THE INDICATOR VALUE OF INSECT SPECIES (*COLEOPTERA*, *LEPIDOPTERA*) AS THE MARKERS OF NATURAL ECOSYSTEMS CONDITIONS WITHIN THE UKRAINIAN CARPATHIANS REGION

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The principles of use Insect species as the markers of conditions and natural status of ecosystems are considered. In this way, indicator (marker) species are those which have specific habitat requirements as well as their presence (absence) reflects the preservation status and natural conditions of diversity of the related biotic communities or complexes. These are predominantly rare, threatened, locally distributed or stenotopic species.

There are 3 categories of indicator Insect species selected as markers of: less disturbed natural ecosystems (I), derivative and semi-natural ecosystems (II), unique ecosystems (III). The 6 ecological groups of indicator species are considered on the base of analysis of their distribution pattern and habitat preferences as well as by the character of tolerance under anthropogenic influences. There are species of non- and extra-zonal habitats (A), forest species (B), ecotone species (C), grassland species (D), species of "cultivated landscape" (E), hydrobionts & amphibionts (F).

The preliminary checklist of indicator species is here presented within a context of four ecological-taxonomical clusters of insects: ground or Carabid beetles (*Coleoptera*, *Carabidae*), saproxylic beetles (*Coleoptera* p.p.), butterflies (*Lepidoptera*, "Rhopalocera"), larger moths (*Lepidoptera*, "Macroheterocera"). The general indicator value of considered species consists in that is analysis of their distribution pattern allows determining most valuable habitats as well as "hot spots" of regional biodiversity of the terrestrial invertebrates on the levels of landscape or biogeocoenosis ecosystems. In this way, there are 12 high-valuable biodiversity areas selected within the Ukrainian Carpathians region.

Key words: biodiversity, bioindication, ecosystem, habitat, rare and threatened insect species, Ukrainian Carpathians

At the present conditions of about total human-made transformation of natural ecosystems in the European continent, which has been becoming up from the beginning of Holocen, the conservation of the remnants of natural ecosystems with its biodiversity still remains one of the most important issues of sustainable development.

Conservation of the entomological complexes diversity as an inalienable attribute of natural ecosystems requires urgently the conservation of some key habitat types. Since complete investigations of Insect fauna within any territory is near impossible by practical causes, then it is necessary to concentrate on the reduced number of species from several indicator groups. Their taxonomical and ecological diversity has to be sufficiently high as well as its identification in the terrain would

not require the use of special hard-working, high-expensive or inconvenient research methods (total collection, as an example). There are general requirements for Insect indicator groups drawn up in the mentioned below way (Kudrna, 1986):

- sufficient taxonomical diversity together with relatively limited amount of taxa;
- wide general spectrum of habitats;
- available condition of ecological and biogeographical investigations;
- specific environmental requirements, various topical and trophical preferences of the several group's representatives;
- accessible discovery and identification in the field without use of high-expensive methods;
- aesthetic attractiveness, that is promoting wider public awareness in the nature conservation issues.

In this way, **indicator (marker) species** are those, which have specific habitat requirements as well as their presence (absence) reflects the preservation status and natural conditions of diversity of the related biotic communities or complexes. These are mostly rare, threatened, a strictly spread or stenotopic species.

Conventionally, the role of such indicators belongs to protected species included into "Red Data Book of Ukraine" (2009) or other Red Lists of diverse ranges. However, most part of protected Insect species, which occur within the region do not correspond to mentioned above requirements. There are lots of widespread, relatively indifferent or less threatened as well as insufficiently known or hardly identified species. It appreciably decreases the value of these species as legislative background for implementation of the nature protection measures.

At present there are 11 high-rank nature protected areas within the Ukrainian Carpathians region, including Carpathian Biosphere Reserve and Gorgany Nature Reserve, 9 National Parks (Skolivski Beskydy, Carpathian, Hutsulshchyna, Verkhovynskyi, Cheremoskyi, Vyzhnytskyi, Uzhanskyi, Zacharovanyi Krai – "Enchanted Land", Synevir) and many other protected areas, such as regional landscape parks, refuges, nature monuments, etc. At the same time, in the view of actual problems of the regional biodiversity conservation, especially its endemic and relic elements, this protected area net needs both territorial and functional optimization.

Thus, the aim of this work is grounding and forming of the list of indicator Insect species with its occurrence reflecting "hot spots" of regional biodiversity of the terrestrial invertebrates on the levels of habitat types, landscape or biogeocoenosis ecosystems.

Materials and methods

The background materials of this work were the results of many years original investigations upon fauna and habitats of *Coleoptera* & *Lepidoptera* within the Ukrainian Carpathian Mts and adjacent territories of Western Ukraine, such as

Subcarpathian and Transcarpathian foothill areas as well as Western Podolian uplands. There are commonly acceptable entomological and geobotanical methods have been using in the framework of related field research. Also numerous former and recent reference works on these topics were analysed.

Most part of these materials was generalized at the data processing for reference books "Red Data Book of the Ukrainian Carpathians" (2011) and "Rare and threatened animal species of the Lviv region (Ukraine)" (2013), workshop reports on the biodiversity of Carpathian Biosphere Reserve, Carpathian and Uzhanskyi National Parks, as well as other areas of the region considered.

In the context of this article the concept of **natural ecosystems conditions** is considered as the status of its accordance onto structural and functional parameters and attributes (such as biodiversity) of the corresponding primeval ecosystem (Kozlovsky, 2015).

Results and Discussions

Categories and ecological groups of indicator species

There are three categories of indicator species considered concerning the ecosystem types as objects of indication.

I. Markers of less-disturbed natural ecosystems

The presence of these species is an evidence of high preservation value and ability of ecosystems to support its native biodiversity, especially populations of characteristic ecological and faunal complexes. It is an important argument for the establishing of protection status of related territories, providing the complex conservation measures for valuable and less-disturbed ecosystems (Kulak, 2002). The species of this category become extinct first in consequence of any environmental changes in their habitat.

II. Markers of derivative and semi-natural ecosystems

There are widespread species but inherent to several habitat types. Their presence or absence indicates the character of transformation changes going on within the corresponding ecosystems. The indicator value of these species is an important in the view of the ability of derivative, semi-natural or managed ecosystems to support biodiversity as well as for the monitoring of dynamics of their development, estimation of the land use changes consequences and, in prospective – the modeling and prognosis of changes within biotic communities of these ecosystems.

III. Markers of unique ecosystems

There are rare species including marginally distributed ones, strict endemics or species with a relic distribution pattern. Their presence indicates an exclusive ecological and faunal originality of the habitats (ecosystems), which should be significant reason for its conservation.

From another side, there are 6 ecological groups of the indicator Insect species reasonable to consider proceeding from its habitat preferences and tolerance to human influences.

A. Species of non- and extra-zonal habitats

Within the broadleaf and mixed deciduous forests zone there are species inherent to high-mountain, mire and wetland, steppe, continental dune, rocky barrens habitats, etc., belonging to this group. These habitats (ecosystems) have restricted or strictly local distribution and there are localities of many rare, endemic and relic species of plants and animals. There are such impacts for the species of this group:

- Spontaneous overgrowing of open grassland habitats with the shrub or tree vegetation, or its artificial afforestation. It is one of much significant threats for the most of the **A** group species,
- Wetland melioration,
- Habitat destruction caused by agriculture, built-up, mastering of "badlands",
- Mass pesticide use on croplands surrounding the little isolated remnants of extra-zonal meadow steppes,
- Fragmentation of the habitats with followed isolation of the rare species populations.

Other kinds of human impacts such as grazing, grass burning out or mowing down, as well as natural (climate changes) impacts require monitoring research upon vegetation cover condition and population status of rare Insect species.

B. Forest species

Here obligate saproxylic insect species are often considered as ecological relics of virgin forests (I category) together with the species being able to inhabit various derivative forest ecosystems (II category) are belonging to the group.

The general threats for species of category I are given as follows:

- Destruction of the virgin and old-growth natural forests. Recently there are only small fragments of these forests remain in the Ukrainian Carpathians. They need the priority conservation measures and the presence of rare Insect species there could be an additional background for their protection;
- Forestry management that foresees a withdrawal of dead wood. Exactly here is a conflict arises between the forestry practice and nature conservation requirements (Nieto, Alexander, 2010).

Another item of the threat is small-area continuous logging with large amount of the timber remains during the vegetation season. These felling areas become locations of attraction and reproduction of many rare saproxylic Insect species (e.g. *Eurythyrea austriaca* (Linnaeus, 1767), *Rosalia alpina* (Linnaeus, 1758), *Cerambyx cerdo* (Linnaeus, 1758), etc.) which were perish obviously in masses after the bringing out the timber and clearing of that lots.

