

## BIOTOPIC PREFERENCES OF SHREW SPECIES (SORICOMORPHA: SORICIDAE) IN THE REPUBLIC OF MOLDOVA

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### ABSTRACT

Although the shrews are the smallest mammals of the world, they have an important role in nature, being important link within the animal trophic chains. Five shrew species inhabit in Moldova: common shrew (*Sorex araneus*), pygmy shrew (*S. minutus*), bicolored white-toothed shrew (*Crocidura leucodon*), lesser shrew (*C. suaveolens*), water shrew (*Neomys fodiens*) and Mediterranean shrew (*Neomys anomalus*). The studies were performed during 2003-2016 in various types of ecosystems and ecotones on the territory of the republic. 732 shrews from 5 species were collected: 304 common shrews (*Sorex araneus*), 171 pygmy shrews (*S. minutus*), 131 white-toothed shrews (*Crocidura leucodon*), 112 lesser shrews (*C. suaveolens*) and 14 Mediterranean shrews (*Neomys anomalus*). The highest diversity was registered in wet biotopes and their ecotones. The *Sorex* species have significant predilection for the ecotones of wet biotopes, *Crocidura* species – for wet biotopes, forest belts and agrocenoses, while *N. anomalus* – only for wet habitats. The Cluster analysis showed high similarity of shrew communities from paludous biotopes all over the territory of the republic and between various types of ecotones. The highest zonal abundance of all species was registered in the central part. Three species (*C. leucodon*, *N. fodiens*, *N. anomalus*) are included in the Red Book of Moldova.

**Key words:** shrews, ecology, distribution, abundance, dynamics, biotopic predilection, similarity

### Introduction

The shrews (Soricidae, Soricomorpha) are the smallest and short-time living mammals with the life cycle of about one year. This group of great importance for ecosystem functioning was rather poor studied in the Republic of Moldova in comparison with other mammal groups. On the republic territory there are 6 shrew species: common shrew (*Sorex araneus*), pygmy shrew (*S. minutus*), bicolor white-toothed shrew (*Crocidura leucodon*), lesser shrew (*C. suaveolens*), water shrew (*Neomys fodiens*) and Mediterranean water shrew (*N. anomalus*), of which the bicolor, water and Mediterranean shrews are rare species listed in the Red Book of Moldova (10). The water shrew (*N. fodiens*) wasn't recorded in our studies neither in other researchers studies for over 90 years. The species is mentioned only by Brauner (15), after which it was cited as occurring on the territory of the republic even after numerous studies of small mammal fauna (6, 13, 19). But all the researchers that studied the shrew fauna didn't find the water shrew on the republic territory (20, 21, 24).

The studies of shrews started in the 60's of the past century with subsequent publication of a valuable paper (21), which is the only work dedicated exclusively to insectivore species. After that this group study was practically abandoned and till 90's data on shrews can't be found. In the 90's can be found several papers concerning small

mammal fauna, including the shrews (3, 23, 24). After 2000 data on shrew species can be found in some works of general character (4, 5, 6). In the last decade the intense study of shrews was resumed (7, 8, 9, 10, 26 etc.) and data on their faunistics, ecology, biotopic preferences, status can be found.

Shrews are hygrophilous species that occur mostly in wet habitats and near various water basins, but they also inhabit the woods, forest shelter belts and plantations, they can be met in open biotopes and even in anthropogenic ecosystems, such as agricultural, rural or urban ones. The shrews are sensitive to anthropogenic disturbances and can serve as indicators of ecosystem stability.

The paper presents multiannual data on the spreading of the shrews in different types of ecosystems, in the ecotone zone, the biotopic distribution and relative biotopic predilection.

### Materials and methods

The studies have been carried out in 2003-2016 in various types of ecosystems on the whole territory of the Republic of Moldova (fig. 1).

In the northern zone the studies were performed in Sorooca, Râșcani, Briceni, Glodeni, Edineț, Rezina, Drochia, Fălești and Ocnița districts; in the central zone – Chișinău municipality, Orhei, Strășeni, Călărași, Ungheni, Nisporeni, Anenii-Noi and Criuleni districts; in the southern zone – Cimișlia, Ștefan-Vodă, Căușani, Basarabesca, Cantemir, Cahul and Taraclia districts. The

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territories of the reserves „Codri”, „Plaiul Fagului”, „Pădurea Domnească”, „Prutul de Jos” were investigated, as well as anthropogenic ecosystems. The following types of ecosystems were considered: forest, paludous, riparian, agrocoenosis, wet forest, as well as different types of ecotone: forest belt, forest-paludous, forest-agrocoenosis, paludous-agrocoenosis, paludous-grassland, wet ditch.

