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Small mammals of xerothermic grasslands of south-eastern Poland

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Abstract: *Small mammals of xerothermic grasslands of south-eastern Poland*. Xerothermic grasslands are open habitats with rich and diverse grassy and herbaceous flora. The abundance of fauna is also related to the richness and uniqueness of flora, especially stenotopic species of invertebrates. Much less is known about the vertebrate fauna of these habitats. The vertebrates which can potentially form characteristic assemblages on xerothermic grasslands are small mammals. The aim of this paper is to study the quantitative and qualitative structure of small-mammal communities that inhabit protected xerothermic grasslands in south-east of Poland at the interface of three geographical macroregions: Lublin Upland, Volhynian Upland and Western Bug Basin. 488 small mammals of 13 species were captured over the 1,558 days of live-trapping. It was found that xerothermic grasslands are quite rich habitats in terms of small mammal fauna: species richness from 8 to 11; species diversity index from 1.7 to 2.0; number of mammals captured per 100 trap-days from 24.7 to 50.9. The most frequent species were *Microtus arvalis* (Pallas, 1778), *Apodemus agrarius* (Pallas, 1771) and *Sorex araneus* (Linnaeus, 1758), i.e. mammals that are also typical of agricultural areas. About 20% of captured mammals were species typical of other (e.g. wet or wooded) habitats neighbouring xerothermic grasslands. During our study, we did not catch any the southern birch mouse *Sicista subtilis* (Pallas, 1773); this indicates that this mammal, if still present in this area, is an extremely rare species. The data presented in this paper may be used to create or update protection plans for the surveyed nature reserves or Natura 2000 sites.

Key words: xerothermic grasslands, small mammals, nature reserves, Natura 2000

INTRODUCTION

Xerothermic grasslands are thermophilic steppe-type grass communities whose occurrence is conditioned by climate, soil, and landform. In Poland these habitats occur outside the climatic zone of the steppes, mainly in the uplands of southern Poland, and the Vistula, Odra, and Warta valleys (Mróz and Bąba 2010, Barańska et al. 2013). Xerothermic grasslands are open (usually treeless) habitats with rich and diverse grassy and herbaceous flora, often with relict and rare species (Barańska et al. 2013). They are dominated by plant and animal species from the southern Palearctic areas, representing Pontic-Pannonian, Mediterranean and Irano-Turanian elements (Mazur and Kubisz 2000). From the phytosociological point of view, these communities belong mainly to the *Festuco-Brometea* class; however, they are strongly diversified in terms of species composition, the genetics of these species, soil type, and historical transformations and land use (Barańska et al. 2013).

The flora of xerothermic grasslands in Poland is well known and, due to its uniqueness, diversity, and richness, is the object of both scientific research and various conservation measures (Bąba 2003, 2004, Czarnecka 2009, Denisow and Wrzesień 2015). These activities most often relate to strengthening the populations of the rarest species and maintaining optimal habitat features, mainly by restraining ecological succession by removing trees and shrubs, mowing or grazing, raking out needle cover, etc. (Barańska et al. 2013). The abundance and diversity of fauna are also related to the richness and uniqueness of the flora of xerothermic grasslands. In particular, invertebrates are commonly studied (Mazur and Wanat 1994, Mazur and Kubisz 2000, Weiss et al. 2013) because in these systematic groups there are many stenotopic species that are closely related to xerothermic habitats (Mazur and Kubisz 2000). On the example of the Przęślin steppe reserve near Wiślica, Mazur and Wanat (1994) showed how rich this stenotopic fauna can be: in an area of less than 1 ha, about 150 species of beetle from the family Curculionidae live, of which nearly 30% of the species are characteristic to this environment.

Much less is known about the vertebrate fauna of xerothermic grasslands. Larger vertebrates usually do not create the characteristic multi-species communities that are typical of invertebrates in these habitats, mainly because xerothermic grasslands are usually small area habitats (several, a dozen, or sometimes several dozen hectares). They use these habitats only as a part of their home range, e.g. as feeding grounds or places for nesting. Such species in xerothermic grasslands are often an important element of their biodiversity, but they do not usually constitute indicator species for these habitats.

