

Composition and diversity of psocid (*Insecta: Psocoptera*) taxocoenoses in forest ecosystems of the *Abieti-fageta* s. lat. zone in the Western Carpathian Mts.

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ABSTRACT: Psocid (Psocoptera) taxocoenoses were studied in forest ecosystems of the Western Carpathian Mts. in 1997–2001. As a study frame, vegetation tiers (VT = altitudinal vegetation zones) of geobiocoenological or forest-typological system were used. Lower units of forest typological system (forest type complexes) were used for the classification of ecological conditions and the material found in forest ecosystems of *Abieti-fageta* s. lat. communities (5th fir-beech VT) was evaluated in detail. This VT is the most widespread in the regions under study (the Moravskoslezské Beskydy Mts., the Vsetínské vrchy Hills and Javorníky). 2,023 adults comprising 28 species were found in the 5th VT. *Caecilius burmeisteri* was found as eudominant species; *Philotarsus picicornis*, *Caecilius flavidus* and *Peripsocus subfasciatus* were found as dominant species. In natural geobiocoenoses with the level of naturalness 1 or 2, the following species were found: *Mesopsocus unipunctatus*, *Caecilius flavidus*, and *Caecilius burmeisteri* as eudominant and *Caecilius despaxi* as dominant. Taxocoenoses of psocids were evaluated by Detrended Correspondence Analysis (DCA) and Divisive Cluster Analysis (DvCIA). The axes were interpreted in DCA-analysis as follows: the *x*-axis denotes the influence of VTs and the *q*-axis refers to the influence of hydricity. This material was compared with other material obtained from various vegetation tiers in the Western Carpathians Mts. The characteristic species composition of psocids in the 5th VT was as follows: *Caecilius flavidus* – *C. burmeisteri* – *C. despaxi* – *Metylophorus nebulosus* – *Philotarsus picicornis*.

Keywords: *Psocoptera*; taxocoenoses; diversity; forest ecosystems; vegetation tier; *Abieti-fageta* s. lat.; Moravskoslezské Beskydy Mts.; Vsetínské vrchy Hills; Javorníky Mts.; Western Carpathian Mts.

The psocids were studied only in some areas of the Czech Republic, mostly in various mountains of Moravia and Silesia, e.g. in the Hrubý Jeseník Mts., Kralický Sněžník Mt. (OBR 1949) and the Moravskoslezské Beskydy Mts. (OBR 1952, 1965). Only occasional captures were published from other areas of the Czech Republic. A complex psocopterological research was initiated in the territory of the Czech Republic and Slovakia in 1997 (cf. HOLUŠA 2003a).

Mostly faunistic data are available in this country at present. However, HOLUŠA (2001) studied an ecological problem of the dependence of psocid taxocoenoses composition on vegetation tier (VT = altitudinal vegetation zone) in the Smrk Nature Reserve, HOLUŠA (2003b) in the Mazák Nature Reserve and the same author (HOLUŠA 2007b) in the V Podolánkách Nature Reserve. All these reserves are located in the Moravskoslezské Beskydy Mts. In

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the Podbeskydská pahorkatina Hills psocid occurrence was also evaluated in the framework of forest type complexes in the Kamenec Nature Reserve (HOLUŠA 2005) and in the alluvium of the Odra River (Poodří Protected Landscape Area) (HOLUŠA 2007a). Moreover, MÜCKSTEIN and HOLUŠA (2003) studied the composition of psocid taxocoenoses in different ecosystem types and its dependence on the naturalness level of forest ecosystems in the region of the Žďárské vrchy Hills. The latest ecological study brings data on the composition of psocid taxocoenoses of 7th (*Fageti-piceeta* s. lat.) and 8th (*Piceeta* s. lat.) VT in the Moravskoslezské Beskydy Mts. and the Oravské Beskydy Mts. in Slovakia (HOLUŠA 2007c).

