



Polish Botanical Studies 19

This issue of *Polish Botanical Studies* is dedicated to

KRYSZYNA GRODZIŃSKA
on the 70th anniversary of her birth

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AN APPRECIATION OF PROFESSOR KRYSZYNA GRODZIŃSKA ON THE OCCASION OF HER SEVENTIETH BIRTHDAY

BARBARA GODZIK & KAZIMIERZ ZARZYCKI

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CHANGES IN TRACE METAL DEPOSITION IN AUSTRIA BETWEEN 1991 AND 2000

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Abstract: Mosses have been employed to monitor atmospheric heavy metal deposition in Austria since 1991, following the method of international studies using *Hylocomium splendens*, *Pleurozium schreberi*, *Hypnum cupressiforme* and *Abietinella abietina* as monitoring species. In 1995 and 2000, samples were taken at approx. 230 sites, accounting for 3.5 sampling points per 1000 km², distributed on a regular grid. In 1991 only 43 sites were analyzed in regard to national deposition patterns. Al, Co, Cr, Cu, Fe, Hg, Mo, Ni, Pb, V, and Zn were analyzed by ICP-AES, As by FIAS, and Cd by AAS. On a national scale the average concentrations of Cd, Mo, Ni, Pb, and V were found to decrease significantly. For As, Co, Cr, Fe, and Zn, minor reductions in deposition were observed. For Cu, and Hg, a distinct increase in concentrations since 1991 was detected. The increase in Cu is probably associated with increasing traffic emissions; the reasons for the Hg increase remain unclear. On a local scale (single sampling sites) the concentrations varied. There were cases of elements sharply decreasing nationally but increasing locally, the possible causes being increasing emissions from local sources like traffic, local combustion or local industry; another possible reason is contamination of samples by soil dust. The results are discussed in an international context.

Key words: mosses, biomonitoring, heavy metals, Austria

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AREAL DIFFERENCES IN METAL POLLUTION IN INDICATOR PLANT SAMPLES FROM SOUTHERN PARTS OF FINLAND, POLAND AND BRITISH COLUMBIA

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Abstract: Levels of Al, Fe, Mn, Zn, Cu, Cd and Hg in leaves of 22 species of terrestrial indicator plants from numerous randomly selected localities in the southern parts of British Columbia, Finland and Poland were analyzed by AAS. The main material comprised 2008 chemical analyses performed on 309 samples randomly collected from 87 localities in the three

extensive study areas. Although insufficient for comparisons within species, the material considered in toto revealed two important features of the metal pollution spectrum: strong dominance of Cd in southern Poland, and dominance of Hg in southern British Columbia. Metal pollution in southern Finland more resembled the Polish type. The interaction of soil fertility, Cd pollution and pest resistance in forest decline is discussed.

Key words: Plant bioindicators, southern Poland, southern Finland, southern British Columbia, metal pollution

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CONCENTRATIONS OF HEAVY METALS IN *MOEHRINGIA TRINERVIA* (CARYOPHYLLACEAE) IN THE NIEPOŁOMICZE FOREST (S POLAND) – CHANGES FROM 1984 TO 1999

BARBARA GODZIK & GRAŻYNA SZAREK-ŁUKASZEWSKA

Abstract: The Puszcza Niepołomicka forest is a large forest complex which has been affected by pollution from the big urban-industrial agglomeration of Kraków for over 50 years. *Moehringia trinervia* (L.) Clairv., a species commonly occurring in the forest, was used in a 1984 study assessing heavy metals contamination. After a lapse of 15 years the study was repeated in 1999. Samples of *M. trinervia* were collected once more, and concentrations of the same elements (Cd, Pb, Zn, Cu) were determined in the plant. The concentrations of Cd and Cu in the plant material collected in 1999 were lower than in the 1984 samples, and the differences were statistically significant (Cd in 1984, 6.85 to 16.14 $\mu\text{g g}^{-1}$; Cd in 1999, 1.31 to 14.34 $\mu\text{g g}^{-1}$). The zinc concentration also differed from its natural level in *Moehringia trinervia* (Zn in 1984, 241.4 to 457.1 $\mu\text{g g}^{-1}$; Zn in 1999, 203 to 428 $\mu\text{g g}^{-1}$). The concentrations of all studied elements differed between sampling sites. Just as in 1984, the western part of the forest (situated closest to the town and the steelworks) was most contaminated with heavy metals.