For the most of the **B** group species of category II the following threats seem to be actual:

- Felling of natural forests together with shifting of its tree species composition and replacing it by the monoculture stands,
- Changes in spatial structure by reducing of the strata and parcellar complexity of the forest ecosystems,

- Digression of the forest litter, herbaceous and dwarf shrub or undergrowth strata in consequence of grazing, forestry management and recreation pressure.

C. Ecotone species

This group includes characteristic habitants of various woodland-grassland intermediate zones as well as early succession stages of forest vegetation, woodland clearings and margins, shrubs, overgrowing forest fellings, etc. There are mainly those species, which extinction is an evidence of significant changes of environmental conditions within corresponding ecosystems in the way of supporting the general biodiversity, have an indicator value (category II). It becomes both as a consequence of spontaneous overgrowing of open lots and woodland clearings by trees and shrubs, and as a result of reduction of spatial structure of the natural ecotones because of land use management.

D. Grassland species

The grassland (meadow), predominantly semi-natural habitats of diverse types are populated with various ecotone or eurytopic species as well as original habitants of hygrophile (wetland), acidiphile (heathland) or xerophile (derivative xeric or native meadow-steppe) ecosystems. Some of them prefer both hygrophile and xerophile open habitats avoiding derivative mesophile meadows, and they form specific ecological group of "distopic" grassland species. Exactly there are some butterflies: *Euphydryas aurinia* (Rottemburg, 1775), *Phengaris alcon* ([Denis et Schiffermueller], 1775), *Ph. teleius* (Bergstraesser, 1779), *Ph. nausithous* (Bergstraesser, 1779), etc. Their reaction onto human impact is equivocal because of environmental requirements of several species and their optimum existence under environmental conditions being within wider scale of digression – demutation stages of the grassland-meadow ecosystems. Among the mean threats of the **D** species should be mentioned:

- Spontaneous overgrowing of grasslands by tree or shrub vegetation because of change of hydrological regime (drainage) or cessation of extensive haymaking or grazing use,
- Wetlands drainage in the way of melioration, which has led to the shift of plant species composition and herbaceous-moss vegetation stratum, changes of micro-climatic conditions,
- Intense exploitation of meadows (haymaking or grazing) led to falling out of many plant species, packing down the litter and soding (swarding) of the soil.

Regularly frequent cutting out of the grass stand during the vegetation season also has driving to the perishing of pre-imaginal stages of many Insect species.

For the many grassland species intensive haymaking / grazing as with the lack of that pressure have a negative effect. The same impact has to be caused by the burning out of dry grasses at spring or autumn for the species, which are wintering on diverse stages of their life cycle on the ground or on plants.

E. Species of "cultivated landscape"

There is a mixed group of eurytopic and eurychoric species (ubiquists), migrants as well as habitants of various natural ecosystems, which are adapting to the much transformed landscape conditions – such as on croplands, ruderal habitats, gardens, orchards, parks, urbanized locations. An indicator value (II category) should belong to the species, which presence or absence is an evidence of favourable for the biodiversity supporting land use regime of traditional extensive management.

F. Hydrobionts and amphibionts

There are species, which inhabit permanently or are related by their life cycles and ecology to freshwater habitats. It is water contamination considered as main threat for these species (above 60% of protected species). Another threats for several ones are caused by drainage melioration, hydro-technical constructions, deterioration of the bank areas, intensive fishery with regular fall down of the water level in pounds or chemical processing of the bottoms (*Dytiscus latissimus* (Linnaeus, 1758): *Coleoptera*), dragging of timber by the streams (*Cordulegaster* sp.: *Odonata*). These include a specific ecological group of hygrophile ground beetles (*Coleoptera*, *Carabidae*), e.g. "stream hygrophils". They are vulnerable to bank erosion, destruction and draining of the stream and river's beds, timber dragging, cutting out of subalpine dwarf wood or pastoral digression on the high-mountain meadows.

Checklist of indicator Insect species of the Ukrainian Carpathians

There are four ecology-taxonomical clusters of Insect species with specific environmental requirements considered as the groups to be used for indicating the conditions and status of natural ecosystems within the Ukrainian Carpathians region.

The distribution ranges of several species are given in the way of compilation of the biogeographical units substantiated by A. Emelyanov (1974) and O. Kryzhanovskii (2002). Ecological characteristics of ground beetles (*Coleoptera*, *Carabidae*) are given following the scheme of H. Turin with co-authors (2003). Also original ecogeographical classification is used here for ecological (environmental) characteristics of the indicator species (Kanarskyi, Geryak, Lyashenko, 2011; Kanarskyi, 2015).

Ground (or Carabid) beetles (*Coleoptera*, *Carabidae*): Table 1.

This is one of the most well studied taxonomical groups in biogeography and ecological aspects. Being mostly carnivorous non-flying insects, the Carabid beetles show strict habitat selection, because the local environmental conditions as geomorphology, climatic and spatial characteristics, geological history of the area, evolution of the population together with the contemporary anthropogenic transformation processes are the key ecological factors that determinate their distribution. All of the mentioned above makes the ground beetles a good model group for diverse biogeography and ecological research, especially indicator and monitoring investigations.

General regional diversity is about 450 species (Rizun, 2003).

Main references: Roubal, 1930; Lazorko, 1963; Burakowsky, Mroczkowsky, Stefanska, 1973, 1974; Rizun, 1990, 2003; Hurka, 1996; Lie, Kleinfeld, 2001; Turin,

Table 1.

Preliminary checklist of the indicator species: Carabid beetles (Coleoptera, Carabidae)

Taxa	Biogeography	Ecology	Habitat	Conservation status	Regional status	Ct	Indicator value
Carabus clatratus Linnaeus, 1761	Euro-Siberian	Temperate, hygro-tyrphophile	riparian & damp woodland, mires, wetlands	none	Rare & local, Pre-Carpathians & Transcarpathian lowland	I_A	less disturbed riparian woodlands & wetlands
Carabus intricatus Linnaeus, 1761	European	Nemoral, sylvicol	broadleaf & mixed forests	IUCN-lr	Rare & local on NE mega-slopes, widely distributed & abundant on SW mega-slopes, foothills & lower montane forest zone	I_B	less disturbed broadleaf & mixed forests of NE mega-slopes (thermophile cases) with high biodiversity
Carabus ulrichii Germar, 1824	European	Nemoral-montane, sylvicol-praticol	broadleaf forests & ecotones	none	Local on NE & widely distributed on SW mega-slopes, foothills & lower montane forest zone	II_B II_C	broadleaf forests & ecotones of NE mega-slopes (thermophile cases) with high biodiversity
Carabus excellens Fabricius, 1798	East-European	Nemoral, hygro-termophile sylvicol-praticol	lowland broadleaf forests	none	Rare & local, NW Pre-Carpathian lowland (ssp. nov.?)	III_B	unique riparian-terraced forest ecosystems
			thermophile oak woodland		Local, SE Pre-Carpathian foothills	II_B	thermophile woodland with high biodiversity
Carabus zawadzkii zawadzkii Kraatz, 1854	East-Carpathian endemic	Nemoral-montane, hygrophile, sylvicol	broadleaf & mixed forests	HD II,IV	Less abundant or local, lower montane forest zone	II_B	montane forests with inherent native biodiversity
Carabus zawadzkii ronayi Csiki, 1906			broadleaf forests		Local, Transcarpathian lowland & Volcanic Carpathians Mts	II_B	thermophile woodland with high biodiversity
Carabus zawadzkii seriatissimus Reitter, 1896			riverine damp woodland		Rare & local, Maramaros Mts, lower montane forest zone	I_B III_B	less disturbed & unique forest ecosystems of Maramaros Mts