The vertebrates which can potentially form characteristic communities on xerothermic grasslands are small mammals. The open nature of these habitats, the specific thermal and hydrological conditions, the low vegetation, and the large number of invertebrates (as a potential source of food) may result in the formation of a relatively specific assemblage of small mammals in these areas. In addition, there is also a species that could be considered as a characteristic species of these steppe (xerothermic) habitats: the southern birch mouse *Sicista subtilis* (Pallas, 1773) (Cserkész et al. 2009), which has been caught in Poland in the xerothermic habitat of Machnowska Góra reserve (Baraniak et al. 1998), however, the exact habitat of this species and the current composition of small mammal fauna throughout the south-eastern part of the Lublin region are both relatively poorly understood. Only very little data is available in atlas publications (Pucek and Raczyński 1983, Okarma et al. 2016) and a few reliable faunistic works based on trapping data (Ziomek 1998).

The aim of this paper is to study the quantitative and qualitative structure of the small-mammal communities inhabiting various xerothermic grassland habitats in the south-eastern of Poland at the junction of three geographical macroregions: Lublin Upland, Volhynian Upland and Western Bug Basin (Kondracki 2002). Previously the structure of the small-mammal communities inhabiting these specific habitats has not been analysed in detail. One of the few excep-

tions is the work of Ziomek (1998) on the small mammals of Central Roztocze Upland, in which some typical xerothermic habitats were studied. In our study, only protected xerothermic habitats were chosen (the most valuable and best-preserved habitats); allowing to use our dataset for conservation, or management plans of these protected areas.

MATERIAL AND METHODS

Study area

The study was carried out in Poland (Europe), in the south east part of Lubelskie Voivodeship in three macroregions: Lublin Upland (Mesoregion Grabowiec Interfluves), Volhynian Upland (Mesoregions Hrubieszów Basin and Sokal Ridge) and Western Bug Basin (Mesoregion Belz Plain) (Kondracki 2002). The studied region is agricultural with a low proportion of wooded areas (below 20%) and a low level of urbanization. It is characterized by hot summers (mean above 17°C), cold winters (mean below –3°C), and low annual precipitation (mean below 550 mm).

Five protected area consisting the most valuable and best-preserved xerothermic grassland habitats were selected: Rogów, Machnowska Góra, Gliniska, Skarpa Dobużańska and Zachodniowołyńska Dolina Bugu. In case of Rogów, Machnowska Góra and Skarpa Dobużańska, the study was conducted on the whole area of reserves, whereas in the case of Zachodniowołyńska Dolina Bugu, the study was conducted only in the xerothermic part of the grasslands on loess slopes in the Bug valley between the villages of Czumów and Gródek. In Gliniska the study was carried out with the exception of places where regular mowing was carried out and the vegetation was very short (part of the reserve was prepared as a place for the reintroduction of *Spermophilus suslicus*). Detailed data on all study areas are presented in Table 1.

Trapping procedure

Small mammals were captured in live traps, marked, and then released at the trapping site. Three types of live traps were simultaneously used: wooden box traps (90 × 80 × 200 mm), metal multicapture Ugglan traps (60 × 90 × 240 mm) and pitfall traps (plastic buckets with a diameter of 30 cm and a depth of 50 cm, buried even with the surface of the ground). The proportion of traps used for each study site was as follows: wooden traps 50%, Ugglan traps 25%, pitfall traps 25%. Traps were loaded with food bait (a mixture of oats, pumpkin seeds, peanuts, and some frozen crickets) and a piece of apple. Traps were set along a transect, usually consisting of 20–30 traps spaced about 20 m from one another (traps of different types were set in random order). Each trapping session lasted usually four days. Captured animals were described in terms of species, sex (if possible – the sex of shrews was not determined), reproductive activity and body mass. Individuals captured for the first time were marked by fur clipping. Trapping sessions were carried out in July and August for three years for each study site. Detailed information on study years, trapping effort and number of trapped animals is presented in Table 2. During 1,558 trap-days, 488 individuals of 13 species were captured. The study was conducted according to the permis-

TABLE 1. Characteristics of the study areas: their size, protection status and location.