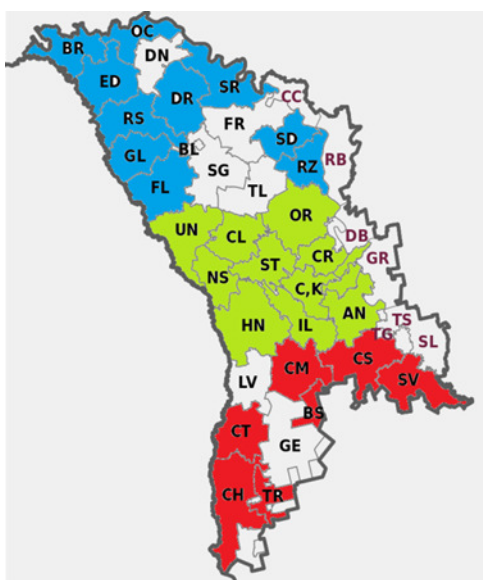


Fig. 1 – Study districts

The material was collected with snap traps, live traps and by collecting dead individuals. The traps were placed in line of 40 to 100 pieces, baited with bread imbued with sunflower oil. All caught individuals were identified, the sex, age and reproductive status were described. The ecological analysis of the material included the indexes of abundance, frequency, similarity (Cluster analysis) and relative biotopic predilection according to formula:

$$I_p = (nb \cdot N - nc \cdot Nb) / (nb \cdot N + nc \cdot Nb - 2nb \cdot Nb),$$

where nb – number of individuals of certain species in a biotope, nc - number of individuals of certain species in all biotopes, Nb - number of individuals of all species in a biotope, N - number of individuals of all species in all biotopes (18). The index value ranges from -1 to 1: if the index value is between 0.31 and 1 the predilection of a species for a biotope is significant, -0.3 – 0.3 the species is indifferent toward a certain biotope, from -0,31 to -1 the species has no predilection for the biotope. The diversity of shrew communities was calculated using Shannon, Simpson and Berger-Parker indexes, the species richness – using Margaleff index.

## Results and discussions

In total 732 shrews from 5 species were collected: 304 common shrews (*Sorex araneus*), 171 pygmy shrews (*S. minutus*), 131 bicolor shrews (*Crocidura leucodon*), 112 lesser shrews (*C. suaveolens*) and 14 Mediterranean water shrews (*Neomys anomalus*). During the whole study period the water shrew wasn't recorded. The most frequent and abundant is the common shrew, recorded in all studied areas and in most ecosystems, followed by the lesser and bicolor shrew. The most rare and less frequent was the Mediterranean shrew, which is a hydrophilous stenotopic species, listed in the Red Book of Moldova (11) as endangered species.

The shrews prefer natural ecosystems that are less affected by anthropogenic activity. Thus, most species and most individuals have been recorded in nature reserves, wet valleys in deep forests, in the abundant aquatic vegetation of water basins, where human access and anthropic activity are limited.

*Sorex araneus* is a common and the most spread species among shrews. It was registered in the majority of studied biotopes, with a frequency of 84% in natural and of 17% in anthropogenic ones. In the southern zone it was found in the reserves Codrii Tigheci, Prutul de Jos (Beleu lake), on the banks of Manta lake and in agrocoenosis nearby, in swamp sectors, wet ditches with hydrophilous vegetation, in reed from lake shore, in woods, in forest belts and at ecotone zone. In the center of the republic the common shrew is widely spread in Codri and Plaiul Fagului reserves in various types of biotopes: in woods, at forest edge, in wet valleys, on the shore of water basins, in swamp sectors, in agricultural ecosystems situated on the reserve territory or nearby. Also, the species was registered in various natural and anthropogenic ecosystems from the central districts, mostly in woods, paludous biotopes (ponds, fish farms, swamp sectors), at forest edge, in shelter belts and in agrocoenosis near water basins. In the northern zone it is widely spread in the reserve Pădurea Domnească in most of studied ecosystems as well as in various biotopes from the northern districts. In general, during the study years the common shrew was the most abundant species in woods, paludous biotopes, wet forests, at the ecotone forest-paludous and forest-agrocoenosis (fig. 2). In previous researches the species was registered as common on the whole territory (14, 21), in forest ecosystems and wet habitats from the reserves Codri (14, 15), Plaiul Fagului (4, 23, 26), Pădurea Domnească (5), in wet biotopes of Prutul de Jos reserve (12, 23), in forest belts (25), in woods (1, 2, 8) and in other types of ecosystems on the whole territory of the republic (7, 9, 19).