Carabus rothi mendax Csiki, 1906 [= *incompsus* Kraatz, 1880]	South-East Carpathian endemic	Montane, hygrophile, alpicol-sylvicol	upper forest zone & subalpine dwarf wood, meadows & ecotones	none	Rare & local, Chornohora, Maramaros & Chyvchyn Mts, (800)1400-2000 m	I_A III_A	less disturbed subalpine ecosystems with high diversity of rare & endemic species
Carabus rothi hampei Kuster, 1846	South-East Carpathian endemic	Nemoral, mesophile, sylvicol-praticol	thermophile open woodland & ecotones	HD II,IV	Local, Volcanic Carpathians Mts foothills & insular volcanic massifs	III_C	unique Pannonian thermophile woodland ecosystems & ecotones
Carabus sylvestris transylvanicus Dejean, 1826	Mid-European montane	Montane, alpicol	open alpine & subalpine grassland habitats	none	Carpathian endemic ssp., alpine zone of Chornohora & Svydovets Mts, above 1700-1800 m	II_A III_A	alpine ecosystems with high diversity of rare & endemic species
Carabus fabricii Panzer, 1812	Mid-European montane	Montane, petrophile, alpicol	open stony alpine & subalpine habitats	none	Extremely rare & local, Carpathian endemic ssp. *malachiticus* C.G.Thomson, 1875, Chornohora & Maramaros Mts, above 1850 m	III_A	unique alpine ecosystems of Chornohora & Maramaros Mts
					Extremely rare & local, strict endemic ssp. *ucrainicus* Lazorko, 1951, Gorgan Mts, above 1600 m	III_A	unique subalpine ecosystems of Gorgan Mts
Carabus irregularis montandoni Buysson, 1882	European montane	Montane, sylvicol	broadleaf, mixed & needle forests, 300-2000 m	none	Local or less abundant, montane forest & subalpine zones	I_B	less disturbed montane forests
Carabus auronitens escheri Palliardi, 1825	European montane	Montane, sylvicol	montane forests, subalpine & alpine habitats, 300-2500 m	none	Widely distributed, Carpathian endemic ssp., montane forest, subalpine & alpine zones	II_B	montane forests & subalpine dwarf wood with inherent native biodiversity

Carabus variolosus Fabricius, 1787	Mid-European montane	Montane, stream hygrophile	montane riverine & stream habitats	HD II,IV	Widely distributed, montane forest zones	I_A I_F	less disturbed riverine & stream ecosystems
Cychrus attenuatus Fabricius, 1792	Mid-European montane	Montane, sylvicol	broadleaf & mixed forests	none	Local, montane beech & mixed forests, NW part of region	II_B	montane forests with inherent native biodiversity of Mid-European montane complex
Leistus baenningeri Roubal, 1926	East-Carpathian endemic	Montane, stream hygrophile, alpicol-sylvicol	subalpine needle forest & dwarf wood zone, stream habitats, above 1500 m	none	Extremely rare & local, strict endemic, Chornohora & Maramaros Mts	III_A	unique subalpine ecosystems of Chornohora & Maramaros Mts
Nebria jokischii hoepfneri Dejean, 1826	Mid-European montane	Montane, stream hygrophile	montane riverine & stream habitats	none	Local, montane forest zones	I_A I_F	less disturbed riverine & stream ecosystems
Nebria heegeri Dejean, 1826	SE Carpathian endemic	Montane, stream hygrophile	montane riverine & stream habitats	none	Local, montane forest zones, SE part of region	I_A I_F	less disturbed riverine & stream ecosystems
Nebria transsylvanica Germar, 1824	SE Carpathian endemic	Montane, hygrophile, alpicol	damp alpine & subalpine habitats	none	Local, alpine & subalpine zones, Chornohora, Svydovets, Gorgan, Chyvchyn & Maramaros Mts	I_A II_A	alpine & subalpine ecosystems with high diversity of rare & endemic species
Nebria fuscipes Fuss, 1850 [=*fussi* Bielz, 1850]	East-Carpathian endemic	Montane, stream hygrophile	montane riverine & stream habitats	none	Local, montane forest, subalpine & alpine zones	I_A I_F	less disturbed riverine & stream ecosystems

Nebria reitteri Rybinski, 1902	East-Carpathian endemic	Montane, stream hygrophile	montane stream habitats	none	Local, upper montane forest & subalpine zones	I_A I_F	less disturbed riverine & stream ecosystems
Elaphrus ullrichii L. Redtenbacher, 1842	Mid-European	Nemoral, hygrophile	riparian & damp woodland, ecotones, river banks	none	Rare & local, river valleys of lower forest zone	I_A III_A	less disturbed riverine ecosystems with high biodiversity
Deltomerus carpathicus (Miller, 1868)	East-Carpathian endemic	Montane, stream hygrophile	montane stream habitats	none	Local, montane forest & subalpine zones	I_A I_F	less disturbed riverine & stream ecosystems
Pterostichus burmeisteri Heer, 1841 [= *metallicus* Fabricius, 1792]	Mid-European montane	Montane, sylvicol	broadleaf & mixed forests	none	Local, lower montane forest zone, NW part of region	II_B	montane forests with inherent native biodiversity of Mid-European montane complex
Abax ovalis (Duftschmid, 1812)	Mid-European	Nemoral, sylvicol	broadleaf & mixed forests	none	Very local, lower montane forest zone, marginal NW part of region	III_B	unique ecosystems of fir-beech mixed forests with inherent native biodiversity of Mid-European montane complex
Platyderus rufus (Duftschmid, 1812)	South-Mid-European	Nemoral, sylvicol	broadleaf forests, esp. on calcareous soils	none	Rare & local, foothills & lower montane forest zone	I_B III_B	less disturbed broadleaf forests with high biodiversity
Chlaenius spoliatus (Rossi, 1790)	South-Mid-European	Nemoral, hygrophile	riparian habitats	none	Rare & local, foothills & lower montane forest zone	I_A III_A	less disturbed riverine ecosystems with high biodiversity

Notes. **Conservation status:** RDB – Red Data Book of Ukraine (2009), categories: (e) – endangered (disappearing); (r) – rare; (v) – vulnerable; BC – Bern Convention, Annexes; HD – Habitat Directive, 1992, Annexes; IUCN (-categories) – IUCN Red List of Threatened Animals (2010)

Penev, Casale, 2003; Freude et al., 2004; Farkac, Kopecky, Vesely, 2006; Rizun, Mateleshko, 2011; Dreano et al., 2015.

Saproxylic beetles (*Coleoptera*: *Rhyssodidae*, *Lucanidae*, *Cetoniidae*, *Buprestidae* p.p., *Elateridae* p.p., *Cerambycidae* p.p., etc.): Table 2.

Sapro-xylophagous or saproxylic carnivorous species which are related ecologically to the natural processes of timber destruction. There are many species of the virgin and olg-growth forest ecosystems, considered as ecological relics in recently transformed natural conditions of European continent (Nieto, Alexander, 2010). Here we present mostly larger species, which are relatively easy to discover and identify in the field.

General regional diversity is about 200-300 species (of the families pointed above).

Main references: Roubal, 1936; Plavilshchikov, 1936, 1940, 1958; Rikhter, 1952; Medvedev, 1964; Zahajkevych, 1978; Dolin, 1982, 1988; Burakowsky, Mroczkowski, Stefanska, 1983, 1985, 1990; Yanitskii, 1996; Laibner, 2000; Rizun, Konovalova, Yanytsky, 2000; Bartenev, 2003(2004); Polska czerwona ksiega zwierzat, 2004; Mateleshko, 2009a, 2009b, 2010, 2011; Mateleshko, Roshko, Yanytsky, 2011.

Butterflies (*Lepidoptera*, *Papilionoidea* [= *Rhopalocera*]): Table 3.

This is one of the most popular, attractive and well studied both by ecology and biogeography Insect group. Being phytophagous on the larval stages and anthophile on the imaginal stages these species are predominantly inherent to various ecotone or natural and semi-natural grassland habitats. There are good indicators on the level of landscape (partly biogeocoenoses) ecosystems, as well as many locally distributed or stenotopic species among the butterflies. Its indicator aspects were elucidating for a long time in many reference sources (Kudrna, 1986, etc.). There are burnets (*Zygaenidae*, *Zygaena sp.*), ecologically close to butterflies, which could be also considered within this indicator cluster.

General regional diversity is about 150 species (Popov, Plyushch, 2004).

Main references: Rizun, Konovalova, Yanytsky, 2000; Gorbunov, 2001; Benes, Konvicka, 2002; Polska czerwona ksiega zwierzat, 2004; Popov, Plyushch, 2004; Tschikolovets, 2005; Buszko, Maslowski, 2008; Kanarsky, 2011 a, b; Kudrna, Pennerstorfer, Lux, 2015.

Larger moths (*Lepidoptera*: *Bombycoidea*, *Lasiocampoidea*, *Noctuoidea* [= *Macroheterocera*]): Table 4.

With the small exceptions, predominantly phytophagous on the larval stage species populate diverse ecosystems and habitats as well as cultivated and managed cases. In general, moths could be used as indicators on the level of landscape ecosystems only, because they have to be discovered mostly by nocturnal attraction to the light sources. Using these methods, it is very often a problem to localize the species habitats or locations exactly.

General regional diversity is about 600-800 species (Kanarskyi, Geryak, Lyashenko, 2011; Kanarskyi et al., 2012, etc.).

Table 2.