Key words: Heavy metals, *Moehringia trinervia*, Niepołomice Forest, accumulation

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TRACE ELEMENTS IN THE LICHENS *USNEA AURANTIACO-ATRA* AND *USNEA ANTARCTICA* FROM THE VICINITY OF URUGUAY'S ARTIGAS RESEARCH STATION ON KING GEORGE ISLAND, MARITIME ANTARCTIC

JERZY SMYKLA, EWA SZAREK-GWIAZDA & BEATA KRZEWICKA

Abstract: The paper reports trace element content in thalli of the fruticose macrolichens *Usnea aurantiaco-atra* and *U. antarctica* in the vicinity of Uruguay's General Artigas Research Station (King George Island, Maritime Antarctic). The mean content of trace elements ($\mu\text{g g}^{-1}$) in *U. aurantiaco-atra* was as follows: Cd 0.08 ± 0.1 , Pb 3.8 ± 1.7 , Cu 6.6 ± 1.9 , Zn 21.4 ± 7.5 , Mn 13.0 ± 9.7 , Fe 394.8 ± 183.9 , Sr 30.5 ± 13.3 and Cr 0.34 ± 0.1 . In *U. antarctica* the levels were Cd 0.33 ± 0.37 , Pb 15.0 ± 14.9 , Cu 67.6 ± 60.9 , Zn 25.7 ± 14.0 , Mn 28.8 ± 20.0 , Fe 1313.9 ± 341.3 , Sr 16.8 ± 2.5 and Cr 5.6 ± 1.4 . *U. antarctica* accumulated higher content of Pb, Mn, Fe and Cr, but lower Sr than *U. aurantiaco-atra*. Shortcomings, advantages and requisites of the use of lichens as biomonitors are discussed.

Key words: Biomonitoring, trace elements, environmental pollution, lichens, *Usnea aurantiaco-atra*, *Usnea antarctica*, King George Island, Maritime Antarctic

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PINUS CEMBRA, A LONG TERM BIOINDICATOR FOR AMBIENT OZONE IN SUBALPINE REGIONS OF THE CARPATHIAN MOUNTAINS

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Abstract: Ozone has become an all pervasive air pollutant that adversely affects vegetation in the Carpathian Mountains of

Central and Eastern Europe. Information is available about the sensitivity of vegetation to ozone at elevations up to 800 meters asl. A long-term bioindicator is needed to determine the effects of ozone brought into the region by long range transport on vegetation in subalpine and timberline ecotones in the Carpathian Mountains. *Pinus cembra* L. is a long lived conifer that is found in these regions. Some individual trees appear to be sensitive to ozone and might be good bioindicators. The suitability of *P. cembra*, based on its characteristics and response to ozone, as a long term bioindicator for ambient ozone in the Carpathian Mountains is considered here.

Key words: Ozone, *Pinus cembra*, bioindicator, subalpine, Carpathian Mountains

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INFLUENCE OF DIFFERENT ARBUSCULAR MYCORRHIZA FUNGAL (AMF) STRAINS ON HEAVY METAL UPTAKE BY *PLANTAGO LANCEOLATA* (PLANTAGINACEAE)

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Abstract: Tissue concentration and total shoot uptake of Cd, Zn and Pb were determined in *Plantago lanceolata* L., a plant highly responsive to mycorrhiza, inoculated with a number of arbuscular mycorrhizal fungal (AMF) strains. The plants were grown in rhizoboxes on substratum collected from zinc spoil. Their growth was positively correlated with all mycorrhizal parameters, estimated on the basis of aniline blue staining and alkaline phosphatase (ALP) activity. Heavy metal uptake depended on the fungal strain used. Plants inoculated with AMF strains originating from soils not affected by heavy metals had higher metal concentrations in tissues than plants inoculated with strains from polluted areas. Negative correlations were found between shoot Pb and Zn concentrations and mycorrhizal parameters characterizing the ALP activity of AMF mycelium and arbuscules. Evaluation of total mycorrhiza gave much less clear results. The use of *P. lanceolata* for monitoring purposes is discussed.

