cryptocline* fungus on infected yew needles in dry conditions appear raised black „pepper grains“

Fig 4b. Initial formation of a cream coloured spore mass oozing out from the acervuli under sufficient humidity

According to Morgan-Jones (1973), the mature stroma of a fruiting body of *Cryptocline* fungus is subcuticular, intraepidermal, and the acervuli have on average 200–400 µm. Fruiting bodies, 15–25 µm in thickness, are relatively poorly-developed from thin-walled, pseudoparenchymatic (textura angularis), slightly brownish to hyaline cells, 5–7 µm in size, formed by the basic stroma. An acervulus towards to the centre can achieve a thickness about 40 µm. Cylindrical and hyaline conidiogenous cells are formed from the upper, compactly arranged, stromal cells. Conidiogenous cells are enteroblastic, phialidic, discrete, indeterminate, cylindrical, hyaline, smooth, with 1–2 percurrent proliferations (Petrak, 1924). Bifurcate and partite, smooth-walled fungal hyphas with subhyaline to tan appearance can be observed on cross-sections of the injured tissue of needles.

Despite the accounts by Morgan-Jones (1973) and Von Arx (1957), *Cryptocline* remains a very heterogeneous entity. The only common feature shared by the recently described species is the epidermal to subepidermal location of the conidiomata. According to the pressent knowledge, conidiogenous cells may be discrete or integrated on branched septate conidiophores. Conidiogenesis may be typically phialidic, percurrently phialidic or annellidic, conidia may be cylindrical, fusiform or doliiform and have either a small area of abscission or a relatively wide base scar. Separation of the taxa on the basis of conidial morphology and nature of the conidiogenous process would fragment the genus into several distinct groups.

Conidia are ellipsoid to oval, one-celled, hyaline to slightly pigmented, 5–15 × 4–5 µm, rarely with two oil drops (Fig 5). According to Petrak (1925) conidia are hyaline or brownish, thin walled, eguttulate or guttulate, smooth, cylindrical to doliiform or ellipsoid, with a broad, flat base. The fungus forms dark colonies with aerial, pale brown or olive to greyish mycelium on potato-dextrose agar (Fig 6a, b). The fungus grows relatively slowly, the average growth rate is 3.02 mm/day.

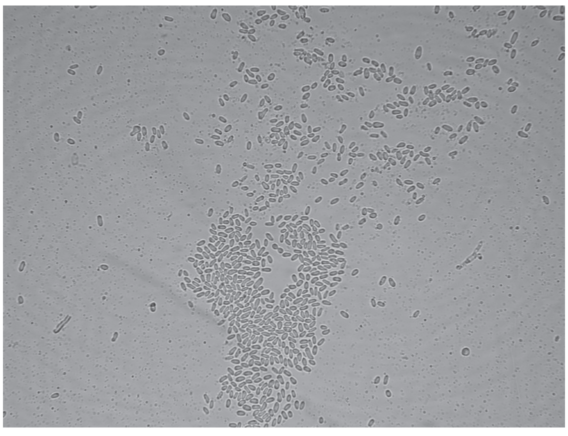


Fig 5. Ellipsoidal to ovoid and hyaline to slightly pigmented conidia (400x)

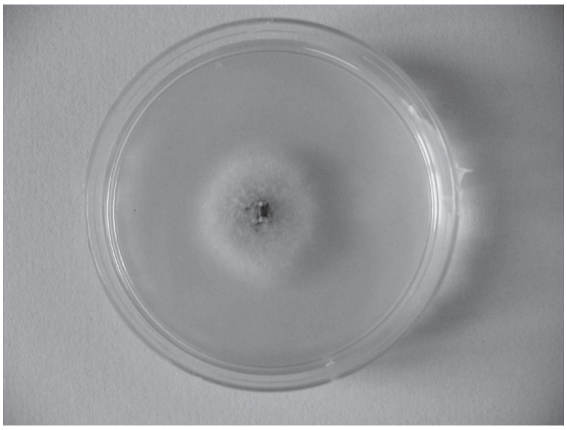


Fig 6a. Cultures of *Cryptocline taxicola* 5 days after inoculation on potato-dextrose agar

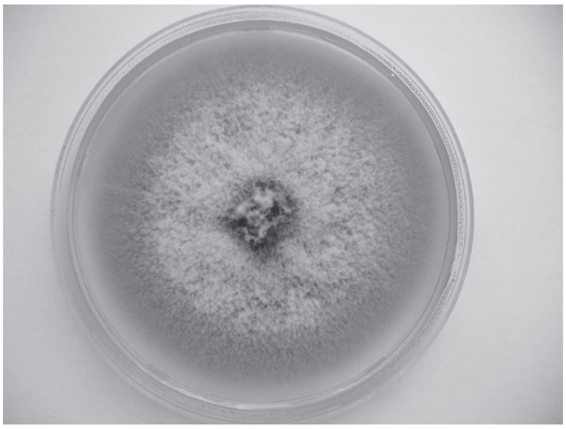


Fig 6b. Cultures of *Cryptocline taxicola* 9 days after inoculation on potato-dextrose agar

Our results are comparable with studies carried out in Canada (Vujanovic and St-Arnaud, 2001), Germany (Pehl and Wulf, 2002), Norway (Talgø et al., 2003) and in the Czech Republic (Šafránková, 2008), Table 1. In Slovakia, for the first time was the fungus recorded in 2007 (Bukvayová, 2007). An increasing occurence of this needle fungus with evident parasitic attributes on *Taxus baccata* – as a relatively resistant tree species has been affirmed by all the mentioned authors.

Table 1. Comparison of biometric characteristics and morphological features of *Cryptocline taxicola* on *Taxus* sp. reported by other authors and examined material from Slovakia

Author(s)	Acervuli	Conidia	Conidiophores	Mycelium
Vujanovic, St-Arnaud (2001)	On the upper surface of needles (circular to subcircular, yellowish, surrounded by brown circles, subcuticular to intraepidermal, at first covered, later exposed by the fissure of the cuticule, and 150–350 µm wide)	Ellipsoidal to oval, truncate at the base, obtuse at the apex, hyaline to slightly pigmented Size: 8–17 × 4–5 µm	Phialidic, cylindrical, hyaline Size: 10–20 × 2.5–4.5 µm	Septate, brownish on PDA
Pehl, Wulf (2002)	On the upper side, rarely at the bottom of needles	Elliptic to ovoid, smooth, thin-walled, hyaline, 1-celled, granular plasma inside, rarely with 1–2 oil drops Size: 12–18 × 5–8 µm	Hyaline, cylindrical Size: 25 × 3.5–5 µm	Wooly, aerial, olive-brown to grey colonies on MA Growth: 1.4 mm/day
Talgø et al. (2003)	On both – the upper and lower side of the needles	Ovoid, smooth Size: 11–18 × 5–8 µm	Absent	Dark colonies, aerial mycelium a greyish appearance on PDA
Bukvayová (2007)	On both the upper and lower side of the needles, black, surrounded by brown circles	Ellipsoidal to oval, thick-walled, truncate at the base, obtuse at the apex, hyaline to mildly pigmented Size: 15.6 × 6.85 µm	Hyaline, phialidic, cylindrical Size: 15 × 3.5 µm	Feltlike to wooly, dense, olive-brown to greyish brown, aerial, slow-growing mycelium
Šafránková (2008)	On both – the upper and lower surface of the needles, black, subepidermal, 160–370 × 90–145 µm, surrounded by brown circles	Ellipsoid to oval, pale brown to hyaline, with granular plasma inside, sporadically with two oil drops, flat at the base, rounded at the apex, thick-walled, without septa Size: 10–18 × 4.5–8.4 µm	Hyaline, cylindrical with phyalides Size: 12–18 × 2.8–3.4 µm	Dark colonies with greyish aerial mycelium on PDA
Examined material (2009)	Black, subcircular, on the upper surface, more massed on the lower side of necrotic needles	Ellipsoidal to ovoid, thick-walled, smooth-walled, brownish to hyaline, nonseptate, grainy inside, rarely with two oil drops Size: 5–15 × 4–5 µm	Absent	On PDA aerial, pale brown to greyish colonies with olive-brown shade, mycelium hyaline, branched, septate Growth: 3.02 mm/day

Control

Mechanical control consists in removing the infected needles as a source of new infection, possibly also in cutting off the damaged branches. According to Vujanovic and St-Arnaud (2001), the decreased disease occurrence was associated with sanitary measures that consisted of cutting off the symptomatic branches. However, favourable conditions during the growing seasons, eg high temperatures and excessive precipitation could be responsible for the increased incidence on the Pacific yew. It is evident that cutting measures have not stopped the fungal propagation and disease expression, and that the first are only temporary solutions. In our observations, favourable conditions (high temperatures and precipitation) during the growing season 2009 could be probably factors influencing the relatively increased incidence of *Cryptocline* needle disease also on English yew.

Lawrence and Moltzan (2007) state that more information is needed for better timing of chemical treatments. For now, the advice can be to apply in the spring – as needles emerge, treatment with a chlorothalonil-based fungicide. In chemical control, application of fungicides based on mancozeb – considerably decreasing the infectious pressure, is rather often used for elimination of the fungal spores. Considering the relatively sporadic incidence of the pathogen and short periods of investigation, many authors do not suppose that a chemical treatment were necessary. This approach accords with Šafránková (2008) because she suggests that, at present, there are no fungicides recognised as effective against the disease caused by *C. taxicola.* Therefore, spraying of fungicide Dithane M45 on sympto-matic yews growing in private gardens was applied at the owner's request. The positive effect of the fungicide treatment repeated three times at 14-day intervals is evident (Fig 7). However, if the fungus has already penetrated the tissue of the host tree, fungicides are ineffective. Therefore, preventive measures, in particular reduction of air moisture by adequate aeration of plan-tings are very important. It is equally important to use a noninfectious material in the new planting. According to Vujanovic and St-Arnaud (2001), inappropriate stand selection, unfavorable water conditions and a thin organic soil layer may predispose yew to infection by *Cryptocline* pathogen.

Within the needle diseases, *Cryptocline taxicola* was assessed to be a pathogen of low importance, but recent observations show that it possesses a large degree of potential parasitism (Wulf and Pehl, 2002).

To obtain more details about occurrence and important attributes of this fungal pathogen in Slovakia, the research requires to continue. Further investigations are needed in order to propose an adequate control strategy against the *Cryptocline* disease in our conditions.

Fig 7. *Taxus baccata* var. *fastigiata Robusta* after repeated fungicide treatment (Dithane M45)

Acknowledgement

This study was carried out with support from the scientific projects VEGA of the Slovak Academy of Sciences 2/7026/27 and APVV-0421-07.

References

Arx, J.A. von 1957. *Revision der zu Gloeosporium gestellten Pilze* [Revision of fungi in Gloeosporium genus]. Amsterdam: Noord-Hollandsche Uitg. Mij. 153 p.

Brandenburger, W. 1985. *Parasitische Pilze an Gefäßpflanzen in Europa* [Parasitic fungi on vascular plants in Europe]. Stuttgart, New York: Gustav Fischer Verlag. 1248 p.

Bukvayová, N. 2007. Cryptocline taxicola (All.) Petr. – a new plant pathogen reported in Slovak republic. *Pl. Protec. Sci.*, 43: 122–124.

Ellis, M.B., Ellis, J.P. 1997. *Microfungi on Land Plants. An Identification Handbook*. Slough: Richmond Publishing. 868 p.

Lawrence, R., Moltzan, B. 2007. Cryptocline taxicola Discovered on Yew. Forest Pathologist's Notes. Missouri Forest Health Update, Missouri Department of Conservation [cit. 2009-05-07]. http://216.119.79.248/pdfs/Forest%20Health%20Update_2007-3.doc

Morgan-Jones, G. 1973. Genera coelomycetarum. VII. Cryptocline Petrak. *Can. J. Bot.*, 51: 309–325.

Pehl, L., Wulf, A. 2002. Nadelschäden an Taxus baccata L. durch Cryptocline taxicola (All.) Petr.

[Needle disease on Taxus baccata L. caused by Cryptocline taxicola (All.) Petr.]. *Nachr.-Bl. Dtsch. Pfl.-Schutzdienst*, 54: 266–268.

Petrak, F. 1925. Mykologische Notizen. VIII. [Mycological notes]. *Ann. mycol*., 23 (1/2): 24.

Thomas, P.A., Polwart, A. 2003. Taxus baccata L. Biological flora of the British Isles. No. 229. *J. Ecol*., 91: 489–524.

Sutton, B.C. 1980. *The Coelomycetes*. Key, Surrey: Commonwealth Agricultural Bureaux. 696 p.

Šafránková, I. 2008. Occurence of Cryptocline taxicola (All.) Petr. on needles of Taxus spp. – symptoms and morphological features. *Acta Univ. agric. silvic. Mendel. Brun.*, LVI (2): 199–202.

Talgø, V., Ørstad, K., Stensvand, A. 2003. Cryptocline taxicola. *Grønn kunnskap*, 7 (101D): 1–2.

Vujanovic, V., St-Arnaud, M. 2001. First report of Cryptocline taxicola infecting Pacific yew (Taxus brevifolia) in eastern North America. *Pl. Dis.*, 85: 922.

Wulf, A., Pehl, L. 2002. Needle disease on Taxus baccata caused by Cryptocline taxicola. In Uotila, A., Ahola, V. (eds). *Proceedings of the IUFRO working party 7.02.02 Shoot and foliage diseases, meeting in Hyytiälä, Finland, 17–22 June, 2001.* Helsinki, p. 198–201.

Choroba ihlíc tisa obyčajného spôsobená parazitickou hubou *Cryptocline taxicola* (All.) Petr. zaznamenaná v meste Nitra

Súhrn

Koncom jari a začiatkom leta vegetačného obdobia roku 2009 boli na ihliciach *Taxus baccata* var. *fastigiata* (Lindl.) Loudon a *Taxus baccata* var. *fastigiata Robusta* rastúcich v súkromných záhradách mesta Nitra zaznamenané charakteristické symptómy choroby spôsobenej hubou rodu *Cryptocline*. Z nekrotických a chlorotických ihlíc napadnutých stromov bola izolovaná huba *Cryptocline taxicola* (All.) Petr. identifikovaná ako pôvodca ochorenia ihlíc tisa. Bol potvrdený opakovaný výskyt tejto doteraz zriedka sa vyskytujúcej parazitickej huby tisa obyčajného, ktorá bola na Slovensku po prvýkrát zaznamenaná až v roku 2007. Práca popisuje na základe štúdia kulturálnych a morfologických vlastností skúmaného patogéna rozlišujúce morfologické znaky huby, jej anamorfného štádia (acervuly, konídie) a charakteristiku huby na živnom médiu (vzhľad kultúry, rýchlosť rastu mycélia). Čierne, takmer okrúhle plodničky (acervuly) huby boli prevažne sústredené na spodnej, menej na vrchnej strane nekrotických ihlíc. Huba vytvára elipsoidné až vajcovité, hrubostenné konídie s hladkou stenou, hnedasté až hyalinné, bez priehradok, so zrnitým vnútrom, zriedkavo aj s dvoma olejovými kvapkami, s priemernou veľkosťou 5–15 × 4–5 μm. Na zemiakovo-dextrózovom agare (PDA) formuje svetlohnedé až šedasté kolónie postupne s olivovohnedým nádychom a vzdušné, hyalinné, rozkonárené mycélium s priehradkami. Rýchlosť rastu mycélia huby na PDA je v priemere 3.02 mm deň$^{-1}$. Vzhľadom na to, že tis obyčajný je známy ako drevina napádaná iba niekoľkými hubovými patogénmi, izolácia a následná identifikácia huby *C. taxicola* ako sporadicky sa vyskytujúceho pôvodcu ochorenia bola pomerne neočakávaná. Z tohto hľadiska sa huba *C. taxicola* ukazuje ako významný patogén asimilačných orgánov *Taxus baccata* L. v Európe, vrátane Slovenska.

Received July 3, 2009
Accepted August 3, 2009

FOLIA OECOLOGICA – vol. 36, no. 2 (2009). ISSN 1336-5266

Soil-ecological properties and plant communities in the Nature Reserve Chynoriansky luh

Ján Kukla[1], Margita Kuklová[2]

Institute of Forest Ecology of the Slovak Academy of Science, Štúrova 2, 960 53 Zvolen, Slovak Republic, [1]E-mail: kukla@sav.savzv.sk, [2]E-mail: kuklova@sav.savzv.sk

Abstract

Kukla, J., Kuklová, M. 2009. Soil-ecological properties and plant communities in the Nature Reserve Chynoriansky luh. *Folia oecol.*, 36: 86–93.

The edaphotope of the Nature Reserve Chynoriansky luh is formed by Pleistocene gravel sands overlaid in Holocene with very heavy clayey 2.5 to 3 m thick carbonate alluvial sediments. During year the ground water level ranged between 1.69–2.33 m. The closest to the soil surface was in April and in the first decade of May when the water levels in Bebrava and Nitra rivers were high. The redox processes are manifested in a depth of 50 cm and more. Luvi-Calcaric Fluvisols are neutral, clayey to clay, with maximum content of coarse clay in a depth of 20–30 cm and physical clay usually in a depth of 50–70 cm. The humus content ranges between 3.2–4.2%, carbonate content 0.1–0.4%. The layers below 80 cm have up to 1.5% carbonates and are mildly alkaline. The content of plant available P in topsoil is 2–3 times higher and of available K 1.2–1.6 times higher than the limits for rich or very good reserves in neutral clayey soils. Amount of available P in lower soil layers is in general insufficient, of available K good. The maximum amount of available P was found near a forest edge (possible impact of field fertilisation in surroundings). The content of exchangeable cations ranges between 128–208 mmol kg^{-1}, from which 66–74% are Ca^{2+}, 21–26% Mg^{2+}, 3–6% K^+ and 1–4% Na^+ ions. The dominant herb species of the heminitrophilous group of types of geobiocoens *Ulmi-Fraxineta carpini superiora* belonging to the wetted edaphic-hydric order of geobiocoens is *Allium ursinum* accompanied by the other heminitrophilous species mainly *Mercurialis perennis*, *Glechoma hederacea, Galeobdolon luteum, Alliaria petiolata.* From lianas locally occurs *Hedera helix* and allochtonous North American species *Parthenocissus quinquefolia.*

Key words

floodplain forest, fluvisols, heminitrophilous phytocoenoses, Nature Reserve Chynoriansky luh

Introduction

Forests, one of the biggest natural treasures of Slovakia, covered the whole territory of the land in the past. However, development of agriculture was connected with progressive reduction of the forest area, primarily in lowlands with favourable climate and soil conditions. The Nature Reserve Chynoriansky luh is a last remnant of waterlogged, originally coherent forests of the Bebravská niva floodplain. It has been preserved in spite of intensive human activities in Slovak lowlands primarily of agricultural character. From the more recent human impacts are noticeable activities connected with intensification of agriculture, primarily with the effort to drainage grounds regularly waterlogged in the springtime, application of mineral fertilisers in high amounts, and abundant visitation of inhabitants from the close villages. Differences in frequency, intensity and duration of floods are considered being the most important factors determining differences in species composition and structure of floodplain forest vegetation (Lockaby et al., 1997; Dubová, 1998; Burke et al., 2003; Maděra, 2001; Penka et al., 1985; Kuklová and Kukla, 2006).

The objective of this study was to assess the impact of soil-ecological conditions in the relation to structure and composition of the phytocoenoses growing in the Nature Reserve Chynoriansky luh floodplain.

The study site

The Nature Reserve (NR) Chynoriansky luh is situated in the lower part of the Bebrava floodplain (Mazúr et al., 1986), NW from the Chynorany village, district Partizánske (48º37'15" N, 18º15'58" E), at an altitude of 175 m a.s.l. The territory has prolonged N-S form, with an area of 46.2592 ha. It is situated in lowland and surrounded with intensively managed agricultural land. The parent rock consists of young, argillic, slightly carbonaceous alluvia of the rivers Bebrava and Nitra, and it is deposed on more ancient gravel-sand terraces of the same water-flows. Basic characteristics of studied phytocoenoses are described in Table 1.

The climate of NR is primary determined by its geographic position. According to the Miklós et al. (2002) the NR territory belongs to the warm climatic region with a number of summer days (with a maximum temperature ≥25 °C) in a year ≥50. The climate sub-region is warm, moderately dry with moderately cold winters (temperature in January >–3 °C). The mean annual temperature in the NR is 8.4 °C and mean annual precipitation total 600–650 mm. The mean temperature in January is –2 to –3 °C, in July 18 to 19 °C. The number of days with snow cover is 50.

Material and methods

Geobiocoenoses of NR Chynoriansky luh were studied on three established monitoring plots (MP 1 to MP 3; Fig 1). Macromorphological characteristics of soils were described and soil sampling was made in 1997 according to Šály and Ciesarik (1991). The soils were classified according to ISSS-ISRIC-FAO (1994, in Collective, 2000).

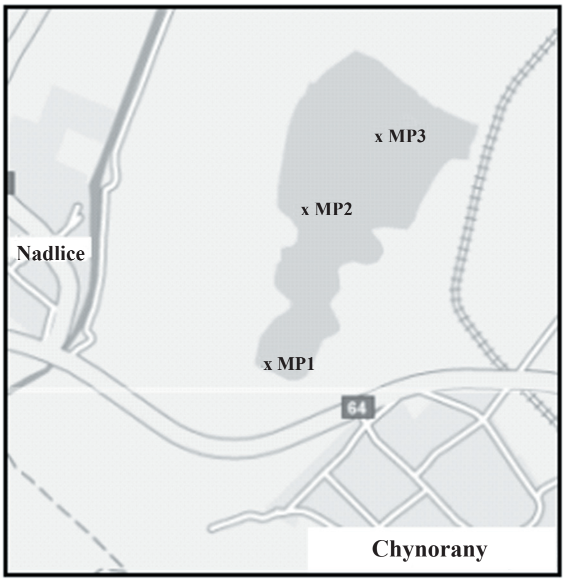


Fig 1. Localisation of the monitoring plots in Nature Reserve Chynoriansky luh

The soil samples were air dried and sieved with a mesh 2 × 2 mm. The contents of dry matter and hygroscopic water were determined gravimetrically, the carbon content oxidimetrically, following Ťurin, the particle size-distribution by laser analyser (FRITSCH analysette 22) using supersound and sodium hexametaphosphate. The values of active and exchange acidity (ratio of fine earth to water and 1 M KCl 1 : 2.5) were obtained using glass and calomel electrodes of a digital pH-meter, the type 08211/1 Radelkis, and the carbonate content using a Janko´s volumetric calcimeter. The amounts of accessible phosphorus and potassium were determined using the methods by Bray-Kurz and Schachtschabel (Hraško et al., 1962; Šály and Ciesarik, 1991).

Table 1. Basic characteristics of studied phytocoenoses

Monitoring plot	MP 1	MP 2	MP 3
Soil		Luvi-Calcaric Fluvisol	
Ground water level [cm]	–155 (–140)	–190 (–170)	–130 (–115)
Edaphic-hydric order		Wetted	
Edaphic-trophic interorder		Heminitrophilous	
Group of types of geobiocoens		*Ulmi-Fraxineta carpini superiora pannonica*	
Type of geobiocoens		953 Garlic elm-ash forest with hornbeam	
Stocking	0.7	0.6–0.7	0.6–0.7
Canopy [%]	80	80	70
Cover of herb layer [%]	90–100	60	90–100

The phytocoenological reléves were made in 1997 according to principles given in Zlatník (1976a) and the classification of geobiocoenoses was made in the sense of Hančinský (1972) and Zlatník (1976b). The plant taxa names are given according to Dostál (1989).

Results and discussion

Soil properties

The NR territory is formed by Pleistocene gravel sands overlaid in Holocene with very heavy clayey 2.5 to 3 m thick carbonate alluvial sediments. The macro-morphology of the soils on the monitoring plots (MP) is following:

MP 1 – Luvi-Calcaric Fluvisol, humus form a typical mull

Ool 1–2 cm layer consisting mostly of oak leaves

Oof +

Aoq 0–6 cm, black-brown, clay-loam, moderately compact, with coarse crumbs to lumped, moist, medium penetrated by roots, without skeleton

Bt 6–60 cm, yellow-brown, clayey, compact, lumpy, moist, medium penetrated by roots, without skeleton, beginning with 25 cm from the soil surface heavier, polyedric and lumpy

Bgt 60–85 cm, grey-brown, clayey with rusty spots on polyedric walls, very compact, lumpy, moist, roots rare, without skeleton

Go 85–155 cm, grey with rusty spots, clayey, very compact, lumpy, moist, roots rare, without skeleton

Ground water was found at a depth of 155 cm, the groundwater level was stabilised at a depth of 140 cm.

MP 2 – Luvi-Calcaric Fluvisol, humus form a typical mull

Ool 1 cm thin layer consisting mostly of oak and hornbeam leaves

Oof +

Aoq 0–6 cm, black-brown, clay-loam, moderately or medium compact, with coarse crumbs to lumped, moist, medium penetrated by roots, without skeleton

Bt 6–50 cm, brown, clayey, very compact, lumpy, moist, medium penetrated by roots, without skeleton

Bgt 50–75 cm, brown, with a light grey hue, clayey, very compact, moist, medium to low penetrated by roots, without skeleton

Go1 75–118 cm, grey with light rusty spots, clayey, very compact, polyedric to platy, moist, with few roots, without skeleton

Go2 118–180 cm, grey, with more conspicuous rusty spots, clayey, very compact, lumpy, moist, with rare roots, without skeleton

Ground water was found at a depth of 190 cm, the groundwater level was stabilised at a depth of 170 cm.

MP 3 – Luvi-Calcaric Fluvisol, humus form a typical mull

Ool + – l cm incoherent layer consisting mostly of oak leaves

Aoq 0–7 cm, black-brown, clay-loam, moderately compact, with coarse crumbs, moist, medium penetrated by roots, without skeleton; through passages after the roots penetrate to 15 cm, rarely up to 30 cm from the soil surface

Bt 7–45 cm, yellow-brown, clayey, compact, polyedric and lumpy, moist, moderately or medium penetrated by roots, without skeleton,

Go 45–70 cm, grey with light grey and rusty spots, clayey, compact, polyedric and lumpy, moist, low or medium penetrated by roots, without skeleton

Gor 70–140 cm, grey, with rusty spots, clayey, very compact, lumpy, moist to wet, little penetrated by roots, without skeleton

Ground water was found at a depth of 130 cm, the groundwater level was stabilised at a depth of 115 cm.