Preliminary checklist of the indicator species: saproxylic beetles (Coleoptera p.p.**)**

Taxa	Biogeography	Ecology	Habitat	Conservation status	Regional status	Ct	Indicator value
RHYSODIDAE							
Rhysodes sulcatus (Fabricius, 1787)	West-Palearctic	Subboreal	old-growth broadleaf & mixed forests	HD II	Rare & local, foothils & montane forest zones	I_B	less disturbed forest ecosystems
LUCANIDAE							
Lucanus cervus Linnaeus, 1758	West-Palearctic	Nemoral	broadleaf forests & woodland	RDB(r) BC III HD II	Rare, local or locally abundant (SW foothills), from lowland to lower forest zone	I_B II_E	natural broadleaf forests & woodland; cultivated landscape with high biodiversity
Ceruchus chrysomelinus Linnaeus, 1758	Euro-Siberian	Boreal-Montane	montane beech, mixed & needle forests	none	Rare, local or locally abundant, montane forest zones	I_B	less disturbed forest ecosystems
CETONIIDAE							
Osmoderma eremita (Scopoli, 1763) [= *barnabita* Motschulsky, 1845]	European	Nemoral	broadleaf forests & woodland, esp. riverine	RDB(v) BC II HD II,IV IUCN-lr	Rare & local, from lowland to lower forest zone	I_B II_E	natural broadleaf forests & woodland; cultivated landscape with high biodiversity
Gnorimus variabilis (Linnaeus, 1758) [= *octopunctatus* Fabricius, 1775]	European	Nemoral	broadleaf or mixed forests & woodland	none	Rare & local, from lowland to lower forest zone	I_B II_E	natural broadleaf forests & woodland; cultivated landscape with high biodiversity

Protaetia aeruginosa (Linnaeus, 1767) [= *speciosissima* Scopoli, 1786]	Euro-Mediter-ranean	Nemoral	broadleaf forests & woodland, esp. thermophile oak forests, old parks & orchards	none	Rare, local or less abundant, from lowland to lower forest zone	I_B II_E	natural thermophile broadleaf forests & woodland; cultivated landscape with high biodiversity
Protaetia fieberi (Kraatz, 1880)	Euro-Mediter-ranean	Thermophile	old-growth oak forests & woodland	none	Rare & local, insular volcanic massifs of Transcarpathians	III_B	unique Pannonian thermophile oak woodland ecosystems
Pritaetia lugubris (Herbst, 1786) [= *marmorata* Fabricius, 1792]	Euro-Siberian	Subboreal	broadleaf & mixed forests	none	Local & less abundant, from lowland to lower forest zone	I_B	less disturbed or natural broadleaf & mixed forest ecosystems
BUPRESTIDAE							
Dicerca berolinensis (Herbst, 1779)	European	Nemoral	old-growth beech forests	none	Local, rare or less abundant, foothills & lower forest zone	I_B	less disturbed beech forest ecosystems
Eurythyrea austriaca (Linnaeus, 1767)	West-Palearctic	Nemoral	old-growth mixed fir forests, up to 800 m	none	Local, rare or less abundant, foothills & lower forest zone	I_B	less disturbed mixed fir forest ecosystems
Eurythyrea quercus (Herbst, 1780)	Euro-Mediter-ranean	Thermophile	old-growth oak forests & woodland	none	Extremely rare & local, foothills of Volcanic Carpathians Mts	I_B III_B	unique less disturbed oak forest & woodland ecosystems
Anthaxia candens (Panzer, 1792)	Euro-Mediter-ranean	Thermophile	thermophile woodland & cultivated landscape	none	Rare & local, foothills of Volcanic Carpathians Mts & insular volcanic massifs	II_E	cultivated landscape with high biodiversity

Anthaxia helvetica Stierlin, 1868	European	Montane	montane needle & mixed forests, up to 1200 m	none	Rare & local, montane forest zones	I_B	less disturbed needle & mixed forest ecosystems
ELATERIDAE							
Lacon lepidopterus (Panzer, 1801)	Euro-Siberian	Subboreal-montane	virgin montane needle & mixed forests	none	Extremely rare & local, montane forest zones	I_B III_B	unique virgin needle & mixed forest ecosystems
Lacon querceus (Herbst, 1784)	European	Nemoral	old-growth oak forests & woodland	none	Extremely rare & local, foothills of Volcanic Carpathians Mts & insular volcanic massifs	I_B III_B	unique less disturbed oak forest & woodland ecosystems
Limoniscus violaceus (P.W. Mueller, 1821)	European	Nemoral	virgin broadleaf & mixed forests	HD II IUCN-vu	Extremely rare & local, west Volcanic Carpathians Mts	I_B III_B	unique virgin broadleaf forest ecosystems
Ampedus quadrisignatus (Gyllenhal, 1817)	European	Nemoral	old-growth broadleaf forests	IUCN-en	Extremely rare & local, foothills of Volcanic Carpathians Mts	I_B III_B	unique less disturbed oak forest ecosystems
Elater ferrugineus (Linnaeus, 1758)	European	Nemoral	old-growth broadleaf forests & woodland, old parks	none	Rare & local, foothills & lower montane forest zone of E Beskyd & Volcanic Carpathians Mts	I_B II_E	less disturbed broadleaf forest ecosystems; cultivated landscape with high biodiversity
CEROPHYTIDAE							
Cerophytum elateroides (Latreille, 1804)	European	Nemoral	old-growth broadleaf forests & woodland	none	Extremely rare & local, foothills of Volcanic Carpathians Mts	I_B	less disturbed broadleaf forest & woodland ecosystems

PELTIDAE							
Peltis grossa (Linnaeus, 1758)	Euro-Siberian	Boreal-montane	old-growth needle & mixed forests	none	Rare & local, montane forest zones	I_B	less disturbed needle & mixed forest ecosystems
CUCUJIDAE							
Cucujus cinnaberinus (Scopoli, 1763)	European	Subboreal	old-growth broadleaf & mixed forests	RDB(v) BC II HD II,IV IUCN-Ir	Local, rare or less abundant, from lowland to upper montane forest zone	I_B	less disturbed forest ecosystems
Cucujus haematodes (Scopoli, 1763)	Euro-Siberian	Boreal-montane	old-growth needle & mixed forests	none	Extremely rare & local, upper forest zone	I_B III_B	unique less disturbed needle & mixed forest ecosystems
OEDEMERIDAE							
Ditylus laevis (Fabricius, 1787)	Euro-Siberian	Subboreal, hygrophile	virgin stream valleys in montane forests	none	Extremely rare & local, upper Uzh river basin	I_B III_B	unique virgin forest & stream valley ecosystems
BORIDAE							
Boros schneideri (Panzer, 1795)	Euro-Siberian	Boreal-montane	old-growth needle & mixed forests	HD II	Rare & local, montane forest zones	I_B	less disturbed needle & mixed forest ecosystems
CONONOTIDAE							
Agnathus decoratus (Germar, 1818)	European	Nemoral	old-growth riverine woodland	none	Extremely rare & local, foothills & lower forest zone of SW mega-slopes	I_A I_B	less disturbed riverine woodlsand ecosystems
CERAMBYCIDAE							

Aegosoma scabricornis (Scopoli, 1763)	Euro-Mediterranean	Thermophile	old-growth broadleaf forests & woodland, old parks & orchards	none	Local, rare or less abundant, lowland & foothills of SW mega-slopes	I_B II_E	less disturbed broadleaf forests & woodland; cultivated landscape with high biodiversity
Cerambyx cerdo (Linnaeus, 1758)	West-Palearctic	Nemoral	old-growth oak forests & woodland, old parks	RDB(v) BC II HD II,IV IUCN-vu	Rare & local, lowland & foothills	I_B II_E	less disturbed oak forests & woodland; cultivated landscape with high biodiversity
Rosalia alpina (Linnaeus, 1758)	West-Palearctic	Nemoral-montane	old-growth montane beech & mixed forests	RDB(v) BC II HD II,IV IUCN-vu	Local, rare (NE mega-slopes) or locally abundant (SW mega-slopes), from foothills to upper forest zone	I_B	less disturbed or natural beech & mixed forest ecosystems
Aromia moschata (Linnaeus, 1758)	West-Palearctic	Subboreal	riverine valley woodland & various ecotones, parks, orchards	RDB(v)	Local, rare or less abundant, from lowland to lower montane forest zone	II_C	riverine valley woodland & ecotones with high biodiversity
Purpuricenus kaehleri (Linnaeus, 1758)	Euro-Mediterranean	Thermophile	thermophile woodland & ecotones, parks, orchards	RDB(v)	Extremely rare & local, foothills of Volcanic Carpathians Mts & insular volcanic massifs	II_C	thermophile woodland & ecotones with high biodiversity
Pachyta lamed (Linnaeus, 1758)	Holarctic	Boreal-montane	old-growth montane spruce forests & ecotones	none	Extremely rare & local, recently single find in subalpine zone of Chornohora Mts	I_B III_B	unique less-disturbed montane needle forest ecosystems