Name of the study area	Protection status	The objectives of protection*	Area (ha)*	Geographical coordinates*	Physico-geographical location **
Machnowska Góra	Nature reserve (also part of Natura 2000 site PLH060018)	preservation, for scientific and didactic reasons, of xerothermic communities with numerous protected species of flora and fauna	25.30	23.58105 50.37171	Macroregion: Western Bug Basin Mesoregion: Belz Plain
Skarpa Dobużańska	Nature reserve (also part of Natura 2000 site PLH060039)	preservation of xerothermic communities with rare species of steppe plants	5.07	23.71486 50.58048	Macroregion: Volhynian Upland Mesoregions Sokal Ridge
Rogów	Nature reserve (also part of Natura 2000 site PLH060062)	preservation, for scientific and didactic reasons, of the places of occurrence of rare steppe plants and xerothermic plants with a relict population of *Carlina onopordifolia*	0.95	23.52335 50.79794	Macroregion: Lublin Upland Mesoregion: Grabowiec Interfluves
Zachodnio-wołyńska Dolina Bugu	Natura 2000 site PLH060035	inter alia: conservation of xerothermic grasslands in a favourable condition	77.81(total area 1556)	24.0612 50.6786	Macroregion: Volhynian Upland Mesoregion: Hrubieszów Basin
Gliniska	Nature Reserve (also part of the Natura 2000 PLH060029)	preservation of the place of occurrence of *Spermophilus suslicus*	34.00	23.63278 50.85997	Macroregion: Lublin Upland Mezoregion: Grabowiec Interfluves

* Source of information: http://crfop.gdos.gov.pl; ** according to regionalization of Poland (Kondracki 2002).

sion of the Regional Director for Environmental Protection in Lublin.

Data analysis

Data were analysed on the basis of the following parameters and methods:

– Community composition, characterized based on the relative abundance of each species, calculated as the number of individuals of a given species divided by the total number of individuals of all species and expressed as a percentage.
– Species richness, defined as the number of species recorded within a given study site.
– Species diversity, calculated by the Shannon–Wiener index (H') for each site using a natural logarithm.
– Relative abundance of the small mammal, defined as the number of

TABLE 2. Species composition and contribution of small mammals, species richness, and species diversity index in particular studied sites. Characteristics of the study years and trapping effort for the particular study sites

Specification	Zachodnio--wołyńska Dolina Bugu	Gliniska	Skarpa Dobużańska	Rogów	Machnowska Góra
Apodemus agrarius	6.25	9.86	17.35	29.46	38.74
Apodemus flavicollis	0	11.27	6.12	7.14	0
Apodemus sylvaticus	3.13	2.82	0	0	11.71
Micromys minutus	0	1.41	0	1.79	3.60
Mus musculus	1.04	5.63	0	0	0
Microtus arvalis	11.46	46.48	15.31	27.68	24.32
Microtus oeconomus	20.83	2.82	15.31	4.46	5.41
Microtus subterraneus	15.63	1.41	5.10	0	0.90
Myodes glareolus	1.04	2.82	6.12	15.18	0
Sorex araneus	28.13	11.27	27.55	12.50	8.11
Sorex minutus	8.33	4.23	5.10	1.79	5.41
Crocidura leucodon	2.08	0	2.04	0	1.80
Neomys fodiens	2.08	0	0	0	0
Number of individuals	96	71	98	112	111
Trapping effort (number of trap-days)	388	260	290	220	400
Number of individuals per 100 trap-days	24.74	27.31	33.79	50.91	27.75
Study years	2012; 2013; 2014	2012; 2013; 2014	2011; 2012; 2013	2010; 2011; 2012	2011; 2012; 2014

individuals (all species) captured per 100 trap-days.