*Sorex minutus* is rather spread almost as the common shrew, but is more rare. It prefers the same habitats as the previous species and in the optimal biotopes the pygmy shrew can be even more abundant than the common one. Thus, the species was recorded in all the districts mentioned for the common shrew in most of the ecosystems, but with lower frequency – 68% in wet habitats and only 9% in anthropogenic ones. The pygmy shrew is wide spread in the most ecosystems of the reserves Prutul de Jos, Codri, Plaiul Fagului, Pădurea Domnească. In woods it prefers wet valleys, swamp sectors wet ditch with hygrophilous vegetation, forest edge, more seldom it can be met in forest belts, agrocoenosis and meadows. Unlike the common

shrew, it avoids the recreational sectors. Near the water basins the species is even more abundant than the common shrew. It was registered in agrocoenosis, but only at their ecotone with wet biotopes. In previous studies the pygmy shrew was registered as widespread on the republic territory, but less numerous than the common shrew (14, 21). It was mentioned the species preference for humid forest sectors, for habitats near forest rivulets of the reserves (4, 5, 14, 15, 23, 26), its higher abundance in paludous habitats of Prutul de Jos reserve (12, 23), in forest ecosystems (1, 2, 8), as well as in other types of ecosystems from (9, 19).

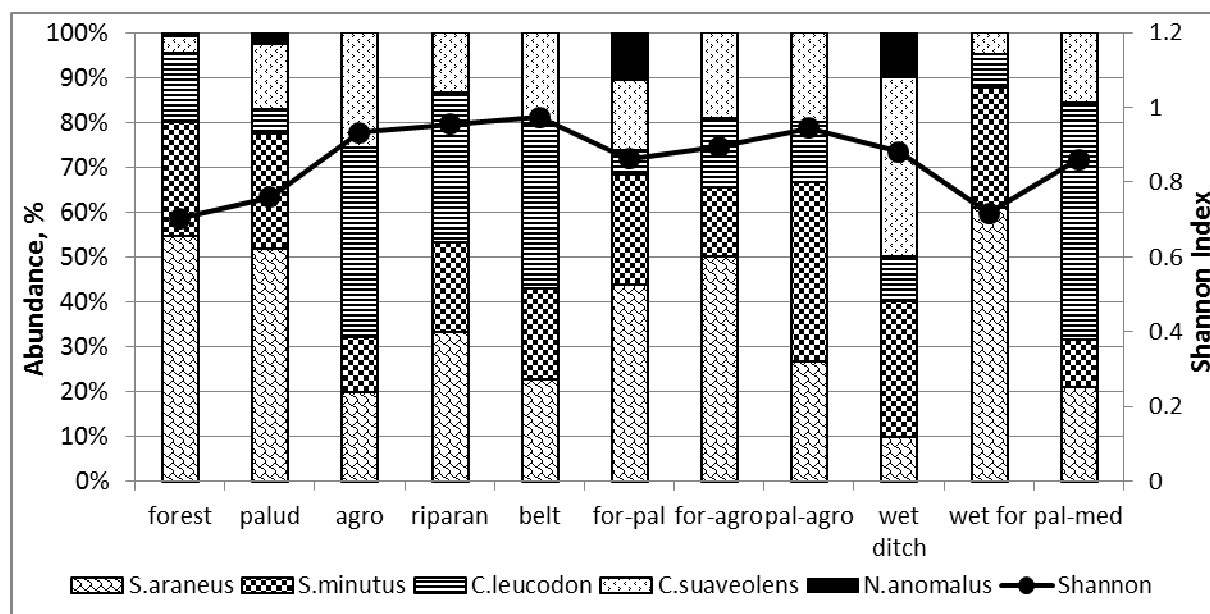


Fig. 2 – Abundance and diversity of shrew communities in various types of ecosystems in 2003-2016