Macroleptura thoracica (Creutzer, 1799)	Euro-Siberian	Subboreal	broadleaf & mixed forests	none	Extremely rare & local, single finds in lower montane forest zone of SW mega-slopes	I_B III_B	unique less-disturbed montane beech & mixed forest ecosystems
Pseudogaurotina excellens Brancsik, 1874	East-Carpathian endemic	Montane	old-growth montane needle forests & ecotones	HD II,IV	Extremely rare & local, upper montane forest zone, Chornohora, Svydovets & Maramaros Mts	I_B III_B	unique virgin or less-disturbed montane needle forest ecosystems
Cornumutila quadrivittata (Gebler, 1830)	Euro-Siberian boreoalpine	Montane	old-growth montane & subalpine spruce forests & woodland	none	Extremely rare & local, single finds in subalpine zone of Chornohora Mts	I_B III_B	unique virgin or less-disturbed montane needle forests & subalpine woodland
Morimus funereus Mulsant, 1863	Euro-Mediter-ranean	Thermophile	old-growth broadleaf forests	RDB(v) HD II IUCN-vu	Rare & local, SE foothills of Bukovine Carpathian Mts	I_B III_B	unique less-disturbed broadleaf forest ecosystems

Table 3.

Preliminary checklist of the indicator species: butterflies (Lepidoptera: Papilionoidea [= Rhopalocera])

Taxa	Biogeography	Ecology	Habitat	Conservation status	Regional status	Ct	Indicator value
PAPILIONIDAE							
Parnassius apollo (Linnaeus, 1758)	Euro-Siberian	Subboreal-montane, xeromontane	open stony habitats, esp. on calcareous soils & barrens	RDB(e) BC II HD IV IUCN-vu	Extremely rare & local, formerly finds in montane forest zones	III_A	unique xero-petrophile montane grassland habitats

Parnassius mnemosyne (Linnaeus, 1758)	Euro-Siberian	Subboreal-montane, ecotone mesophile	woodland clearings & meadows, various ecotones	RDB(v) BC II HD IV	Locally abundant, from foothills to subalpine zones	II_C	natural or semi-natural ecotones with complexe structure & high biodiversity
Zerynthia polyxena ([Denis et Schiffermueller, 1775])	Pontic-Mediter-ranean	Submediter-ranean, hygro-thermophile	riverine woodland, clearings & other ecotones	RDB(v) HD IV	Rare & local, lowland & foothills of SE Pre-Carpathians & Trans-carpathians	II_A	natural or semi-natural riverine ecotones with high biodiversity
PIERIDAE							
Leptidea morsei major Grund, 1905	Euro-Siberian	Subboreal, hygro-thermophile	riverine woodland, clearings & other ecotones	HD II,IV	Rare & local, lowland & foothills of SE Pre-Carpathians & Trans-carpathians	II_A	natural or semi-natural riverine ecotones with high biodiversity
Pieris bryoniae (Huebner, 1791)	European	Montane, ecotone mesophile	montane & subalpine woodland clearings & meadows	none	Local & less abundant, montane forest, subalpine & alpine zones	II_C III_C	"primeval high-montane" ecotones; relic habitats of alpine species in montane forest zones
Colias palaeno (Linnaeus, 1761)	Euro-Siberian	Boreal-montane, tyrphophile	raised (olygothrophic) peat bogs	RDB(e)	Extremely rare & local, recently single location in Watershed-Verkhovyna area	III_A	unique montane raised bogs with relic species
NYMPHALIDAE							
Argynnis laodice (Pallas, 1771)	Euro-Siberian	Subboreal, hygro-xerophile	woodland clearings & meadows	none	Local & less abundant, foothills & montane forest zones	II_C	natural or semi-natural ecotones with complexe structure & high biodiversity

Boloria aquilonaris (Stichel, 1908)	Euro-Siberian	Boreal-montane, tyrphophile	raised (olygothrophic) peat bogs	none	Rare & local, few locations in foothills & montane forest zones	III_A	unique montane raised bogs with relic species
Boloria eunomia (Esper, 1799)	Holarctic	Boreal-montane, tyrphophile	raised peat bogs & swamp meadows	none	Local, rare or less abundant, lowland & foothills	II_A III_D	peat bogs & swamp meadows with relic species
Euphydryas aurinia (Rottemburg, 1775)	Palearctic	Subboreal, hygro-xerophile	damp or xeric woodland clearings & meadows	BC II HD II	Rare & local, few locations in lowland, foothills & montane forest zones	III_D	unique ecotone & meadow habitats with high biodiversity
Euphydryas maturna (Linnaeus, 1758)	Euro-Siberian	Subboreal, woodland hygrophile	damp woodland, esp. riverine	BC II HD II, IV IUCN-dd	Rare & local, few locations in lowland & foothills	I_B I_C	less disturbed damp woodland & ecotones
Melitaea cinxia (Linnaeus, 1758)	West-Palearctic	Subboreal, hygro-xerophile	damp or xeric woodland clearings & meadows	none	Local, rare or less abundant, lowland & foothills	II_C II_D	natural or semi-natural ecotones & meadows with high biodiversity
Melitaea diamina (Lang, 1789)	Euro-Siberian	Temperate, hygro-xerophile	damp or xeric woodland clearings & meadows	none	Local, rare or less abundant, from lowland to lower montane forest zone	II_C II_D	natural or semi-natural ecotones & meadows with high biodiversity
Melitaea phoebe ([Denis et Schiffermueller, 1775])	West-Palearctic	Subboreal, hygro-xerophile	damp or xeric woodland clearings & meadows	none	Local, rare or less abundant, lowland & foothills	II_C	natural or semi-natural ecotones with complexe structure & high biodiversity
Coenonympha hero (Linnaeus, 1761)	Euro-Siberian	Temperate, hygrophile	damp woodland clearings, swamp meadows, wetlands	RDB (v) BC II HD IV	Rare & local, lowland & foothills of NE mega-slopes	II_C II_D	natural or semi-natural damp woodland ecotones & meadows with high biodiversity

Coenonympha tullia (Mueller, 1764)	Holarctic	Boreal-montane, tyrphophile	mires, peat bogs & swamp meadows	none	Local, rare or less abundant, from lowland to subalpine zone	II_A II_D	natural or semi-natural peat bogs & swamp meadows with high biodiversity
Lasiommata petropolitana (Fabricius, 1787)	Euro-Siberian	Boreal-montane, woodland mesophile	montane needle forests & woodland	none	Extremely rare & local, single finds in upper montane forest zone of NE mega-slopes	III_B	unique montane forest ecosystems with boreo-alpine relic species
Lopinga achine (Scopoli, 1763)	Euro-Siberian	Subboreal, woodland mesophile	broadleaf and mixed forests & woodland	BC II HD IV	Local, rare or less abundant, lowland & foothills	II_B	broadleaf and mixed forests & woodland with natural structure
Hipparchia fagi (Scopoli, 1763)	Euro-Mediter-ranean	Submediter-ranean, woodland xero-thermophile	thermophile woodland	none	Rare & local, foothills & insular volcanic massifs of SW mega-slopes, SE Pre-Carpathian foothills	III_B III_C	unique Pannonian thermophile woodland & ecotones
Brintesia circe (Fabricius, 1775)	Pontic-Mediter-ranean	Submediter-ranean, ecotone xero-thermophile	thermophile woodland & ecotones	none	Rare & local, foothills & insular volcanic massifs of SW mega-slopes, SE Pre-Carpathian foothills	III_B III_C	unique Pannonian thermophile woodland & ecotones
Satyrus dryas (Scopoli, 1763)	Euro-Siberian	Subboreal, hygro-xerophile	damp or xeric woodland clearings & meadows	none	Local, locally abundant, from lowland to lower montane forest zone	II_C II_D	natural or semi-natural ecotones & meadows with high biodiversity
Chazara briseis (Linnaeus, 1764)	West-Palearctic	Submediter-ranean, grassland xero-thermophile	xeric stony grassland & steppes	none	Extremely rare & local, formerly single finds in foothills & lower montane forest zone of Pokut & Bukovine Carpathians	III_A	unique xero-petrophile montane grassland habitats