– The dissimilarity in the composition of small-mammal communities among study sites was evaluated by means of agglomerative hierarchical clustering analysis (AHC) and was expressed as a dendrogram. We used Euclidean distance to present dissimilarity between sites and Ward's method to agglomerate the analysed sites into clusters (classes). Statistical tests were performed using XLSTAT statistical software.

RESULTS

In total, we captured 488 small mammals, representing 13 species:

– Five species from family Muridae: striped field mouse *Apodemus agrarius* (Pallas, 1771); yellow-necked mouse *Apodemus flavicollis* (Melchior, 1834); wood mouse *Apodemus sylvaticus* (Linnaeus, 1758); Eurasian harvest mouse *Micromys minutus* (Pallas, 1771) and house mouse *Mus musculus* (Linnaeus, 1758).

– Four species from subfamily Arvicolinae (family Cricetidae): common vole *Microtus arvalis* (Pallas, 1778); root vole *Microtus oeconomus* (Pallas, 1776); field vole *Microtus subterraneus* (de Selys-Longchamps, 1836); bank vole *Myodes glareolus* (Schreber, 1780).
– Four species from family Soricidae: common shrew *Sorex araneus* (Linnaeus, 1758); pygmy shrew *Sorex minutus* (Linnaeus, 1766); Eurasian water shrew *Neomys fodiens* (Pennant, 1771) and bicoloured white-toothed shrew *Crocidura leucodon* (Hermann, 1780).

The studied habitats had the following species richness: range 8–11, mean 9.6; standard deviation 1.34. The most frequent species captured on all sites were *M. arvalis*, *A. agrarius* and *S. araneus* (Fig. 1). The total share of these three species in the small mammals' community was 63%. The other species can be divided into two groups. The first group (total share 14.35%) includes species whose habitat preferences may also include open, dry areas (*C. leucodon*, *S. minutus*, *M. subterraneus*, *A. sylvaticus*), whereas the second group (about 22% of the animals caught) incudes species typical for wet (*M. oeconomus*, *N. fodiens*) and wooded habitats (*A. flavicollis*, *M. glareolus*), or synanthropic species (*M. musculus*).

The studied xerothermic habitats differed from each other in species composition and proportion of particular species (Table 2). Agglomerative hierarchical clustering (Fig. 2) showed three groups (classes) of the studied sites. The first class includes the Zachodniowołyńska Dolina Bugu and Skarpa Dobużańska sites, mainly due to the large propor-

