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В издании, подготовленном по итогам XVII международной научно-практической конференции «Актуальные проблемы экологии – 2022» (Гродно, 5–6 октября 2022 г.), представлены статьи исследователей из Беларуси, России, Украины, Италии, Чехии, Польши, посвящённые теоретическим и практическим аспектам сохранения биоразнообразия, влияния факторов окружающей среды на биологическую активность организмов, совершенствования методов экологического мониторинга. Рассматривается достаточно широкий спектр вопросов рационального использования и повышения устойчивости водных и почвенных ресурсов, ресурсов атмосферы в условиях изменения климата. Значительное внимание уделяется вопросам развития пищевых технологий. Представлен опыт деятельности по экологическому образованию и просвещению в интересах устойчивого развития. Адресуется студентам, магистрантам, аспирантам и преподавателям средних и высших учебных заведений, научным сотрудникам.

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РАЗДЕЛ 1.
УСТОЙЧИВОЕ ИСПОЛЬЗОВАНИЕ И ОХРАНА РАСТИТЕЛЬНОГО МИРА

УДК 581.526.33

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ECO-COENOLOGICAL AND CONSERVATIONAL CHARACTERISTICS OF MIRES IN THE MONTI SIBILLINI NATIONAL PARK (ITALY)

This study aims to characterise the ecology of the remnant fen and transition mire communities of the Monti Sibillini National Park (Central Apennines). Transition mire communities are poor in species and colonize karst dolines that suffer desiccation during the summer. Fens are richer in species and colonize small patches continuously supplied by spring water. These fragile ecosystems are threatened with extinction caused by climate change: an increasing trend in temperature has been registered in the last thirty years. Understanding in detail the dynamics and the ecological features that regulate their survival is fundamental to give the correct strategies to ensure their conservation.

Keywords: relict fens, transition mires, Central Apennines, climate change, conservation, karst planes, Monti Sibillini National Park.

In Italy, mires are mainly distributed in the Alpine and Temperate areas of Northern Italy. In the Mediterranean regions, these communities have scattered distribution usually occupying small patches at high elevations [1]. Although these communities are highly localized, they host several alpine and boreal species at the southern limit of their distribution range. Some of the most important biodiversity hotspots of the Central Apennines are the karst plains of Castelluccio di Norcia, in the Sibillini Mountains National Park. These karst plains host remnant fen and transitional mire communities in which several rare species survive (e. g., *Blysmus compressus*, *Carex buxbaumii, C. davalliana, Eriophorum latifolium, Sphagnum* spp). Although this area is well known in terms of flora and vegetation [2, 3, 4], a detailed study on the ecology of these communities is still missing.

The karst plains are located at an altitude of 1275 to 1335 m a.s.l. Traditionally these plains are exploited for agricultural use. The main agricultural management practices are grazing and annual mowing. Fen and mire communities are found respectively in karst depressions of different sizes and water springs.

In 2022 (from July to August) 182 vegetation plots of 1 m^2 were made following the Braun-Blanquet method [5]. To detect as much diversity and structure of the vegetation communities as possible, we placed two orthogonal transects for each doline, starting from the centre of the dolines and following the East-West and North-South directions. For each spring we positioned one transect along the water course and several perpendicular transects along its length. Each relevé had a distance of 1 m between each other and the transect finished when the vegetation was being replaced by the surrounding grasslands. We also recorded the cover and the height of the litter and collected soil samples in each plot. In sampled areas we placed also soil temperature dataloggers. For climatic analysis, ERA5-Land monthly averaged data of 2 m temperature and total precipitation were taken for our study area for the years 1951 to 2021 from Copernicus Data Store [6].

The first results show that transition mires are species poor, with an average of 6 species per plot. The species richness increases along the transects, passing from only 1 or 2 species in several central plots of the doline, to 6 in the ecotonal zone, to 22–27 species out of the doline. The average height of the litter, given by the dead leaves of *Carex* species, was 15 cm and the higher it was, the more monospecific the plot resulted. Transition mires were found to be dominated by *C. acuta* and *C. vesicaria*, with other associated species as: *Agrostis canina, Carex leporina, Deschampsia cespitosa, Galium palustre, Juncus inflexus, Leontodon autumnalis, Polygonum bistorta, Potentilla erecta, Sanguisorba officinalis, Trifolium spadiceum, Veronica scutellata* and mosses as *Sphagnum subsecundum, S. platyphyllum*, *Aulacomnium palustre* and *Polytrichum commune.*

The fens are more diverse in term of species richness, with an average of 16 species per plot. The minimum number of species in a plot was of 7 to 9 species and a maximum of 27, with high richness values also in the central parts of the transect. The litter was in most cases absent or had a low height and cover. Dominant species are: *Agrostis stolonifera, Briza media, Calliergonella cuspidata, Carex acuta,*