Key words: *Plantago lanceolata*, arbuscular mycorrhizal fungi (AMF), heavy metal uptake, soil toxicity monitoring, vitality test (ALP)

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MICROBIAL COMMUNITY STRUCTURE AND ACTIVITY IN THE HUMUS LAYER OF A FOREST EXPOSED TO MODERATE POLLUTION (RATANICA CATCHMENT, SOUTHERN POLAND)

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Abstract: Based on the amounts of certain fatty acids extracted from the soil, the biomass of different groups of microorganisms was estimated at two phytosociologically differing sites of a forest catchment. The signature phospholipid fatty acids (PLFAs) indicated qualitative similarities in the microbial community structure between the sample sites. Fungi and bacteria were more abundant at the site dominated by deciduous trees associated with fertile soils than at the site dominated by Scots pine and associated with less fertile sandy soils. Neutral lipid fatty acids (NLFA) and NLFA/PLFA ratios, measured as indicators of accumulation of storage compounds, were higher at the less fertile site, especially for fatty acids of eukaryotic origin (18:1 ω9c and 18:2 ω6,9c) and those common in most organisms (saturated fatty acids). Soil dehydrogenase activity (DHA) was used as an indicator of the biological activity of soil microorganisms. Enzyme activity varied greatly in the soil samples collected at sites on three transects across the forest catchment. DHA activity in the area dominated by deciduous trees was significantly higher than in the area dominated by coniferous species.

Key words: Bacteria, dehydrogenase, fungi, neutral lipid fatty acids, phospholipid fatty acids, soil fertility

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FUNGI AND ARSENIC-TOLERANT BACTERIA IN THE HYPOGEAN ENVIRONMENT OF AN ANCIENT GOLD MINE IN LOWER SILESIA, SW POLAND

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Abstract: The occurrence of the chemoautotrophic bacteria *Pseudomonas* sp. and the sulphide-oxidizing aerobic bacteria *Beggiatoa alba*, *Thiothrix* sp. in the ancient gold mine at Złoty Stok (Sudetes) is reported, as is the occurrence of fungal species belonging to the accidental troglomenes group represented by *Antrodia serialis*, *Coprinus micaceus*, *Fomitopsis*

rosea, *Gloeophyllum trabeum*, *Mycena amicta*, *Ophiostoma polyporicola*, *Paxillus panuoides*, *Psilocybe marginata*, *Physisporinus vitreus* and *Sphaerodes fimicola*. In addition, fungi (*Mycena strobilicola* and *Tapesia fusca*) from the nearby Jaskinia Radochowska cave are discussed. The morphology of each species is described. Fungi living in the permanent darkness of the mine, where the temperature is a constant *ca* 10°C and relative humidity close to 100%, exhibit smaller-diameter basidiomata, very narrow annual carpophore zones (*Gloeophyllum*), variable numbers of pores per mm (*Fomitopsis*, *Physisporinus*) enhanced color and odor, inhibited sexual reproduction and basidiocarp distortion (*Fomitopsis*, *Mycena*). Aerial mycelia of some fungi were observed (*Physisporinus*, clavariaceous fungus). The characters of *Paxillus panuoides* and *Psilocybe marginata* growing inside the mine differed very little from those growing outside the mine. Chemoautotrophic bacteria, distributed in the deeper part of the mine, appear antagonistic to the saprotrophic fungi (*Physisporinus*). No fungi fructifications occur on woody detritus covered with sulphur bacteria in the mine water. Only short, black, densely-branched rhizomorphs of *Physisporinus vitreus* were noted on spruce logs standing in the water. The mine water is characterized by high concentrations (*ca* 4100 µg/ml) of SO₄ and low concentrations (< 1 µg/ml) of NO₂, NO₃ and PO₄. High concentrations of heavy metals and arsenic were noted in the chemoautotrophic bacteria, whereas among the fungi investigated only *Physisporinus vitreus* is characterized by notably high concentrations of Cd and Zn.