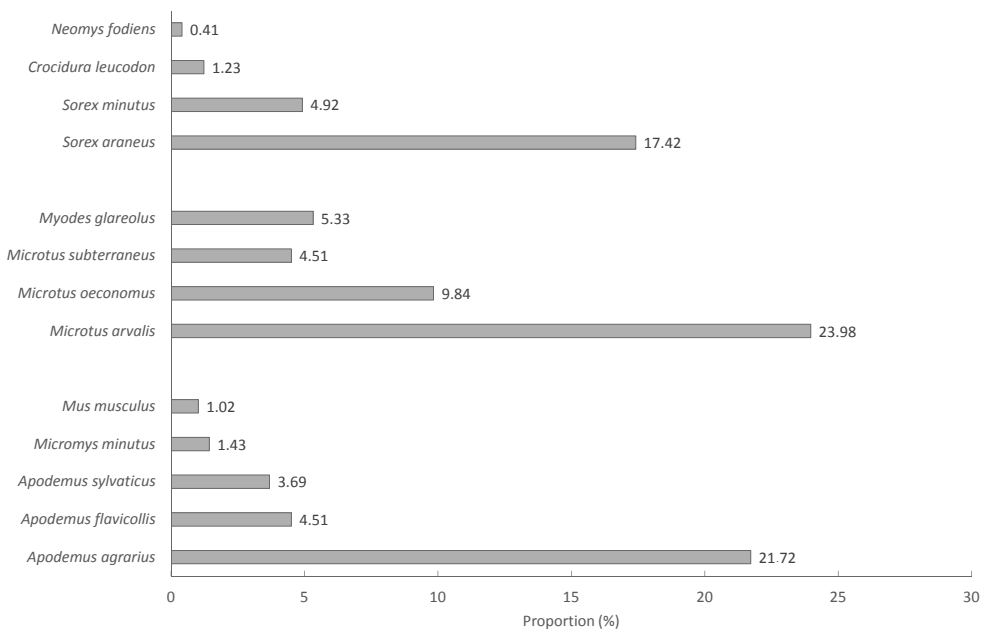

FIGURE 1. Species composition and proportion of species in all xerothermic habitats studied

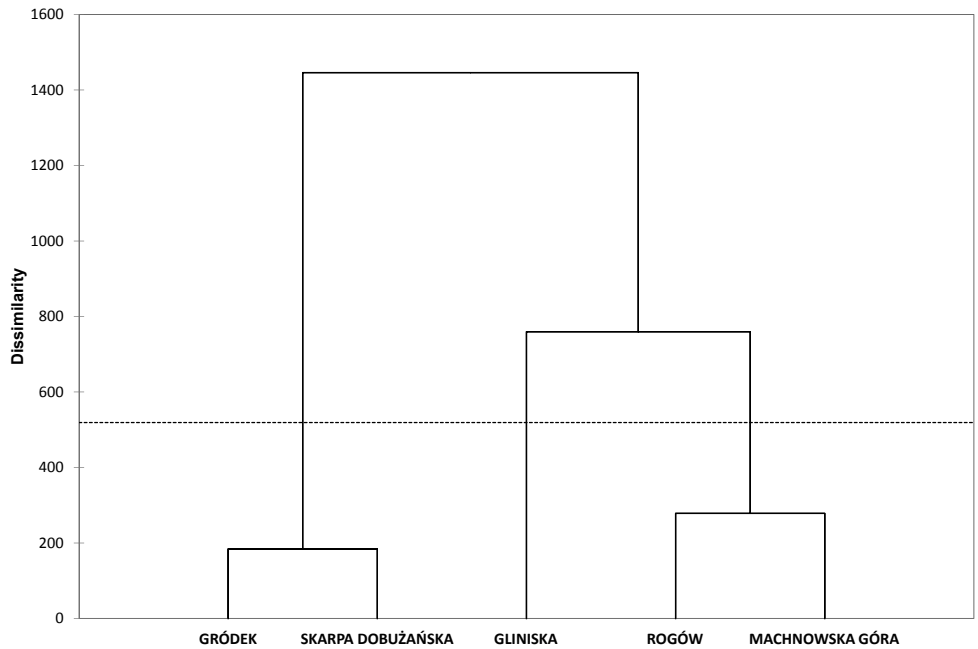

FIGURE 2. Dendrogram of dissimilarity in composition of small mammals' communities in the studied sites (agglomerative hierarchical clustering; dissimilarity – Euclidean distance; agglomeration method – Ward's method)

tion in the community of *S. araneus* and *M. oeconomus*. The second class includes only the Gliniska site, mainly due to the large proportion of *M. arvalis*. The third class includes the Rogów and Machnowska Góra sites, mainly due to the large proportion of *A. agrarius* and *M. arvalis*.

The species richness and diversity index for the surveyed small mammal communities in xerothermic habitats were relatively high: 8 to 11 species were found on each sites, which gave high species diversity index values, from 1.7 to 2.0 (Fig. 3).