*Crocidura leucodon* is a vulnerable species listed in the Red Book of Moldova (11). Nevertheless, in its preferred habitats it was registered rather frequent (42%). It is a less hygrophilous species in comparison to *Sorex* genus species. The bicolor shrew was also registered in open type and more arid biotopes, such as pastures, meadows, valleys with shrub vegetation. In the southern zone the species was recorded only in forest type ecosystems: woods, forest edge, forest belts and plantations and in humid ditch with hygrophilous vegetation. In the center of the republic the species was abundant in agricultural ecosystems and forest belts, being registered also in various types of ecotones (fig. 2). In the northern zone the bicolor shrew was found mostly in paludous and riparian habitats. In the past century the species was mentioned as very rare (14, 17, 21,

27) registered only in the woods from the central zone. In the last two decades it was found in wet habitats and agrocoenosis from the reserves Plaiul Fagului (4, 23, 26), Pădurea Domnească (5, 23), Prutul de Jos (12), protected areas (Trebujeni, Unguri-Holosnita, La Castel) and in various types of ecosystems from the whole territory of the republic (1, 2, 7, 8, 10, 19).

*Crocidura suaveolens* has the same biotopic preferences as the previous species, but it is more spread and frequent (47%-63%). It was recorded in anthropogenic ecosystems and even in localities, being also called „garden shrew”. In previous studies the species presence is mentioned for the three zone of Moldova (14, 20, 21). In the last decades the species was registered in open biotopes from the reserves (4, 23, 26), as well as in various ecosystems on the whole territory (1, 2, 7, 8, 10, 19).

It is cited as common species in localities (11, 19), where it is dominant and the most spread in urban ecosystems (13).

*Neomys anomalus* is the most hydrophilous species among the shrews from our territory. It is a rare endangered species listed in the Red Book of Moldova (11). It was registered in paludous biotopes, wet ditch with hydrophilous vegetation, in wet valleys from natural woods in the center of the republic and at ecotone forest-paludous biotope, where it was rather abundant (fig. 2). It is the most anthropophobic species among shrews and can serve as indicator of surface water pollution. The Mediterranean shrew was mentioned as rare species in the first studies (17, 20), but later Lozan (21) mention that it is a rather common shrew species in paludous and riparian habitats from central and southern zones, being even more abundant than the common shrew (up to 10% among small mammals in the southern zone). Toward the end of the past century the species became very rare and abundance decreased from 10% in the 1960's to 0.4% in the

90's (3, 24). After 2000 the Mediterranean shrew was registered in small amount in reserves (4, 5, 26) and in wet habitats from several districts of the republic (2, 7).

After analyzing the diversity indexes it was emphasized that the Shannon and Simpson indexes are the highest in riparian biotope, in shelter belts, wet ditch and at the ecotone paludous-agrocoenosis, where the individuals are relatively even distributed among species (tab. 1). The Simpson dominance index is the highest in wood, paludous biotope and wet forest, where all the species are present, but only one dominant and constitute about half of shrew community. Species richness evaluated after Margaleff is the highest in riparian habitats and wet ditch, where the individual number is low, but their distribution among species is even. The Berger-Parker index indicate the highest diversity in wood, paludous and wet forest biotopes, at ecotone paludous-meadow, where 1-2 species dominate and constitute more than 70% of shrews (tab. 1).

**Table 1** - Indexes of diversity and species richness of shrew communities in 2003-2016 in R. Moldova

	wood	paludous	agro	riparian	belt	for-pal	for-agro	pal-agro	wet ditch	wet forest	pal-med
Shannon J'	0.703	0.76	0.932	<b>0.954</b>	<b>0.974</b>	0.863	0.894	<b>0.945</b>	0.881	0.717	0.861
Simpson dom.	<b>0.382</b>	<b>0.357</b>	0.291	0.229	0.26	0.279	0.308	0.273	0.2	<b>0.438</b>	0.322
Simpson div.	2.618	2.804	3.441	<b>4.357</b>	<b>3.839</b>	3.587	3.25	3.667	<b>5</b>	2.284	3.109
Margaleff	1.959	1.687	2.047	<b>3.401</b>	2.079	2.278	2.827	2.42	<b>4</b>	2.48	<b>3.128</b>
Berger-Parker	<b>0.545</b>	<b>0.519</b>	0.422	0.333	0.369	0.439	0.5	0.4	0.4	<b>0.61</b>	<b>0.526</b>