Erebia manto trajanus Hormuzaki, 1895	European	Montane, mesophile alpicol	montane woodland clearings & meadows, above 1000 m	RDB (r)	Rare & local, E Carpathian endemic ssp.; upper montane forest, subalpine & alpine zones, Chornohora, Maramaros & Chyvchtn Mts	III_A	unique subalpine or alpine ecotones & meadows with rare & endemic species
Erebia pronoe (Esper, 1780)	European	Montane, hygrophile alpicol	montane woodland clearings & damp meadows, above 1000 m	none	Extremely rare & local, formerly single finds in Watershed-Verkhovyna ridge & Gorgan Mts	III_A	unique subalpine or alpine ecotones & meadows with rare & endemic species
RIODINIDAE							
Hamearis lucina (Linnaeus, 1758)	European	Submediter-ranean, ecotone mesophile	woodland clearings & meadows	RDB (v)	Local, rare or less abundant, from lowland to lower montane forest zone	II_C	natural or semi-natural ecotones with complexe structure & high biodiversity
LYCAENIDAE							
Lycaena helle ([Denis et Schiffermueller, 1775])	Euro-Siberian	Boreal-montane, hygro-tyrphophile	damp woodland clearings, mires, peat bogs & swamp meadows	none	Rare & local, few locations in lowland & foothills area	III_A III_D	unique wetland & peat bog ecosystems with relic species
Pseudophilotes vicrama schiffermuelleri Hemming, 1929	Pontic-Mediter-ranean	Submediter-ranean, grassland xero-thermophile	stony or calcareous xeric grassland & steppe habitats	none	Rare & local, foothills & lower montane forest zone	II_A II_D	natural or semi-natural xeric grassland habitats with high biodiversity
Scolitantides orion (Pallas, 1771)	Euro-Siberian	Subboreal, grassland xero-thermophile	stony, silicate or calcareous xeric grassland & steppe habitats	none	Extremely rare & local, recently single location at Chorna Hora volcanic massif	III_A	unique xero-petrophile volcanic habitats

Glaucopsyche alexis (Poda, 1761)	Euro-Siberian	Subboreal, hygro-xerophile	damp or xeric woodland clearings & meadows	none	Local, rare or less abundant, from lowland to lower montane forest zone	II_C	natural or semi-natural ecotones with complexe structure & high biodiversity
Phengaris alcon alcon [Denis et Schiffermueller, 1775]	Euro-Siberian	Subboreal, hygrophile	damp woodland clearings & meadows	IUCN-lr	Rare & local, lowland & foothills	II_D	natural or semi-natural wetlands & damp meadows with complexe structure & high biodiversity
Phengaris alcon rebeli Hirschke, 1908	? European	Montane, xeromontane	montane stony or calcareous xeric grassland habitats	IUCN-lr	Extremely rare & local, few finds in montane forest zones	III_A III_D	unique montane xeric grassland habitats
Phengaris arion (Linnaeus, 1758)	Euro-Siberian	Subboreal, grassland xerophile	xeric grassland & heath habitats	BC II HD IV IUCN-lr	Local, rare or less abundant, from lowland to lower montane forest zone	II_D	natural or semi-natural xeric grassland & heath habitats with high biodiversity
Phengaris teleius (Bergstraesser, 1779)	Euro-Siberian	Subboreal, hygro-xerophile	damp or xeric woodland clearings & meadows	BC II HD II, IV IUCN-lr	Local, rare or less abundant, from lowland to lower montane forest zone	II_C II_D	natural or semi-natural ecotones & meadows with high biodiversity
Phengaris nausithous (Bergstraesser, 1779)	Euro-Siberian	Subboreal, hygro-xerophile	damp or xeric woodland clearings & meadows	BC II HD II, IV IUCN-lr	Local, rare or less abundant, from lowland to lower montane forest zone	II_C II_D	natural or semi-natural ecotones & meadows with high biodiversity

Plebejus optilete (Knoch, 1782)	Horarctic	Boreal-montane, tyrphophile	raised (olygothrophic) peat bogs, montane heath habitats	none	Rare & local, from lowland to subalpine zone	II_D III_A	unique montane raised bogs with relic species; subalpine habitats with rare & endemic species
Polyommatus amandus (Schneider, 1792)	Palearctic	Subboreal, hygro-xerophile	damp or xeric woodland clearings & meadows	none	Rare & local, foothills to lower montane forest zone of Volcanic Carpathians Mts	III_D	unique grassland habitats with high biodiversity
Polyommatus daphnis ([Denis et Schiffermueller, 1775])	Pontic-Mediter-ranean	Submediter-ranean, grassland xero-thermophile	xeric grassland & steppe habitats	none	Rare & local, foothills of SW mega-slopes	II_D	natural or semi-natural xeric grassland habitats with high biodiversity
Polyommatus dorylas ([Denis et Schiffermueller, 1775])	Euro-Mediter-ranean	Submediter-ranean, grassland xero-thermophile	stony or calcareous xeric grassland & steppe habitats	none	Extremely rare & local, foothills & lower montane forest zone, Volcanic, Pokut & Bukovine Carpathians Mts	III_A III_D	unique xeric grassland habitats with high biodiversity
HESPERIIDAE							
Pyrgus andromedae (Wallengren, 1853)	European	Arctic-Alpine, alpicol	stony subalpine & alpine habitats, above 1500 m	none	Extremely rare & local, recently single find at Chornohora Mts	III_A	unique subalpine & alpine habitats
Carterocephalus silvicolus (Meigen, 1829)	Euro-Siberian	Boreal, woodland hygrophile	damp woodland clearings	none	Extremely rare & local, recently single location at Upper-Dnister lowland	III_B	unique riparian-terraced forest ecosystems

Table 4.

Preliminary checklist of the indicator species: larger moths (Lepidoptera: Bombycoidea, Lasiocampoidea, Noctuoidea [= "Macroheterocera"])

Taxa	Biogeography	Ecology	Habitat	Conservation status	Regional status	Ct	Indicator value
SPHINGIDAE							
Proserpinus proserpina (Pallas, 1771)	West-Palearctic	Subboreal, hygro-thermophile	warm woodland clearings, margins & other ecotones	RDB(r) BC II HD IV IUCN-dd	Local, rare or less abundant, lowland & foothills	II_C	natural or semi-natural ecotones with complexe structure & high biodiversity
Hemaris fuciformis (Linnaeus, 1758)	West-Palearctic	Subboreal, ecotone mesophile	woodland clearings, margins & other ecotones	none	Local, rare or less abundant, from lowland to upper forest zone	II_C	natural or semi-natural ecotones with complexe structure & high biodiversity
Hemaris tityus (Linnaeus, 1758)	West-Palearctic	Subboreal, ecotone mesophile	woodland clearings, margins & other ecotones	RDB(r)	Local, rare or less abundant, from lowland to lower forest zone	II_C	natural or semi-natural ecotones with complexe structure & high biodiversity
Marumba quercus ([Denis et Schiffermueller, 1775])	Euro-Mediter-ranean	Submediter-ranean, woodland xero-thermophile	thermophile oak forests & woodland	RDB(r)	Extremely rare & local, recently single location at Akli-Gyula insular volcanic massif	III_B	unique Pannonian thermophile oak forest & woodland ecosystems

SATURNIIDAE							
Saturnia pyri ([Denis et Schiffermueller, 1775])	Euro-Mediterranean	Submediterranean, hygro-thermophile	warm broadleaf woodland, parks, gardens & orchards	RDB(v) BC II IUCN-vu	Widely distributed in lowland & foothills of SW-mega-slopes; rare & local in SE Pre-Carpathians	II_E	cultivated landscape with high biodiversity
Saturnia spini ([Denis et Schiffermueller, 1775])	Euro-Centralasian	Steppe, ecotone xero-thermophile	steppe woodland & shrub habitats	RDB(e)	Extremely rare & local (probably extinct), formerly single finds in extreme SE & SW foothills	III_A	unique extra-zonal woodland-steppe ecosystems
LEMONIIDAE							
Lemonia dumi (Linnaeus, 1761)	European	Submediterranean, grassland mesophile or xerophile	mesoxeric or mesophile meadows	none	Rare & local, foothills & lower montane forest zone	II_D	natural or semi-natural meadows with high biodiversity
Lemonia taraxaci ([Denis et Schiffermueller, 1775])	Euro-Siberian	Subboreal-montane, grassland mesophile	montane mesophile meadows & pastures	RDB(v)	Rare & local, single finds in lower montane forest zone	II_D	natural or semi-natural montane meadows with high biodiversity
LASIOCAMPIDAE							
Eriogaster catax (Linnaeus, 1758)	Euro-Siberian	Subboreal, ecotone xero-thermophile	warm xeric shrubs & ecotones	BC II HD II, IV IUCN-dd	Rare & local, foothills of SW-mega-slopes	II_C	natural or semi-natural xeric ecotones with high biodiversity