DISCUSSION

Xerothermic grasslands are considered as one of the richest plant communities, consisting many protected and rare, often relict species of plants and animals (especially invertebrates). Important group of these habitats is the small mammals, which occur there quite often compared to other habitats studied in the Lublin Region. For the habitats studied in this work, the average capture rate per 100 trap-days was in the range 24.7–50.9 individuals, while for other habitats in nearby regions described in the literature, the capacity was similar or even lower. For example, in the agricultural landscapes of Lublin Upland the number of mammals captured per 100 trap-days was 15–54 (Łopucki et al. 2013). In Roztocze Region, Ziomek (1998) trapped 16.1–31.8 small mammals per 100 trap-days in forest habitats and 10.7–33.3 individuals in open habitats. Of course, these comparisons should be treated cau-

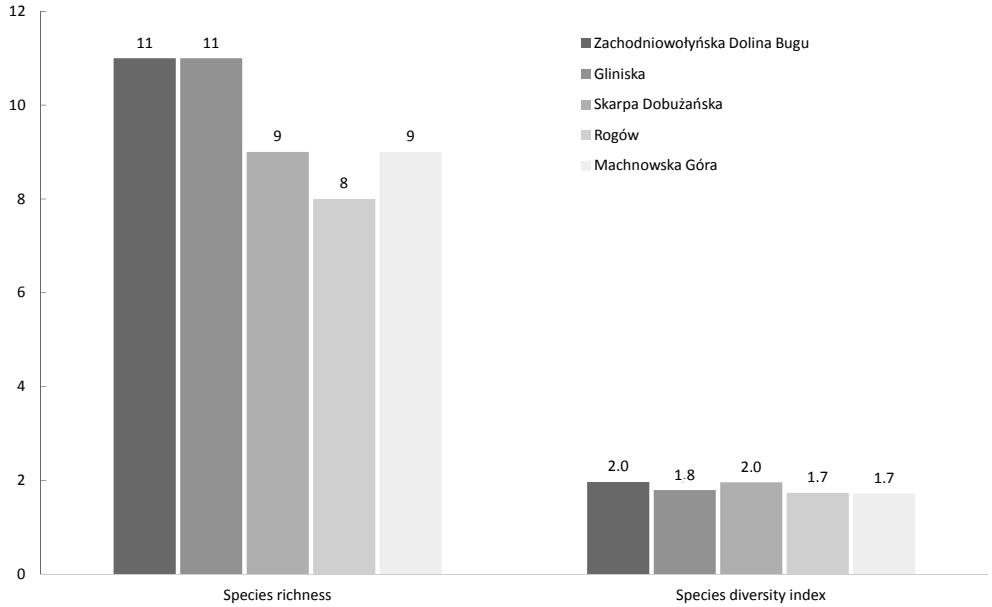

FIGURE 3. Species richness and diversity index of the studied xerothermic habitats

tiously because data presented in different works could have been obtained by various methods and in different seasons. Nevertheless, the presented comparison shows that diverse and abundant small mammal fauna lives in the studied xerothermic habitats. The high species richness (8–11) and species diversity (1.7––2.0) indexes recorded on the studied sites are probably related to the fact that these xerothermic habitats are relatively small in size and most often have an elongated shape, thus the impact of neighbouring habitats is high. For the xerothermic habitats of Roztocze Region, also were found a similar species richness index of 11 and captured species typical for other (mainly forest) habitats (Ziomek 1998).

In our study, the most frequent species captured on all sites were *M. arvalis*, *A. agrarius* and *S. araneus*; these species are typical also in agricultural areas (Gliwicz and Kryštufek 1999, Zima 1999). The proportion of these three species in the small mammal community was 63%. These results partly correspond to the results obtained by Ziomek (1998) for the xerothermic habitats of Roztocze Region, where *M. arvalis* was the dominant rodent species and *S. araneus* was the dominant shrew species; however, the proportion of *A. agrarius* was very low and *M. glareolus* and *A. sylvaticus* were the subdominant species. In our study the smaller proportion of species associated with trees and shrubs, as well as the increased proportion of species typical for open habitats (including arable lands), may be a result of the conservation activity on the studied reserves, including removal of shrubs to maintain their open character (Barańska et al. 2013). Other

species we captured include those whose habitat preferences may also cover the dry open habitats (*C. leucodon*, *S. minutus*, *M. subterraneus* and *A. sylvaticus*), as well as species typical of other, e.g. wet (*M. oeconomus*, *N. fodiens*) or forests habitats (*A. flavicollis*, *M. glareolus*), or synanthropic species (*M. musculus*). The presence of species of humid or forest habitats in xerothermic grassland is caused by the fact that these species are common in the neighbouring habitats (they probably used xerothermic habitats despite other habitat preferences or migrating animals were captured). Such a phenomenon of increased presence of untypical species for xerothermic habitats is particularly visible for the study sites located near river valleys (Skarpa Dobużańska, Zachodniowołyńska Dolina Bugu) of near forests (Rogów).