C. buxbaumii, C. davalliana, C. flacca, *C. hirta, C. panicea, C. viridula, Chara sp*., *Blysmus compressus, Deschampsia cespitosa, Drepanocladus aduncus Eleocharis quinqueflora, Epilobium parviflorum, Equisetum palustris, Eriophorum latifolium, Festuca arundinacea, Hypericum tetrapterum, Juncus articulatus, J. inflexus, Linum catharticum, Parnassia palustris, Potentilla erecta* and *Veronica beccabunga.*

Climatic analysis for Castelluccio plains highlighted that July and August are the driest and the hottest months of the year for these plains. An increasing trend of mean annual temperature from 1951 has been seen and the anomaly analysis evidenced a prevalence of positive anomalies of temperature (meaning that the observed temperature was warmer than the long-term average baseline) in the last thirty years, contrary to previous years. Such changes threaten the stability of ecosystems and the survival of fens and mires that have found so far suitable refugia in central Italy, which are now at risk to disappear with a consequent homogenization of the landscape. The aim of future data analyses is to complete the ecological characterization of relict fens and mires in all localities known for the Mediterranean regions and the climatic description of such microrefugia, through the analysis of species ecology and their tolerance to summer stress and through the analysis of abiotic variables and the management of the area. The goal is to give the correct guidelines for their future protection and conservation.

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ЭКОЛОГА-ЦЭНАТЫЧНАЯ І САЗАЛАГІЧНАЯ ХАРАКТАРЫСТЫКА ГОРНЫХ БОЛОТ НАЦЫЯНАЛЬНАГА ПАРКУ «МОНЦІ СІБІЛІНІ» (ІТАЛІЯ)

Гэта даследаванне мае на мэце ахарактарызаваць экалогію рэшткавых балот і пераходных балот нацыянальнага парку Монці Сібіліні (Цэнтральныя Апеніны). Суполкі пераходных балот бедныя відамі і каланізуюць карставыя лагчыны, якія летам высыхаюць. Балоты больш багатыя відамі і каланізуюць невялікія ўчасткі, якія стала забяспечваюцца крынічнай вадой. Гэтыя далікатныя экасістэмы знаходзяцца пад пагрозай знікнення з-за змены клімату: за апошнія трыццаць гадоў назіраецца тэндэнцыя павышэння тэмпературы. Дэталёвае разуменне дынамікі і экалагічных асаблівасцей, якія рэгулююць іх выжыванне, мае фундаментальнае значэнне для выпрацоўкі правільных стратэгій для забеспячэння іх захавання.

Ключавыя словы: рэліктавыя балоты, пераходныя балоты, Цэнтральныя Апеніны, змяненне клімату, захаванне, карставыя плоскасці, Нацыянальны парк Монці Сібіліні[1].

УДК 595.384.16

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СТАТИЧЕСКИЕ ПОКАЗАТЕЛИ ПОПУЛЯЦИЙ ДЛИННОПАЛОГО РАКА В УСЛОВИЯХ ИНТЕНСИВНОГО ПРОМЫСЛА

Общая биомасса, плотность, средние размеры самцов или самок популяций длиннопалого рака характеризуются широкой изменчивостью, отсутствием достоверной корреляционной взаимосвязью. Анализ статических показателей необходимо вести с учетом пола особей, поскольку нет синхронизации и равнозначных изменений параметров у самцов и самок.

Ключевые слова: длиннопалый рак, статические показатели популяций.

[1]Сведения об авторах, заголовок статьи, аннотация и ключевые слова приведены на белорусском языке для расширения читательской аудитории.

РАЗДЕЛ 5.
МОНИТОРИНГ ЗАГРЯЗНЕНИЯ АТМОСФЕРЫ И КЛИМАТИЧЕСКИЙ МЕНЕДЖМЕНТ

УДК 574:591.5

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IMPACT OF ENVIRONMENTAL FACTORS ON THE VARIABILITY OF BODY SIZE AND SEXUAL SIZE DIMORPHISM OF *CARABUS ODORATUS* SHILL. (CARABIDAE, COLEOPTERA)

Body size variation in animals is of great interest, especially in mountain ecosystems. We analyzed that characteristic in ground beetle *Carabus odoratus* at Barguzin Ridge (Buryatia, Russia). Ground beetles were measured for 6 linear traits. We revealed the negative correlation between beetles body size and the following environmental variables: soil moisture, precipitation level, the date of positive temperatures on the soil surface, population density, snow cover tickness, frost-free period, snow cover duration, minimum soil temperatures in July (peak activity) and January (diapause). Positive correlation was found in soil temperature at the 5 and 10 cm depth, and minimal soil temperatures. It is noted, the higher was the quantitative factor`s value, the larger were the beetles by all six measured traits. Sexual dimorphism occurred in relation to three traits: males decreased their elytra size due to the delay in the onset of positive temperatures, and minimal soil temperatures in July more intensively than females. Minimal soil temperatures in January affected males` pronotum and head size in higher level too. Besides males increased their head length more effectively. The males were smaller than females by all traits in a whole. However, sexual dimorphism in the size of beetles, depending on environmental factors, was revealed only in 7 studied traits out of 72 parameters.
Keywords: body size variation, environmental factors, ground beetles, Barguzin Ridge.