Eriogaster lanestris (Linnaeus, 1758)	Euro-Siberian	Subboreal, ecotone mesophile	woodlands, shrubs & ecotones	none	Rare & local, lowland & foothills	II_C	natural or semi-natural woodland & ecotones with high biodiversity
Phyllodesma ilicifolia (Linnaeus, 1758)	Euro-Siberian	Temperate, woodland hygrophile	damp & swamp woodland habitats	IUCN-vu	Extremely rare & local, former finds in Pre-Carpathians; recently single find in upper Tisa river valley	III_B	unique riverine & damp woodland ecosystems
NOTODONTIDAE							
Drymonia velitaris (Hufnagel, 1766)	European	Submediter-ranean, woodland xero-thermophile	thermophile oak woodland	none	Rare & local, few locations in foothills of NE & SW mega-slopes	III_B	unique thermophile oak woodland with high biodiversity
Peridea anceps (Goeze, 1781)	West-Palearctic	Subboreal, woodland mesophile	broadleaf (oak) forests & woodland	none	Rare & local, lowland & foothills	II_B	natural oak forests & woodland with high biodiversity
Phalera bucephaloides (Ochsenheimer, 1810)	Mediter-ranean	Mediter-ranean, woodland xero-thermophile	thermophile oak woodland	none	Rare & local, few locations at insular volcanic massifs of Transcarpathians	III_B	unique Pannonian thermophile oak woodland ecosystems
LYMANTRIIDAE							

Penthophera morio (Linnaeus, 1767)	European	Montane, xeromontane	warm mesoxeric montane meadows, esp. calcareous	none	Extremely rare & local, recently single location at Vyhorlat Mts (Volcanic Carpathians); former finds in SE Pre-Carpathians	III_D	unique montane mesoxeric meadows with high biodiversity
ARCTIIDAE							
Chelis maculosa (Gerning, 1870)	Pontic-Mediterr-anean	Steppe, grassland xero-thermophile	xeric grassland & steppe habitats	none	Extremely rare & local, recently single location at Beregovo volcanic uplands; former finds in SE Pre-Carpathians	III_A	unique Pannonian xeric grassland ecosystems
Parasemia plantaginis (Linnaeus, 1758)	Holarctic	Boreal-montane, ecotone mesophile	woodland clearings, margins & other ecotones	none	Rare & local, montane forest & subalpine zones	II_C	natural or semi-natural montane ecotones with complexe structure & inherent high biodiversity
Rhyparia purpurata (Linnaeus, 1758)	Euro-Siberian	Subboreal, ecotone xero-thermophile	warm xeric woodland clearings, shrubs, margins & other ecotones	none	Rare & local, from lowland to lower montane forest zone	II_C	natural or semi-natural xeric ecotones with complexe structure & high biodiversity
Hyphoraia aulica (Linnaeus, 1758)	Euro-Siberian	Subboreal, ecotone xero-thermophile	open woodland, clearings & margins, esp. on calcareous or silicate substrates	none	Rare & local, from lowland to lower montane forest zone	II_C	natural or semi-natural woodland & ecotones with complexe structure & high biodiversity

Pericallia matronula (Linnaeus, 1758)	Euro-Siberian	Subboreal, ecotone mesophile	open woodland, clearings, margins & meadows	RDB(v)	Rare & local, from lowland to lower montane forest zone	II_C	natural or semi-natural woodland & ecotones with complexe structure & high biodiversity
Callimorpha dominula (Linnaeus, 1758)	European	Subboreal, ecotone hygrophile	damp woodland clearings, margins & meadows	RDB(v)	Local or locally abundant, from lowland to upper montane forest zone	II_C	natural or semi-natural woodland & ecotones with complexe structure & high biodiversity
Callimorpha quadripunctaria (Poda, 1761)	Euro-Mediter-ranean	Submediter-ranean, hygro-thermophile	thermophile woodland, clearings & margins, esp. riverine	HD II	Local or locally abundant, from lowland to lower montane forest zone (esp. on SW mega-slopes)	II_C	natural or semi-natural woodland & ecotones with complexe structure & high biodiversity
EREBIDAE							
Calymma communimacula ([Denis et Schiffermueller, 1775])	Mediter-ranean	Mediter-ranean, ecotone xero-thermophile	xerothermophile woodland clearings & shrubs	none	Rare & local, few locations at insular volcanic massifs of Transcarpathians	III_C	unique Pannonian thermophile woodland ecosystems & ecotones
NOCTUIDAE							

Diachrysia zosimi (Huebner, 1822)	Euro-Siberian	Subboreal, hygrophile	damp woodland clearings, meadows & wetlands	none	Rare & local, lowland & foothills	II_A II_D	natural or semi-natural damp meadows & wetlands with high biodiversity
Euchalcia variabilis (Piller, 1783)	Euro-Siberian	Boreal-montane, hygrophile	damp woodland clearings, margins & meadows	RDB(r)	Local, rare or less abundant, montane forest zones	II_C	natural or semi-natural montane ecotones with high inherent biodiversity
Euchalcia modestoides Poole, 1989	Euro-Siberian	Subboreal-montane, ecotone or grassland mesophile	montane meadows & ecotones	none	Extremely rare & local, few locations at foothills & lower montane forest zone	III_D	unique natural or semi-natural montane meadows & ecotones with high inherent biodiversity
Lamprotes c-aureum (Knoch, 1781)	Euro-Siberian	Subboreal-montane, hygrophile	damp woodland clearings, margins & meadows	none	Rare & local, from lowland to lower montane forest zone	II_C	natural or semi-natural montane ecotones with high inherent biodiversity
Gortyna borelii (Pierret, 1837)	Euro-Mediterranean	Submediterranean, hygro-thermophile	riparian grasslands & wetlands, saline habitats	HD II, IV	Extremely rare & local, single finds at Upper Tisa lowland	III_A III_D	unique Pannonian riparian grasslands & wetlands
Cucullia argentea (Hufnagel, 1766)	Euro-Siberian	Subboreal, grassland xero-thermophile	xeric grassland habitats, esp. psammophile	RDB(v)	Extremely rare & local, single former finds at foothills of Pre- & Transcarpathians	III_A	unique xeric grassland habitats

Diachrysia zosimi (Huebner, 1822)	Euro-Siberian	Subboreal, hygrophile	damp woodland clearings, meadows & wetlands	none	Rare & local, lowland & foothills	II_A II_D	natural or semi-natural damp meadows & wetlands with high biodiversity
Euchalcia variabilis (Piller, 1783)	Euro-Siberian	Boreal-montane, hygrophile	damp woodland clearings, margins & meadows	RDB(r)	Local, rare or less abundant, montane forest zones	II_C	natural or semi-natural montane ecotones with high inherent biodiversity
Euchalcia modestoides Poole, 1989	Euro-Siberian	Subboreal-montane, ecotone or grassland mesophile	montane meadows & ecotones	none	Extremely rare & local, few locations at foothills & lower montane forest zone	III_D	unique natural or semi-natural montane meadows & ecotones with high inherent biodiversity
Lamprotes c-aureum (Knoch, 1781)	Euro-Siberian	Subboreal-montane, hygrophile	damp woodland clearings, margins & meadows	none	Rare & local, from lowland to lower montane forest zone	II_C	natural or semi-natural montane ecotones with high inherent biodiversity
Gortyna borelii (Pierret, 1837)	Euro-Mediter-ranean	Submediter-ranean, hygro-thermophile	riparian grasslands & wetlands, saline habitats	HD II, IV	Extremely rare & local, single finds at Upper Tisa lowland	III_A III_D	unique Pannonian riparian grasslands & wetlands
Cucullia argentea (Hufnagel, 1766)	Euro-Siberian	Subboreal, grassland xero-thermophile	xeric grassland habitats, esp. psammophile	RDB(v)	Extremely rare & local, single former finds at foothills of Pre- & Transcarpathians	III_A	unique xeric grassland habitats