Particle-size analyses point out an extremely high proportion of clay fraction, and, on the other hand, a very low amount of fine and coarse sand, in general quartz (Table 2). Physical clay content throughout the soil profile is the most uniform on MP 3, ranging within a relatively narrow interval 39–49%, with a maximum at a depth of 20–40 cm. Similar profile pattern of physical clay was found in soil on MP 2, however, its amount fluctuated in considerably greater range (32–56%), and the maximum was at a depth of 50–70 cm. Maximum content of physical clay (40–63%) was found on MP 1 where the clay content increased with the depth up to 50–70 cm, similar to MP 2.

Accumulation of the physical clay in the central parts of the soil profiles was a result of coupled influence of processes of illimerisation and colmatation (argillization caused by periodical percolation of turbid flood water). Gleying in the medium parts of the soil profiles is associated with waterlogging and argillization of soil layers.

Maximum amounts of less mobile coarse clay were on all plots found already at a depth of 20–40 cm. Having reached a maximum, the coarse clay content in general decreased with increasing depth, with exception of MP 3 where the minimum was already found at 50–70 cm. On this plot was also found the different (in comparison with MP 1 and MP 2) profile course of dust fraction, decreasing only to 20–40 cm and reaching its absolute maximum (44%) at a depth of 50–70 cm.

The content of soil clay, humus and soluble salts is close connected with the content of dry matter and hygroscopic water making 94–96%, and 3–5%, respectively (Table 3). Important factor in nutrient cycling in floodplain forest ecosystems is soil humus. Its amount in surface A-horizons of the studied soils ranged between

3.2–4.2%, with a maximum on MP 2. The profile course of soil humus is well balanced.

Active reaction in the upper soil layers was on all the plots within range 6.4–6.9, i.e as a rule in neutral interval (Table 3). These values indicate presence of the heminitrophilous edaphic-ecological interorder of geobiocoens limited by pH_{H_2O} values 6.0–7.2 within 5 cm topsoil mineral layer (Kukla, 1993). The presence of carbonates (to 1.5%) increases values of the soil reaction turning to mild alkaline (pH_{H_2O} > 7.2) at about 80 cm depth.

Table 2. Particle size analysis of soils

Monitoring Plot	Subcompartment	Horizon	Sample	Fine earth fraction [mm]					Soil kind
				Clay		Dust	Sand		
				Physical	Coarse		Fine	Coarse	
				<0.002	<0.01	0.01–0.05	0.05–0.1	0.1–2.0	
			[cm]	[%]					
MP 1	2,379	Aoq	1–6	39.96	67.64	22.00	5.46	4.90	Clayey
		Bt	20–30	55.88	82.90	11.00	4.80	1.30	Clay
		Bt/Go	50–70	63.20	78.84	8.36	6.00	6.80	
		Goc1	80–100	56.36	69.96	13.48	7.64	9.10	Clayey
		Goc2	120–140	57.48	71.84	12.12	6.74	9.30	
MP 2	2,378	Aoq	1–6	38.64	65.96	26.40	5.06	2.06	Clayey
		Bt	20–30	48.00	78.08	17.12	3.80	1.00	Clay
		Bt/Go	50–70	56.12	76.28	12.88	6.84	4.00	
		Goc1	80–100	45.72	58.72	20.56	12.12	8.60	Clay loam
		Goc2	120–140	31.96	44.64	33.48	14.28	7.60	Loam
MP 3	2,380	Aoq	1–6	40.80	69.72	23.24	4.64	2.40	Clayey
		Bt	20–30	49.36	79.48	16.12	3.40	1.00	Clay
		Go	50–70	38.68	46.88	44.20	4.92	4.00	Clay loam
		Groc1	80–100	48.64	65.00	21.72	7.58	5.70	Clayey
		Groc2	120–140	38.68	54.60	30.84	10.26	4.30	Clay loam

Table 3. Results of some soil analyses

Monitoring Plot	Sample		Dry matter	Hygr. water	Cox	Humus	$pH_{H_2O} - pH_{KCL}$		Eqv. $CaCO_3$
	Horizon	[cm]	[%]		[%]				[%]
MP 1	Aoq	1–6	94.94	3.50	2.16	3.72	6.89	6.04	0.3
	Bt	20–40	95.05	3.75	2.33	4.02	6.37	5.56	0.1
	Go	50–70	94.27	4.32	2.21	3.81	6.86	5.92	0.4
	Goc1	80–100	94.19	4.57	2.18	3.76	7.42	6.24	0.7
	Goc2	120–140	93.81	4.81	1.78	3.07	7.34	6.55	1.4
MP 2	Aoq	1–6	96.24	2.81	1.88	3.24	6.44	5.45	0.3
	Bt	20–30	95.48	3.43	2.15	3.71	6.71	5.85	0.2
	Go	50–70	94.95	3.87	2.11	3.64	6.88	5.85	0.3
	Goc1	80–100	95.79	3.23	1.91	3.29	7.09	6.37	0.4
	Goc2	120–140	95.33	3.47	1.98	3.41	7.20	6.35	1.5
MP 3	Aoq	1–6	95.62	3.18	2.45	4.22	6.44	5.71	0.1
	Bt	20–30	95.69	3.39	2.23	3.84	6.77	5.53	0.1
	Go	50–70	94.54	4.20	1.96	3.38	6.87	5.44	0.2
	Groc1	80–100	95.27	3.54	2.08	3.59	7.33	6.28	1.2
	Groc2	120–140	95.96	3.08	1.86	3.21	7.16	6.15	0.5

Physiological state of plants is close connected with nutrient content in the soil. The decisive factor is the amount of so called plant accessible or releasable nutrients supposed to be accepted by plants. The most important plant nutrients in soils of the NR Chynoriansky luh are nitrogen, phosphorus and potassium. Favourable course of nitrification depends on the optimum – for nitrification bacteria, reaction values in the upper layers of Fluvisols (pH_{H_2O} 6.0–6.5), and on a favourable ratio of acid and basic components in litter of so called valuable broadleaved species, primarily in the NR dominating ashes.

Nutrient reserves in neutral clayey soils are considered rich or very good if the concentration of accessible P is higher than 26 mg kg^{-1} and the concentration of accessible K is above 154 mg kg^{-1}. The contents of accessible P found in humus horizon A of the studied fluvisols are 2–3 times higher and the contents of accessible K are 1.2–1.6 times higher than the limits for rich or very good reserves in neutral clayey soils (Hraško, 1962). Because the amounts of accessible phosphorus found in lower situated mineral layers are in general insufficient and the phosphorus could be in the upper soil layers accumulated by bioaccumulation, the role of fertilisation of the surrounding agricultural land in the topsoil accumulation of P is not entirely clear. Partly can be the impact of fertilisation assumed from the fact that the maximum amount of accessible phosphorus was found on MP 1 situated near a forest edge.

Reserves of accessible K in medium and lower situated layers of the fluvisols can not be in general evaluated as good. Bioaccumulation of K is considerably lower compared to P bioaccumulation. This is no surprise when we consider the possible fixation of K by clay minerals and rare occurrence of more potassium accumulating grass species in the herb layer.

The sorption complex of the fluvisols has evident prevalence of bivalent ions over monovalent ones (Table 4). By mass ratio is the amount of calcium 4.2–5.8 times higher compared to magnesium, by molar ratio it is 2.6–3.5 times more calcium compared to magnesium. The actual content of exchangeable cations ranges between 128–208 mmol kg^{-1}, from which 66–74% are Ca^{2+}, 21–26% Mg^{2+}, 3–6% K^{+} and 1–4% Na^{+} cations. There has not been found salinization of the soil profile.

The described soils have transition character assembling features of fluvisols (formation from alluvial sediments), luvisols (translocation of physical clay in the medium part of the soil profile) and gleys (redox processes caused by ground water), according to Collective (2000). However, the fluvisols are defined as soils with an ochric A-horizon without other diagnostic horizons except G horizons. Consequently, considerably extent brown alluvial soils of the Vega type (Kubiena, 1953; Šály, 1978, 1982) have been excluded from the classification. According to ISSS-ISRIC-FAO (1994) can be studied soils classified as Luvi-Calcaric Fluvisols.

Dynamics of ground water level

Existence of floodplain forests primarily depends on the ground water level, supplied continually or periodically, by means of capillary elevation, to the physiologically effective part of the soil profile. The finer is the soil grain, the higher is the point of capillary elevation. If there is a permanent decrease of ground water level

Table 4. Content of exchangeable cations

Sample [cm]		1–6	20–30	50–70	80–100	100–120
Monitoring plot	Adsorbed cations	[mg kg^{-1}]				
MP 1	Ca^{2+}	4,875.0	4,625.0	5,250.0	5,250.0	5,875.0
	Mg^{2+}	922.5	797.5	960.0	1,022.5	1,210.0
	K^{+}	355.0	240.0	288.0	264.0	269.0
	Na+	21.5	15.0	28.5	71.0	103.5
MP 2	Ca^{2+}	3,625.0	4,375.0	4,875.0	4,500.0	3,500.0
	Mg^{2+}	797.5	847.5	847.5	822.5	772.5
	K^{+}	329.0	259.0	250.0	187.0	142.0
	Na^{+}	111.0	51.0	53.5	48.5	113.5
MP 3	Ca^{2+}	4,125.0	4,125.0	4,750.0	4,875.0	4,500.0
	Mg^{2+}	797.5	897.5	1,022.5	1,060.0	1,062.5
	K^{+}	342.0	208.0	250.0	208.0	187.0
	Na^{+}	66.0	83.5	61.0	91.0	141.0

under 3 m from the soil surface, the influence of ground water on the moisture of the soil profile geobiocoenoses is in general low; and in the case of greater as 5–6 m depth entirely disappear.

The results of the ground water level change observations on monitoring plot M 1 are presented in Table 5. We can see that the ground water level in 1998 ranged between 1.69–2.33 m. The closest to the soil surface was in April and in the first decade of May when the water levels in Bebrava and Nitra rivers were high. At about mid-May to the end of August followed a decrease connected with lower precipitation and increasing of evapotranspiration. Abundant precipitation in September and October caused increase of water levels in streams followed by elevation of the water table in the NR.

The decisive importance for the water supply to floodplain forests has the ground water level in the summer when the water loss from the soil is the highest and the amount of water accessible for plants in the surface soil layers decreases considerably. Over the whole period of study, the ground water table did not decrease to such a depth in order to could be assumed the possibility of origination of an acute shortage of water accessible for plants. The highest ground water level – 1.3 m below the soil surface, was observed in the spring l997 (digging soil pits). In years where the precipitation amount is above normal values, can the ground water level (according to data of the local inhabitants) reach even the soil surface.

The intensity of flood events in the past is documented by a network of oxbows developed mainly in the northern half of the NR. Because of temporary or permanent lack of air, the clay layer is interfered by redox processes of various intensities manifested already in middle part of the soil profile (in a depth >50 cm). In terms of geobiocoenology, the studied geobiocoenoses belong to the wetted edaphic-hydric order of geobiocoens.

Plant communities

The NR Chynoriansky luh is one of the last remnants of the original vegetation of floodplain forests with rather well preserved species composition of the phytocoenoses. Moderately disturbed is only the age, diameter, height and spatial structure of the forest stands. Immediate contact of the NR with the surrounding agricultural land is reflected on the ecotone effect in which elements of the forest flora mixed with elements of the open land.

In the spring aspect of the phytocoenoses is evident a considerable vertical differentiation in woody plant complex of geobiocoenoses. Together with ash (*Fraxinus angustifolia* subsp. *danubialis*) and oak (*Quercus robur*), significantly assert oneself maple (*Acer campestre*) on MP 1, hornbeam (*Carpinus betulus*) on MP 2 and evidently dominant ash with a smaller admixture of oak on MP 3.

Higher transparency of ash crowns (in comparison with other tree species) can be documented on MP 3, with more abundant of *Corylus avellana* and especially dominant *Padus avium* in the undergrowth. From rare species occur in the main storey *Tilia cordata*, subdominant is *Acer pseudoplatanus* and solitarily also *Ulmus laevis*. MP 1 is characterised by local openings with the most intensive natural regeneration of ash trees. Lateral light is utilized by *Crataegus monogyna* and *Sambucus nigra*. The liana *Hedera helix* mounts the trees only rarely while mass occurrence of this phenomenon was registered in the NE part of the NR, also near the forest edge. An allochtonous North American liana *Parthenocissus quinquefolia* occurs on MP 2. The seeds have probably brought by birds from nearby gardens.

The spring aspect of the NR herb layer is characterised by a very high total cover reaching up to 90–100%. The absolute dominance has everywhere the hemi-nitrophilous to nitrophilous species *Allium ursinum*. Coming of a warmer and drier period in mid-June with lower light supply under the fully developed leaves of crown canopy respond this species by gradual decline. On MP 1 was during the just discussed period observed considerably lower total cover of the herb layer.

The species diversity of the NR phytocoenoses is quite low. Abundant to dominant occur only other hemi-nitrophilous to nitrophilous species as *Galeobdolon luteum*, *Glechoma hederacea, Hedera helix* and *Mercurialis perennis*. Solitarily there is also present *Lamium maculatum* subsp. *maculatum*, eventually *Galium aparine* and *Alliaria petiolata* species. From rare species was on MP 3 recorded *Arum alpinum* and on MP 1

Table 5. Dynamics of ground water level

Month	April				May			June		
Day	15	20	25	30	10	20	30	10	20	30
Depth [cm]	1.69	1.64	1.62	1.62	1.60	1.68	1.78	1.69	1.79	1.94
Month	July		August		September		October		November	
Day	10	25	10	25	10	30	12	30	15	30
Depth [cm]	1.94	2.02	2.12	2.33	2.23	2.04	1.85	1.65	1.65	1.60

Acquilegia vulgaris. All phytocoenoses show conspicuously heminitrophilous character in the spring aspect.

From geobiocoenological point of view, the analysed phytocoenoses belong to the group of forest types *Ulmeto-Fraxinetum carpineum*, forest type 953 Garlic elm-ash forest with hornbeam (Hančinský, 1972). According to a more resent classification (Zlatník, 1976b) it is the group of types of geobiocoens *Ulmi-Fraxineta carpini superiora pannonica* representing the driest communities of the wetted edaphic-hydric order of geobiocoens (floodplain forests).

The tree species composition has been relatively well preserved; however, there has been a considerable shift of edificators of the original biocoenoses (*Quercus robur, Fraxinus angustifolia* subsp. *danubialis, Ulmus laevis*) in favour of the ash. Locally occur *Carpinus betulus* and *Acer campestre* in groups elsewhere these species of lower growth are absent. *Ulmus laevis, Tilia cordata, Acer pseudoplatanus* and *Acer platanoides* are only rare, occurring in general in the understorey where their vitality is suppressed because of the lack of light and competitive pressure by higher woody plants. Rarely also occurs *Cerasus avium*, on the other hand, *Padus avium* is abundant to dominant in the NE part of the NR, however, often in a dense shrub layer only.

The actual stocking of the oak-ash stands aged in the dominant layer up to 160 year range in general between 0.6–0.7. The woody plant complex as a whole, however, provides a relatively shade environment, thanks to a well-developed crown layer connected both horizontally and vertically. In effect, natural regeneration (primarily in *Fraxinus angustifolia* subsp. *danubialis*) has only been limited to open micro-localities. Totally insufficient at the current stage of the stand development is the natural regeneration of pedunculate oak – the species providing and also tolerating the biggest shadow from all tree species on the site. This reality will probably have been maintained up to the beginning of natural disintegration of the main stand.

Conclusions

The paper deals with impact of soil-ecological conditions on the structure and composition of the phytocoenoses of the Nature Reserve Chynoriansky luh. The NR is one of the last remnants of the original vegetation of floodplain forest with rather well preserved species composition of the phytocoenoses and belongs to unique ecosystems.

Particle-size analyses of fluvisols point out an extremely high proportion of clay fraction, and, on the other hand, a very low amount of fine and coarse sand. The profile course of soil humus is well balanced. Its amount in surface A-horizons of the studied soils ranged between 3.2–4.2% and carbonate content 0.1–0.4%. The active reaction in the upper soil layers was on all the plots within range 6.4–6.9, ie as a rule in neutral interval. The most important plant nutrients in soils of the NR Chynoriansky luh are nitrogen, phosphorus and potassium. The contents of accessible P found in humus horizon A of the studied fluvisols are 2–3 times higher and the contents of accessible K are 1.2–1.6 times higher than limits for rich or very good reserves in neutral clayey soils. Amount of available P in lower soil layers is in general insufficient, of available K good.

In the phytocoenoses is evident a vertical differentiation in woody plant complex. In a function of the edificator – together with *Fraxinus angustifolia* and *Quercus robur*, significantly assert oneself *Acer campestre* (on MP 1), *Carpinus betulus* (on MP 2) and evidently dominant ash with a smaller admixture of oak (on MP 3). The species diversity in the herb layer is quite low. All phytocoenoses show conspicuously heminitrophilous character with absolute dominance of *Allium ursinum* species.

Acknowledgement

This work was supported by the Slovak Research and Development Agency under the contract No. APVV-0102-06, Scientific Grant Agency of the Ministry of Education of Slovak Republic and the Slovak Academy of Sciences under the contract No. 2/7161/27, 2/7162/7.

References

Burke, M.K., King, S.L., Gartner, D., Eisenbies, M.H. 2003. Vegetation, soil and flooding relationships in a blackwater floodplain forest. *Wetlands*, 23 (4): 988−1002.

Collective, 2000. *Morfogenetický klasifikačný systém pôd Slovenska. Bazálna referenčná taxonómia* [Morphogenetic soil classification system of Slovakia. Basic referential taxonomy]. Bratislava: VÚPOP, Societas pedologica Slovaka. 76 p.

Dostál, J. 1989. *Nová květena ČSSR 2* [New flora of the Czechoslovak Socialistic Republic 2]. Praha: Academia. 1548 p.

Dubová M. 1998. Chemistry of water from channel Dendeš in the natural reservation Chynoriansky luh. *Folia oecol.*, 24: 103–112.

Hančinský, L. 1972. *Lesné typy Slovenska* [Forest types of Slovakia]. Bratislava: Príroda. 307 p.

Hraško, J. 1962. *Soil analyses* [Rozbory pôd]. Bratislava: SVPL. 342 p.

Kubiena, W. 1953. *Bestimmungsbuch und Systematik der Böden Europas*. Stuttgart: Springer-Verlag. 388 p.

Kukla, J. 1993. The direct determination of the geobiocene edaphic-trophic orders and interorders. *Ekológia (Bratislava),* 12, 4: 373–385.

Kuklová, M., Kukla, J. 2006. Natural reserve Chynoriansky luh, its ecology and biometry of dominant herb species. *Ekológia (Bratislava),* 25, 4: 341–351.

Lockaby, B.G., Jones, R.H., Clawson, R.G., Meadows, J.S., Stanturf, J.A., Thornton, F.C. 1997. Influences of harvesting on functions of floodplain forests associated with low-order, blackwater streams. *Forest Ecol. Mgmt*, 90: 217−224.

Maděra, P. 2001. Response of the floodplain forest communities herb layer to changes in the water regime. *Biologia (Bratislava),* 56, 1: 63−72.

Mazúr, E., Lukniš, M., Balatka, B., Loučková, J., Sládek, J. 1986. *Geomorphological division of SSR and ČSSR* [Geomorfologické členenie SSR a ČSSR.]. Mapa mierky 1 : 500 000. Bratislava: Slovenská kartografia.

Miklós, L. (ed.) et al. 2002. *Atlas krajiny Slovenskej republiky* [Landscape Atlas of the Slovak Republic]. Bratislava: Ministerstvo životného prostredia SR; Banská Bystrica: SAŽP. 344 p.

Penka, M., Vyskot, M., Klimo, E, Vašíček, F. 1985. *Floodplain Forest Ecosystem. I. Before Water Management Measures.* Praha: Academia. 466 p.

Šály, R. 1978. *Pôda – základ lesnej produkcie* [The soil – basis of forest production]. Bratislava: Príroda. 233 p.

Šály, R. 1982. *Pedológia a mikrobiológia* [Soil science and microbiology]. Zvolen: VŠLD, Odd. reprografie VDL. 384 p.

Šály, R., Ciesarik, M. 1991. *Pedológia, Návody na cvičenia* [Soil science, Practicum]. Zvolen: LF VŠLD. 123 p.

Zlatník, A. 1976a. *Přehled skupin typů geobiocénů původně lesních a křovinových v ČSSR* [Survey of groups of types of geobiocoens primarily forest and shrubby in the C.S.S.R]. Brno: *Zprávy Geogr. úst. ČSAV*, 13: 55–64.

Zlatník, A. 1976b. *Lesnická fytocenologie* [Forest phytocenology]. Praha: Státní zemědelské nakladatelství. 495 p.

Pôdno-ekologické vlastnosti a rastlinné spoločenstvá Prírodnej rezervácie Chynoriansky luh

Súhrn

Územie PR je tvorené pleistocénnymi štrkopieskami prekrytými v holocéne zrnitostne ťažkými slabo karbonátovými ílovými aluviálnymi sedimentmi hrubými 2,5–3 m. Frekvencia záplav klesla po odvodnení okolitých poľnohospodárskych pozemkov rúrkovou drenážou. V súčasnosti sa hladina podzemnej vody pohybuje v hĺbke 1,69–2,33 m. Najbližšie k pôdnemu povrchu bola v apríli a v prvej dekáde mája, keď bola veľmi vysoká hladina vody v riekach Bebrava and Nitra. Redox procesy nastupujú v 50 cm hĺbke. Fluvizem luvizemná karbonátová je neutrálna, ílovitohlinitá až ílovitá, s maximálnym obsahom hrubého ílu v hĺbke 20–30 cm a fyzikálneho ílu spravidla v hĺbke 50–70 cm. Obsah humusu kolíše medzi 3,2–4,2 %, karbonátov 0,1–0,4 %. Hlbšie vrstvy (< 80 cm) obsahujúce do 1,5 % karbonátov sú mierne alkalické. Obsah rastlinám prístupného P vo vrchnej časti fluvizeme je 2–3-krát vyšší a prístupného K 1,2–1,6-krát vyšší ako limity pre bohaté alebo veľmi dobré zásoby v neutrálnych ílových pôdach. V nižších pôdnych vrstvách je obsah prístupného P spravidla nedostatočný, prístupného K dobrý. Maximálne množstvo prístupného P bolo zistené v blízkosti lesného okraja (možný vplyv hnojenia okolitých polí). Obsah výmenných katiónov sa pohyboval v rozpätí 128–208 mmol kg^{-1}. Z toho bolo 66–74 % Ca^{2+}, 21–26 % Mg^{2+}, 3–6 % K^{+} a 1–4 % Na^{+} iónov. Dominantným bylinným druhom heminitofilnej skupiny typov geobiocénov *Ulmi-Fraxineta carpini superiora* patriacej do zamokreného edaficko-hydrického radu geobiocénov je *Allium ursinum* sprevádzaný inými heminitofilnými druhmi, najmä *Mercurialis perennis*, *Glechoma hederacea,* *Galeobdolon luteum* a *Alliaria petiolata.* Z lian sa lokálne vyskytuje *Hedera helix*, na MP 2 aj alochtónny severoamerický druh *Parthenocissus quinquefolia.*

Received July 6, 2009
Accepted August 18, 2009

Caterpillars of Lepidoptera in crowns of mountain ash (*Sorbus aucuparia* L.) in the Ore Mountains

Emanuel Kula[1], Jan Patočka[2], Václav Šimon[1]

[1]Department of Forest Protection and Game Management, Faculty of Forestry and Wood Technology, Zemědělská 3, CZ-613 00 Brno, Czech Republic, E-mail: kula@mendelu.cz
[2]Institute of Forest Ecology of the Slovak Academy of Sciences, Štúrova 2, 960 53 Zvolen, Slovak Republic

Abstract
Kula, E., Patočka, J., Šimon, V. 2009. Caterpillars of Lepidoptera in crowns of mountain ash (*Sorbus aucuparia* L.) in the Ore Mts. *Folia oecol.,* 36: 94–107.

Mountain ash (*Sorbus aucuparia* L.) is an important substitute tree species in stands in the Ore Mountains loaded with air-pollution. Among 84 caterpillar species (Lepidoptera) obtained by the method of shaking off from mountain ash crowns in 2008, the highest abundance was found in the species *Campaea margaritata* (L.)*, Venusia cambrica* Curtis*, Opisthograptis luteolata* (L.) and *Hedya nubiferana* (Haw.). The species diversity increased with altitude without showing preferences for individual species. In the early spring aspect (31 species), there were most abundant *Hedya nubiferana*, *H. pruniana* (Hbn.) and *Trachycera advenella* (Zincken); in the spring aspect (57 species) *Agriopis aurantiaria* (Hbn.) and *Alsophila aescularia* (Den. et Schiff.); in the summer aspect (55 species) *V. cambrica*; in the late summer aspect (23 species) *O. luteolata* and *C. margaritata*; in the autumnal aspect (11 species) *C. margaritata.* Damage to the mountain ash berries ranged from 21.3 to 94.1%, and it was caused by *Argyresthia conjugella* (Zell.). Moths of the species hatched in the gradation years at the of effective temperatures about 900 ºC.

Keywords
insect-pests, Lepidoptera larvae, Ore Mts (Erzgebirge Mts), phenology, *Sorbus aucuparia* L.

Introduction

In the air-polluted higher situated locations of the Krušné hory Mts (Ore Mountains), the mountain ash (*Sorbus aucuparia* L.) has become an important ”accessory” in stands of substitute species (3,130 ha) growing in seriously disturbed site conditions (Balcar et al., 2008). The species, relatively resistant to sulphur dioxide, grows fast and creates the local environment with leaf litter improving soil conditions, although not as effectively as birch (*Betula* sp.) (Kubelka et al., 1992; Ulbrichová and Podrázský, 2002). The high attractiveness of this woody plant for forest animals is, however, a disadvantage (browsing, deer barking and winter browsing) for the plant itself (Eiberle and Bucher, 1989; Sloup et al., 2008). The damaged, weakened trees are exposed to subsequent attack by fungal pathogens, eg *Stereum rugosum* Pers. and *Pholiota squarrosa* Kumm. (Jančařík, 1999).