Key words: mine, basidiomycete fungi, chemoautotrophic bacteria, ecology, heavy metals

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SPECIFIC FEATURES OF THE FLORA OF COLLIERY SPOIL HEAPS IN SELECTED EUROPEAN REGIONS

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Abstract: This study characterizes the diversity of spontaneous vascular flora composition on colliery spoil heaps in several European coal field regions, also considering their geography and climatic conditions (as a transect *ca* 3000 km in length). Four European industrial regions with highly developed pit coal mining industries were studied: the Black Country (United Kingdom), the Ruhr Basin (Germany), Upper Silesia (southern Poland) and Donbass (eastern Ukraine). The composition of each local flora was analyzed in terms of its geography and history, and the ecology of the species. The floras were also compared with regard to selected ecological indicator values. Native hemicryptophytes with similar trophic requirements dominated in all regional floras. Marked similarities were noted in the share of anthropophytes, the proportions of life form groups, and the trophic indicator values for the recorded plant species. Significant differences were noted along the east-west European transect for the following indicators: continentality of the flora, substrate humidity preferences of species, light indicator values, and the spectra of ecological groups in the flora. The composition of spontaneous flora of mining spoil heaps was correlated with the phytogeography of the areas. Plant species from native flora constituted the principal source of diaspores during succession of vegetation in areas degraded by mining waste, independent of the climatic zone in which the sites were located. These species initiate the succession processes that result in the formation of permanent plant cover.

Key words: Flora, spontaneous succession, colliery spoil heaps, Europe

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DOES *ARMERIA MARITIMA* SUBSP. *HALLERI* (PLUMBAGINACEAE) OCCUR IN POLAND?

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Abstract: In the 1950s, *Armeria maritima* subsp. *halleri* (Wallr.) Á. Löve & D. Löve (Plumbaginaceae), an endemic species occurring in the Harz Mountains and associated with soils rich in heavy metals, was described in the Olkusz mining district of Poland as a characteristic plant species of the calamine community on zinc-lead spoils. Serious taxonomic questions arise from the different habits of the plants on the calamine site. Based on comparative cultivation of plants for 12 months, it was found that only one population of these plants occurs on the calamine spoil heap in Bolesław near Olkusz, and that under extremely harsh conditions (drought, starvation, heavy metals, high insolation) some plants within this population are dwarfed. *Armeria* Willd. plants growing on calamine spoils differ considerably from *Armeria* plants growing on unpolluted soil (Osowiec site), which are classified as belonging to a taxon common in Poland, *A. maritima* subsp. *elongata* (Hoffm.) Bonnier. These differences are genetically established. They manifest mainly in shorter stalks and shorter outer involucre bracts of inflorescence buds. Calamine plants are smaller. The differences we demonstrated are, however, much smaller than those described in the taxonomic literature. We propose reducing the taxonomic rank of *A. maritima* subsp. *halleri* plants in Poland, and to consider them a calamine form or variety of *A. maritima* (Mill.) Willd. In floristic investigations in the field, we suggest paying attention first to the appearance of the inflorescence buds in order to distinguish the calamine form. On plants of the calamine form (variety), the outer involucre bracts are usually shorter or the same length as the inner bracts. Flower color, a feature given in floristic data as distinguishing calamine *Armeria* plants, is unhelpful, because it shows the same variability in every investigated group of plants.