The aim of the systematic study of psocids conducted in the Western Carpathian Mts. in 1997–2001 was to define species diversity and characteristic species composition of psocids in particular vegetation tiers (vegetation tiers according to PLÍVA 1971, 1991 were used) and to prove an applicability of vegetation tiers or lower units of geobiocoenological or forest-typological systems in zoocoenological studies.

METHODS

The net of equally distributed geobiocoenological research plots was situated in regions of eastern Moravia, eastern Silesia and northern Slovakia in the territory of Polonic and West Carpathian biogeographical subprovinces (i.e. in the region of the Western Carpathian Mts.). Plots were selected in all VTs occurring in this region, i.e. from the 3rd (communities of *Querci-fageta* s. lat.) to the 9th tier (communities of *Pineta mugii* s. lat.) (cf. HOLUŠA, HOLUŠA 2008). Plots were located in such parts of forest stands that represent a particular VT and where it was possible to collect a representative material of psocids. Approximately the same number of permanent plots was located in all VTs. Permanent plots were marked out in the best-preserved parts of nature reserves [with the level of naturalness 1 or 2 according to ELLENBERG (1973, 1978)] and additional plots were selected in modified parts of nature reserves or in managed forests with the level of naturalness 3 or 4 according to ELLENBERG (1973, 1978).

Sampling was carried out in the same way in all VTs during the research and the material from the 5th (i.e. *Abieti-fageta* s. lat.) VT is presented in this study. The research was conducted in 1997–2001.

Material was obtained from permanent sampling sites during the vegetation period (from the be-

ginning of May to the middle of September). The samples were collected by sweeping with a sweep net of 50 cm mouth in diameter. Branches of trees and bushes were beaten with the same sweep net in the extent of about 1 m from the branch end and up to approximately 2.5 m height, 30 sweepings or beatings were carried out in each locality. Individual collecting of adults also complemented these methods. Caught psocids were sucked into an exhaustor and stored in a small test tube with 70% alcohol in the author's collection. All samples were collected and identified by the author. Monographs by GÜNTHER (1974) and LIENHARD (1998) were used for identification; nomenclature, zoogeographical distribution and ecological demands were commented according to LIENHARD (1977, 1998). Samples were sorted into vectors which represent "habitats of psocids". The following factors were taken into account for the purpose of sorting: biogeographical region, ecological conditions (according to the forest type complexes) and tree or shrub species from which the material was obtained (samples were also distinguished according to the capture method, i.e. captured either in a herb layer or by the Malaise trap). For example: *BE5Sm*, where *BE* denotes the Beskydský biogeographical region (No. 3.10, cf. CULEK 1996), *5S* represents forest type complexes *Abieto-Fagetum mesotroficum* and *sm* is an acronym for the tree species *Picea abies*.

Diversity was evaluated by Shannon-Wiener (H_S) and Brillouin diversity index (H_B), which were computed according to KAESLER and MULVANY (1976a,b). Diversity indexes of individual habitats were calculated from the total number of captured specimens, however, in the case of a higher number of specimens these were reduced to a constant number (30, 60, 120, 240 and 480) (Table 1). Some material was excluded from statistical processing because of a small number of collected specimens in some plots (i.e. species with a lower number than 5 specimens or 2 species even less than 3 specimens) to prevent data distortion.

The material was evaluated by Detrended Correspondence Analysis (DCA) and by Divisive Cluster Analysis (DvCIA) in modification – Twin-span algorithm. Modified SW Decorana was used to process the DCA analysis, which was adapted for zoocoenological data processing (POVOLNÝ, ZNOJIL 1990).

Acronyms of trees and shrubs (investigated tree species): *sm* – *Picea abies* (L.) Karsten, *bk* – *Fagus sylvatica* L., *jd* – *Abies alba* Mill., *jb* – *Malus sylvestris* Mill., *jiv* – *Salix caprea* L., *pod* – copse.

The characteristics of the 5th vegetation tier (*Abieti-fageta* s. lat.)