As for phytophages, heavy defoliation of mountain ash is caused by *Gonionema quinquepunctata* (Fabr.) (Urban, 1998; Kula, 1999). The species *Lochmaea crataegi* (Forst.) (Schmidt 1989), *Strophosomus melanogrammum* (Forst.), *Phyllobius arborator* (Herbst) (Urban 1999, Kula and Šimon, 2007) and *Eriophyes pyri* (Pagenstecher) (Kula et al., 2007) are important pests of the crown fauna. *Agrilus mendax* Mnnh. and *Saperda scalaris* (L.) (Kangas, 1942) cause a serious damage to this woody plant.

A relatively broad spectrum of Lepidoptera caterpillars (148) is related to mountain ash by feeding on. Out of them, only *Stigmella hahniella* (Wörz) is considered to be a monophage of this species (Reiprich, 2001). *Operopthera brumata* (L.) with outbreaks in the boreal region of Fennoscandinavia attacked primarily *Prunus padus* L. and *S. aucuparia* (90% defoliation); on the other hand, *Alnus incana* (L.) Moench., *Betula pubescens* (Ehrh.) were attacked much less severely (25% defoliation) (Tikkanen et al. in contrast to 1998). In the Northern Sweden, caterpillars of *Epirrita autumnata* (Borkh.) feed on mountain ash leaves (Neuvonen et al., 1987). Ivinskis et al. (1991) observed an important population of *Aporia crataegi* (L.) on *Sorbus* sp. and *Salix* sp. in forest stands.

Klinkowski and Nolte (1951) classified *H. nubiferana* [syn. *Argyroploce variegana* (Hbn.)] and *Spilonota* [syn. *Tmetocera*] *ocellana* (Den. et Schiff.) as pests of fruits of mountain ash growing in the vicinity of orchards. According to Nagy (1977), *Cydia pomonella* (L.) attacked not only fruits of apple trees (0.6–26%) in orchards but also wild-growing *Malus sylvestris* Mill., *Sorbus torminalis* (L.) and *S. semiincisa* Borbás. Nevertheless, Křístek et al. (1992) mention that *Argyresthia conjugella* (Zell.) is the most important pest of mountain ash fruits.

The aim of this paper is to provide an overview on the fauna of caterpillars developing on mountain ash in forest stands in the air-polluted area of the Eastern Ore Mountains.

Methods and the area of monitoring

Caterpillars were shaken off from crowns of trees aged 15–60 years, by means of hammer blows (4 kg) on the tree stem. Two pieces of canvas 2 × 2 m in size were placed under the crown projection. The caught individuals were killed and conserved in 75% ethanol. The caterpillars were sampled at 31 localities situated at altitudes from 496 to 870 m (Table 1). At the time of the first sampling (7/5/2008), the degree of mountain ash foliage development differentiated according to the location (from stands with unfolding leaves to fully unfolded stands). A phenological shift was noted in the degree of flower development (27/5), and subsequently in the formation of rowanberries (14/6) (Table 2). The majority of localities were affected by cold weather, which was probably the cause of unpollinated flowers. The area of monitoring includes 31 localities situated from the Děčínská vrchovina Upland (N 50°47'40", E 14°07'55") (localities 1–3) to the Mount St. Sebastian in the Ore Mountains (N 50°30'41", E 13°16'21") (localities 4–31) (Table 1). Seven control samplings were carried out monthly: two in May and the other five from June 14 to October 15, 2008.

The phenology of flight activities of the selected species of butterflies was determined using a Minnesota light trap with RVL 250 W discharge lamp situated in the Sněžník locality (cadastral area Jílové – Sněžník, 14°04' E, 50°46' N, faunistic square 5250), altitude 570 m asl, daily inspection (1/4–30/10/1989–2007)

Table 1. List of the study localities and phenological characteristics of mountain ash trees in these localities (Ore Mountains, 2008)

Locality	Altitude	Location		Foliage			Flowers	Fruits	Phenology category
		N	E	Breaking buds [%]	Created leaves [%]	Crown foliage [%]			
					7. 5. 2008		27. 5. 2008	14. 6. 2008	
1	713	50°47'40"	14°05'55"	10	90	90	PUB	PVP	B
2	598	50°47'03"	14°05'17"	0	100	90	PUB	PV	A
3	526	50°47'59"	14°01'10"	0	100	100	K-100%	PV	A
4	672	50°45'38"	13°58'28"	60	40	30	PUB	PVP	B
5	734	50°45'05"	13°57'16"	20	80	70	PUB	PVP	B
6	703	50°45'11"	13°54'51"	0	100	90	PUB	PVP	B
7	756	50°44'02"	13°54'21"	70	30	40	PUB	PV+20% O	B
8	762	50°42'32"	13°51'04"	30	70	70	PUB	PVP	B
9	770	50°43'16"	13°49'56"	30	70	70	PUB	PV	B
10	868	50°43'36"	13°45'44"	90	10	10	PUT	PV+20% O	C
11	832	50°41'51"	13°43'20"	50	50	40	PUT	PVP	B
12	862	50°42'16"	13°41'31"	90	10	10	PUT	100% O	C
13	782	50°41'49"	13°37'03"	90	10	10	PUT	100% O	C
14	664	50°41'45"	13°34'03"	80	20	20	PUB	PV+50% O	C
15	800	50°41'31"	13°38'32"	90	10	10	PUB	PV+50% O	C

Table 1. Continued

Locality	Altitude	Location		Foliage			Flowers	Fruits	Phenology category
		N	E	Breaking buds [%]	Created leaves [%]	Crown foliage [%]			
					7. 5. 2008		27. 5. 2008	14. 6. 2008	
16	863	50°39'17"	13°38'37"	90	10	10	PUT	*	B
17	742	50°38'08"	13°36'54"	0	100	90	*	*	A
18	496	50°37'05"	13°37'19"	0	100	100	K-100%	PVV	A
19	855	50°33'18"	13°23'03"	80	20	15	PUT	PV+50% O	C
20	810	50°32'59"	13°23'16"	20	80	60	PUT	PVP	B
21	722	50°32'40"	13°23'51"	0	100	90	K-100%	PVP	A
22	870	50°34'50"	13°25'33"	90	10	5	PUT	100% O	C
23	821	50°34'54"	13°24'47"	40	60	40	PUT	100% O	C
24	800	50°33'35"	13°24'25"	80	20	70	PUT	PVP	B
25	798	50°33'01"	13°24'07"	0	100	90	PUB	PVP	B
26	562	50°31'58"	13°23'44"	0	100	90	*	*	A
27	686	50°32'05"	13°21'44"	20	80	80	K-50%	PVP	B
28	714	50°34'40"	13°18'12"	90	10	10	PUB	PVP	B
29	842	50°31'28"	13°14'09"	70	30	25	PUB	100% O	C
30	837	50°30'41"	13°16'21"	40	60	50	PUB	PVP	B
31	745	50°28'38"	13°16'35"	50	50	40	K-30%	PVP	B

PUT – closed flowers, dark flower-buds; PUB – closed flowers, white flower-buds; K – fully developed flowers; *– undetected
PV – created fruit, undamaged; PVP – created fruit, damaged; O – not set established fruit, fading away; PVV – large fruits
A – early onset of leaf unfolding and fading away; B – standard; C – delayed leaf unfolding and fading away

Table 2. Health condition of rowanberries in the period of their maturity (Ore Mountains, 2008)

Locality	Fructification	No. of examined fruits	No. of caterpillar-infested fruits	Proportion of caterpillar-infested fruits [%]	No. of rot-attacked fruits	No. of dry fruits	No. of healthy fruits
1	Sporadic	85	42	49.41	15	4	24
2	Low	114	73	64.04	5	5	31
3	Medium	69	20	28.99	7	7	35
4	Sporadic	94	78	82.98	4	8	4
5	Sporadic	84	79	94.05	2	2	1
6	Low	79	59	74.68	2	11	7
7	Sporadic	90	68	75.56	8	9	5
8–17	No occur						
18	Heavy	88	19	21.59	5		64
19–23	No occur						
24	Sporadic	80	69	86.25	5	6	0
25–27	No occur						
28	Sporadic	98	80	81.63	6	4	8
29	No occur						
30	Low	91	78	85.71	3	6	4
31	Low	95	79	83.16	6		10

(Kula 2007). The Sörensen index of species similarity and equitability was calculated according to Losos et al. (1984). A dendrogram was created according to the method of Ward (Statsoft, 2007) based on a quantitative-qualitative evaluation.

The caterpillars were determined by Jan Patočka, the nomenclature is given according to Laštůvka and Liška (2007).

Results and discussion

Species composition of the caterpillar communities

In total, 84 species of caterpillars were determined on mountain ash. Reiprich (2001) mentions only 38 of them. During the growing season, altogether 15–35 species of caterpillars were noted in the particular localities. According to the index of species similarity, there is a high conformity (>70%) between stands 18 and 2–12; on the contrary, very low between stands 25 and 2–4, 8–12, 15–18 (<25%). The equitability is relatively high (0.83–0.94), the species diversity index is balanced similarly (2.31–3.26). The dendrogram created by using the Ward method (Fig 1) consists of four sections representing relatively distant stands in locations situated at medium-altitudes (20–4), Eastern part of the Ore Mountains (24–6), higher and medium locations (29–10) and the Děčínská vrchovina Upland (5–1). By the frequency, *Campaea margaritata, Venusia cambrica* and *Opisthograptis luteolata* can be assigned to the generally distributed species of the Děčínská vrchovina Upland and the Eastern Ore Mountains (Table 3). *V. cambrica* showing a eudominant proportion (11.2%) was accompanied by three dominant species: *Hedya nubiferana* (8.52%), *C. margaritata* (6.17%) and *O. luteolata* (5.5%). In the studied area, species diversity increased with increasing altitude: from 61 species (496–700 m asl) to 78 species (701–870 m asl). Nevertheless, we did not observe preferences to altitudinal zones in the particular species (Table 3).

In the early spring aspect, 31 species were recorded with the dominant position of *H. nubiferana* (33.1%), *Hedya pruniana* (22.8%) and *Trachycera advenella* (9.5%). In the spring aspect, 57 species of caterpillars occurred; the highest proportion of them showed Geometridae, namely *Agriopis aurantiaria* (10.8%), *Alsophila aescularia* (10.3%) accompanied by *Orthosia gothica, Ypsolopha horridella* and *Pandemis cerasana.* In total, 55 species of caterpillars characterized the summer aspect in crowns of mountain ash, with the very marked position of *V. cambrica* (35.5%). In the late summer aspect, the species diversity decreased (23 species); the most important position showed Geometridae *O. luteolata* (27.1%), *C. margaritata* (14.3%), *Eupithecia* sp. and *Biston betularia* (L.). Although the autumnal aspect included 11 species, *C. margaritata* predominated in the mountain ash crown and its all-season abundance culminated there (Table 4).

Eudominant and dominant species

Venusia cambrica Curtis. Caterpillars of this species were generally distributed across the studied area (97% stands), being dominant in the mountain ash crown

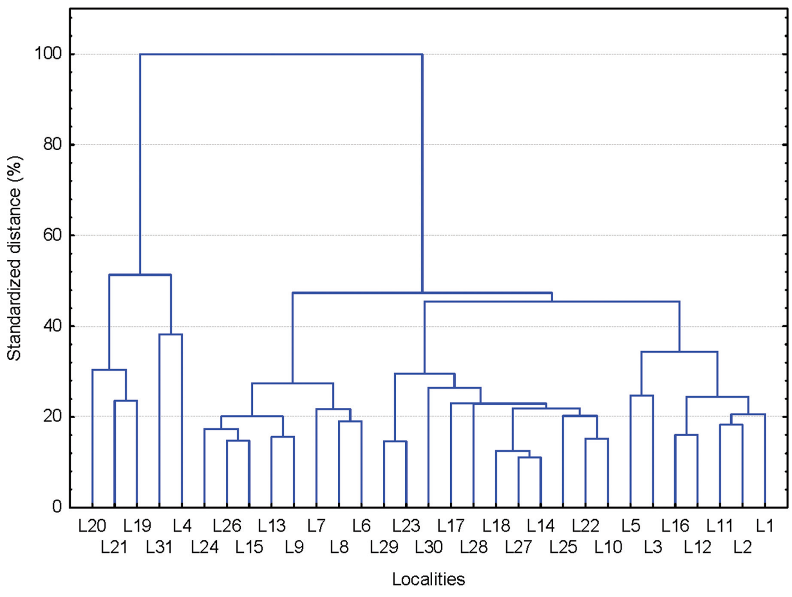


Fig 1. Dendrogram showing the similarity between samples of caterpillars collected from mountain ash in the Eastern part of the Ore Mountains (L1–L31: localities 1–31)

Table 3. Dominance (D) of abundant species of Lepidoptera caterpillars obtained from mountain ash crowns in two altitudinal zones and their frequency over the study area (Ore Mountains, 2008)

Species	Altitude [m] 496–700 D [%]	Altitude [m] 701–870 D [%]	Frequency [%]
Campaea margaritata (L.)	5.66	6.35	96.77
Venusia cambrica Curtis	12.42	10.76	96.77
Opisthograptis luteolata (L.)	3.62	6.18	90.00
Hedya nubiferana (Haw.)	10.69	7.73	86.67
Agriopis aurantiaria (Hbn.)	5.66	3.78	83.33
Chiasmia alternata (Den. & Schiff.)	3.30	2.29	80.00
Ypsolopha horridella (Tr.)	2.04	3.09	80.00
Orthosia gothica (L.)	2.04	3.84	76.67
Pandemis cerasana (Hbn.)	3.14	3.26	73.33
Alsophila aescularia (Den. & Schiff.)	2.52	4.18	70.00
Hedya pruniana (Hbn.)	3.93	5.21	66.67
Lycia hirtaria (Cl.)	2.20	2.40	66.67
Operophtera brumata (L.)	3.46	2.06	66.67
Trachycera advenella (Zinck.)	4.40	3.21	60.00

Table 4. Total number of caterpillars obtained from mountain ash crowns in the 31 study localities in the Ore Mountains corresponding to the five aspects of the growing season 2008 Aspect: ČJ (early spring until 10/5), J (spring 11/5–20/6), L (summer 21/6–15/8), PL (late summer 16/8–15/9), P (autumnal 16/9–30/10)

Aspects	ČJ	J	L	PL	P	Sum	
Species/Aggregate trapping	N	N	N	N	N	N	%
Acleris sp.	0	3	0	1	0	4	0.17
*Acronicta leporina (*L.)	0	0	1	0	0	1	0.04
Acronicta psi (L.)	0	0	1	1	1	3	0.13
Acronicta strigosa (Den. & Schiff.)	0	0	13	0	0	13	0.55
Acronicta tridens (Den. & Schiff.)	0	0	2	0	0	2	0.08
Agriopis aurantiaria (Hbn.)	11	89	2	0	0	102	4.28
Agriopis marginaria (Fabr.)	0	2	0	0	0	2	0.08
Alcis repandata (L.)	4	16	1	1	4	26	1.09
Allophyes oxyacanthae (L.)	13	26	0	0	0	39	1.64
Alsophila aescularia (Den. & Schiff.)	0	85	4	0	0	89	3.73
Apocheima pedarium (Fabr.)	0	7	0	0	0	7	0.29
Arctiidae g. sp.	0	1	0	0	0	1	0.04
Argyresthia conjugella (Zell.)	0	0	0	0	3	3	0.13
Archips crataeganus (Hbn.)	0	40	0	0	0	40	1.68
Archips podanus (Scop.)	2	4	0	0	0	6	0.25
Archips xylosteanus (L.)	0	7	0	0	0	7	0.29
Atolmis rubricollis (L.)	1	1	17	13	0	32	1.34
Biston betularia (L.)	0	0	11	16	3	30	1.26
Calliteara pudibunda (L.)	0	0	2	0	0	2	0.08
Campaea margaritata (L.)	16	5	22	35	69	147	6.17
Cleora cinctaria (Den. & Schiff.)	0	1	5	1	0	7	0.29
Colocasia coryli (L.)	0	0	4	0	0	4	0.17

Table 4. Continued

Aspects	ČJ	J	L	PL	P	Sum	
Species/Aggregate trapping	N	N	N	N	N	N	%
Colotis pennaria (L.)	0	13	0	0	0	13	0.55
Conistra vaccinii (L.)	0	3	0	0	0	3	0.13
Cosmia trapezina (L.)	0	4	0	0	0	4	0.17
Cydia janthinana (Dup.)	0	0	0	0	1	1	0.04
Cydia sp.	0	0	4	1	0	5	0.21
Dahlica sp.	0	0	3	15	11	29	1.22
Diloba caeruleocephala (L.)	1	4	0	0	0	5	0.21
Diurnea fagella (Den. & Schiff.)	0	0	2	1	0	3	0.13
Dryobotodes eremita (Fabr.)	0	0	1	0	0	1	0.04
Ectropis crepuscularia (Den. & Schiff.)	0	0	21	3	0	24	1.01
Eilema deplana (Esp.)	1	3	1	1	0	6	0.25
Eilema lurideolum (Zinck.)	1	0	0	0	0	1	0.04
Electrophaes corylata (Th.)	1	0	5	16	0	22	0.92
Epirrita autumnata (Borkh.)	0	0	1	0	0	1	0.04
Epirrita dilutata (Den. & Schiff.)	2	12	1	0	0	15	0.63
Erannis defoliaria (Cl.)	1	11	0	0	0	12	0.50
Eulia ministrana (L.)	0	0	2	9	0	11	0.46
Eupithecia sp.	0	0	31	20	0	51	2.14
Eupsilia transversa (Hufn.)	0	1	0	0	0	1	0.04
Gelechiidae g. sp.	0	1	0	0	0	1	0.04
Geometridae g. sp.	1	12	2	0	0	15	0.63
Hedya nubiferana (Haw.)	161	42	0	0	0	203	8.52
Hedya pruniana (Hbn.)	111	5	0	0	0	116	4.87
Hypomecis punctinalis (Scop.)	0	0	3	3	0	6	0.25
Chiasmia alternata (Den. & Schiff.)	0	15	40	5	1	61	2.56
Chiasmia notata (L.)	0	0	0	0	1	1	0.04
Chloroclysta siterata (Hufn.)	0	0	8	1	0	9	0.38
Choristoneura hebenstreitella (Müll.)	0	4	2	0	0	6	0.25
Jodis lactearia (L.)	0	0	8	0	0	8	0.34
Lamprosticta culta (Den. & Schiff.)	0	0	1	5	3	9	0.38
Lasiocampa quercus (L.)	1	1	0	3	0	5	0.21
Lithosia quadra (L.)	0	2	2	0	0	4	0.17
Lycia hirtaria (Cl.)	0	4	52	0	0	56	2.35
Lycia pomonaria (Hbn.)	0	6	5	0	0	11	0.46
Malacosoma neustria (L.)	11	0	0	0	0	11	0.46
Neosphaleroptera nubilana (Hbn.)	0	1	0	0	0	1	0.04
Noctuidae g. sp.	1	3	13	4	1	22	0.92
Nola cucullatella (L.)	3	8	1	0	0	12	0.50
Odontopera bidentata (Cl.)	0	0	7	5	0	12	0.50
Ochropacha duplaris (L.)	0	0	1	0	0	1	0.04
Operophtera brumata (L.)	18	40	0	0	0	58	2.43
Operophtera fagata (Scharf.)	5	6	0	0	0	11	0.46
Opisthograptis luteolata (L.)	2	0	61	66	2	131	5.50
Orgyia antiqua (L.)	0	3	8	2	0	13	0.55
Orthosia cerasi (Fabr.)	0	30	14	0	0	44	1.85

Table 4. Continued

Aspects	ČJ	J	L	PL	P	Sum	
Species/Aggregate trapping	N	N	N	N	N	N	%
Orthosia gothica (L.)	0	73	7	0	0	80	3.36
Orthosia incerta (Hufn.)	0	8	18	0	0	26	1.09
Orthosia sp.	6	9	0	0	0	15	0.63
Orthotaenia undulana (Den. & Schiff.)	32	1	0	0	0	33	1.38
Pandemis cerasana (Hbn.)	26	47	4	0	0	77	3.23
Pandemis cinnamomeana (Tr.)	0	1	0	0	0	1	0.04
Pandemis corylana (Fabr.)	0	3	0	0	0	3	0.13
Pandemis heparana (Den. & Schiff.)	0	0	9	0	0	9	0.38
Paraswammerdamia lutarea (Haw.)	0	18	0	1	1	20	0.84
Parectropis similaria (Hufn.)	0	0	21	0	0	21	0.88
Peribatodes rhomboidarius (Den. & Schiff.)	0	0	10	3	0	13	0.55
Phalera bucephala (L.)	0	0	2	0	0	2	0.08
Plagodis pulveraria (L.)	0	0	2	0	0	2	0.08
Poecilocampa populi (L.)	0	1	0	0	0	1	0.04
Psyche casta Pallas	0	1	0	0	0	1	0.04
Ptilodon capucina (L.)	0	0	1	0	0	1	0.04
Recurvaria leucatella (Cl.)	0	13	0	0	0	13	0.55
Recurvaria nanella (Den. & Schiff.)	3	7	0	0	0	10	0.42
Semioscopis steinkellneriana (Den. & Schiff.)	1	0	1	3	0	5	0.21
Spilonota ocellana (Den. & Schiff.)	2	2	0	0	0	4	0.17
Swammerdamia compunctella (Herr.-Schäff.)	0	1	0	0	0	1	0.04
Tortricidae g. sp.	1	15	4	0	1	21	0.88
Trachycera advenella (Zinck.)	46	38	0	0	0	84	3.52
Trichiura crataegi (L.)	1	0	0	0	0	1	0.04
Trichosea ludifica (L.)	0	0	3	0	0	3	0.13
Venusia cambrica Curtis	0	1	257	9	0	267	11.20
Ypsolopha horridella (Tr.)	0	66	1	0	0	67	2.81
Total	486	826	725	244	102	2,383	100.0

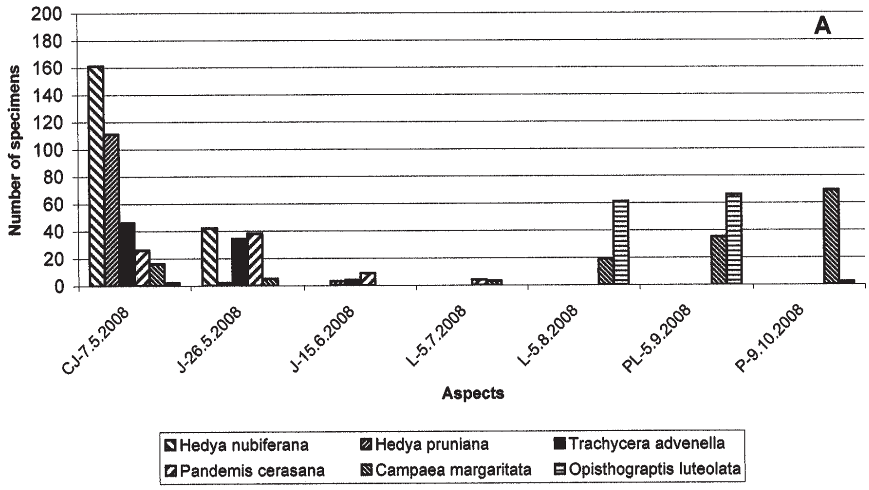
fauna. The adults were not trapped into light traps (Kula, 2007). This mountain species, mentioned by Ebert et al. (2001) at locations 800–1250 m asl, was caught in the Ore Mountains at altitudes 500–900 m asl, the most abundant being in the lowest situated localities. It is considered as a monophage on mountain ash (Ebert et al., 2001, also according to our results), although some authors admit that this species also feed on birch as an additional nutritive plant (Warnecke, 1943) or on shrub layer (Lange, 1920). Data on its development on *Vaccinium myrtillus* L. are not to take with full confidence (Vorbrodt, 1914). Raspé et al. (2000) specified caterpillar feeding to August. According to our results obtained by trapping on mountain ash, the main occurrence of caterpillars was recorded in the period July–August, with sporadic finds in mid-June and culmination at the beginning of August; the occurrence lasted up to the beginning of September (Fig 2B).

Hedya nubiferana (Haw.). Although this species is considered as a polyphage on various broadleaved species (Kennel 1908, Razowski 2001), according to our experience, it only lives on trees of the family Rosaceae. According to the above mentioned authors, caterpillars (after wintering) feed on flowers, developing buds and leaves, from April to May. In our case they created the most important component of the mountain ash crown fauna, particularly in the spring aspect, with a sporadic occurrence in May (Fig 2A). In spite of differences in the foliage of mountain ash in the early spring aspect – from sparse foliaged stands to fully foliaged stands, the dominance of *Hedya nubiferana* caterpillars was relatively balanced (35.5–34.3–30.2%). They were found in 87% monitored stands. According to the quoted authors, imagoes occur from July to August. They were very abundant in the light trap (June – beginning of September) and showed another peak in July–mid-August with a maximum of 123 individuals/night (5/8/2003). Population dynamics (1989–2007) was differentiated, and after culmination in 2003 it retreated.

Hedya pruniana (Hbn.). Its caterpillars live on various broadleaved species mainly of the family Rosaceae. It winters, and in early spring occurs in crowns of trees and shrubs (Kennel, 1908; Razowski, 2001; Reiprich, 2001). In our case the species usually occurred on mountain ash (proved on 67% localities), which is remarkable, because, according to the experience of the second author, in other regions of Bohemia and Slovakia it occurred, almost exclusively on the genus *Prunus.* It showed an increased abundance in localities 19 and 20 (area of Boleboř – Kalek). In the spring aspect, caterpillars approached the dominance of *H. nubiferana* (Fig 2A). In stands with the early start of leaf unfolding, the population dominance was markedly lower (17.2%) than in stands with the standard course (24.7%) and delayed flushing (28%). In some years, the imagoes in the light trap were less numerous than *H. nubiferana*. It occurred from mid-May to August, without an evident culmination, nevertheless, with a more compact proportion to the end of June.

Campaea margaritata (L.). It is a generally distributed species reaching the medium-altitude locations (Bergmann, 1955). It occurs in one or two generations. Two generations usually occur in warmer regions and years (Celton, 1936; Patočka et al., 1999; Ebert et al., 2003). Its caterpillars are polyphagous on broadleaved species, preferring the family of Fagaceae (Patočka et al., 1999). The moth flies from mid-May to mid-October (Ebert et al., 2003); in case of two generations, in mid-May, and then from August to October.