Key words: *Armeria maritima* subsp. *halleri*, calamine flora, zinc-lead spoils, metallophyte

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PHYSIOLOGICAL, CHEMICAL AND GROWTH RESPONSES OF BIG CONE DOUGLAS FIR (*PSEUDOTSUGA MACROCARPA*) TO PHOTOCHEMICAL SMOG AND NUTRITIONAL DEFICIENCIES

ANDRZEJ BYTNEROWICZ

Abstract: Effects of photochemical smog and nutritional deficiencies on ecologically important tree species in southern California, big cone Douglas fir [*Pseudotsuga macrocarpa* (Vasey) Mar] were investigated. Two-year-old seedlings were exposed for two summer seasons to ambient and sub-ambient levels of photochemical smog in open-top chambers located at Tanbark Flat, San Dimas Experimental Forest, in the San Gabriel Mountains of southern California. The exposed to air pollution seedlings were supplied with the complete; -50% nitrogen (N); -50% magnesium (Mg); or -50% (N+Mg) nutrient solutions. Two years of exposures to ambient smog did not cause foliar injury or significant changes in growth, physiology, biochemistry or chemistry of the studied seedlings. The seedlings were significantly affected by changes in N and Mg supply. Growth, rate of physiological processes, concentrations of pigments, concentrations of stable carbon [C] isotope, and chemical composition of plants, were significantly affected by the reduced N supply. Strong interaction between N and Mg has been found as well as significant effects of N supply on uptake of other elements. Magnesium supply in the growing medium strongly affected uptake of phosphorus (P) and C assimilation. The observed decline of big cone Douglas fir in the southern California mountains may be caused by nutritional imbalances in habitats typical for this species.

Key words: air pollution, ozone, particulate matter, nutrients, trees, mountains, southern California

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SCOTS PINE AND THE CHANGING ENVIRONMENT – NEEDLE RESPONSES

SATU HUTTUNEN & SIRKKU MANNINEN

Abstract: We studied Scots pine needles as indicators of air pollution and enhanced UV-B responses in the world's northernmost open-top chambers and in field experiments. The paper reviews three experiments examining needle responses to elevated levels of sulphur dioxide, nitrogen oxides and ozone, enhanced carbon dioxide and ozone, and enhanced ozone alone. Some *in situ* results on enhanced UV-B responses at Pallas National Park are also reported. Abundant stomatal uptake of sulphur dioxide manifested as sulphur accumulation in needles was observed. In the open-top chamber experiments,

Scots pine needles exhibited disturbances in wax and stomatal development. Disorganization in the stomatal rows and delays in the development of tubular waxes were typical of ozone and nitrogen oxide treatment. Carbon dioxide and ozone treatment stimulated needle growth in Scots pine seedlings, but ozone treatment alone reduced needle length and dry weight. On the other hand, ozone treatment increased the amount of epicuticular waxes. In the timberline enhanced UV-B experiment, the most noteworthy result was that both current-year and previous-year needles responded to the treatment.

Key words: Needle growth, epicuticular waxes, wax amount, stomatal density, specific leaf area

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ECOPHYSIOLOGICAL RESPONSES OF SUBARCTIC SCOTS PINE TO ULTRAVIOLET (UV) RADIATION

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Abstract: The focus of our field studies in the subarctic of Finnish Lapland from 1997 onwards has been to investigate the effect of solar UV radiation on the ecophysiology of Scots pine. Our studies have indicated that solar UV-B_{BE} exclusion during 1997–2002 caused transient effects on the growth of both Scots pine seedlings and saplings, which may not be related to changes in Photosystem II efficiency, however. Studies of the phylloplane fungi of Scots pine needles showed that *Aureobasidium pullulans* (de Bary) Arnaud and *Cladosporium* sp. populations were found to decrease, and *Phoma* sp. to increase, with UV exposure, but there was no UV effect found for total populations. It was also shown that both UV-B radiation and increasing temperature enhance the nitrate reductase (NR) activity of Scots pine needles. On the other hand, our earlier studies have shown that the defence mechanisms (increase in the concentration of soluble phenolics, thickening of the epi- and hypodermal cell layers) of the Scots pine were functioning against ambient solar UV radiation. The daily UV dose rates during 1997–2002 were not very high and in our experiments, the exposure periods of three growing seasons were probably not long enough to cause greater effects that may be cumulative in nature and occur only after longer experimental periods.