Introduction. Body size is the proxy of many traits in animals [1]. Therefore, it is of current interest to study its variation especially taking into account foregoing climate changes [2]. We used ground beetles as the object as they are regarded to be satisfied bioindicators [3].

Study organism. *Carabus odoratus barguzinicus* Shil, 1996 was chosen as a model species for our research. This is the largest ground beetle that dwells here, convenient in measurement. *C. odoratus* is abundant (17.6 % of the total population) in the entire gradient of the Barguzin Ridge. It is endemic there. According to the classification of life forms, *C. odoratus* belongs to epigebiontes and zoophages with extraintestinal digestion. *C.odoratus* has a two or three-year life cycle with a summer development period and a winter diapause at the imago and larval stages in the study area [4]. The following measurements were made: elytra length and width, pronotum length and width, head length and distance between eyes. We selected undamaged specimens for habitat analysis, but without fixing the selection time (year, month, decade). Finally, our data set included 984 specimen from 8 biotopes for the period 1988–2014.

Study design. We sampled beetles at four altitudes where 12 environmental factors have been recording permanently. Investigation took place on Barguzin Ridge (Buryatia, Russia, 54°42′ N 110°24′ E). The study area is characterized by a relatively gentle uplift from the shore of Lake Baikal (454–460 m above sea level) to the low-mountain part of the ridge (at elevations of 535–721 m), steeper to the upper border of the forest (1407 m), and a sharp rise to the highest point of the watershed ridge the pass (1667 m). Entomological plots were located in characteristic biotopes of a 30-km high-altitude transect in the Davsha River Valley, from the shore of the Lake Baikal to the top of the mountain [5].

Statistical analysis. We processed material in R using linear models [6, 7]. The latter permit us to conclude what environmental factor affected beetles size and was that effect different for males and females.

$$Size_{i,j,k} = a_{i,0} + a_{i,1} \cdot I^{male}_{i,j,k} + a_{i,2} \cdot X_{i,j,k} + a_{i,3} \cdot I^{male}_{i,j,k} \cdot X_{i,j,k} + \varepsilon_{i,j,k}$$
$$\varepsilon_{i,j,k} \sim Norm(0, \sigma^2_{i,j}),$$

- α_{i1} – the difference between the average size of females and males in a whole by all data set;
- α_2 – the value of shift in female trait size under the certain environmental factor impact; if it was positive, the factor increased female's trait size, and vice versa;

- α_3 – the difference in regression slopes for males and females and its significance, in other words, the response of males and females for the environmental factor; the significance of α_3 tells that the shifts in trait differs in males and females in value.

Table – Results of correlation analysis «morphometric traits – environmental factors» in Carabus odoratus

Factors/Traits	Elytra length	Elytra width	Pronotum lenght	Pronotum width	Head length	Distance between eyes
Humidity	↓	↓	↓	↓	o	↓
Soil t ºC, 5 cm	↑	↑	↑	↑	↑	↑
Soil t ºC, 10 cm	↑	↑	↑	↑	↑	↑
Min soil t ºC	↑	↑	↑	↑	↑	↑
Precipitation level	↓	↓	↓	↓	↓	↓
Positive t ºC date	↓	↓	↓	↓	↓	↓
Abundance	↓	o	↓	↓	o	↓
Snow cover tickness	↓	↓	↓	↓	↓	↓
Snow cover duration	↓	↓	↓	↓	↓	↓
Frost-free period	↓	↓	↓	↓	↓	↓
Minimal t ºC in July	↓	↓	↓	↓	o	↓
Minimal t ºC in January	↓	↓	↓	↓	o	↓

↑ – positive correlation
↓ – negative correlation
↓ – sexual dimorphism
o – no correlation

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ЭКОЛОГИЧЕСКАЯ БЕЗОПАСНОСТЬ КАК НОВОЕ СВОЙСТВО ФУНКЦИОНИРОВАНИЯ СИСТЕМЫ ТЕПЛОСНАБЖЕНИЯ В РОССИИ

Возрастающие потребности экономики и социальной сферы обуславливают увеличение объемов потребления энергии. Теплоэнергетика в значительной степени оказывает негативное влияние на окружающую среду, в связи с чем целесообразно, помимо экономической безопасности, связанной с развитием надежности и экономичности теплоэнергетики, говорить об ее экологической безопасности, способствующей снижению негативного воздействия на окружающую среду.

Ключевые слова: теплоэнергетика, теплоснабжение, устойчивое развитие, экологическая безопасность, энергетическая безопасность.