We detected caterpillars in 97% monitored stands in a balanced proportion (1–12 pieces). The highest abundance was noted in October. After wintering, their number substantially decreased (Fig 2A), similarly as on birch in the Ore Mountains (Kula, 2007). The



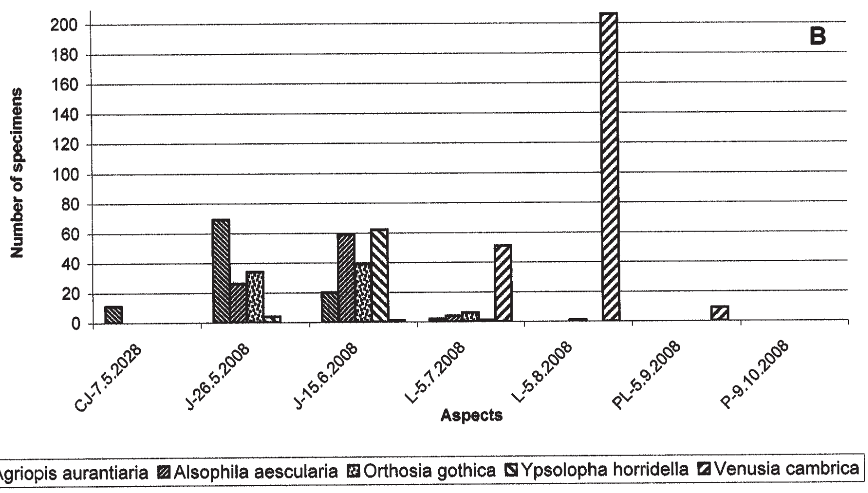


Fig 2. Seasonal changes in the total number of caterpillars obtained from mountain ash crowns in the 31 localities in the Ore Mountains in 2008 (CJ, J, PL, P: aspects, see Table 4)

imagoes belonged to the commonly occurring species the abundance of which culminated in 2002 and 2006 (KULA, 2007).

Opisthograptis luteolata (L.). It is an abundant species distributed from lowlands up to mountain locations. Various authors (REUTTI, 1898; KOCH, 1984; REIPRICH, 2001; EBERT et al., 2003) mention one or two or even more generations. Imagoes can occur from April to September. Caterpillars created an important component of the late-summer fauna of mountain ash (August–mid–September). They occurred throughout the region (90% monitored stands) without any site preference (1–15 pieces). It the area of Sněžník, we did not prove two generations because imagoes occurred from 23 April to 12 July. The species abundance culminated rather shortly in the first half of June; after a faster increase a slower decline occurred (Fig 2A). Population density values did not show bigger variations, they commonly did not exceed 10 individuals per night.

Agriopis aurantiaria (Hbn.). The species is polyphagous (broadleaved species and larch) with considerable vertical distribution. It shows a trend towards local gradations (ŠUŠLÍK and KULFAN, 1993; PATOČKA et al., 1999; EBERT et al., 2003). Caterpillars are relatively numerous on birch trees, and they do not manifest evident population dynamics (KULA, 2007); on mountain ash, it occurred in 70% monitored stands, from May to mid-June at numbers of 1–11 individuals per a sample (Fig 2B).

Alsophila aescularia (Den. & Schiff.). The species is distributed from lower to medium locations. It is a polyphage on broadleaved species and shows a potential for occasional gradations (SCHNEIDER, 1938; BERGMANN, 1955; CARTER, 1984; PATOČKA et al., 1999). REIPRICH (2001) does not mention it on mountain ash. The species was observed at altitudes of 500–900 m asl, with a higher proportion in stands at above 700 m asl (11.5%) than below 700 m asl (2.5%). We sampled caterpillars from the end of May to the beginning of July; the most intensive sampling ran in the mid-June (Fig 2B). In 70% monitored stands, a balanced proportion was noted (1–11 ex.) (Table 3). In the light trap on Sněžník, imagoes occurred from 25 March to 8 May, without marked fluctuations in abundance. In total, only 59 individuals arrived in 1989–2007.

Orthosia gothica (L.). The species is commonly distributed from lowlands to mountains. It is broadly polyphagous, its caterpillars live on broadleaved and coniferous trees as well as on some herbs (BERGMANN, 1954; FORSTER and WOHLFAHRT, 1960; KOCH, 1984; KULFAN, 1994; PATOČKA et al., 1999; PATOČKA and KULFAN in press). Caterpillars occurred in mountain ash stands (out of 77% monitored) in low abundance. In crowns of birch in a nearby locality Sněžník, caterpillars occurred sporadically (KULA, 2007). On Sněžník, imagoes were noted in a light trap from March to mid-June with a culmination in the 2nd and 3rd thirds of April (Fig 2B). The highest numbers of individuals caught per a night were: 187 (17/4/2004) and 173 (17/4/2004). The particular years markedly differed in abundance, and population dynamics became characterised (typical) by repeated and frequent culminations (1992–1993, 1996–1997, 1999–2000, 2002, 2004 and 2007).

Pandemis cerasana (Hbn.). This broadly polyphagous species is mainly distributed on trees. Sometimes it displays gradations. Larvae of the 3rd instar winter in splits of bark or between connected leaves (PATOČKA, 1955). In spring, they attack young shoots; later browse leaves (SCHWENKE, 1974; RAZOWSKI, 2001; REIPRICH, 2001; PATOČKA and KULFAN, in press). On mountain ash in our study, the species showed a broad distribution (73% stands) but low abundance. In the crown fauna of birch trees, we trapped only 64 caterpillars from the beginning of May to the beginning of August with a maximum at the end of May (KULA, 2006). The occurrence of caterpillars indicated the partial second generation, which was not mentioned by RAZOWSKI (2001). Imagoes were recorded as early as May but the common occurrence was noted from June to August, high arrivals and proportion had peaks between 15/6 and 10/7. The last individuals were found towards the end of September. At the Sněžník locality, it was the third most abundant species caught into the light trap (1989–2007). Its population dynamics became evident base on irregular culminations (1992, 1999–2000, 2002–2003) (Fig 2A).

Lycia hirtaria (Cl.). It is a spring species with imagoes occurring sometimes as early as in February (EBERT et al., 2003). Caterpillars were found in 67% monitored mountain ash stands (1–12 individuals) from the end of May, with a culmination at the turn of June and July. It occurred uniformly at altitudes 500–900 m asl in the Ore Mountains, and showed higher proportion at higher locations (up to 700 m asl 2.2%, above 700 m asl 6.6%). We trapped imagoes in the Sněžník locality from April to mid-June with the same intensity of increase and decline of culmination. As a rule, the maximum of abundance occurred in the last third of April. The species maximum arrival to the light trap was 60 individuals per night (1/5/2003).

Ypsolopha horridella (Tr.). Females lay eggs on woody species of Pomoideae and Prunoideae (PATOČKA and KULFAN, in press). Caterpillars were found on mountain ash in mid-June. Their abundance changed with the development of foliage (9.8–8.3–6.1%). Although imagoes are attracted by light (they occur in July and August) (EMMET, 1996), no individual was found in the light trap in the Sněžník locality in 1989–2007.

Argyresthia conjugella (Zell.). Imagoes occur from the end of July to August and mating comes about at nights with a light intensity of 500–2000 lx. Females lay individual eggs at a light intensity of 50–500 lx on developing rowanberries (JAASTAD et al., 2005). Caterpillars hatch 14 days later, gnaw out fruits and damage also seeds. Fully developed caterpillars leave fruits and pupate in litter (August–October) (KŘÍSTEK et al., 1992). At the high rowanberry crop in 2006, the proportion of the invaded rowanberries was low (<10%). In 2008, the fruit production in the studied area decreased due to unpollinated flowers. Full fecundity was noticed only in site 18 (altitude 496 m asl). At locations between 526 and 870 m asl, rowanberries occurred sporadically or were missing at all). In 2008, the degree of damage to rowanberries caused by moth larvae was very high (49.4–94.1%) in stands with the low and sporadic occurrence of rowanberries. Only sites with a high and medium crop of mountain ash in the lowest-situated localities recorded lower attacks (21.6–29%) (Table 2). In the same period, we observed a very low attack (0–3.2%) on mountain ash trees with high fruit production in the urban areas of Brno - Líšeň and Černá pole (Czech Republic) and Krakow (Poland), and along a road outside forest (Libouchec – Chlumec) (Czech Republic). In 1970, a 36.3% attack on rowanberries was confirmed in the Ore Mountains, and in the České středohoří (the Bohemian Highlands) Mountains (Křístek et al., 1992). According to the imagoes trapped in the light trap, the species population dynamics was irregular (culmination in 2002 and 2007). A direct effect of climatic factors on changes in population dynamics of imagoes in the study years 1997–2007 was not detected. In the Sněžník locality, imagos occurred from mid-May to July with a culmination between 13/6–22/6 and a maximum abundance of 177–318 individuals (June 13–23, 2008). Due to the early beginning of spring (higher temperatures and lower precipitation in April), the hatching in the year of culmination (2007) began nearly 20 days earlier than in 2008. In the period 18/5–12/6 2007, 28.6% imagoes from the total of the whole growing season were recorded, in contrast to the only 6.1% adult moths in 2002 (Fig 3). The sum of positive temperatures on 30/4 in 2002 and 2007 reached a value of 322.3 and 554.4 °C, respectively. The hatching of imagoes began between 24/5–28/5/2007 at a temperature sum of 912.2 °C and in the period 8/6–12/6/2002 at a temperature sum of 896 °C. In the period of culmination 13/6–17/6/2007, the sum of temperatures reached 1261.1 °C, while the culmination 23/6–27/6/2002 was characterized by a temperature sum of 1,078.9 °C. In the other years 1997–2005, the beginning of hatching was related to a temperature sum ranging from 603.6–1070.1 °C (Table 5). In Scandinavia, it represents an important pest of orchards, as in case of lacking food, the females invade fruit orchards where they destroy crop (Ahlberg, 1927; Kobro, 1995; Sperens, 1997). In areas with the natural occurrence of mountain ash, it is a common species and the intensity of attacks to rowanberries is dependent on the fecundity of the mountain ash trees. To monitor the occurrence of butterflies, it is possible to use sexual pheromones (Jaastad et al., 2002).

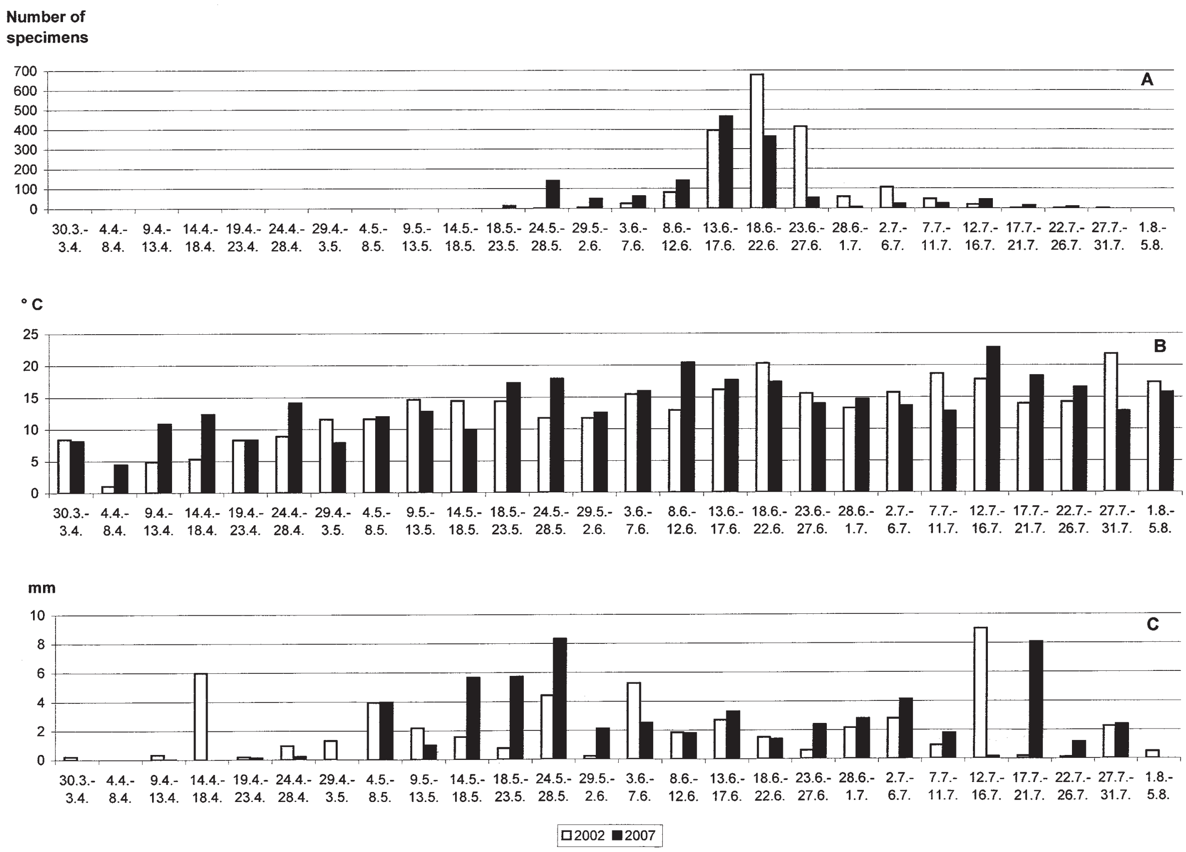


Fig 3. Seasonal changes in flight activity (A) of *Argyresthia conjugella* imagoes (Zell.) (Sněžník, light trap) depending on temperature (B) and precipitation total (C)

Table 5. Seasonal changes in the flight activity of *Argyresthia conjugella* imagoes (number of specimens collected) and sum of effective temperatures at the beginning of hatching (Sněžník, 1997–2007)

Year/Datum	18. 5.–23. 5.	24. 5.–28. 5.	29. 5.–2. 6.	3. 6.–7. 6.	8. 6.–12. 6.	13. 6.–17. 6.	18. 6.–22. 6.	23. 6.–27. 6.	28. 6–1. 7.	2. 7.–6. 7.	7. 7.–11. 7.	12. 7.–16. 7.	17. 7.–21. 7.	22. 7.–26. 7.	27. 7.–31. 7.	1. 8.–5. 8.	6. 8.–10. 8.	11. 8.–15. 8.	16. 8.–20. 8.	21. 8.–25. 8.	26. 8.–30. 8.	Sum of imagos	Sum of temperatures
1997					6	59	141	4	71	61	16	36		4	1					1		400	603.6
1998							29	87	24						6							146	1070.1
1999							41	47		439	30	8	3	1	2						1	572	880.8
2000		3	8	47	23	18	33	4	1			1							1			139	843.5
2001	3					18		1	10	16	5	12		6	5	1		1				78	855.7
2002		1	5	24	81	395	677	413	59	106	47	19	1	1	1							1,830	896.0
2003		2	5	23	19	11	9	13	4	3		4	2		1							96	685.7
2004			1	4	7	4	15	60	105	162	15	34	77	22	4	1	1					512	758.0
2005				5		23	24	60	14	13	1	6			1							147	662.0
2006						3		9	2	1	4	4	1	4								28	×
2007	13	139	48	60	140	466	363	52	6	23	24	43	15	7								1,399	912.2
Total	16	145	67	163	285	997	1,332	750	296	829	154	168	99	46	21	3	1	2	1	1	1	5,377	

× Data lacking

Conclusion

We studied moth caterpillars on mountain ash across a wide area of the Ore Mountains by the method of shaking off from trees. Our research results, have allowed us to include the caterpillars of *Venusia cambrica, Campaea margaritata, Opisthograptis luteolata* and *Hedya nubiferana* among generally distributed ones of the mountain ash fauna (84 species). The numerical proportion was balanced, and the altitudinal gradient of the area became partly evident in the species diversity. Communities of caterpillars on mountain ash changed according to the season: in the early spring aspect (31 species), *H. nubiferana*, *H. pruniana* and *Trachycera advenella* predominated; in the spring aspect (57 species), it was *Agriopis aurantiaria* and *Alsophila aescularia*; in the summer aspect (55 species) *V. cambrica*; in the late summer aspect (23 species) *O. luteolata* and *C. margaritata* and in the autumnal aspect (11 species) *C. margaritata.* Under conditions of the lack of rowanberries after frost damage, the attack by caterpillars of *Argyresthia conjugella* increased (21.3–94.1%). In the gradation years 2002 and 2007, the moths hatched at the sum of effective temperatures of about 900 °C.

Acknowledgement

This study was supported by the grants MSM 6215648902, VEGA 2/0110/09 and by the following companies and authorities: Netex, Alcan Extrusions, District Offices in Děčín all in Děčín, Setuza in Ústí n. L., ČEZ Praha holding, Lafarge Cement in Čížkovice, North-Bohemia Mines in Chomutov, Dieter Bussmann in Ústí n. L.

References

AHLBERG, O. 1927. Rönnbärsmalen, Argyresthia conjugella Zell. En redogörelse för undersökningar åren 1921–26. *Meddn Centralanst. Förs.-vägendet Jordbr.-omradet, Landbr.-Ent. Avd. (Stockholm)*, 324: 1–127.

BALCAR, V., KULA, E., LOMSKÝ, B., MAUER, O., ŠRÁMEK, V. 2008. Porosty náhradních dřevin (PND) a jejich ohrožení biotickými a abiotickými faktory [Substitute tree species stands at risk due to biotic and abiotic factors] In SLODIČÁK, M., BALCAR, V., NOVÁK, J., ŠRÁMEK V. et al. *Lesnické hospodaření v Krušných horách*. Edice Grantové služby LČR, 3. Hradec Králové: Lesy České republiky; [Teplice]: Grantová služba LČR; Strnady: Výzkumný ústav lesního hospodařství a myslivosti. p. 143–178.

BERGMANN, A. 1954. *Die Grossschmetterlinge Mitteldeutschlands: unter besonderer Berücksichtigung der Formenbildung, der Vegetation und der Lebensgemeinschaften in Thüringen sowie der Verflechtung mit der Fauna Europas. Band 4/1 und Band 4/2*: *Eulen-Verbreitung, Formen und Lebensgemeinschaften*. Jena: Urania. XX+1060 p.

BERGMANN, A.1955. *Die Grosschmetterlinge Mitteldeutschlands. Band 5/1.* Jena: Urania. 155 p.

CARTER, D. J. 1984. *Pest Lepidoptera of Europe with special reference to the British Isles*. Dordrecht, Boston: W. Junk; Hingham, MA: Distributor for the U. S. and Canada, Kluwer Academic Publisher. 431 p.

CETON, J.C. 1936. Metrocampa margaritata L. *Ent. Z. (Frankfurt.(M.),* 49: p. 545.

EBERT, G. et al. 2001. *Die Schmetterlinge Baden-Wüttembergs. Band 8, Nachtfalter VI.* Stuttgart: Ulmer. 541 p.

EBERT, G. et al. 2003. *Die Schmetterlinge Baden-Württembergs. Band 9, Nachtfalter VII.* Stuttgart: Ulmer. 609 p.

EIBERLE, K, BUCHER, H. 1989. Interdependenzen zwischen dem Verbiss verschiedener Baumarten in einem Plenterwaldgebiet. *Z. Jagdwiss.*, 35 (4): 235–244.

EMMET, A.M. 1996. *The moths and butterflies of Great Britain and Ireland. Vol. 3. Yponomeutidae – Elachistidae*. Colchester: Harley. 452 p.

FORSTER, W., WOHLFAHRT, T. A. 1960. *Die Schmetterlinge Mitteleuropas. Band III. Spinner und Schwärmer (Bombyces und Sphinges)*. Stuttgart: Franckh. VII+239 p., VIII+28 Taf.

IVINSKIS, P., SVITRA, G., STEPANAUSKAS, R., STITHLIS, D., USELIS, V. 1991. 1 macrolepidoptera new and 84 species of macrolepidoptera rare for the Lithuanian fauna. In VALENTA, V. *Novye i redkie dlya Litovskoi SSR vidy nasekomykh: soobshcheniya i opisaniya 1191 goda*. Vil'njus, p.18–29.

JAASTAD, G., BENGTSSON, M., ANDERSON, P., KOBRO. S., KNUDSEN, G., WITZGALL, P. 2002. Sex pheromone of apple fruit moth Argyresthia conjugella (Lepidoptera: Argyresthiidae). *Agric. Forest Ent.*, 4: 233–236.

JAASTAD, G., KNUDSEN, G.K., KOBRO, S., WITZGALL, P. 2005. When does the apple fruit moth (Argyresthia conjugella) fly and oviposit? *Ent. exp. appl.***,** 115 (2): 351–353.

JANČAŘÍK, V. 1999. Infekční choroby náhradních dřevin pro imisní oblast Krušných hor. [Infection diseases of substitute tree species in air-polluted area of the Ore Mountains] In BADALÍK, V. et al. *Problematika zachování porostů náhradních dřevin v imisní oblasti Krušných hor. Sborník referátů z celostátní konference, Most 18.–19. 5. 1999.* Praha: Ministerstvo zemědělství ČR, p. 77–82.

KANGAS, E. 1942. Forstentomologische Studien an einigen Laubholzern. *Ann. ent. fenn.*, 8 (2): 142–63.

KENNEL, J. 1908. *Die Palaearktischen Tortriciden*. Stuttgart. 742 p.

Klinkowski, M, Nolte, H.W. 1951. Knospenwickler als Schädlinge der Eberesche. *Nachr. Bl. dtsch. Pfl. Sch. Dienst.*, 5 (11): 212–213.

Kobro, S. (1995). Attack by the apple fruit moth in 1994. *Gartneryrket*, 11: 19–21.

Koch, M., 1984. *Wir bestimmen Schmetterlinge.* Leipzig: Neumann. 792 p.

Křístek, J., Jančařík, V., Procházková, Z., Skrzypczynska, M. Uroševič, B. 1992. *Škůdci semen, šišek a plodů lesních dřevin*. [Pests of seeds, cones and fruits of forest tree species]. Praha: Brázda, 286 p.

Kubelka, L. et al. 1992. *Obnova lesa v imisemi poškozené oblasti severovýchodního Krušnohoří.* [Forest regeneration in area of NE Ore Mountains damaged by airborne pollutants]. Praha: Ministerstvo zemědělství ČR. 133 p.

Kula, E. 1999. Biotičtí škodliví činitelé v porostech náhradních dřevin [Biotic harmful agents in stands of substitute tree species]. In Badalík, V. et al. *Problematika zachování porostů náhradních dřevin v imisní oblasti Krušných hor. Sborník referátů z celostátní konference, Most 18.–19. 5. 1999.* Praha: Ministerstvo zemědělství ČR, p. 19–26.

Kula, E. 2006. Geometridae (Insecta – Lepidoptera) in stands of substitute species with the dominant position of birch. *J. Forest Sci.,* 52 (5): 197–207.

Kula, E. 2007. *Motýli porostů náhradních dřevin v imisním území Sněžníku* [Moths of stands of substitute species in the air-polluted area of the Sněžník Mts.]. Kostelec nad Černými lesy: Lesnická práce. 107 p.

Kula, E., Buchta, I., Pokorná, M. 2007. Eriophyidae of broadleaved species in the eastern Krušné hory Mts. In Kula, E., Hrdlička, P. *Forestry Research in the Ore Mts. Reviewed proceeding from the national scientific workshop = Lesnický výzkum v Krušných horách. Recenzovaný sborník z celostátní vědecké konference, Teplice, Czech Republic, 19. 4. 2007.* Brno: Mendel University of Agriculture and Forestry Brno, p. 150–159.

Kula, E., Šimon, V. 2007. Curculionidae in the crown fauna of forest trees in the area of Sněžník. In Kula, E., Hrdlička, P. *Forestry Research in the Ore Mts. Reviewed proceeding from the national scientific workshop = Lesnický výzkum v Krušných horách. Recenzovaný sborník z celostátní vědecké konference, Teplice, Czech Republic, 19. 4. 2007.* Brno: Mendel University of Agriculture and Forestry Brno, p. 173–184.

Kulfan, J. 1994. Zur Saisondynamik der Raupenzönosen (Lepidoptera) an Fichten. *Ent. Probl.,* 25: 63–72.

Lange, E. 1920. Beitrag zur Kenntnis der Lebensgeschichte von Larentia cambrica Curt. *Dt. ent. Z. Iris,* 34: 211–216.

Laštůvka, Z., Liška, J. 2007. *Checklist of Lepidoptera of the Czech Republic. (Insecta, Lepidoptera)*. 39 p. [cit. 2008-09-17].
http://old.mendelu.cz/~zooapi/checklist.pdf

Losos, B., Gulička, J., Lellák, J., Pelikán, J. 1984. *Ekologie živočichů* [Ecology of animals]. Praha: Státní pedagogické nakladatelství. 316 p.

Nagy, B. 1977. Presence and use of natural food sources of the codling moth (Laspeyresia pomonella L.) in Hungary. Comportement des insectes et milieu trophique. Tours 13–17 septembre 1976. *Colloq. int. Cent. nat. Rech. sci*., 211–225.

Neuvonen, S., Haukioja, E. & Molarius, A. 1987. Delayed inducible resistance against a leaf-chewing insect in four deciduous tree species. *Oecologia*, 74: 363–369.

Patočka, J. 1955. K otázke zimovania motýľov škodiacich na duboch a kontroly obaľovačov dubových podľa zimujúcich vajíčok [How do overwinter the moths causing damage to oak trees and how to check the leafroller Tortrix viridana based on the number of its overwintering eggs]. *Lesn. Čas. (Zvolen)*, 1: 80–101.

Patočka, J., Krištín, A., Kulfan, J., Zach, P. (eds) 1999. *Die Eichenschädlinge und ihre Feinde*. Zvolen: Institut für Waldökologie der SAW. 396 p.

Patočka, J., Kulfan, J. *Lepidoptera of Slovakia: bionomics and ecology* = Motýle Slovenska: bionómia a ekológia. Bratislava: Veda, 312 p.

Raspé, O., Findlay, C., Jaquemart, A. L. 2000. Sorbus aucuparia L. *J. Ecol.*, 88: 910–930.