The 5th vegetation tier (*Abieti-fageta* s. lat.) (cf. HOLUŠA, HOLUŠA 2008) represents geobiocoenoses where *Fagus sylvatica* is a dominant species in natural conditions, it creates the main level and also fills the overtopped level (of the height ca 47–48 m). Significant edificators – *Abies alba* has its optimum there (with the representation up to 40%, of the height in the co-dominant level up to 60 m) and *Picea abies* occurs only individually (with the representation reaching up to 10%, of the height up to 60 m). *Acer pseudoplatanus* L. and *Ulmus glabra* Huds. occur as additional tree species mostly in the overtopped level. They increase their representation at debris sites. There are *Tilia cordata* Mill., *Tilia platyphyllos* Scop., *Acer platanoides* L. and also *Padus avium* L. as individual additions (generally in the overtopped level). The occurrence of these species ends in the 5th VT, they do not occur in higher VTs. Localities with the 5th VT can be characterized as higher uplands and parts of mountains. The 5th VT occurs at the altitude from 460 to 920 m a.s.l. with the centre of occurrence in the interval of 640–660 m a.s.l. Soil types were formed on the flysch series of rocks of sandstones, claystones and shales, sporadically on deluvial loams. Cambisols are the prevailing soil type; less frequently there are podzols or rankers. The 5th VT takes up large areas in Natural Forest Area (= NFA) 40 and 41. It fills the territory of ca 18.0% in the north-eastern Moravia and Silesia. A greater part of the 5th VT area was changed to monoculture or stands with dominance of *Picea*

abies. *Abies alba* and other tree species are mostly missing also in stands of *Fagus sylvatica*. *Abies alba* is represented relatively commonly only in NFA 41 (the Hostýnsko-vsetínské vrchy Hills and Javorníky Mts.) (mostly within the Czech Republic). The Salajka National Nature Reserve was characterized by PRŮŠA (1985) as the best-preserved virgin forest of the 5th VT, both with tree species composition and spatial structure. With a high probability, there are the best-preserved geobiocoenoses in the whole Czech Republic. This locality was studied also in the framework of this work. Natural geobiocoenoses are represented in the Mazák National Nature Reserve (HOLUŠA, HOLUŠA 2003) in the Moravskoslezské Beskydy Mts.

The following forest type complexes were classified at the study plots (ranked according to the system): 5N – *Abieto-Fagetum lapidosum acidophilum*, 5S – *Abieto-Fagetum mesotrophicum*, 5B – *Abieto-Fagetum eutrophicum*, 5F – *Abieto-Fagetum fastigiosum lapidosum mesotrophicum*, 5H – *Abieto-Fagetum illimerosum trophicum*, 5D – *Fagetum acerosum deluvium*, 5A – *Acereto-Fagetum lapidosum*, “5E” – code is used for solitaire trees outside forests, without sorting into forest type complexes.

RESULTS AND DISCUSSION

2,023 adults comprising 28 species were found in total – only *Caecilius burmeisteri* was a eudominant species, and *Philotarsus picicornis*, *Caecilius flavidus* and *Peripsocus subfasciatus* were dominant species. In natural geobiocoenoses with the level of naturalness 1 or 2, *Mesopsocus unipunctatus*, *Caecilius*