Key words: Ultraviolet radiation, Scots pine, *Pinus sylvestris*, subarctic, ecophysiology, defence mechanisms, nitrate reductase (NR) activity, Photosystem II, phylloplane fungi

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THE NUMERICAL COMPLEXITY (BIODIVERSITY) OF MESIC OLD GROWTH DECIDUOUS FORESTS THROUGHOUT THE WORLD

PAUL FREDERICK MAYCOCK

Abstract: Using identical sampling techniques a total of 69 stands were selected from among more than 400, as satisfying the criteria of mesic old growth deciduous forests in different regions of the formation, including China, Japan, Central Eastern United States, Michigan, Ontario, Slovakia, Czech Republic, Poland, Ukraine, England and Chile. Stands were analyzed for numerical representation of species as well as life form components of trees, woody lianas, shrubs, herbs, herbaceous climbers, parasites, saprophytes, and epiphytes. Stands have been organized on the basis of values expressing diversity at these various world locations. There is clear division between numerical complexity of North American, Chinese and Japanese mesic old growth forests and those of central and eastern Europe and Chile, but all regions are marked by considerable variation. Latitude and elevation in Japan do not appear as strong influences on biodiversity. Strong dominance of *Fagus* spp. reduces numerical complexity but that of *Acer* spp. appears to enhance it, in all regions.

Key words: phytosociology, mesic old growth deciduous forests, life forms, biodiversity

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DIFFERENT LANDSCAPE PATTERNS OF SUBALPINE SPRUCE FORESTS IN THE TATRA MTS AND BABIA GÓRA MASSIF (WEST CARPATHIANS)

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Abstract: Differences in the diameter structure of subalpine spruce stands in the Tatra Mts and Babia Góra massif are studied in this paper. The subalpine forests in both ranges are among the most pristine forests in the West Carpathians and in

Europe as a whole. These well-preserved forest stands provide a unique opportunity to study their structural patterns even on large spatial scales. Data collected on small plots below 1 ha as well as across large tracts of hundreds of hectares were used for analyses. The density of stands in the Tatra Mts was much higher than on Babia Góra Mt., and the volume of stands was slightly higher. In the Tatras the diameter distribution of spruce trunks was distinctly right-skewed, while on Babia Góra the most abundant were the middle diameter classes from 30 to 50 cm. Cutting of trees and rejuvenation of stands should be considered even in the most pristine parts of the Tatra forests. However, their structure might be the result of diverse topography, which modifies wind action, insolation and avalanche activity. In the subalpine Tatra landscape, probably small patches of spruce forests are affected by disturbances occurring with different frequency and intensity, instead of one disturbance regime. The more uniform topography of Babia Góra means that disturbances cover extensive areas, resulting in relatively small variation in the structure of the subalpine forests.

Key words: subalpine spruce forest, *Plagiothecio-Piceetum*, spatial pattern, disturbance, West Carpathians

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LICHENS OF THE BIAŁA WODA NATURE RESERVE IN THE MAŁE PIENINY MTS (WESTERN CARPATHIANS)

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Abstract: This paper describes the occurrence and distribution of 278 lichen species within the Biała Woda Nature Reserve in the Małe Pieniny Mts (Western Carpathians), of which 20.08% are mountain species, 36.6% are listed on the "red list" of endangered lichens in Poland, 9.3% are subject to legal protection, and 15.1% are monitoring species on the qualitative scale of Hawksworth and Rose (1970). A list of apophytes is also given. The implications of these findings for conservation of lichen species in Poland are suggested.