Razowski, J. 1991. The catalogue of the species of Tortricidae (Lepidoptera). Part I: Palaearctic Chlidanotinae and Tortricidnae: Cochylini, Rortricini, Caracini, Cnephasiini. *Acta Zool. Crac.,* 34: 99–162.

Razowski, J. 2001. *Die Tortriciden (Lepidoptera, Tortricidae) Mitteleuropas*. Bratislava: František Slamka. 319 p.

Reiprich, A. 2001. *Triedenie motýľov Slovenska podľa hostiteľov (živných rastlín) ich húsenic: Die Klassifikation der Schmetterlinge der Slowakei* laut den *Wirten (Nährpflanzen) ihrer Raupen*. Spišská Nová Ves: Správa Národného parku Slovenský raj vo Vydavateľstve Slovenského zväzu ochrancov prírody a krajiny SNP. 480 p.

Reutti, C. 1898. *Übersicht der Lepidopteren-Fauna des Grossherzogtums Baden (und der anstossenden Länder).* Berlin. 361 p.

Schmidt, O. 1989. Zur Gefährdung der Vogelbeere durch Insektenfrass. *Allg. Forstz.*, 14: 358–359.

Schneider, C. 1938. Berichtigung zu: Eine für Württemberg neue Noktuide (Lep.). *Ent. Z. (Frankfurt.(M.),* 52: 279.

Schwenke, W. 1974. *Die Forstschädlinge Europas*. 2. Hamburg, Berlin: Paul Parey. 500 p.

Sloup, M. et al. 2008. Vliv zvěře na lesní ekosystémy v Krušných horách [Effect of game on the forest ecosystems in the Krušné hory Mts.]. In Slodičák, M., Balcar, V., Novák, J., Šrámek V. et al. *Lesnické hospodaření v Krušných horách*: *Forestry management in the Krušné hory Mts*. Edice Grantové služby LČR, 3. Hradec Králové: Lesy České republiky; [Teplice]: Grantová služba LČR; Strnady: Výzkumný ústav lesního hospodářství myslivosti, p. 201–223.

Sperens, U. 1997. Fruit production in Sorbus aucuparia L. (Rosaceae) and pre-dispersal seed predation by the apple fruit moth (Argyresthia conjugella Zell.). *Oecologia*,110 (3): 368–373.

StatSoft ČR s. r.o. 2007. STATISTICA Cz (software package for data analysis), version 8.0. [cit. 2008-11-04].
http://www.statsoft.cz

Šušlík,V., Kulfan, J. 1993. Húsenice motýľov (Lepidoptera) ako indikátory a škodcovia buka v imisnej oblasti hliníkárne pri Žiari nad Hronom [Moth larvae (Lepidoptera) – bioindicators and pests of beech in the surroundings of the aluminium smelter in Žiar nad Hronom]. *Lesn. Čas. – For. J.*, 39: 387–394.

Tikkanen, O.P., Roininen, H., Niemela, P., Tahvanainen, J., Zinovjev, A. 1998. Use of host plants by Operopthera brumata L. (Lep., Geometridae) during the first recorded outbreak in the subcontinental boreal zone of Fennoscandia. *J. appl. Ent.*, 122 (5): 247–253.

Ulbrichová, I., Podrázský, V. 2002. Hodnocení listnatých přípravných dřevin z hlediska obnovy a ochrany půdy v Krušných horách [Evaluation of main broad-leaved preparatory tree species from the viewpoint of restoration and protection of forest soils in the Ore Mountains]. In Slodičák, J. Novák (eds). *Výsledky lesnického výzkumu v Krušných horách v roce 2001: Results of forestry research in the Ore Mts. in 2001*. Jíloviště-Strnady: Výzkumný ústav lesního hospodářství a myslivosti, p. 21–28.

Urban, J. 1998. Příspěvek k poznání mandelinky Gonioctena (=Phytodecta) quinquepunctata F. (Chrysomelidae, Coleoptera) [A contribution to the knowledge of a chrysomelid beetle Gonioctena (=Phytodecta) quinquepunctata F. (Chrysomelidae, Coleoptera)]. *Acta Univ. agric. silvic. Mendel. Brun.*, 46 (1): 7–23.

Urban, J. 1999. Listopas šedý (Strophosoma melanogrammum Forst.) – škůdce mladých buků a jeřábu ptačího na Ždársku [Strophosoma melanogrammum Forst. a pest on young beech trees and on European montain ash in the Žďár region]. *J. Forest Sci.*, 45(2): 64–80.

Vorbrodt, K. 1914. Geometridae, Arctiidae, Syntomidae, Zygaenidae, Limacodidae, Psychidae, Thyrididae, Cossidae, Aegeriidae, Hepialidae. In Vorbrodt, K., Müller-Rutz, J. *Die Schmetterlinge der Schweiz. II. Band*. Bern: K.J. Wyss. 727 p.

Warnecke, G. 1943. Die bisher bekannt gewordene Verbreitung der Larentia cambrica Curt. in Mitteleuropa (Lep., Geom.). *Mitt. Münchn. ent. Gesell.*, 33: 165–169.

Housenky motýlů v korunové fauně jeřábu ptačího (*Sorbus aucuparia* L.) v Krušných horách

Souhrn

Jeřáb ptačí (*Sorbus aucuparia* L.) je významně zastoupenou dřevinou v porostech náhradních dřevin imisního území Krušných hor. Z 84 zjištěných druhů housenek řádu Lepidoptera v korunách jeřábu v r. 2008 metodou sklepávání měly nejvyšší abundanci *Campaea margaritata* (L.)*, Venusia cambrica* Curtis*, Opisthograptis luteolata* (L.), *Hedya nubiferana* (Haw.). S nadmořskou výškou se zvýšila druhová diverzita, bez zásadní preference se mění dominance u jednotlivých druhů. V časně jarním aspektu (31 druhů) byly nejpočetnější *Hedya nubiferana*, *H. pruniana* (Hbn.), *Trachycera advenella* (Zincken); v jarním (57 druhů) *Agriopis aurantiaria* (Hbn.)*, Alsophila aescularia* (Den. et Schiff.); v letním (55 druhů) *V. cambrica*; v pozdně letním (23 druhů) *O. luteolata, C. margaritata*; v podzimním (11 druhů) *C. margaritata.* Poškození malvic jeřabin v rozsahu 21,3–94,1 % způsobila *Argyresthia conjugella* (Zell.), jejíž motýli se líhli v gradačních letech při sumě efektivních teplot okolo 900 °C.

Received March 4, 2009
Accepted June 6, 2009

Distribution of organic carbon, microbial biomass carbon and enzymatic activity in profile of luvisols under different tree species

Silvia Labudová[1], Nora Szombathová[2], Jana Maková[3], Roman Labuda[4]

[1]Department of Microbiology, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic, E-mail: silvia.labudova@uniag.sk
[2]Department of Pedology and Geology, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic, E-mail: nora.szombathova@uniag.sk
[3]Department of Microbiology, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic, E-mail: jana.makova@uniag.sk
[4]Biopure Referenzsubstanzen GmbH, Technopark 1, 3430 Tulln, Austria, E-mail: roman.labuda@biopure.at

Abstract

Labudová, S., Szombathová, N., Maková, J., Labuda, R. 2009. Distribution of organic carbon, microbial biomass carbon and enzymatic activity in profile of luvisols under different tree species. *Folia oecol.*, 36: 108–115.

Selective influence of different deciduous and coniferous tree species (original or introduced) on chemical characteristics (pH, humus quality, total organic carbon (C_{org}), hot water extractable C (C_{hwe}), microbial biomass C (C_{mic}) and dehydrogenase activity (DHA) was studied in the Nature Reserve Arboretum Mlyňany, Slovakia. The soil profiles of nine stands represented by three deciduous trees (oak, sugar maple and cherry laurel), five coniferous (spruce, yew, white fir, Japanese cedar and Himalayan pine), and one meadow stand (taken as a reference) were included in this study. It was found that the plant cover influenced all measured parameters. The average C_{org}, C_{hwe}, C_{mic} and DHA were higher in A horizons in deciduous soils (DS) than in coniferous soils (CS). The average proportion of C_{hwe}/C_{org} in A horizon was higher in DS (about 4%) than in CS (over 3%), which was comparable with that in the meadow (3.16%). The average proportion of C_{mic}/C_{org} was found to be the highest in the meadow soil (6.13%) in comparison with DS (2.18%) and CS (1.35%). In most stands, the proportion of C_{mic}/C_{org} as well as C_{hwe}/C_{org} increased with depth, indicating a higher decrease rate in organic matter than in microbial biomass. The most favourable humus quality in A horizon in terms of HA/FA ratio was found under the trees meadow (0.92), whereas those under deciduous and coniferous were much lower and identical (0.53).

Key words

dehydrogenase activity, forest, hot water extractable carbon, meadow, microbial biomass carbon, organic carbon

Introduction

Tree species differ in their effects on soil quality and nutrient cycling. This is most often explained by differences in the quantity and quality of the overground litter produced, as well as by the rhizodeposition. These factors supplemented by the physico-chemical soil conditions have a great influence on the live and active part of the soil organic matter (SOM). Microbial biomass plays a primary role in the degradation of SOM, thus microorganisms exert feed-back effects on vegetation via mineralization and subsequently the release of mineral nutrients (Priha, 1999; Zechmeister-Boltenstern et al., 2000).

Forest soils, especially their upper horizons, are well known to possess high amounts of organic carbon. Despite this fact, their microbial activity is often energy-limited, because most of the soil C is chemically recalcitrant and/or physically inaccessible for the microbial cells. It is almost sure that the heterotrophic microorganisms gain a significant proportion of their energy from the water-soluble C pool because of its small molecular size and easy accessibility to microorganisms (Wagai and Sollins, 2002). According to many studies, water-soluble substances are more easily leached from the leaf litter of deciduous species, including birch than from coniferous species, including Scots pine and Norway spruce (Harris and Safford, 1996; Hongve, 1999).

Appart from climate, the SOM turnover is governed not only by C, but also N, polyphenols or pH of soils (Priha, 1999; Priha et al., 2001). More specifically, critical levels of C and plant nutrients that limit the enzyme activities of microbial decomposers have been found to be important in determining nutrient release from litter (Seneviratne, 2000).

Since there is lack of knowledge about the influence of introduced tree species on soil chemical and microbial properties, the objective of this study was the comparison of quantity and quality of soil organic matter, including hot water extractable carbon content, and some microbial characteristics under different coniferous and deciduous tree species in Nature Reserve Arboretum Mlyňany, Slovakia, established more than 100 years ago.

Material and methods

Study site

The study stands were located in the Nature Reserve Arboretum Mlyňany in Southwest Slovakia (E 18°21', N 48°19', altitude 165–217 m above sea level). The location is characterized by continental climate with an average annual temperature of 9.7 °C and an average annual precipitation of 566 mm (Hrubik et al., 2006). The Arboretum is situated on Neocene clay, sand and rubble sand, covered with loess, mostly without carbonates (Steinhübel, 1957; Skobla and Kovac, 1967). The main soil subtype in the studied area has been classified as Stagni Haplic Luvisols, except of the stand under Himalayan pines where the soil was classified as Haplic Luvisols (ISSS-ISRIC FAO, 1994).

The Arboretum Mlyňany was established 116 years ago with the goal to collect mainly sempervirens leafy woody plants introduced from South Europe, East Asia, North America and Korea. By the total area of 67 ha as well as by the range of the planted exotic tree taxa the Arboretum Mlyňany belongs to the biggest of its kind in central Europe.

A total of nine sites was selected in this study: one meadow site and eight forest sites: oak (*Quercus cerris,* L.), sugar maple (*Acer saccharinum,* L.), cherry laurel (*Prunus laurocerasus,* L.), spruce (*Picea abies,* L.), yew (*Taxus baccata,* L.), Himalayan pine (*Pinus wallichiana,* Jacks.), Japanese cedar (*Cryptomeria japonica,* D. Don.) and white fir (*Abies concolor,* Lindl. ed. Gord.). The studied sites differed in their ground vegetation cover. Herbs and grasses were more abundant in the deciduous stands, especially in the sugar maple stand. The meadow soil with no trees served as a reference.

Soil sampling

Trees in Arboretum have been planted in dense monoculture groups consisting of minimally five trees. The area occupied by each tree species varies between 100–250 m^2. Each pedological pit was trenched at the centre of chosen monoculture (experimental site). Thus, the determined soil properties represent the influence of the selected tree species. All experimental sites have been established on the same geological substrate and soil type. Therefore, it was appropriate to consider in this study the major differences among the soils under different tree species. The dimensions of the soil pits were: width 0.5–0.6 m, length 1.5–2.0 m, depth 1.0–1.5 m.

The soil samples were taken in spring 2005. The chemical characteristics were made in fresh and dry soil samples sieved through a 2 mm mesh. The biological soil properties (microbial biomass, enzymatic activity) were determined in soil samples incubated in plastic bags at 4 °C during 8 weeks.

Soil analyses

The content of total soil organic carbon (C_{org}) was analyzed by dichromate oxidation according to the Tyurin method (Arinuskina, 1961). The soil pH was evaluated as pH_{KCl} in a soil suspended in 1 M KCl (1:2.5). The hot water extractable carbon (C_{hwe}) was determined by method of the Körschens et al. (1990), humus fractionation by the Kononova-Belchikova method (1961). The microbial biomass carbon (C_{mic}) was determined by the fumigation-extraction method, as described by Vance et al. (1987), based on the difference between C extracted with 0.5 M K_2SO_4 from chloroform-fumigated and unfumigated soil samples. The microbial quotient (C_{mic}/C_{org}) was calculated by expressing C_{mic} as a percentage of total soil C_{org}. Dehydrogenase activity (DHA) was analyzed using TTC method according to Casida et al. (1964). Other chemical parameters characterizing soil properties in the Arboretum under oak, cherry laurel and yew were published by Szombathova et al. (2006), and those under pine and cedar by Szombathova et al. (2008).

Statistical analyses

To determine whether the differences between the averages for different tree species were significant, multifactor analysis of variance and Tukey´s test were used. Two-sample analysis and one-way analysis of variance were used to determine whether the differences between soils of three ecosystem types – deciduous (DS), coniferous (CS) and meadow (M) were significant. The statistical analyses were made in program Statgraphics Vers. 5.0 (1991).

Results and discussion

The chosen locality (Arboretum) was ideal to study how soils developing on the same substrate can be influenced by presence of different woody plant species. Alltogether, the results of our analyses demonstrated that the vegetation have clearly modified the chemical and microbiological properties of the soil.

The soil reaction (pH_{KCl}) varied from strong acid to acid at the forests sites (except of Bt and Bt/C horizons in pine soil) and it was also acid in meadow (Table 1). The average soil pH values of the A horizons was slightly lower in DS (4.13) than in CS (4.33), and higher in M (5.38) (Table 4). Contrary, studies of other authors referred to higher pH of humus horizons under deciduous trees (birch) than under coniferous (pine and spruce) (Priha and Smolander, 1996; Priha, 1999; Smolander and Kitunen, 2002). The evaluation of whole soil profiles showed that the highest pH was under the Himalayan pine (pH 7.04 in Bt/C horizon) (Table 1). We suppose that it was due to carbonates in the soil forming substrate (loess) in this part of the Arboretum. Soil forming substrate under other studied trees and meadow contained no carbonates.

The carbon content was the highest in the organic horizons (Oo) at all sites and decreased with depth. The humus layer was the thinnest under oak (0.03 m), but it had a higher concentration of C_{org} (4.89 %) (Table 1). Similar results have been reported by Priha and Smolander (1996) who also observed that the humus horizon under deciduous tree (birch) was thinner than under spruce, indicating that decomposition rates in relation to litter production were lower under spruce than under birch. Mineral A horizons in DS had higher C_{org} content than CS and M, and varied from 1.89% (cherry laurel) to 4.89% (oak), while in the coniferous stands C_{org} varied from 1.12% (cedar) to 2.91% (fir) (Table 1). The differences among the three ecosystem types (DS, CS and M) were statistically significant (Table 4). These results indicate a positive effect of broad leaf litter on C_{org} accumulation in soil.

Dissolved organic matter is a major source for leaching of many elements from forest floor. Our results showed substantial differences in C_{hwe} content among the experimental sites and among the horizons (Table 1). In general, the highest amounts of C_{hwe} were found in Oo horizons at all sites, most pronouced under pine (1,830 mg kg^{-1}) and cedar (2,020 mg kg^{-1}). The comparison between A horizons in DS, CS and M showed that the sites richer C_{hwe} were found under deciduous trees (930 mg kg^{-1}) than under CS (570 mg kg^{-1}) and M (410 mg kg^{-1}) ($P < 0.01$) (Table 4). Smolander and Kitunen (2002) also found that the concentration of water-extractable dissolved organic carbon (DOC) was higher, or at the same level in the deciduous soil (birch) than in coniferous (spruce and pine). The potentials for DOC production per unit mass of deciduous litter have been reported to be larger than those of other forest litters (Harris and Safford, 1996; Hongve, 1999). However, this may not necessarily be reflected in the soil DOC concentrations which are determined by both production

Table 1. Chemical and microbial characteristics of soil profiles at the studied sites

Horizon – depth [m]	pH_{KCl}	C_{org} [%]	HA/FA	C_{hwe} [mg kg^{-1}]	C_{mic} [mg kg^{-1}]	C_{mic}/C_{org} [%]	C_{hwe}/C_{org} [%]	DHA [μgTPF g^{-1} dry soil mass h^{-1}]
				Spruce				
Oo 0.03–0.0	3.35	4.10	nd	1,020	956.30	2.33	2.49	4.48
Ao 0.0–0.15	3.45	1.48	0.53	230	450.24	3.04	1.57	3.95
Bt 0.15–0.48	3.34	0.67	0.86	180	300.28	4.51	2.72	1.43
Btg 0.48–1.2	3.59	0.37	3.53	100	193.31	5.23	2.65	0.32
				Fir				
Oo 0.05–0.0	4.80	4.07	nd	1,400	495.11	1.22	3.44	1.13
Ao 0.0–0.10	5.80	2.91	nd	1,030	392.35	1.35	3.54	4.28
A/B 0.10–0.40	4.60	1.47	nd	530	266.57	1.81	3.61	1.53
Bt 0.40–0.75	4.30	0.32	nd	50	265.78	8.31	1.41	0.36
Btg > 0.75	4.60	0.08	nd	20	230.66	28.83	2.50	0.20

Table 1. Continued

Horizon – depth [m]	pH_{KCl}	C_{org} [%]	HA/FA	C_{hwe} [mg kg^{-1}]	C_{mic} [mg kg^{-1}]	C_{mic}/C_{org} [%]	C_{hwe}/C_{org} [%]	DHA [μgTPF g^{-1} dry soil mass h^{-1}]
				Yew				
Oo 0.02–0.0	4.00	4.05	nd	1,250	773.91	1.91	3.07	3.36
Ao 0.0–0.20	3.90	2.11	0.39	700	318.42	1.51	3.31	2.25
Bt 0.20–0.60	3.55	0.70	0.47	100	121.11	1.73	1.49	0.20
Btg 0.60–0.9	3.70	0.33	0.77	70	142.02	4.30	2.09	0.16
				Pine				
Oo 0.02–0.0	5.33	5.86	nd	1,830	101.81	0.17	3.12	5.58
Au 0.0–0.25	4.85	1.59	0.61	480	72.50	0.46	3.01	2.53
Au/Bt 0.25–0.35	5.16	0.74	0.66	170	51.29	0.69	2.28	1.13
Bt 0.35–0.60	6.96	0.28	0.94	130	106.01	3.79	4.61	0.77
Bt/C 0.60–1.0	7.04	0.17	1.06	90	30.69	1.81	5.41	0.34
				Cedar				
Oo 0.02–0.0	5.72	4.21	nd	2,020	109.92	0.26	4.80	6.49
Au 0.0–0.20	3.63	1.12	0.61	400	43.96	0.39	3.54	0.85
Btg 0.20–0.8	3.42	0.27	1.00	80	32.00	1.19	3.00	0.20
				Oak				
Oo 0.02–0.0	4.45	4.96	nd	1,310	1,039.25	2.10	2.64	11.85
Ao 0.0–0.03	4.50	4.89	0.45	1,050	1,336.40	2.73	2.14	10.96
A/Bt 0.03–0.15	3.68	2.24	0.38	770	477.13	2.13	2.92	7.43
Bt 0.15–0.50	3.49	1.03	0.48	270	312.61	3.03	2.97	3.28
Btg 0.50–0.80	3.63	0.56	1.16	190	247.52	4.42	3.36	0.23
				Sugar maple				
Oo 0.02–0.0	4.05	3.95	nd	1,430	672.64	1.70	3.62	10.58
Au 0.0–0.20	3.80	2.22	0.61	910	338.62	1.53	4.11	6.96
Bt 0.20–0.40	3.55	0.45	0.93	150	124.84	2.77	3.24	0.34
Btg 0.40–1.1	3.70	0.31	1.79	40	71.53	2.31	1.26	0.00
				Cherry laurel				
Oo 0.02–0.0	4.95	3.20	nd	980	623.86	1.95	3.06	10.02
Au 0.0–0.23	4.10	1.89	0.52	840	428.87	2.27	4.43	5.95
Bt 0.23–0.60	3.55	0.55	0.46	290	195.32	3.55	5.27	1.18
Btg 0.60–0.9	3.40	0.14	0.90	100	182.34	13.02	7.00	0.20
				Meadow				
Oo 0.05 – 0.0	5.20	3.35	nd	740	1,083.28	3.57	2.44	11.50
Au 0.0–0.25	5.38	1.31	0.92	410	803.96	6.13	3.16	6.60
Bt 0.25–0.55	4.91	0.38	2.41	260	216.93	5.79	6.92	0.98
Btg 0.55–0.80	4.03	0.26	6.28	250	227.91	8.70	9.46	0.10

C_{org}, total organic carbon; HA/FA, humic to fulvic acids ratio; C_{hwe}, hot water extractable carbon; C_{mic} microbial biomass carbon, proportion of C_{mic}/C_{org} and C_{hwe}/C_{org}; DHA, dehydrogenase activity; nd, not determined

and consumption. As to the comparison of soils from various forest types, the effects of forest vegetation on the quantity and composition of low molecular weight compounds in the soil organic matter were discussed in many studies (Jandl and Sollins, 1997; Hackl et al., 2000; Smolander and Kitunen, 2002).

High concentration of C_{hwe} in A horizons at deciduous sites resulted in a high proportion of C_{org} (about 4%) except of oak (2.14%) (Table 1). We suppose that the low proportion C_{hwe} of C_{org} in the soil under oak was not caused by the deficiency of C_{hwe}, but rather by a comparatively high C_{org} content (down to the depth of 0.50 m), which was consequently manifested in constant C_{hwe}/C_{org} proportion in the whole soil profile (Table 1). It needs be mentioned that the original growth in the Arboretum was oak-hornbeam forest, and the soil pit on this plot was trenched inside it. Of the all coniferous sites, the narrowest C_{hwe}/C_{org} at the same layer was found in soil under spruce (1.57 %), and the highest under fir and cedar (3.54%) (Table 1). Comparing the soil profiles, the highest C_{hwe}/C_{org} proportion was found in the meadow soil profile (from 2.44% in Oo to 9.46% in Btg horizon) (Table 1). Similar results were found in the proportion of microbial biomass carbon of C_{org}. Likewise, other labile fraction of organic carbon – oxidizable by $KMnO_4$ reached the highest proportion of C_{org} in soil profile on the meadow (Szombathova et al., 2005).

The quality of humus (determined as HA/FA ratio) increased with depth in each profile studied (Table 1). The most favourable humus quality in A horizon was found under M (0.92), whereas HA/FA ratios in A horizons under DS and CS were the same (0.53) (Table 4). In terms of HA/FA ratios determined for the whole soil profile, it is evident that the highest humus quality was in the meadow soil (HA/FA = 3.20) (Table 2). Interestingly, the average humus quality in the whole soil profile was higher in CS sites (0.95) than that under DS sites (0.77), which is in agreement with the report published by Lesna and Kulhavy (2003) who also found higher HA/FA ratio under coniferous Norway spruce compared to European beech. However, degrees of humification were higher under beech, and color quotient $Q_{4/6}$ showed that HA of the beech stand was more condensed and therefore of higher quality than of spruce stand.

The amount of microbial biomass carbon (C_{mic}) had a similar declining tendency with depth as it was in the case of organic carbon, but not in all experimental sites. The highest amounts of C_{mic} were in the Oo horizons within all experimental sites, but mainly in meadow and oak soils (1,083.28 and 1,039.25 mg kg^{-1}, respectively) in comparison to the other experimental sites (Table 1). The amount of C_{mic} in this layer followed the order meadow > oak > spruce > yew > sugar maple > cherry laurel > fir > cedar > pine. Similar values for the upper soil layers (up to 0.1 m) in grassland and oak soils were also reported in a study by Ananyeva et al. (2008). Despite the high C_{org} content and its water-extractable fraction in Oo horizons of two coniferous species (pine and cedar), the last were characterized by the lowest C_{mic} contents (101.81 mg kg^{-1} and 109.92 mg kg^{-1}, respectively) (Table 1). Presumably, the composition of extractable carbon compounds was not favourable for microbial utilization, although, according to Smolander and Kitunen (2002), soil microbial biomass and activities appeared to be more correlated with a total concentration of dissolved organic carbon than with its characteristics. Evaluation of C_{mic} in A horizons (Table 3) showed the highest microbial biomass C content in oak soil (1,336.60 mg kg^{-1}), despite the fact that the oak leaf litter is slower-decomposed by microorganisms due to high lignin and tannin content than eg grassland litter (Waldrop and Firestone, 2004) and/or sugar maple leaf litter (Myers et al., 2001).Our results are in accordance with the results of previous studies carried out in different types of forest ecosystems (Bauhus et al., 1998; Priha et al., 2001; Priha et al., 1999; Smolander et al., 2002), although in most of the studies mentioned, the deciduous stands were represented by birch not by oak. According to a study by Hackl et al. (2000), C_{mic} content may differ under the same tree species growing on soil types differing in their chemical characteristics (soil moisture, pH, N_t etc.).