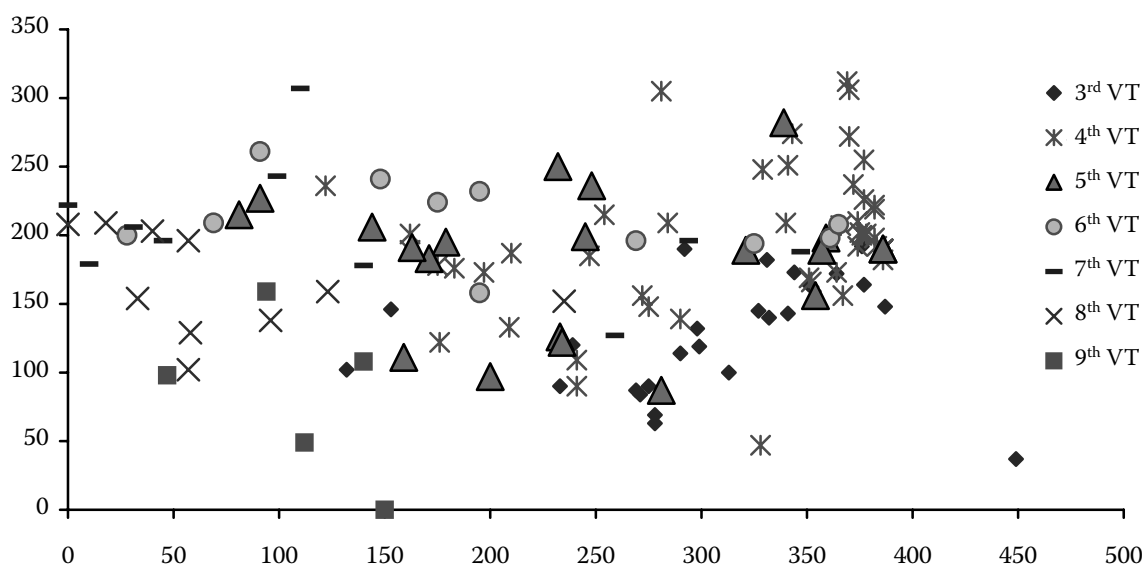


Fig. 1. DCA analysis of psocid biotopes with marked biotopes of *Abieto-fageta* (5th VT) tier (axis *x* – gradient of vegetation tiers, axis *q* – gradient of hydricity)

Higher values of diversity indexes were computed for the 5H communities in the BE5Hsm psocid biotope with a reduced number, i.e. $N_{30} - H_S$ 1.31 and H_B 1.58, a high value was also found for the VS5Bsm psocid biotope with a reduced number, i.e. $N_{30} - H_S$ 1.27 and H_B 1.51 (Table 1).

The DCA-analysis might be interpreted as follows: the x -axis denotes the influence of VTs and the q -axis refers to the influence of hydricity (cf. HOLUŠA 2007c). These factors might increase a presumption of mutual correlation, but all VTs include habitats with high hydricity – flooded habitats, waterlogged and peaty habitats as well as dry or desiccating habitats. As each VT comprehends a large scale of habitats – from dry to peaty habitats, the hydricity of the habitat does not correlate with the altitude within the collected material. Habitats of the 5th VT create a large field in the gradient of VTs (along the x -axis, Fig. 1), which has a small shift into higher VTs in comparison with the fields of the 4th or 3rd VTs. From the aspect of hydricity, the field is narrower than the field of the 4th VT and it is placed into the field centre of the 4th VT. Habitats of the 5th VT are “drier” than habitats of the 3rd VT.

Habitats of the 5th VT are represented in more groups in the DvCIA-analysis, which is caused by the tree species spectrum in this VT. Habitats of broad-leaf trees are sorted into the following groups: A-I-b and A-II-a; habitats of *Picea abies* and *Abies alba* are sorted into the following groups: B-I-b, B-II-a and B-II-B-1 (Fig. 2). There is a clear similarity of broad-leaf habitats (i.e. tree species, mainly *Fagus sylvatica*) and habitats of “lower” VTs, i.e. the 3rd and 4th VT.

The characteristic species combination of the 5th VT can be identified as follows: *Caecilius flavidus* – *C. burmeisteri* – *C. despaxi* – *Metylophorus nebulosus* – *Philotarsus picicornis*. *Elipsocus moebiusi* is missing in this VT, in contrast to the 4th VT. There are numerous representations of psocid species typical of middle altitude – *Enderleinella obsoleta*, *Cuneopalpus cyanops* and *Caecilius piceus*. The occurrence of *Caecilius despaxi* was found as the differential feature between the 4th and 5th VT.