Key words: lichens, lichenicolous and saprobic fungi, lichen conservation, Pieniny, Carpathians, Poland

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VEGETATION OF THE KHANGAI AND KHENTEI MTS (MONGOLIA) AND LEVELS OF HEAVY METALS AND MACROELEMENTS IN PLANTS

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Abstract: Floristic studies were carried out in two mountain ranges of Mongolia at nine localities. Two of them were situated in the Khentei Mountains, and the remaining seven in the Khangai Mountains. These localities represented mostly steppe (grass piedmont steppe, dry mountain steppe, stony mountain steppe, meadow mountain steppe, grass dry steppe) and meadow communities. In each plant community, plant material was sampled from circular study plots for analysis of heavy metals concentrations (Cd, Pb, Cu, Ni, Cr, Zn, Fe). Concentrations of Cd ranged from 0.087 to 0.333 $\mu\text{g g}^{-1}$, Pb from 1.31 to 5.68 $\mu\text{g g}^{-1}$, Cu from 4.62 to 8.73 $\mu\text{g g}^{-1}$, Ni from 0.65 to 7.84 $\mu\text{g g}^{-1}$, Cr from 0.28 to 11.61 $\mu\text{g g}^{-1}$, Zn from 29.9 to 45.8 $\mu\text{g g}^{-1}$, and Fe from 204 to 3839 $\mu\text{g g}^{-1}$. Differences in metal concentrations between study plots should be attributed principally to differences in plant composition and soils between sites. The effect of local pollution sources (industry, transport) is insignificant in this region. The findings on heavy metal levels in plants from the Khentei and Khangai Mts indicate that these are clean areas.

Key words: Vegetation, essential elements, heavy metals, Mongolia.

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STUDIES ON THE FLORISTIC DIVERSITY OF FOREST PHYTOCOENOSSES FROM THE LAS PIWNICKI FOREST RESERVE NEAR TORUŃ

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Abstract: The Las Piwnicki forest reserve, situated at the edge of the Vistula River valley in northern Poland, constitutes an

island of natural vegetation among pine monocultures and agrocoenoses. In recent decades, stands of Scots pine, a species probably introduced here by man 200 years ago, have declined massively. This has led to regeneration of Central European deciduous forest communities of the oak-linden-hornbeam type. Periodic observations since the 1960s, continued on permanent study plots, have indicated an increase in the structural homogeneity of forest communities. In this process the number of species has dropped, and α and β diversity have decreased.

Key words: forest regeneration, species richness, α diversity, β diversity, florula diversity, nature conservation

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ORCHARD MEADOWS OF BANSKÁ ŠTIAVNICA TOWN (CENTRAL SLOVAKIA)

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Abstract: The orchard meadows of Banská Štiavnica represent an archaic, relict type of meadow. They are a reservoir of high and sustainable biological diversity, both local and regional. We have initially classified these orchard meadows in two associations: *Poo-Trisetetum* Knapp ex Oberd. 1957 and *Ranunculo bulbosi-Arrhenatheretum* Ellmauer 1993. Similar plant communities are distributed in other volcanic mountains of the Western Carpathians (Vtáčnik, Pohronský Inovec and Kremnické vrchy Mts). To determine whether they represent a separate plant community of the *Arrhenatherion* alliance, a revision of phytosociological records from all mentioned areas will be needed.

Key words: *Poo-Trisetetum*, *Ranunculo bulbosi-Arrhenatheretum*, orchard meadow, relict plant communities, urban vegetation

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OSMOTIC STRESS INDUCES CAM METABOLISM IN CULTURES OF *MESEMBRYANTHEMUM CRYSTALLINUM* (AIZOACEAE) *IN VITRO*

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Abstract: The facultative halophyte *Mesembryanthemum crystallinum* shifted its mode of carbon assimilation from the C₃ pathway to the *Crassulacean Acid Metabolism* (CAM) in response to water stress in culture *in vitro*. Plants treated with 1, 2 or 3% PEG, used as a water stress factor, showed diurnal fluctuation of malate content in leaves. Our results suggest that the level of CAM induction is related to the osmotic potential of the medium. Under water deficit, inhibition of photosystem II (PSII) (as a decline of the Fv/Fm ratio) was observed. Inhibition of PSII was shown not to be a prerequisite of CAM induction.

Key words: C₃-CAM shift, *in vitro* culture, *Mesembryanthemum crystallinum*, osmotic stress, photoinhibition, PEG

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