The proportion of microbial biomass carbon of the total organic carbon is generally considered as a sensitive indicator of changes in soil organic matter quality (Anderson et al., 1989; Lavahun et al. 1996; Sparling, 1992; Stevlikova et al., 2003). By comparing the A horizons between the individual trees, the highest and the lowest values of C_{mic}/C_{org} were found under coniferous – spruce and cedar (3.04% and 0.39%, respectively) (Table 1). On contrary, other authors (Bauhus et al., 1998; Smolander et al., 2002) found higher C_{mic}/C_{org} proportion under birch (2.5%) than under spruce and pine (2.0 and 1.7%, respectively). Dyckmans et al. (2003) specified that in forest (n = 27), grassland (n = 32) and arable (n = 39) soils located in Northern Germany, the C_{mic}/C_{org}

Table 2. Chemical and microbial characteristics of soil profiles. Means of whole soil profiles at the studied sites for each type of ecosystem (coniferous forest, deciduous forest and meadow). Different superscripts indicate that the values are significantly different between the sites at $P < 0.01$

Type of ecosystem	pH_{KCl}	C_{org} [%]	HA/FA	C_{hwe} [mg kg^{-1}]	C_{mic} [mg kg^{-1}]	DHA [µgTPF g^{-1} dry soil mass h^{-1}]
Conifers	4.43[a]	1.76[a]	0.95[a]	580[a]	255.68[a]	2.03[a]
Deciduous	3.91[b]	1.97[a]	0.77[b]	630[a]	447.36[b]	5.19[b]
Meadow	4.88[a]	1.33[a]	3.20[c]	420[a]	583.02[b]	4.80[b]

C_{org}, total organic carbon; HA/FA, humic to fulvic acids ratio; C_{hwe}, hot water extractable carbon; C_{mic}, microbial biomass carbon; DHA, dehydrogenase activity proportion (FE-method) in the 0–10 cm layer varied from 0.3% to 4.3% with an average of 1.5%. Simek and Santruckova (2002) stated that C_{mic}/C_{org} proportion is higher in less fertile soils with low C_{org} content. In most sites the C_{mic}/C_{org} proportion increased with depth. This tendency was most obvious under the fir cover where C_{mic}/C_{org} in Btg horizon reached 28.8%, while under cherry laurel it was 13.02%, and under the meadow 8.7% (Table 1). Increasing tendency of C_{mic}/C_{org} ratio with depth indicates a more intensive decline of organic matter than microbial biomass with depth of soil profile (Table 1). This tendency was less evident under the meadow. We suppose that the high microbial colonization and thus lower C_{mic}/C_{org} proportions in Btg horizon under the meadow occurred due to abundant susceptible organic matter that could be transported from upper to lower soil horizons by percolating water in ilimerization process, which was the most evident under the abovementioned experimental site. In other study (Ananyeva et al., 2008), however, the C_{mic}/C_{org} values in natural ecosystems were higher in the 0–0.05 m than in 0.05–0.1 m soil layer.

The dehydrogenase activity (DHA) was 2- or 3-times higher under the deciduous tree species and the meadow than that under the coniferous trees. Significant differences in DHA were observed amongst the humus layers and also amongst the average values of DHA across entire soil profiles (Tables 2, 4). In general, the highest DHA was found in litter layers in all experimental sites except of fir (Table 1). DHA, C_{mic} as well as C_{org} showed a similar tendency within soil profile, ie all characteristics declined with depth.

We can conclude that all the parameters investigated (C_{org}, C_{hwe}, C_{mic} and DHA) showed to be influenced by both plant cover and soil depth. In general, except DHA under fir, all parameters were the highest in the organic horizons and decreased with depth. The contents of C_{org} and C_{hwe} in organic horizons were higher for coniferous soils than those measured in deciduous soils. On the other hand, biological characteristics determined in this layer (C_{mic} and DHA) were higher in DS than in CS. A horizons showed higher average C_{org}, C_{hwe}, C_{mic} and DHA in DS in comparison to CS. Also, the average proportion C_{hwe} of C_{org} in A horizons was higher in DS (about 4%) than those in CS (over 3%), or as high as in M (3.16%). On contrary, the average C_{mic}/C_{org} proportion was higher in M soil (6.13%) compared to DS (2.18%) and CS (1.35%). In most cases the proportion of C_{mic}/C_{org} as well as C_{hwe}/C_{org} tended to be higher with increasing depth. The most favourable

Table 3. Chemical and microbial characteristics of humus horizons at the studied sites. Different superscripts indicate that the values are significantly different between the sites at $P < 0.01$

Tree species	pH_{KCl}	C_{org} [%]	HA/FA	C_{hwe} [mg kg^{-1}]	C_{mic} [mg kg^{-1}]	DHA [μgTPF g^{-1} dry soil mass h^{-1}]
Spruce	3.45^{a}	1.48^{a}	0.53^{a}	230^{a}	450.24^{a}	3.95^{a}
Fir	5.80^{b}	2.91^{b}	nd	1,030^{b}	392.35^{b}	4.28^{b}
Yew	3.90^{c}	2.11^{c}	0.39^{b}	700^{c}	318.42^{c}	2.25^{c}
Pine	4.85^{d}	1.59^{d}	0.61^{c}	480^{d}	72.50^{d}	2.53^{c}
Cedar	3.63^{e}	1.12^{e}	0.61^{c}	400^{e}	43.96^{e}	0.85^{d}
Oak	4.50^{f}	4.89^{f}	0.45^{d}	1,050^{f}	1,336.60^{f}	10.96^{e}
Sugar maple	3.80^{g}	2.22^{g}	0.61^{c}	910^{g}	338.62^{g}	6.96^{f}
Cherry laurel	4.10^{h}	1.89^{h}	0.52^{a}	840^{h}	428.87^{h}	5.95^{g}
Meadow	5.38^{i}	1.31^{i}	0.92^{e}	410^{d}	803.96^{i}	6.60^{h}

Abbreviations see Table 2

Table 4. Chemical and microbial characteristics of humus horizons at the studied sites for each type of ecosystem (coniferous forest, deciduous forest and meadow) – mean values. Different superscripts indicate that the values are significantly different between the sites at $P < 0.01$

Type of ecosystem	pH_{KCl}	C_{org} [%]	HA/FA	C_{hwe} [mg kg^{-1}]	C_{mic} [mg kg^{-1}]	DHA [μgTPF g^{-1} dry soil mass h^{-1}]
Conifers	4.33^{a}	1.84^{a}	0.53^{a}	570^{a}	255.49^{a}	2.48^{a}
Deciduous	3.95^{b}	3.00^{b}	0.53^{a}	930^{b}	701.30^{b}	7.96^{b}
Meadow	5.38^{c}	1.31^{a}	0.92^{b}	410^{a}	803.96^{b}	6.60^{b}

Abbreviations see Table 2

humus quality in A horizon was found under meadow (0.92), whereas HA/FA ratios in A horizons were the most favourable under deciduous and coniferous were the same (0.53).

Acknowledgement

We are grateful to the staff of the Department of Pedology and Geology at the Slovak University of Agriculture for their help with soil sampling. This work was funded by the Scientific Grant Agency of Ministry of Education of the Slovak Republic – grant number 1/1279/04 and 1/4406/07.

References

Ananyeva, N.D., Susyan, E.A., Chernova, O.V., Wirth, S. 2008. Microbial respiration activities of soil from different climatic regions of European Russia. *Eur. J. Soil Biol.,* 44: 147–157.

Anderson, T.H., Domsch, K.H. 1989. Ratios of microbial biomass carbon to total organic carbon in arable soils. *Soil Biol. Biochem*., 21: 471–479.

Arinushkina, E.V. 1961. *Praktikum po chimii počvy* [Guidance for soil chemical analysis]. Moskva: Izdateľstvo Moskovskogo universiteta.

Bauhus, J., Paré, D., Côté, L. 1998. Effect of tree species, stand age and soil type on soil microbial biomass and its activity in southern boreal forest. *Soil Biol. Biochem*., 30: 1077–1089.

Casida, L.E., Klein, D.A., Santoro, T. 1964. Soil dehydrogenase activity. *Soil Sci.,* 98: 371–376.

Dyckmans, J., Chander, K., Joergensen, R. G., Priess, J., Raubuch, M., Sehy, U. 2003. Adenylates as an estimate of microbial biomass C in different soil groups. *Soil Biol. Biochem*., 35: 1485–1491.

Hackl, E., Bachmann, G., Zechmeister-Boltenstern S. 2000. Soil microbial biomass and rhizosphere effects in natural forest stands. *Phyton,* 40: 83–90.

Harris, M.M., Safford, L.O. 1996. Effect of season and four tree species on soluble carbon content in fresh and decomposing litter of temperate forests. *Soil Sci.,* 161: 130–135.

Hongve, D. 1999. Production of dissolved organic carbon in forested catchments. *J. Hydrol*., 224: 91–99.

Hrubik P., Tomasko I., Hotka P., Kuba J. 2006. Klimatické podmienky Arboréta vo vzťahu k introdukovaným drevinám [The climatic conditions of the Arboretum Mlynany SAS in relation to the introduced woods]. In Mňahončáková, E., Baruszová, N. (eds). *Sídlo, park, krajina. Zborník vedeckých prác a referátov z konferencie s medzinárodnou účasťou a 11. kolokvia katedier krajinárskej a záhradnej tvorby Nitra, 22. november 2006, časť IV.* Nitra: Slovenská poľnohospodárska univerzita, p. 148–161. (CD).

ISSS-ISRIC FAO 1994. *World Reference Base for Soil Resources, Draft*. Wageningen, Rome: 161 p.

Jandl, R., Sollins, P. 1997. Water extractable carbon in relation to below-ground carbon cycle. *Biol. Fertil. Soils,* 25: 196–201.

Körschens, M., Schulz, E., Behm, R. 1990. Heisswasserlöslicher C und N im Boden als Kriterium für das N-Nachliferungsvermögen. *Microbiology,* 145: 305–311.

Kononova, M., Belchikova, N.P. 1961. Uskorennyje metody opredelenija sostava gumusa [Short methods for determining humus quality]. *Počvovedenie*, 125–129.

Lavahun, M.F.E., Joergensen, R.G., Meyer, V. 1996. Activity and biomass of soil microorganisms at different depths. *Biol. Fertil. Soils*, 23: 38–42.

Lesna, J., Kulhavy, J. 2003. Evaluation of humus conditions under different forest stands: beech vs. spruce dominated forest stand. *Ekológia (Bratislava*), 22, Suppl., 3: 47–60.

Myers, R. T., Zak, D. R., White, D. C, Peacock, A. 2001. Landscape – level patterns of microbial community composition and substrate use in upland forest ecosystems. *Soil Sci. Soc. Amer. J.,* 65: 359–367.

Priha, O. 1999. *Microbial activities in soils under Scots pine, Norway spruce and silver birch.* PhD thesis. Helsinki: University of Helsinki. 50 p.

Priha, O., Grayston, S.J., Hiukka, R., Pennanen, T., Smolander, A. 2001. Microbial community structure and characteristics of the organic matter in soils under Pinus sylvestris, Picea abies and Betula pendula at two forest sites. *Biol. Fertil. Soils,* 33: 17–24.

Priha, O., Grayston, S.J, Pennanen, T., Smolander, A. 1999. Microbial activities related to C and N cycling and microbial community structure in the rhizospheres of Pinus sylvestris, Picea abies and Betula pendula seedlings in an organic and mineral soil. *Microb. Ecol*., 30: 187–199.

Priha, O., Smolander, A. 1996. Microbial biomass and activity in soil and litter under Pinus sylvestris, Picea abies and Betula pendula at originally similar field afforestation sites. *Biol. Fertil. Soils,* 24: 45–51.

Seneviratne, G. 2000. Litter quality and nitrogen release in tropical agriculture: a synthesis. *Biol. Fertil. Soils,* 31: 60–64.

Simek, M., Santruckova, H. 2002. Are characteristics of microbial society good indicator of soil quality? In *Biological indicators of soil quality*. Brno: MZLU, p. 32–41.

Skobla, J., Kovac, J. 1967. *Pedologický prieskum ČSSR* [Pedological survey of the ČSSR]. Vieska nad Žitavou: Roľnícke družstvo. 19 p.

Smolander, A., Kitunen, V. 2002. Soil microbial activities and characteristics of dissolved organic C and N in relation to tree species. *Soil Biol. Biochem*., 34: 651–660.

Sparling, G.P. 1992. Ratio of microbial biomass carbon to soil organic C as a sensitive indicator of changes in soil organic matter. *Austral. J. Soil Res.*, 30: 195–207.

Statgraphics, Ver. 5. 1991. Rockville, MD: STSC, Inc.

Steinhübel, G. 1957. *Arborétum Mlyňany v minulosti a dnes* [Arboretum Mlynany in the past and in present]. Bratislava: Slovenská academia vied. 145 p.

Stevlikova, T., Vjatrakova, J., Javorekova, S., Mateova, S. 2003. Effect of land management without farmyard manure application on the amount and the activity of soil microbial biomass. *Pl. Soil Envir.*, 49: 352–358.

Szombathova, N., Zaujec, A., Labudova, S., Labuda, R. 2005. Soil organic matter quality and quantity in Nature Reserve Arboretum Mlynany. In Zaujec, A., Bielek, P., Gonet, S. S. (eds). *Humic substances in Ecosystems 6.* Nitra: Slovenská poľnohospodárska univerzita, p. 181–185.

Szombathova, N., Labudova, S., Labuda, R., Konôpková, J. 2006. The influence of different vegetation on soil chemical properties in Arboretum Mlyňany. *Folia oecol.*, 33: 41–47.

Szombathova, N., Zaujec, A., Labudova, S., Labuda, R. 2008. Soil properties under different vegetation types in the Arboretum Mlyňany. *Folia oecol.*, 35: 51–59.

Vance, E.D., Brookes, P.C., Jenkinson, D.S. 1987. An extraction method for measuring soil microbial biomass. *Soil Biol. and Biochem.*, 19: 703–707.

Wagai, R., Sollins, P. 2002. Biodegradation and regeneration of water-soluble carbon in a forest soil: leaching column study. *Biol. Fertil. Soils,* 35: 18–26.

Waldrop, M. P., Firestone, M. K. 2004. Microbial community utilization of recalcitrant and simple carbon compounds: impact of oak-woodland plant communities. *Oecologia,* 138: 275–284.

Zechmeister-Boltenstern, S., Hackl, E., Bachmann, G., Donat, C. Pfeffer, M. 2000. Microbial nutrient turnover in forests with natural tree species composition. In Hasenauer, H. (ed.). *Forest ecosystem restoration: ecological and economical impacts of restoration processes in secondary coniferous forests. Proceedings of the international conference held in Vienna, Austria 10.–12. April, 2000*. Wien: Univ. of Agricultural Sciences, Inst. of Forest Growth Research, p. 296–390.

Distribúcia organického uhlíka, uhlíka mikrobiálnej biomasy a enzymatickej aktivity v profile hnedozeme pod rôznymi druhmi drevín

Súhrn

Zisťovali sme vplyv rôznych druhov listnatých a ihličnatých drevín (pôvodných aj introdukovaných) na chemické vlastnosti pôdy (pH, kvalitu humusu, celkový obsah organického uhlíka (C_{org}), v horúcej vode extrahovateľného uhlíka (C_{hwe}), uhlíka mikrobiálnej biomasy (C_{mic}) a dehydrogenázovú aktivitu pôdy (DHA) v Prírodnej rezervácii Arborétum Mlyňany. Pôdne profily deviatich stanovíšť boli reprezentované tromi druhmi listnatých drevín (dub cerový, javor cukrový a vavrínovec lekársky), piatimi druhmi ihličnanov (smrek obyčajný, tis obyčajný, kryptoméria japonská, borovica himalájska a jedľa srienistá), a jedným lúčnym porastom (kontrolný variant). Zistili sme, že rastlinný kryt ovplyvnil všetky skúmané pôdne vlastnosti. V humusových (A) horizontoch boli hodnoty C_{org}, C_{hwe}, C_{mic} a DHA vyššie pod porastmi listnatých drevín (DS) v porovnaní s ihličnatými (CS). Priemerné zastúpenie C_{hwe}/C_{org} v A horizontoch bolo väčšie v DS (okolo 4 %) ako CS (nad 3 %), čo bolo porovnateľné aj s lúčnym porastom (3,16 %). Najvyššie priemerné zastúpenie C_{mic}/C_{org} bolo zistené v pôde pod lúčnym porastom (6,13 %) v porovnaní s DS (2,18 %) a CS (1,35 %). Vo väčšine stanovíšť sa zastúpenie C_{mic}/C_{org} rovnako ako C_{hwe}/C_{org} zvyšovalo s hĺbkou, čo poukazuje na intenzívnejší pokles pôdnej organickej hmoty ako mikrobiálnej biomasy. Najvyššiu kvalitu humusu (určenú ako pomer HK/FK) v A horizontoch sme zistili pod lúčnym porastom (0,92), kým kvalita humusu pod porastom listnatých a ihličnatých drevín bola rovnaká (0,53).

Received July 14, 2009
Accepted August 31, 2009

FOLIA OECOLOGICA – vol. 36, no. 2 (2009). ISSN 1336-5266

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

Oto Majzlan[1]**, Peter J. Fedor**[2]

[1]Institute of Zoology, Slovak Academy of Sciences, Dúbravská cesta 21, 845 51 Bratislava, Slovak Republic, E-mail: Oto.Majzlan@fedu.uniba.sk
[2]Department of Ecosozology, Faculty of Natural Sciences, Comenius University, Mlynská dolina, 842 15 Bratislava, Slovak Republic, E-mail: fedor@fns.uniba.sk

Abstract

Majzlan, O., Fedor, P. J. 2009. The phenology of geobiont beetles (Coleoptera) and other arthropods (Arthropoda) in the Vysoké Tatry Mts. *Folia oecol.*, 36: 116–124.

Soil photoeclectors 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 Hymenotera) 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, photoeclectors, soil fauna

Introduction

Soil photoeclectors 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 photoeclectors 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 photoeclectors was frequently applied to analyse the structure and dynamics of soil macrofauna (Durmek et al., 1993; Majzlan, 1986; Majzlan 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, photoeclectors were installed for the first time (Fig 1). The equipment enables to study adults´ hatching activity calculated as their abundance on 1 m^2. A photoeclector (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 photoeclector 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% ethylalcohole 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 m^2, FIRE: 117 individuals per m^2, EXP: 99 individuals per m^2).

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
Auchennorrhyncha	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 m^2. At upper altitudes (1900 m asl) it dropped to 1,500–1,800 individuals per m^2. 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 m^2 and a daily average of 12.87 individuals per m^2 (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 m^2 (Majzlan and Kožíšek, 1995). Near Bratislava (an abandoned garden), we observed a value of 3,854 individuals per m^2 (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 m^2).

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			
Amara eurynota (Panzer, 1797)		0/1	
Amara lunicollis Schioedte, 1837			0/1
Amara plebeja (Gyllenhal, 1810)		0/3	
Amara familiaris (Duftschmid, 1812)		0/7	
Bembidion lampros (Herbst, 1784)		0/1	
Molops piceus (Panzer, 1793)	0/1		
Notiophilus biguttatus (Fabricius, 1779)		0/1	
Pterostichus burmeisteri Heer, 1841	0/2		
Pterostichus foveolatus (Duftschmid, 1812)	0/1		0/2
Pterostichus rufitarsis (Dejean, 1828)			0/1
Pterostichus unctulatus (Duftschmid, 1812)	0/1	0/1	0/2
Sericoda quadripunctata (De Geer, 1774)		1/0	
Trichotichnus laevicollis (Duftschmid, 1812)	1/0		
Dytiscidae			
Agabus melanarius Aubé, 1836	1/0		
Hydroporus palustris (Linnaeus, 1761)	2/0		
Histeridae			
Margarinotus striola (Thomson, 1862)	0/1		
Ptiliidae			
Acrotrichis intermedia (Gillmeister, 1845)	3/1		
Ptenidium laevigatum Erichson, 1845	1/0		
Ptilium caesum Erichson, 1845			1/0
Leiodidae			
Agathidium mandibulare Sturm, 1807			1/0
Scydmaenidae			
Stenichnus collaris (Müller et Kunze, 1822)			2/0
Neuraphes elongatulus (Müller et Kunze, 1822)	0/1		

Table 4. Continued

	REF	FIR	EXT
Family/species			
Staphylinidae			
Acrulia inflata (Gyllenhal, 1813)			1/0
Amischa analis (GravenhorsT, 1802)		5/0	
Amphichroum canaliculatum (Erichson, 1840)			1/0
Anthophagus alpestris Heer, 1839	4/0		
Anthophagus omalinus Koch, 1933	1/0		
Atheta contristata (Kraatz, 1856)			2/0
Atheta fungi (GravenhorsT, 1806)			0/3
Atheta picipes (Thomson, 1856)	4/1	6/7	1/3
Atheta sodalis (Erichson, 1837)	8/0		
Bolitobius castaneus (Stephens, 1832)	1/0		
Bryoporus rufus (Erichson, 1839)			1/0
Carpelimus corticinus (Gravenhorst, 1806)			1/0
Encephalus complicans Kirby, 1832			0/1
Eusphalerum sorbi (Gyllenhal, 1810)			0/1
Gabrius subnigritulus (Gravenhorst, 1802)		0/2	2/0
Geostiba circellaris (Gravenhorst, 1806)	1/0	8/5	1/7
Liogluta granigera (Kiesenwetter, 1850)			1/0
Liogluta microptera Thomson, 1867			1/0
Mycetoporus lepidus (Gravenhorst, 1802)		0/25	5/5
Mycetoporus nigricollis Stephens, 1835	2/0		
Omalium caesum Gravenhorst, 1806	0/1		
Omalium rivulare (Paykull, 1789)	1/0		
Oxypoda alternans (Gravenhorst, 1802)			1/0
Oxypoda annularis (Mannerheim, 1830)	3/0		
Phloeocharis subtillisima Mannerheim, 1830	3/0		
Quedius fuliginosus (Gravenhorst, 1802)	1/0		
Quedius mesomelinus (Marsham, 1802)	1/0		
Quedius punctatellus (Heer, 1839)	2/0		
Stenus fossulatus Erichson, 1840	1/0		
Tachinus laticollis Gravenhorst, 1802	1/0	1/1	
Tachyporus chrysomelinus (Linnaeus, 1758)		1/3	
Tachyporus tersus Erichson, 1839		1/0	
Xantholinus tricolor (Fabricius, 1787)		0/1	
Pselaphidae			
Trimium brevicorne (Reichenbach, 1813)	1/0		
Scarabaeidae			
Aphodius depressus (Kugelann, 1792)	0/1		
Aphodius abdominalis Bonelli, 1812	0/1		
Elateridae			
Athous subfuscus (Müller, 1767)		2/2	16/0
Ctenicera cuprea (Fabricius, 1781)	1/0		
Dalopius marginatus (Linnaeus, 1758)			1/0
Mesotalesus impressus (Fabricius, 1792)		0/1	

Table 4. Continued

	REF	FIR	EXT
Family/species			
Cantharidae			
Malthodes brevicollis (Paykull, 1798)	1/0		
Malthodes fuscus (Waltl, 1838)		1/0	
Malthodes guttifer Kiesenwetter, 1852			2/0
Malthodes hexacanthus Kiesenwetter, 1852	12/0		1/0
Malthodes pumilus (Brébisson, 1835)			10/0
Absidia rufostacea (Letzner, 1845)	7/0		
Anobiidae			
Ernobius abietis (Fabricius, 1792)	1/0		
Cleridae			
Thanasimus femoralis (Zetterstedt, 1828)			1/0
Dasytidae			
Danacea pallipes (Panzer, 1793)	0/1		
Nitidulidae			
Epuraea pygmaea (Gyllenhal, 1808)	3/0		
Epuraea rufomarginata (Stephens, 1830)	1/0	0/1	
Epuraea variegata (Herbst, 1793)		1/0	
Meligethes aeneus (Fabricius, 1775)	1/0		
Pityophagus ferrugineus (Linnaeus, 1761)		1/0	
Rhizophagidae			
Rhizophagus dispar (Paykull, 1800)	2/0	1/1	0/1
Rhizophagus ferrugineus (Paykull, 1800)			1/0
Sphindidae			
Aspidiphorus orbicularis (Gyllenhal, 1808)		1/0	
Cryptophagidae			
Atomaria analis Erichson, 1846	4/5	0/3	
Atomaria bella Reitter, 1875			0/1
Atomaria fusata (Schonherr, 1808)		3/0	
Atomaria ruficornis (Marsham, 1802)		2/1	
Curelius exiguus (Erichson, 1846)		1/0	
Micrambe abietis (Paykull, 1798)	1/1		
Coccinellidae			
Ceratomegilla alpina redt. (Capra, 1928)			1/0
Adonia variegata (Goeze, 1777)	1/0	3/1	
Corylophidae			
Sericoderus lateralis (Gyllenhal, 1827)		0/1	
Lathridiidae			
Aridius nodifer (Westwood, 1839)		5/1	0/1
Corticaria abietorum Motschulsky, 1867	1/5		1/0
Corticaria ferruginea Marsham, 1802			0/1
Corticaria impressa (Olivier, 1790)		1/1	
Corticaria rubripes Mannerheim, 1844	1/0	48/3	4/3
Corticarina fuscula (Gyllenhal, 1827)		38/22	1/0
Cortinicara gibbosa (Herbst, 1793)		8/0	
Dienerella elongata (Curtis, 1830)			2/1

Table 4. Continued

	REF	FIR	EXT
Family/species			
Lathridiidae			
Enicmus fungicola Thomson, 1868		0/19	
Enicmus transversus (Olivier, 1790)		5/1	
Lathridius anthracinus Mannerheim, 1844			4/1
Lathridius brevicollis (Thomson, 1868)		4/8	
Lathridius minutus (Linnaeus, 1767)	0/1		
Melanophthalma distinguenda (Comolli, 1837)		0/1	
Stephostethus rugicollis (Olivier, 1790)			1/0
Ciidae			
Orthocis alni (Gyllenhal, 1813)			1/0
Chrysomelidae			
Altica oleracea (Linnaeus, 1758)		15/3	
Cryptocephalus carpathicus Frivaldszky,	2/0		1/0
Gastroidea polygoni (Linnaeus, 1758)	0/1		
Chaetocnema concinna (Marsham, 1802)		1/0	
Chaetocnema confusa (Boheman, 1851)	1/0	1/0	
Chrysolina varinas (Schaller, 1783)	2/0		
Luperus viridipennis (Germar, 1824)	6/0		
Phyllotreta nemorum (Linnaeus, 1758)	1/0		
Curculionidae			
Hylobius abietis (Linnaeus, 1758)	2/0	0/1	2/3
Notaris aterrimus (Hampe, 1850)	0/1		
Otiorhynchus lepidopterus (Fabricius, 1794)	1/0	1/0	
Otiorhynchus niger (Fabricius, 1775)	5/0	6/0	
Otiorhynchus scaber (Linnaeus, 1758)	3/1		0/3
Polydrusus amoenus (Germar, 1824)	9/0		
Polydrusus pallidus Gyllenhal, 1834	1/0		
Rhinomias forticornis (Boheman, 1843)	0/1		
Scolytidae			
Crypturgus cinereus (Herbst, 1793)			2/0
Dryocoetus autographus (Ratzeburg, 1837)			7/7
Hylastes ater (Paykull, 1800)		2/3	
Hylastes cunicularius Erichson, 1836	2/1	1/0	
Phthorophloeus spinulosus Rey, 1883			1/0
Pityogenes chalcographus (Linnaeus, 1761)			2/0

to Podbanské. At the sample plot (1 m^2), 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 m^2), *Malthodes hexacanthus* (12 individuals per m^2), *Corticaria abietorum* (14 individuals per m^2), *Luperus viridipennis* (16 individuals per m^2) and *Polydrusus amoenus* (19 individuals per m^2). 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 m^2); however, the surprisingly highest abundance of beetles (418 individuals per m^2). Amongst the recorded species, *Mycetoporus lepidus* (25 individuals per m^2), *Athous subfuscus* (14 individuals per m^2), *Corticaria rubripes* (56 individuals per m^2), *Corticaria fuscula* (50 individuals per m^2) and *Altica oleracea* (18 individuals per m^2) 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 occured 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 m^2) was observed at the site EXP. The species spectrum includes the dominant *Athous subfuscus* (16 individuals per m^2) and *Dryocoetus autographus* (14 individuals per m^2).