CONCLUSION

Compositions of psocid taxocoenoses are, as a matter of fact, influenced by the tree species composition, therefore the difference between natural and changed forest geobiocoenoses is clear. It is possible that the diversity of psocid taxocoenoses was “higher” in virgin forests due to the representation of other tree species which are rare or missing at present, and also due to a “better” stand structure.

The results of this work and previous records (HOLUŠA 2007c) verify the hypothesis that vegetation tiers have proved to be a suitable frame for zoocoenological studies. VTs and lower units of geobiocoenological or forest-typological system, together with the description of tree species composition and the level of naturalness form a perfect base for studies focused on the animal taxocoenoses structure. We support the hypothesis that psocids, as a part of forest ecosystem, fully comply with the theorem of geobiocoenoses (ZLATNÍK 1976). Geobiocoenoses consist of specific biocoenoses in relation with abiotic environment; the biocoenosis is formed not only by plants or trees as the main community determinants while the zoocoenosis also constitutes an important part.

Vegetation tiers are units which complexly take into consideration ecological factors of ecosystems in landscape segments and they are an ideal frame for animal studies. According to the results (cf. HOLUŠA 2007c), psocid taxocoenoses are dependent on the main ecological factors of the environment; therefore the VTs are the most appropriate units considering changes in the main ecological factors in landscape segments. This study also confirmed that VT is the main factor with the greatest influence on the variability of psocid taxocoenoses. Finally, the order of psocids can be used for the geobiocoenological classification of ecosystems.

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Složení a diverzita taxocenóz pisivek (*Insecta: Psocoptera*) v lesních ekosystémech vegetačního stupně jedlových bučin (*Abieti-fageta* s. lat.) v západních Karpatech

ABSTRAKT: Během období 1997–2001 byly v lesních ekosystémech v oblasti západních Karpat studovány taxocenózy pisivek (*Psocoptera*). Jako rámec pro studium byly použity vegetační stupně podle systému geobiocenologie, resp. lesnické typologie. Pro klasifikaci stanoviště, tj. ekologických podmínek, byly použity jednotky – soubory lesních typů lesnicko-typologického systému. V práci jsou vyhodnocena pouze společenstva 5. jedlobukového vegetačního stupně, tedy společenstva jedlových bučin (*Abieti-fageta* s. lat.). 5. jedlo-bukový VS je široce rozšířen v oblasti Moravskoslezských Beskyd, Vsetínských vrchů a Javorníků. Celkově bylo zjištěno 2 023 imag 28 druhů: pro všechny stupně přirozenosti geobiocenóz byl eudominantním druhem *Caecilius burmeisteri*, dominantní druhy byly *Philotarsus picicornis*, *Caecilius flavidus* a *Peripsocus subfasciatus*. V přírodních a přirozených geobiocenózách (stupeň přirozenosti 1 a 2) byly jako eudominantní zjištěny druhy *Mesopsocus unipunctatus*, *Caecilius flavidus*, *Caecilius burmeisteri*, jako dominantní druh *Caecilius despaxi*. Taxocenózy pisivek byly vyhodnoceny statistickými metodami

– detrendovanou korespondenční analýzou (DCA) a shlukovou divizní analýzou (DvCIA). V DCA analýze byly osy interpretovány: x osa představuje vliv vegetační stupňovitosti, q osa vliv hydricity. Materiál byl vyhodnocen v rámci širšího srovnání materiálu pocházejícího i z ostatních VS v rámci vnějších západních Karpat. Charakteristická druhová kombinace pisivek pro 5. VS byla stanovena takto: *Caecilius flavidus* – *C. burmeisteri* – *C. despaxi* – *Metylophorus nebulosus* – *Philotarsus picicornis*.

Klíčová slova: *Psocoptera*; taxocenózy; diverzita; lesní geobiocenózy; vegetační stupeň; *Abieti-fageta* s. lat.; Moravskoslezské Beskydy; Vsetínské vrchy; Javorníky; západní Karpaty

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