During our study, we did not catch any southern birch mouse *S. subtilis*, despite the fact that we conducted research in theoretically suitable habitats for it at the right time of the year, and with the recommended trapping methods (Cserkész and Gubányi 2008, Cserkész et al. 2009). This may mean that *S. subtilis*, if it is still present in this area, is an extremely rare species (as was also suggested by Cserkész et al. 2009). The presence of *S. subtilis* in Poland is still waiting for confirmation on the basis of intentionally conducted trapping studies. All current knowledge about this species is based on one accidental capture in 1994 (Baraniak et al. 1998) and bone material from owls' pellets (Cserkész et al. 2009), so it was even impossible to establish the taxonomical position of the Polish population (Cserkész et al. 2016).

CONCLUSIONS

The data presented in this paper are potentially useful for create or update protection plans of the surveyed nature reserves or Natura 2000 sites. Our results contain qualitative and quantitative data on a group of animals that have not been studied before in detail, therefore they expanded the knowledge about the natural value of these reserves. In addition, our data can be used in future research on *S. subtilis*. The trapping effort presented in this paper and lack of success in capturing *S. subtilis* could be an indication that when planning monitoring of this species in the future, much more intense study is needed (many more trapping days should be planned).

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Streszczenie: *Drobne ssaki muraw kserotermicznych w południowo-wschodniej Polsce.* Murawy kserotermiczne są otwartymi siedliskami z bogatą i różnorodną roślinnością trawiastą oraz zielną. Z unikalną roślinnością tych siedlisk powiązane jest także bogactwo faunistyczne, w szczególności dotyczy to stenotopowych bezkręgowców. Fauna kręgowców tych siedlisk jest słabo zbadana. Kręgowcami, które mogą tworzyć specyficzne zespoły gatunków muraw kserotermicznych, są drobne ssaki. Celem pracy było poznanie jakościowej i ilościowej struktury zespołów drobnych ssaków zasiedlających najlepiej zachowane i chronione fragmenty muraw kserotermicznych w południowo-wschodniej Polsce na styku trzech makrore-

gionów geograficznych: Wyżyny Lubelskiej, Wyżyny Wołyńskiej oraz Kotliny Pobuża. Podczas 1558 pułapkodób schwytano 488 drobnych ssaków reprezentujących 13 gatunków. Wykazano, że murawy kserotermiczne mają względnie bogatą faunę drobnych ssaków: bogactwo gatunkowe wyniosło od 8 do 11; wskaźnik różnorodności gatunkowej wyniósł od 1,7 do 2,0, liczba osobników schwytana na 100 pułapkodób wyniosła od 24,7 do 50,9. Najczęściej spotykanymi gatunkami były *Microtus arvalis*, *Apodemus agrarius* i *Sorex araneus*, tj. ssaki typowe również dla obszarów rolniczych. Około 20% schwytanych ssaków reprezentowało gatunki typowe dla innych siedlisk (np. wilgotnych lub leśnych), które sąsiadowały z płatami muraw. Podczas badań nie schwytano smużki stepowej *Sicista subtilis*, co świadczy o tym, że ten ssak o ile jest wciąż obecny w tym rejonie, o tyle jest niezwykle rzadkim gatunkiem. Dane zaprezentowane w niniejszej pracy mogą być użyte do tworzenia i aktualizacji planów ochrony badanych rezerwatów lub obszarów Natura 2000.

Słowa kluczowe: murawy kserotermiczne, drobne ssaki, rezerwaty, Natura 2000

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