In our research, the method of photoeclectors 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.

Acknowledgement

We are grateful to J. Ferenčík for his help in material sampling and J. Čarnogurský for determination of springtails.

References

Andrzjewska L., Kajak, A. 1956. Metodyka entomologicznych badaň ilosciowych na Lukach [Quantitative methods in entomological research carried out in meadows]. *Ekol. pol. Ser. B*, 13 (3): 241–261.

Angelstam, P.K. 1998. Maintaining and restoring biodiversity in European boreal forests by developing natural disturbance regimes. *J. Veget. Sci*., 9: 593–602.

Durmek, V., Majzlan, O., Kodada, J. 1993. Phytophagous Beetles (Coleoptera phytophaga) in the Soil of the Danube Forest Saliceto-Populetum. *Acta zool. Univ. Comen*., 37/17: 17–24.

Funke, W. 1971. Food and Energy Turnover of Leafeating Insects and their Influence on Primary Production. *Ecol. Stud.: Anal. Synth.*, 2: 81–93.

Funke, W. 1983. Arthropodengesellschaften mitteleuropäischen Wälder. (Abundanz und Biomasse – Eklektorfauna). *Verh. Gesell. Ökol. (Göttingen)*, 11: 111–129.

Holstein, J., Majzlan, O. Rychlík, I. 1996. Die Käferfauna zweier Streuobstwiesen in Süddeutschland (Coleoptera). In Gerstmeier, R. *Verhandlungen des 14. Internationalen Symposiums über Entomofaunistik in Mitteleuropa (SIEEC), 4–9. September 1994, München.* München, p. 158–164.

Johnson, E. A. 1992. *Fire and vegetation dynamics – studies from the North American boreal forest*. Cambridge: Cambridge University Press. 129 p.

Majzlan, O. Kožíšek, T. 1995. Bioindicating importance of weevill beetles (Coleoptera: Curculionidae) representing the soil Arthropods in Malé Karpaty PLA. *Ochr. Prír*., 13: 195–205.

Majzlan, O. 1986. Štruktúra a dynamika arthropodocenóz vo vzťahu k ochrane dubových porastov. *Biologia (Bratislava)*, 41/10: 963–969.

Majzlan, O., Fedor, P. 2005. An Influence of the Casoron G Herbicide on the Soil Macrofauna (Eclectorfauna). *Phytopedon (Bratislava)*, 4/2: 40–48.

Majzlan, O. 2008. Flight activity of beetles (Coleoptera) in Vysoké Tatry Mts. (Malaise fauna). *Folia oecol*., 35: 20–29.

Majzlan, O., Holecová, M. 1993. Arthropodocoenoses of an Orchard Ecosystem in Urban Agglomerations. *Ekológia (Bratislava)*, 12/2: 121–129.

McCullough, D.G., Werner, R.A., Neumann, D. 1998. Fire and insects in northern and boreal forest ecosystems of North America. *A. Rev. Ent.*, 43: 107–127.

Payette, S. 1992. Fire as a controlling process in the North American boreal forest. In Shugart, H., Leemans, R., Bonan, G.B. (eds). *A systems analysis of the boreal forest*. Cambridge: Cambridge University Press, p. 44–169.

Reich, M., Roth, M., Majzlan, O. 1984. Die Coleopteren – Zönose im Ökosystem „Obstgarten" – Eklektorfauna. *Jber. Naturwiss. Ver. Wuppertal*, 38: 20–23.

Rowe, J.S., Scotter, G.W. 1973. Fire in the boreal forest. *Quaternary Res.*, 3: 444–464.

Troger, H., Janetschek, H., Meyer, E., Schatz, W. 1994. Schlüpfabundanz von Insekten (Diptera/Coleoptera/Hymenoptera) im zentralalpinen Hochgebirge (Tirol: Ötztal). *Ent. Gen.*, 18 (3/4): 241–260.

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

Súhrn

Výskum fenológie pôdnych bezstavovovcov 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 celkove 5028 jedincov článkonožcov z plochy 3 m^2. Dominantné hodnoty abundancie dosahovali Collembola, Diptera, Coleoptera a Hymenoptera.

Received March 3, 2009
Accepted May 5, 2009

FOLIA OECOLOGICA – vol. 36, no. 2 (2009). ISSN 1336-5266

Concentrations of phosphate phosphorus and total phosphorus in the water in different biotopes of the Nature Reserve Alúvium Žitavy

Jaroslav Noskovič, Alexandra Palatická, Jana Porhajašová, Peter Kováčik

Department of Environmental Sciences and Zoology, Faculty of Agrobiology and Food Resources, Slovak University of Agriculture in Nitra, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic, E-mail: jaroslav.noskovic@uniag.sk

Abstract

Noskovič, J., Palatická, A., Porhajašová, J., Kováčik, P. 2009. Concentrations of phosphate phosporus and total phosphorus in the water in different biotopes of the Nature reserve Alúvium Žitavy. *Folia oecol.*, 36: 125–133.

Over the years 2006–2008 the concentrations of P-PO_4^{3-} and $P_{Tot.}$ were evaluated as dependent on the time and site of sampling in the water of the Nature Reserve (NR) Alúvium Žitavy which is situated in the southwestern part of the Slovak Republic. According to the results obtained, we can calculate the concentration of phosphate phosphorus over the whole monitored period in water of the Nature Reserve was 0.44 mg dm^{-3}. It represented 60.27% of total phosphorus, other forms of phosphorus represented the rest of total phosphorus. Dependent on the sampling site we found out the highest mean P-PO_4^{3-} concentrations over the whole monitored period in summer with the maximum being in August and the lowest in February and March. As dependent on the sampling site mean P-PO_4^{3-} concentrations slightly decreased from the first to the last sampling site. We found out statistically significant influence of all three qualitative factors (sampling year, sampling month, sampling site) in value changes of this form of phosphorus by analysis of variance. The total phosphorus over the whole monitored period was 0.73 mg dm^{-3}. Generally, the lowest mean values over the whole monitored period were in the winter season with minimum being in February. Absolutely, the lowest mean $P_{Tot.}$ concentration was measured in this month in 2008. Analogous to P-PO_4^{3-}, mean $P_{Tot.}$ concentrations in the water generally slightly decreased from the first to the last sampling site. Influence of sampling site was also confirmed statistically. That finding demonstrates the purifying ability of wetland habitats being situated in the nature reserve.

Key words

nature reserve, phosphate phosphorus, total phosphorus, wetland

Introduction

Phosphorus is a limiting factor for production processes in water ecosystems (Lellák et Kubíček, 1991). This phosphorus in the surface water can be dissolved or undissolved in the organic and inorganic form. The inorganic dissolved phosphorus is mainly in the form of phosphate phosphorus (DeBusk, 1999). The algae and bacteria during photosynthesis are making use of phosphate phosphor and its compound is going to incorporated into biomass. For necrotic organisms phosphate phosphor is going to released into the aquatic environment or is fixing to insoluble (aerobic conditions, alkaline environment) form of calcium, magnesium, iron salts. These forms are accumulated in the sediments (Lellák et Kubíček, 1991). Phosphorus is also excreted by animals into the water and then it is used by bacteria and algae (Ambrožová, 2003).

Major processes affecting retention, cycling and release of phosphorus in wetlands are diffusion, plant uptake, litter fall, sedimentation, decomposition of organic matter, sorption and burial and peat accretion. The capacity of wetlands for phosphorus removal is limited compared to their nitrogen removal capacity. There is no permanent loss mechanism for phosphorus in wetlands that is analogous to denitrification; therefore, phosphorus tends to accumulate in wetlands at a higher rate than does nitrogen (DeBusk, 1999).

Material and methods

Research area

The Nature Reserve (NR) Alúvium Žitavy is situated in the cadastral land of the town Hurbanovo and the village of Martovce in the southwestern part of the Slovak Republic (Krajinno-ekologicky plán obce Martovce, 2006). Its area covers 32.53 hectares and it was established as the Nature Reserve in 1993. Aluvium lies in interperineal area of the river Žitava, from its present estuary of the river Nitra to the village Veľký Vék (assumed air line) (Szabóová, 1989). It is closed to surrounding agrocenosis with the remainders of meanders of the original water course of the rivers Nitra and Žitava. There is an open water line of the canal with dense bank vegetation in the central part of the Reserve. The northern part enlarges and there is continuous vegetation of riverine forest. Wetland ecosystems are situated mainly in terrain depression at the edge of the alluvium of the river Žitava (Bridišová et al., 2006).

Its larger part is flooded in the course of the year, but especially in spring. There are different biotopes, aquatic, wetland and riverine vegetation. Riverine forests, particularly, willow stands, almost along Alúvium provide suitable ecological conditions both for nesting of avifauna and hiding places as well. There are more than 76 bird species occurring in this area (Prírodná rezervácia Alúvium Žitavy, 2006). Furthermore, for conservation of fauna and flora genetic resources are very important (Štátny zoznam osobitne chránených častí prírody a krajiny Slovenskej republiky, 2007).

The NR Alúvium Žitavy is a part of the Protected Landscape Area Dunajské luhy (Krajinno-ekologický plán obce Martovce, 2006). The protection objective is biotopes of European importance (riverine willow-poplar and alder wood forests) and species of European importance (*Proterorhinus* sp., *Rhodeus amarus*, *Gobio albipinnatus*, *Bombina bombina*, *Lutra lutra*, *Citellus citellus*, species of national importance *Microtus oeconomus*) (Bridišová et al., 2006). Concurrently, NR Alúvium Žitavy is a part of the Special Protection Area SKSPA 005 Dolné Považie where also belongs a proposed habitat of European importance 0159 Alúvium Žitavy (Krajinno-ekologický plán obce Martovce, 2006). The rarest species of avifauna are, for example *Ardea* sp., *Remiz* sp., *Botaurus* sp., *Circus* sp., *Anas* sp., *Acrocephalus* sp., *Charadrius* sp., *Locustella* sp., etc. In term of protected flora, there are *Leucojum aestivum* vegetated almost in the whole area of the NR and *Nuphar lutea* on water level. *Ceratophyllum* sp., *Lemna minor* and *Lemna trisulca* form a typical green cover on the water level. Along the interperineal area of the river Žitava, there is wetland vegetation from which communities of *Phragmites australis*, *Typha latifolia*, *Carex* sp. and *Scirpus* sp. are dominant (Prírodná rezervácia Alúvium Žitavy, 2006).

Sampling and processing of the material

Taking of water samples was carried out from 6 sampling sites in the NR (see Fig 1). Water samples were taken regularly during the years 2006–2008, on the 15th day each month. The sampling sites were proposed to obtain the best possible data for the evaluation of changes in $P\text{-}PO_4^{3-}$ and $P_{Tot.}$ concentrations in water as dependent on sampling time and site. We have established the following 6 sampling sites:

Sampling site No. 1 (47°51'88" N, 18°09'89" E, 121 meters above sea level) (see Fig 2) – inflow of the river Žitava into the Alúvium. *Phragmites australis* and *Salix* sp. grow along the river Žitava. The average depth is 0.32 metres.

Sampling site No. 2 (47°51'92" N, 18°09'25" E, 111 meters above sea level) (see Fig 3) and **No. 3.** (47°51'83" N, 18°09'25" E, 117 meters above sea level) (see Fig 4) – these sampling sites are typical wetland ecosystems. There is a very dense vegetation of *Phragmites australis* and *Salix* sp. in this part of the NR. Water level is covered by *Lemna minor*. Water in these sites flows very slowly and the height of its level is chaning in the course of the year as dependent on weather in dependence on weather during the year. The average depth is 0.30 meters.

Sampling site No. 4 (47°51'58" N, 18°08'38" E, 129 meters above sea level) (see Fig 5) – is situated near the bridge on which there is a road to the village Martovce. It is also the narrowest part of Alúvium; therefore, water flow reaches the highest speed in the river Žitava. There are typical vegetation of *Phragmites australis*, *Salix* sp. and *Alnus* sp. on the banks of the river Žitava. The average depth is 0.40 meters.

Sampling site No. 5 (47°51'09" N, 18°07'99" E, 116 meters above sea level) (see Fig 6) and **No. 6** (47°50'81" N, 18°07'67" E, 121 meters above sea level) (see Fig 7) – typical wetland ecosystems. The river Žitava flows out of its watershed here while rapid snow melting in spring months and intensive precipitation amount in summer months. Compared to the second and the third sampling site, the river floods the whole area between two slopes. The water level decreases about few meters during dry weather in summer. This part of Alúvium is represented mainly by an open water area. *Typha latifolia*, *Phragmites australis*, *Alnus sp.* and *Salix sp.* grow along the river. The water level in sampling site No. 6 is covered with *Lemna* sp. which forms a typical green cover. Beyond this sampling site the river Žitava flows into the river Nitra. The average depth in sampling site No. 5 is 0.26 meters and 0.39 meters in sampling site No. 6.

In the samples taken, $P\text{-}PO_4^{3-}$ concentrations were determined colorimetrically by stannous chloride and $P_{Tot.}$ colorimetrically by ammonium molybdate.

Fig 1. Ortho-photo map of the Nature Reserve Alúvium Žitavy with marked sampling sites

Fig 2. Sampling site No. 1

Fig 3. Sampling site No. 2

Fig. 4. Sampling site No. 3

Fig 5. Sampling site No. 4

Fig 6. Sampling site No. 5

Fig 7. Sampling site No. 6

The results obtained were graphically processed in term of sample time and sample site, consequently processed statistically. All the statistical analyses were consequently conducted by the statistic system Statgraphics Plus 5.0. The basic statistical characteristics of each data file were calculated for all monitored indicators (see Table 1). The statistical differences based on three qualitative factors (sampling year, sampling month, sampling site) were tested by analysis of variance. LSD test for statistical contrasts testing was used on significance level of 95% and 99%. Pearson for bilateral correlation relationships was used to evaluate indicators observed.

Table 1. Basic statistical characteristics

Indicator	$P\text{-}PO_4^{3-}$ [mg dm^{-3}]	$P_{Tot.}$ [mg dm^{-3}]
Count (n)	216	216
Average	0.44	0.73
Minimum	0.01	0.10
Maximum	0.94	2.10
Median	0.46	0.67
Mode	0.34	0.57
Variance	0.026	0.060
Standard deviation	0.161	0.244
Standard error	0.011	0.017
Range	0.93	2.00
Coefficient of variation [%]	36.644	33.420

Results and discussion

The mean phosphate phosphorus concentration in the water of the NR over the whole monitored period was 0.44 mg dm^{-3} (Fig 8). It represented 60.27% of total phosphorus, other forms of phosphorus represented the rest of total phosphorus. The relationship between $P\text{-}PO_4^{3-}$ and $P_{Tot.}$ is shown in Fig 9. Kuníková et al. (2005) found out that in 2002–2003 the mean concentration of $P\text{-}PO_4^{3-}$ in Anakonda wetland was 0.042 mg dm^{-3}.

Dependent on sampling time (see Fig 10), over the whole monitored period the lowest $P\text{-}PO_4^{3-}$ values were in the early spring with its minimum value being in March (0.24 mg dm^{-3}), the second lowest mean value (0.25 mg dm^{-3}) was in February. The decrease of $P\text{-}PO_4^{3-}$ values in this time is related to unsuitable temperature conditions for decomposition of substances containing organic phosphorus form. According to Palatická (2009) there is a positive correlation dependence between water temperature and the concentration of $P\text{-}PO_4^{3-}$.

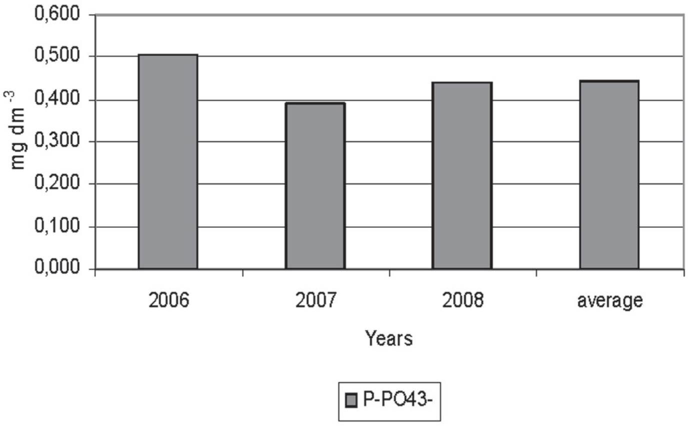


Fig 8. The mean concentrations $P\text{-}PO_4^{3-}$ [mg dm^{-3}] in the years 2006–2008

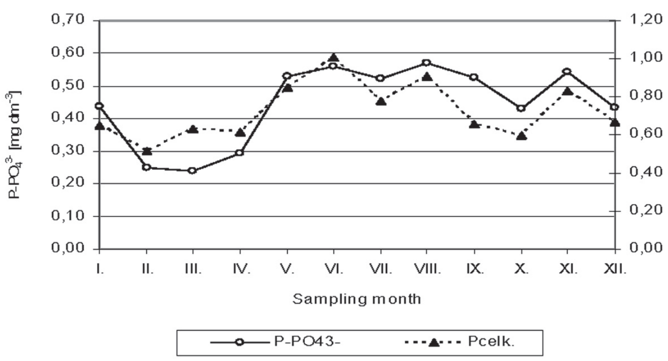


Fig 9. Relationship between mean concentration of $P\text{-}PO_4^{3-}$ and $P_{Tot.}$

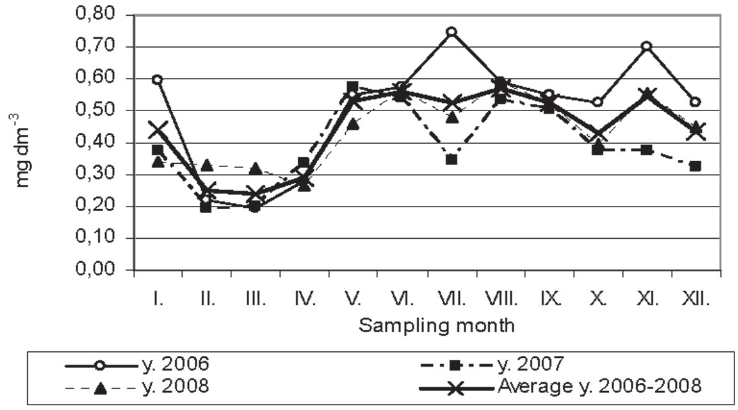


Fig 10. The mean P-PO_4^{3-} concentrations in dependence on sampling time

Mean concentrations of phosphate phosphorus over the whole monitored period were gradually increasing from March to summer. Its maximum mean concentration was in August (0.57 mg dm^{-3}). Sozanský et Noskovič (2002) found the water course Cabajský creek similar seasonal dynamics and Beňačková (2007) in the water Nature Reserve Žitavský luh. According to Pitter (1999), high P-PO_4^{3-} concentrations in summer are due to decomposition of organic substances which is in progress more intensively in higher temperature and under aerobic conditions. During the decomposition dissolved oxygen in water is consumed. Lellák et Kubíček (1991) if oxygen depletion occurs, Fe^{3+} in sediments reduces to dissolved Fe^{2+}, so blocked phosphates are partly released into water above the sediments. Documented by the results Palatická (2009), was found a negative correlation between reliance P-$PO_4^{3-}$and the dissolved oxygen content.

From the diagram of mean P-PO_4^{3-} concentrations as dependent on sampling site (see Fig 11) it can be seen that its values slightly declined and varied from 0.48 mg dm^{-3} in sampling site No. 3 to 0.38 mg dm^{-3} in sampling site No. 6.

The change of concentrations was most significantly influenced by the year of taking samples of this indicator. The highest difference was achieved between the first and the second sampling year. The influence of sampling month and the site of the change of P-PO_4^{3-} concentrations in water was also plumbless. P-PO_4^{3-} positively correlated with $P_{Tot.}$ (r = 0.47).

Mean concentration of total phosphorus during the monitored years was 0.73 mg dm^{-3} (Fig 12). Brantley et al. (2008) found out that from September 1998 to October 2000 the mean concentration of total phosphorus in freshwater wetland in Louisiane was 1.1 mg dm^{-3}. From the diagram of mean concentrations of $P_{Tot.}$ as dependent on sampling time (see Fig 13) it can be seen that the minimum mean concentrations over the whole monitored period were obtained generally in the winter months with minimum being in February (0.51 mg dm^{-3}) in which the lowest mean concentration was measured (0.45 mg dm^{-3}) in this month in 2008. Maximum mean concentration over the whole monitored period was in June (1.01 mg dm^{-3}) when the highest mean value (1.12 mg dm^{-3}) was measured in 2007. The source of total phosphorus is probably an intensive decomposing

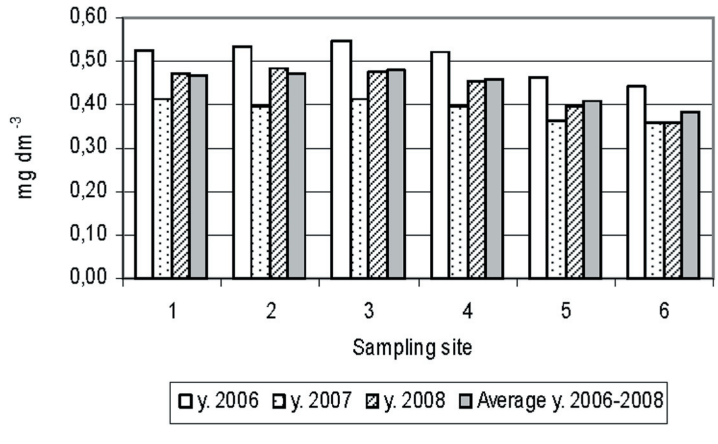


Fig 11. The mean P-PO_4^{3-} concentrations as dependent on sampling site

biomass in sediments. The influence of sampling month on changes of $P_{Tot.}$ concentrations was confirmed also statistically.

Mean concentrations of $P_{Tot.}$ in sampling sites during the monitored years are shown in Fig 14. Similarly to phosphate phosphorus, gradual decrease of its concentrations from the first to the last sampling site can also be seen. A statistically important influence of sampling place on the change of its values was also confirmed, too. Maximum mean concentration of $P_{Tot.}$ over the whole monitored period was in Sampling site No. 1 (0.80 mg dm^{-3}). In 2007 the highest mean concentration (0.92 mg dm^{-3}) was found out in this sampling site. Minimum mean $P_{Tot.}$ concentration over the whole period was in Sampling site No. 6 (0.63 mg dm^{-3}). Brantley et al. (2008) also recorded clear decrease of total phosphorus content in profile of sampling sites in wetland system in Louisiane.

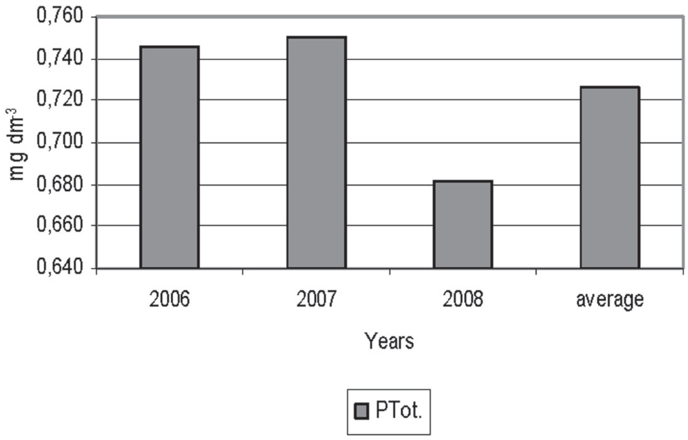


Fig 12. The mean concentrations $P_{Tot.}$ (mg dm^{-3}) in the years 2006–2008

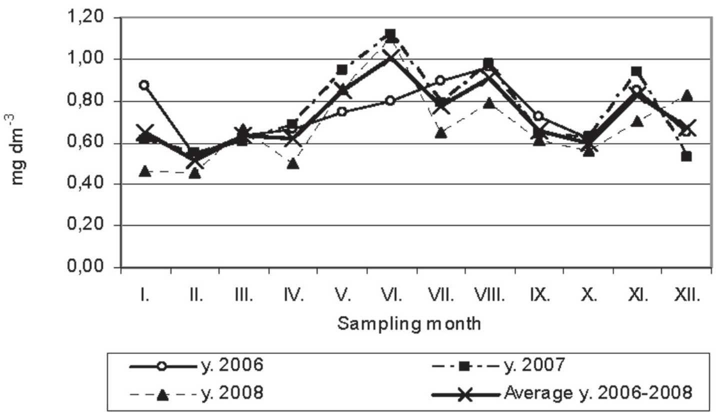


Fig 13. The mean $P_{Tot.}$ concentrations in dependence on sampling time

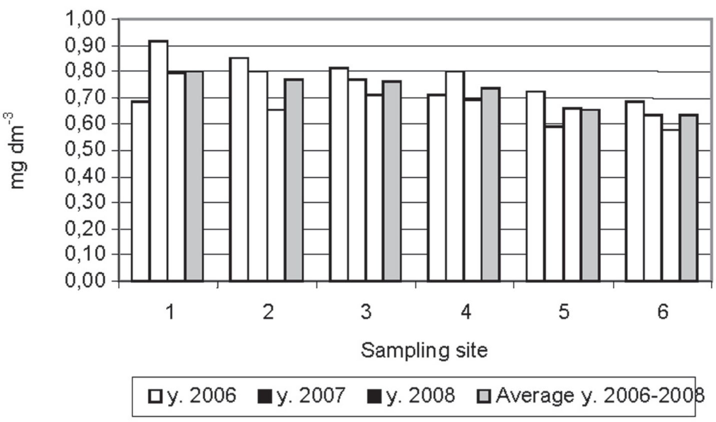


Fig 14. The mean $P_{Tot.}$ concentrations in dependence on sampling site

Acknowledgement

This research was supported within the grant project VEGA 1/0275/08 "A Study of Abiotic and Biotic Parts of the Nature Reserve Alúvium Žitavy and Its Importance for the Biodiversity Conservation of Agricultural Landscape".