Apamea illyria Freyer, 1846	Euro-Siberian	Boreal-montane, alpicol	subalpine & alpine habitats	none	Rare & local, few locations in Chornohora, Svydovets & Gorgan Mts	I_A III_A	less disturbed subalpine & alpine ecosystems
Apamea maillardi (Geyer, 1834)	European	Montane, alpicol	subalpine & alpine habitats	none	Rare & local, few locations in Chornohora & Chyvchyn Mts	I_A III_A	less disturbed subalpine & alpine ecosystems
Apamea unanimis (Huebner, 1813)	Euro-Siberian	Subboreal, hygrophile	damp woodland, wetlands & wet meadows	none	Rare & local, lowland & foothills	I_A III_A	less disturbed unique wetland ecosystems with high biodiversity
Chortodes extrema (Huebner, 1809)	Euro-Centralasian	Steppe, hygro-thermophile	riparian wetlands or xeric grassland habitats	none	Rare & local, few locations at insular volcanic massifs of Transcarpathians	III_A	unique Pannonian xeric grassland habitats
Phragmatiphila nexa (Huebner, 1808)	European	Subboreal, hygrophile	wetlands	none	Extremely rare & local, recently single location in NW Pre-Carpathians	III_A	unique wetland ecosystems of Upper Dnister lowland
Xestia ochreago (Huebner, 1790)	European	Montane, alpicol	subalpine & alpine habitats	none	Extremely rare & local, recently single location in Chyvchyn Mts	I_A III_A	unique less disturbed subalpine & alpine ecosystems
Xestia rhaetica (Staudinger, 1871)	Holarctic	Arctic-alpine, hygrophile alpicol	subalpine & alpine habitats	none	Extremely rare & local, recently single location in Chornohora Mts	I_A III_A	unique less disturbed subalpine & alpine ecosystems

Main references: Rizun, Konovalova, Yanytsky, 2000; Klyuchko, Plyushch, Sheshurak, 2001; Polska czerwona ksiega zwierzat, 2004; Macek et al., 2007, 2008; Geryak, 2009, 2010, 2012, 2013; Geryak et al., 2011; Kanarskyi, Geryak, Lyashenko, 2011; Buszko, Maslowski, 2012; Geryak, Kanarsky, Koval, 2013; Kanarskyi, Geryak, 2014.

The analysis of distribution pattern of the considered indicator Insect species together with the background of many years faunal and ecological investigations allow to select 12 "hot spot" areas of biodiversity within the Ukrainian Carpathians region. All of these areas have specific patterns of biodiversity, high-valuable habitats and ecosystems as well as general threats for biodiversity conservation.

I. The Upper Dnister foothills area: north-west part of Pre-Carpathian foothills including riparian-terraced landscapes of the Upper Dnister lowland.

II. East-Bukovine foothills area: south-east part of Pre-Carpathian foothills with the Prut river valley riparian-terraced landscapes and uplands within the Siret – Prut river valleys intermediate areas.

III. The Upper Dnister Beskydy low-mountain area: Upper Dnister Beskydy Mts with its marginal low-mountain and adjacent foothill areas.

IV. Skolivski Beskydy mountain area: Skolivski Beskydy Mts.

V. Watershed-Verkhovyna mountain area: Carpathian Watershed mountain ridge with adjacent peneplains of Stryi-San and Volovets-Mizhgiria Verkhovyna.

VI. The Upper Uzh mountain area: upper part of the Uzh river basin with adjacent Beshchady and Lower Polonyna Mts.

VII. Vyhorlat volcanic mountain area: western part of Volcanic Carpathians within the Uzh river basin mostly, with eastern Vyhorlat and western Makovytsia volcanic massifs.

VIII. Uholka rocky mountain area: lower southern parts of Polonyna Krasna massif within the Pieniny rocky geo-morphological zone, lower mountain forest zone.

IX. Maramaros rocky mountain area: lower southern parts of Svydovets Mts and western Maramaros Mts with the Tisa and Bila Tisa river valleys, within the Maramaros rocky geo-morphological zone, lower mountain forest zone.

X. Chornohora-Svydovets-Maramaros high-mountain area: upper parts of Chornohora, Svydovets, Maramaros, Hryniava and Chyvchyny Mts from the upper mountain forest zone to subalpine and alpine vegetation zones.

XI. Gorgan mountain area: Gorgany Mts between Mizunka-Svicha and Prut rivers.

XII. The Upper Tisa lowland and volcanic hilly-mountain area: insular volcanic enclaves (e.g. Beregovo massif, Chorna Hora Mt, Akli-Dyula massif, etc.) with adjacent volcanic Avash (Hutyn) Mts and riparian-terraced landscapes of the upper Tisa river basin.

Conclusions

1. The general indicator value of considered Insect species consists in that is analysis of their distribution pattern allows determining most valuable habitats as well as "hot spots" of regional invertebrates biodiversity on the levels of landscape or biogeocoenose ecosystems. In this way, there are 12 high-valuable biodiversity areas selected within the Ukrainian Carpathians region.

2. The presence or absence of several indicator species in its inherent habitats is an evidence for the ability of corresponding ecosystems to support the characteristic biodiversity pattern. It allows estimating those abilities without use of high-expensive, long-term or difficult investigation methods.

3. There are relatively little number of "officially" threatened Insect species, which have an indicator value as the markers of natural ecosystems conditions within the region. At the same time, there are many species, which don't have a conservation status but could pretend to it exactly owing to their indicator value.

4. It is necessary to elaborate detailed regional checklists of indicator invertebrate species for each large natural region (e.g. West Polissia, West Volyn-Podolian Uplands, Ukrainian Carpathians, etc.) corresponding to the habitat concept of biodiversity protection (Habitat Concept…, 2012). It gives availability for upgrading methods of the complex evaluation of natural ecosystems and areas which need protection.

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ІНДИКАТОРНЕ ЗНАЧЕННЯ КОМАХ (*COLEOPTERA*, *LEPIDOPTERA*) ЯК МАРКЕРІВ СТАНУ ПРИРОДНОСТІ ЕКОСИСТЕМ РЕГІОНУ УКРАЇНСЬКИХ КАРПАТ

Ю.В. Канарський

Розглянуто принципи використання окремих груп і видів твердокрилих і лускокрилих комах як маркерів стану природності екосистем. Індикаторні види (маркери) – це види, які мають специфічні вимоги до середовища існування і присутність (відсутність) яких відображає стан природності та збереженості різноманіття відповідних угруповань і комплексів біоти. Виділено 3 об'єктні категорії (I-III) та 6 екологічних груп (A-F) індикаторних видів комах. На основі цього підходу складено списки індикаторних видів регіональної фауни для 4-х еколого-таксономічних груп: туруни (*Coleoptera*, *Carabidae*), сапроксильні жуки (*Coleoptera* p.p.), денні метелики (*Lepidoptera*, "Rhopalocera"), більші різновусі метелики (*Lepidoptera*, "Macroheterocera"). Головне індикаторне значення цих видів полягає в тому, що аналіз особливостей їх поширення дозволяє виявити найбільш цінні оселища і "гарячі точки" різноманіття наземних безхребетних на рівнях ландшафтних і біогеоценозних екосистем. На цій підставі окреслено 12 найважливіших територіальних осередків різноманіття безхребетних Українських Карпат.

Ключові слова: біоіндикація, біорізноманіття, екосистема, оселище, рідкісні й зникаючі види комах, Українські Карпати

ИНДИКАТОРНОЕ ЗНАЧЕНИЕ НАСЕКОМЫХ (*COLEOPTERA*, *LEPIDOPTERA*) КАК МАРКЕРОВ ЕСТЕСТВЕННОГО СОСТОЯНИЯ ЭКОСИСТЕМ РЕГИОНА УКРАИНСКИХ КАРПАТ

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Рассмотрены принципы использования отдельных групп и видов жесткокрылых и чешуекрылых насекомых в качестве маркеров естественного состояния природных и трансформированных экосистем. Индикаторные виды (маркеры) – это виды, которые проявляют специфические требования к среде обитания и наличие (отсутствие) которых отображает естественное состояние и сохранность разнообразия сообществ и комплексов биоты. Выделены 3 объектные категории (I-III) и 6 экологических групп (A-F) индикаторных видов насекомых. На основе данного подхода составлены списки индикаторных видов региональной фауны для 4-х эколого-таксономических групп: жужелицы (*Coleoptera*, *Carabidae*), сапроксильные жуки (*Coleoptera* p.p.), булавоусые чешуекрылые (*Lepidoptera*, "Rhopalocera"), большие разноусые чешуекрылые (Lepidoptera, "Macroheterocera"). Главное индикаторное значение этих видов состоит в том, что анализ особенностей их распространения позволяет выявить наиболее ценные местообитания и "горячие точки" разнообразия наземных беспозвоночных на уровнях ландшафтных и биогеоценозных екосистем. На этом основании выделено 12 важнейших территориальных очагов разнообразия беспозвоночных Украинских Карпат.

Ключевые слова: биоиндикация, биоразнообразие, экосистема, местообитание, редкие и исчезающие виды насекомых, Украинские Карпаты

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