References

Ambrožová, J. 2003. *Aplikovaná a technická hydrobiology* [Applied and technical hydrobiology]. Praha: Vysoká škola chemicko-technologická. 226 p.

Beňačková, J. 2007. *Monitorovanie a hodnotenie kvality vody v Prírodnej rezervácii Žitavský luh z ekologického hľadiska* [Monitoring and evaluation of water quality in the Nature Reserve Žitavský luh from an environmental perspective]. PhD thesis. Nitra: Slovak agricultural university in Nitra. 212 p.

Brantley, C.G., Dayjr., J.W., Lane, R.R., Hyfield, E., Day, J.N., Ko, J.Y. 2008. Primary production, nutrient dynamics, and accretion of a coastal freshwater wetland assimilation system in Louisiana. *Ecol. Engng*, 34: 7–22.

Bridišová, Z., Baláž, I., Ambros, M. 2006. Drobné cicavce prírodnej rezervácie Alúvium Žitavy [Small mammalian in the Nature Reserve Aluvium Zitavy]. *Chrán. Územia Slov.*, 69: 7–9.

DeBusk, W.F. 1999. *Phosphorus Cycling in Wetlands*. [cit.2009-10-15]. http://edis.ifas.ufl.edu/SS302

Krajinno-ekologický plán obce Martovce [Landscape-ecological plan of the municipality Martovce] 2006.

Kuníková, E., Tóthová, L., Hucko, P. 2005. Ekohydrologická štúdia ramien Latorice [Ecohydrological study of distributaries of the river Latorica]. *Vodohosp. Sprav.*, 9–10: 14–17.

Lellák, J., Kubíček, F. 1991. *Hydrobiologie* [Hydrobiology]. Praha: Karlova univerzita. 257 p.

Palatická, A. 2009. *Monitorovanie a hodnotenie kvality vody v Prírodnej rezervácii Alúvium Žitavy* [Monitoring and evaluation of water quality in the Nature Reserve Alúvium Žitava]. PhD thesis. Nitra: Slovak Agricultural University in Nitra. 247 p.

Pitter, P. 1999. *Hydrochemie* [Hydrochemistry]. Praha: Vydavatelství VŠCHT. 568 p.

Prírodná rezervácia Alúvium Žitavy [The Nature Reserve Alúvium Žitavy] 2006. [cit. 2009-10-15]. http://www.zitava.sk/zitava/zitava.php?page_id=turistika_prirodne_hodnoty_aluvium

Sozanský, P., Noskovič, J. 2002. Hodnotenie koncentrácie fosforečnanov vo vodnom toku Cabajský potok [Evaluation of the concentration of phosphates in the water flow Cabajská creek]. In *Aktuálne problémy riešené v agrokomplexe. Zborník z medzinárodného vedeckého seminára, 15. november 2002, Nitra, Slovenská republika*. Nitra: Slovenská poľnohospodárska univerzita, p. 95–98.

Štátny zoznam osobitne chránených častí prírody a krajiny Slovenskej republiky[State list of special protected parts of nature and landscape in Slovak Republic] 2007. [cit. 2009-10-15]. http://uzemia.enviroportal.sk/main/detail/cislo/797

Szabóová, A. 1989. *Príroda okresu Komárno* [Nature of the district Komárno]. Bratislava: Erpo. 216 s.

Koncentrácie fosforečnanového a celkového fosforu vo vode v rôznych biotopoch Prírodnej rezevácie Alúvium Žitavy

Súhrn

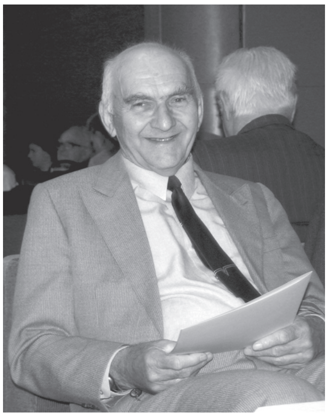
V priebehu rokov 2006–2008 sa vo vode Prírodnej rezervácie Alúvium Žitavy, ktorá sa nachádza v juhozápadnej časti Slovenskej republiky, hodnotili koncentrácie $P\text{-}PO_4^{3-}$ a $P_{Celk.}$ v závislosti od času a miesta odberu. Na základe získaných výsledkov môžeme konštatovať, že priemerná koncentrácia fosforečnanového fosforu vo vode PR za celé sledované obdobie bola 0,44 mg dm^{-3}. Z celkového fosforu predstavoval až 60,27 %, zvyšok tvorili ostatné formy fosforu. V závislosti od času odberu sme najvyššie koncentrácie $P\text{-}PO_4^{3-}$ za celé sledované obdobie zistili v letnom období s maximom v mesiaci august a najnižšie v mesiacoch február a marec. V závislosti od odberového miesta priemerné hodnoty $P\text{-}PO_4^{3-}$ mierne klesali od prvého odberového miesta po posledné. Analýzou rozptylu sme zistili štatisticky významný vplyv všetkých troch kvalitatívnych faktorov (rok odberu, mesiac odberu, miesto odberu) na zmenu koncentrácií tejto formy fosforu. Celkový fosfor za celé sledované obdobie dosiahol priemernú hodnotu 0,73 mg dm^{-3}. Najnižšie priemerné hodnoty za celé sledované obdobie sa vyskytovali spravidla v zimnom období s minimom v mesiaci február, v ktorom sa v roku 2008 namerala aj absolútne najnižšia priemerná koncentrácia. Maximálna priemerná koncentrácia za celé sledované obdobie bola v mesiaci

jún. Podobne ako pri $P\text{-}PO_4^{3-}$, aj pri $P_{Celk.}$ jeho priemerné hodnoty vo vode spravidla mierne klesali od prvého po posledné odberové miesto. Vplyv odberového miesta sa potvrdil aj štatisticky. Uvedené zistenie poukazuje na čistiacu schopnosť mokraďových biotopov nachádzajúcich sa v PR.

Received November 10, 2009
Accepted November 13, 2009

Chronicle

Doc. RNDr. Jan Patočka has died



On March 13, 2009, after a short but serious disease left us our colleague doc. RNDr. Jan Patočka, DrSc., an outstanding entomologist and ecologist, an honorary member of the Slovak Entomological Society and the Czech Entomological Society.

He was born on September 25, 1925, in the town of České Budějovice (Southern Bohemia). In this town he also obtained primary and secondary (real gymnasium) education. After the war, he went to Prague, to study biology at the Charles University. He was graduated in 1948 (RNDr.).

In 1949, he moved to Slovakia and started to work at the just established Forest Research Institutes in Banská Štiavnica. At the period, a team of young entomologists and ecologists was created at this working place. In a very short time, the members of this team: Ing. M. Čapek, K. Charvát, RNDr. V. Pašek, RNDr. J. Patočka, F. J. Turček, had reached excellent results in study of forest insects, their parasitoids and predators, and achieved a considerable international acknowledgement. Jan Patočka published his pioneer works dealing with Lepidoptera associated with poplars, oaks and fir. In some aspects, these works have not been surpassed yet. In 1962, Jan Patočka defended his dissertation (CSc.) on Lepidoptera pupae causing damage to oak trees, and in 1964, he successfully presented his habilitation thesis at the Faculty of Forestry of the University of Forestry and Wood Sciences in Zvolen. He was given fresh incentives also during his one-year study trip to Munich (1964–1965). At this time, his working institution (Research Institute for Forest Management) moved to Zvolen. Here, Jan Patočka continued with his study of relations between Lepidoptera and their host woody plants. In year 1970, he defended his DrSc. – dissertation work at the Faculty of Natural Sciences of the Comenius University in Bratislava. The dissertation work dealt with bionomics, ecology and taxonomy of Lepidoptera associated with fir.

In the period of so called "politic normalisation" following the year 1968, Jan Patočka appeared on the "Black List" of politically unreliable persons. The projects concerning the study of forest Lepitoptera were stopped. The voluminous manuscript of a monograph on Lepidoptera associated with oak, prepared for press, was excluded from publication.

Since 1989, retired, he was working a part-time job at the Institute of Forest Ecology SAS in Zvolen. The change of political climate meant for him academic freedom and new possibilities to publish both in Slovakia and abroad. He continued with intensive study of morphology of Lepidoptera pupae, and also devoted his time to ecology, bionomics, faunistics and protection of Lepidoptera. Every year he published several scientific works. He was always ready to help younger colleagues, and put in contact young people and experienced specialists. Jan Patočka identified lots of materials for Slovak and foreign entomologists. In this period, he published several fairly extensive monographs on Lepidoptera pupae. In the year 1999 was issued the book on oak pests and their natural enemies. The most important appreciation of his life-long work was the offer from the Danish Apollo Books publishing house to publish a collected edition of his study results concerning pupae of Central European Lepidoptera species. The book was issued in two volumes in 2005. Unfortunately, the author's life ended before appearing his last two monographs (dealing with ecology and bionomics of Slovak Lepidoptera and with Lepidoptera in Natura 2000 habitats), the manuscripts of which were submitted for publication in 2009.

Jan Patočka worked in close cooperation with many research institutions, universities and museums in Slovakia and abroad. He also red lectures for students of the Faculty of Ecology and Environmental Sciences of the Technical University in Zvolen and for students of the Faculty of Forestry and Wood Sciences of the Czech University of Life Sciences in Prague.

The records of the Institute of Forest Ecology SAS in Zvolen prove about 228 scientific and expert works of the author.

Jan Patočka was an internationally-recognised and respected scientist. He considerably enhanced knowledge in several areas of entomology and ecology. At the first place, his immense contribution to knowledge of morphology of Lepidoptera larvae and pupae is undisputable. He drew up identification keys for Lepidoptera larvae associated with important forest woody plants in Central Europe and for pupae of almost all Lepidoptera families occurring in Slovakia. The value of these works is evident not only for Lepidoptera identification, but also for taxonomy. Jan Patočka enriched the science with descriptions of several new Lepidoptera species.

He described and supplied with new details the bionomics of many Lepidoptera species. He also explained the influence of the environment on dynamics of their abundance. Especially valuable are his descriptions of consortia of Lepidoptera on several host woody plants (poplars, oaks and fir). He assembled a large piece of data on distribution of several hundreds of Lepidoptera species in Central Europe. He was the head of several research teams studying also other groups of insects feeding on forest woody plants – primarily oaks and fir. He recorded several Lepidoptera species in Slovakia for the first time. Apart from studying Lepidoptera and other insect groups associated with forest woody plants, he also worked on implementing his knowledge in forestry practice. He elaborated original methods for control of and protection against pests in forest management. He had also contributed to nature protection. He participated in projects and helped with preparing research reports concerning threatened Lepidoptera species and their occurrence in protected areas and habitats on Natura 2000.

Jan Patočka was equipped with extraordinary personal faculties for his scientific work. He had an outstanding memory, and sharp and extremely swift perception of details enabling identification of Lepidoptera caterpillars, pupae and adults. He was friendly and tolerant and always ready to help and encourage younger colleagues.

His work was also given support in his own family. His wife helped him also at time when he was having serious problems due to its political orientation. He left one son and two daughters.

We all have lost not only an outstanding scientist, entomologist and ecologist, but also a remarkable, kind-hearted man.

All honour to his memory!

Monographs and extensive works written by doc. RNDr. Jan Patočka, DrSc.

Patočka, J. 1951. *Motýli našich lesních dřevin* [Moths associated with our forest tree species]. Praha: Brázda. 206 p.

Patočka, J. 1954. *Húsenice na duboch v ČSR* [Moth larvae associated with oaks in Czechoslovakia]. Bratislava: Štátne pôdohospodárske vydavateľstvo. 263 p.

Patočka, J. 1954. Housenky škodící na listech topolů [Moth larvae damaging poplar leaves]. *Práce výzk. Úst. lesn. ČSSR*, 5: 165–282.

Patočka, J., Šmelhaus, J. 1959. Lepidoptera. In Kratochvíl, J. (ed.). *Klíč zvířeny ČSR III.* Praha: Nakladatelství ČSAV, p. 631-837.

Patočka, J., Burgan, J., Čapek, M., Stolina, M. 1960. *Die Tannenschmetterlinge der Slowakei*. Bratislava: Vydavateľstvo SAV. 214 p.

Patočka, J., Čapek, M., Charvát, K. 1962. Príspevok k poznaniu korunovej fauny článkovcov na duboch Slovenska, predovšetkým so zreteľom na rad Lepidoptera [Contribution to knowledge about the crown fauna of Arthropoda on oaks, with a special focus on Lepidoptera]. *Biol. Práce SAV*, 7: 1–154.

Patočka, J. 1964. Taxonómia a morfológia spriadača amerického [Taxonomy and morphology of the fall webworm (Hyphantria cunea)]. In Jasič, J. (ed.). *Spriadač americký*. Bratislava: Vydavateľstvo SAV, p. 17–42.

Patočka, J. 1973. Počasie v jarných mesiacoch a priebeh abundančnej dynamiky niektorých listožravých škodcov duba [Weather in spring and seasonal changes in abundance of some leaf-eating oak pests]. In *Problémy ochrany lesov*. Bratislava: Príroda, p. 157–185.

Patočka, J., Kudler, J. 1978. Fam.-Reihe: Geometroidea. In Schwenke, W. (ed.). Die *Forstschädlinge Europas*. Hamburg, Berlin: Paul Parey, p. 218–265.

Patočka, J. 1980. *Die Raupen und Puppen der Eichenschmetterlinge Mitteleuropas*. Monogr. Z. angew. Ent. Hamburg, Berlin: Paul Parey. 188 p.

Čapek, M., Patočka, J. et al. 1985. *Hromadné hynutie dubov na Slovensku* [Mass dieback of oaks in Slovakia]. Bratislava: Príroda. 112 p.

Patočka, J. 1993. Die Puppen der mitteleuropäischen Schmetterlinge aus den Familien Endromidae, Lemoniidae, Saturniidae und Sphingidae (Lepidoptera). *Ann. Naturhist. Mus. Wien,* 94/95 B: 503–545.

Patočka, J. 1995. Die Puppen der mitteleuropäischen Eulen: Charakteristik, Bestimmungstabelle der Gattungen (Insecta, Lepidoptera: Noctuidae). *Ann. Naturhist. Mus. Wien,* 97 B: 209–254.

Patočka, J. 1996. Die Puppen der mitteleuropäischen Eulen: Cucullinae, Heliothinae, Ipimorphinae, Hadeninae, Agrotinae (Lepidoptera: Noctuidae). *Nova Suppl. Ent*., 8: 3–232.

Patočka, J. 1996. Die Puppen der europäischen Blütenspanner. *Dortmunder Beitr. Landeskde. naturwiss. Mitt*., 30: 185–283.

Patočka, J. 1997. Über die Puppen der mitteleuropäischen Schmetterlinge (Insecta: Lepidoptera): Überfamilien Yponomeutoidea, Gelechioidea, Schreckensteinoidea, Epermenoidea und Copromorphoidea. *Linzer biol. Beitr*., 29: 715–751.

Patočka, J. 1998. Die Puppen der mitteleuropäischen Wickler. Lepidoptera: Tortricoidea, Tortricidae. *Nova Suppl. Ent. Berlin*, 12: 3–288.

Patočka, J. 1999. Die Puppen der mitteleuropäischen Schmetterlinge (Lepidoptera). Charakteristik, Bestimmungstabelle der Überfamilien und Familien. *Beitr. Ent., Berlin*, 49: 399–445.

Patočka, J. 1999. Über die Puppen der mitteleuropäischen Schmetterlinge (Insecta: Lepidoptera): Überfamilie Yponomeutoidea: Familien Yponomeutidae, Plutellidae und Acrolepiidae. *Linzer biol. Beitr*., 31: 381–420.

Patočka, J. 2001. Die Puppen der mitteleuropäischen Zünsler: Charakteristik, Bestimmungstabelle der Unterfamilien, Unterfamilien: Galleriinae, Pyralinae und Phycitinae. *Beitr. Ent. Berlin*, 51: 411–517.
Patočka, J. 2003. Die Puppen der mitteleuropäischen Spanner (Lepidoptera, Geometridae). Unterfamilie Ennominae, 1. Teil. *Linzer biol. Beitr*. 35: 1001–1075.
Patočka, J. 2004. Die Puppen der mitteleuropäischen Spanner aus der Unterfamilie Ennominae (Lepidoptera: Geometridae), 2.Teil. *Linzer biol. Beitr*., 35: 315–388.
Patočka, J., Turčáni, M. 2005. *Lepidoptera Pupae. Central European Species*. *Text volume.* Stenstrup: Apollo Books. 542 p.
Patočka, J., Turčáni, M. 2005. *Lepidoptera Pupae. Central European Species*. *Plate volume*. Stenstrup: Apollo Books. 321 p.
Patočka, J., Kulfan, J., Janíková, E. 2009. *Motýle (Lepidoptera) v európsky významných biotopoch Slovenska* [Lepidoptera in the habitats of Community interest in Slovakia]. Zvolen: Ústav ekológie lesa SAV. 100 p.
Patočka, J., Kulfan, J. 2009. *Lepidoptera of Slovakia – bionomics and ecology / Motýle Slovenska – bionómia a ekológia*. Bratislava: Veda. 312 p.

Translated by Dagmar Kúdelová and the author

Ján Kulfan
Institute of Forest Ecology
of the Slovak Academy of Sciences
Štúrova 2
960 53 Zvolen
Slovak Republic
E-mail: kulfan@savzv.sk

Instructions for authors

Folia oecologica is a journal devoted to publishing original scientific papers from the fields of ecology of forest ecosystems, communities and populations of plants, fungi and animals associated with forest environment and also the ecology of woody plants growing in both forest and non-forest environment, human settlements included.

The journal also publishes short communications, methodological and survey papers in the area, book reviews, personalia and information about scientific events. The manuscripts are submitted to reviewers for evaluation of their significance.

Manuscript layout. The manuscripts should be written in English, well-arranged, not exceeding a maximum extent of 20 pages, including tables and figures. The authors are responsible for the quality of the text, manuscripts written in poor English will be returned. Please, send two copies of the manuscript (A4 format, type size 12 font Times New Roman, double-space lines, 3 cm margins on each edge of the page) together with all figures and tables (each on a separate sheet) to the editorial office. Avoid dividing the words, smoothing right text margins; do not define the styles and paragraphs. Do not use either spacing or tabulator for beginning of a paragraph. If the paper has been submitted for publication, send two printed copies and one copy in electronic form (1.44 MB, disk or a CD) as a Microsoft Word file (DOC, or RTF format).

An original scientific paper should comprise: 1. The title. 2. The author's name: full first name and second name. 3. Address: complete address and e-mail address (if available) of all the authors. 4. Abstract: in one paragraph, without references to tables, figures and literature, not exceeding 15 lines (900 characters). 5. Key words (maximum 6). 6. Introduction. 7. Material and methods. 8. Results. 9. Discussion (or Results and discussion). 10. Acknowledgement. 11. References. 12. Summary in Slovak (or in Czech): not exceeding an extent of one page, including the title of the paper in Slovak.

In the papers, it is necessary to use SI symbols. Non-integer numbers should be provided with a decimal point, (e.g. 1.7), not a comma (1.7), the thousands (with exception of years) are separated with a comma: 5,600. The variables in mathematical formulae and expressions should be written in italics, the symbols for functions and constants in the normal font, the matrices in bold capitals, the vectors in bold small letters. Latin names of genera, species, subspecies and varieties are written in italics, the name of the author of the description (or his abbreviation) normally: e.g. *Lymantria dispar* (Linnaeus, 1758), *Lymantria dispar* (L.), *Abies cephalonica* Loud. var. *graeca* (Fraas) Liu. The names of cultivars are written normally, e.g. *Olea europea* L. cv. Chalkidikis. All the tables and figures must be referred to in the text: Table 1, Tables 2–4, Figs 2–4. The authors are asked to indicate placing of the tables and figures on the text margins.

Literature citations. The literature cited in the text should conform to the following patterns: one author – Funke (1971) or (Funke, 1971), two authors – Sokal and Rohlf (1995) or (Sokal and Rohlf, 1995), three and more authors – Alstad et al. (1982) or (Alstad et al., 1982). More than one work written by the same author is to be distinguished with small letters appended after the year: Novák (1950a, 1950b). If the document does not contain either the name of the responsible person or the corporation and if it is not possible to conclude about the author with certainty from other authorities, the work should be cited as written by an Anonymus.
References in the final list are to be provided with the full title and names of all authors; ordered alphabetically and according to the publication year. Latin names of genera, species and sub-species cited in the list of references are to be written in standard type. The titles are to be cited in the original language appended by an English translation (in brackets). The issue number (except the volume number) should be given (in parentheses) only in the case when the volumes are not paginated continually. The titles of periodicals should be cited in shortened form, according to the international rules, conform to the World list of scientific periodicals. The basic instructions can be found in Bojňanský et al. (1982) Periodiká z oblasti biologicko-poľnohospodárskych vied, ich citácia a skratky [Periodicals in area of biological and agricultural sciences, their citations and abbreviations]. Bratislava: Slovenská spoločnosť pre poľnohospodárske, lesnícke a potravinárske vedy pri SAV. 704 p. In the case of a possible ambiguity, cite the periodical under the full name. Titles in languages not using the Latin alphabet should be transliterated keeping with the British Standard 2979 (in the case of the Cyrilic e.g. ж = zh, х = kh, ц = ts, ч = ch, ш = sh, щ = shch, ю = yu, я = ya). (The basic rules can be found e.g. in Bojňanský et al. 1982).

The following form of citation should be used:

Work in a periodical

Sharov, A.A., Liebhold, A.M., Ravlin, F.W. 1995. Prediction of gypsy moth (Lepidoptera: Lymantriidae) mating success from pheromone trap counts. *Envir. Ent*., 24: 1239–1244.

Eiberle, K., Nigg, H. 1984. Zur Ermittlung und Beurteilung der Verbissbelastung. *Forstwiss*. Cbl., 103: 97–110.

Book

Szujecki, A. 1983. *Ekologia owadów leśnych* [Ecology of forest insects]. Warszawa: Państwowe Wydawnictwo Naukowe. 604 p.

Miller, J.R., Miller, T.A. (eds) 1986. *Insect-plant interactions*. New-York: Springer-Verlag. 342 p.

Work published in a book or in a proceedings

Basset, Y., Springate, N.D., Aberlenc, H.P., Delvare, G. 1997. A rewiew of methods for sampling arthropods in tree canopies. In Stork, N.E., Adis, J., Didham, R.K. (eds). *Canopy arthropods*. London: Chapman & Hall, p. 27–52.

Ciberej, J., Kováč, G., Bilá, A. 1999. Faktory ovplyvňujúce početný stav kamzíka vrchovského v TANAP-e [Factors influencing game populations in chamois (Rupicapra rupicapra L.) in the High Tatra National Park]. In Koreň, M. (ed.). *Päťdesiat rokov starostlivosti o lesy TANAP-u. Zborník referátov z konferencie*. Poprad: Marmota Press, p. 111–116.

Dissertation

Chromová, L. 2002. *Pôdne a vegetačné zmeny lesných spoločenstiev okolia obce Brusno (Veporské vrchy)* [Changes in soils and vegetation of forest communities of the Brusno village (the Veporské Mts.)]. PhD thesis. Bratislava: Comenius University, Faculty of Natural Sciences. 122 p.

Tables. The tables should be submitted on separate sheets, not included into the text. The sheets must not be folded. The tables are to be numbered, each after other, with Arabic numerals (Table 1, Table 2…). The text in the caption should always begin with a capital letter. The tables can be self-explicable, not requiring references in the text. The numbering and captioning should be placed over the table, commentaries, if any, under the table. Submitted are only tables prepared in Word and Excel, without vertical grid lines. Use the font size 9. Table width should be of one or two text columns (77 and 160 mm) or 235 mm. Avoid doubling the information in tables and plots.

Figures. Submitted are only high-quality drawings, plots and photographs in black, each on a separate A4 sheet. They can be prepared manually or printed with a laser or an ink printer. Please use only hatching, not shading. Avoid three-dimensional graphs, if possible. In captions use the Arial font. The font size should not exceed 11, the recommended size is 9. If possible, use the unified size. Figure width should be 77, 160 or if necessary, 235 mm. The lines must be well clean-cut and the written text must be distinctly readable also after the diminution. For the electronic version, only MS Excel is acceptable. The backside of sheet should be provided with the number of the figure and the author's name. The graphs and ink drawings must be self-explicable and readable with captions and appended keys of symbols only, without necessity to seek explanations in the text.

Off-prints. Each author and co-authors will obtain one electronic copy of the published paper.

Editorial office. Institute of Forest Ecology SAS, Centre of Scientific Information – Library, Štúrova 2, 960 53 Zvolen, Slovak Republic, e-mail: knizuel@savzv.sk Manuscripts should be sent to the editorial office.