The analysis of relative biotopic predilection for the entire republic territory showed that *S. araneus* has significant predilection for paludous biotopes and wet forest (tab. 2) and by zones it has significant predilection for the ecotone forest-paludous in the south (0,412), for woods (0,36) and paludous biotope (0,38) in the central zone and for the ecotone forest-agrocoenosis in the northern zone (0,34). *S. minutus* has significant predilection for the ecotone paludous-agrocoenosis on the whole territory, for agrocoenosis in the south (0,384), for forest-paludous ecotone (0,347) in the centre and for the ecotones paludous-agrocoenosis (0,521) and paludous-meadow (0,527) in the northern part. *C. leucodon* has significant predilection for agrocoenosis, shelter belts, riparian biotope and

paludous-meadow ecotone (tab. 2) in all studied districts, for woods (0,46), forest belt (0,57) and paludous-agrocoenosis ecotone (0,64) in the south, for agrocoenosis (0,49), riparian (0,329), forest belt (0,359) and paludous-meadow ecotone (0,448) in the center, for paludous (0,42) and riparian (0,63) biotopes in the northern zone. *C. suaveolens* has significant predilection for agrocoenosis and wet ditch on the entire territory, for paludous (0,357) and wet ditch (0,528) in the southern zone, for forest belt (0,318), the ecotones forest-agrocoenosis (0,364) and paludous-agrocoenosis (0,36) in central part, for agrocoenosis (0,656) and paludous-meadow ecotone (0,328) in the northern part. *N. anomalus* has general and zonal significant predilection only for wet habitats (tab. 2)

**Table 2** - Values of relative biotopic predilection index in shrew species on the republic territory

	wood	paludous	agro	riparian	belt	for-pal	for-agro	pal-agro	wet ditch	wet forest	pal-med
<i>S. araneus</i>	0.163	<b>0.373</b>	-0.38	-0.111	-0.32	0,029	0.097	-0.228	-0.615	<b>0.383</b>	-0.233
<i>S. minutus</i>	0.054	0.067	-0.34	-0.079	-0.08	0,027	-0.211	<b>0.385</b>	0.126	0.074	-0.185
<i>C. leucodon</i>	-0.09	-0.122	<b>0.489</b>	<b>0.309</b>	<b>0.41</b>	-0,566	-0.078	-0.154	-0.286	-0.234	<b>0.512</b>
<i>C. suaveolens</i>	-0.709	-0.041	<b>0.397</b>	-0.07	0.159	0,017	0.119	0.143	<b>0.456</b>	0.531	0.016
<i>N. anomalus</i>	-0.423	<b>0.427</b>	-	-	-	<b>0,798</b>	-	-	<b>0.699</b>	-	-

The similarity between shrew communities from various types of biotopes from the northern, central and southern zones was calculated and the Cluster analysis was performed (fig. 3). A separate cluster is formed by the ecotone forest-agrocoenosis, forest belt from the north and forest-paludous ecotone from the south with the highest similarity of over 90%. Another cluster is formed by paludous biotopes from the three zones and forest ecosystems from the center, which had a rich shrew fauna and the similarity of more than 80%. In many cases the biotopes are grouped by zones, which prove the zonal similarity of shrew biotopic distribution. This, a similarity of about 80% was registered between the forest belt and forest-agrocoenosis ecotone from the

northern part (83,33%), between forest belt and agrocoenosis in center (81,48%), between forest and forest belts in the southern zone (78,79%), as well as between the forest ecosystems from the central and northern zones (80,77%) that form a cluster. Another cluster is formed by wet biotopes and their ecotones from the northern and southern zones with a similarity ranging between 70-80%: forest-paludous N – paludous-agrocoenosis N – wet forest S – paludous-agrocoenosis S (fig. 3). The lowest similarity was found between riparian biotopes from the north and south and agrocoenosis from the southern part (less than 60% similarity).

Bray-Curtis Cluster Analysis (Single Link)

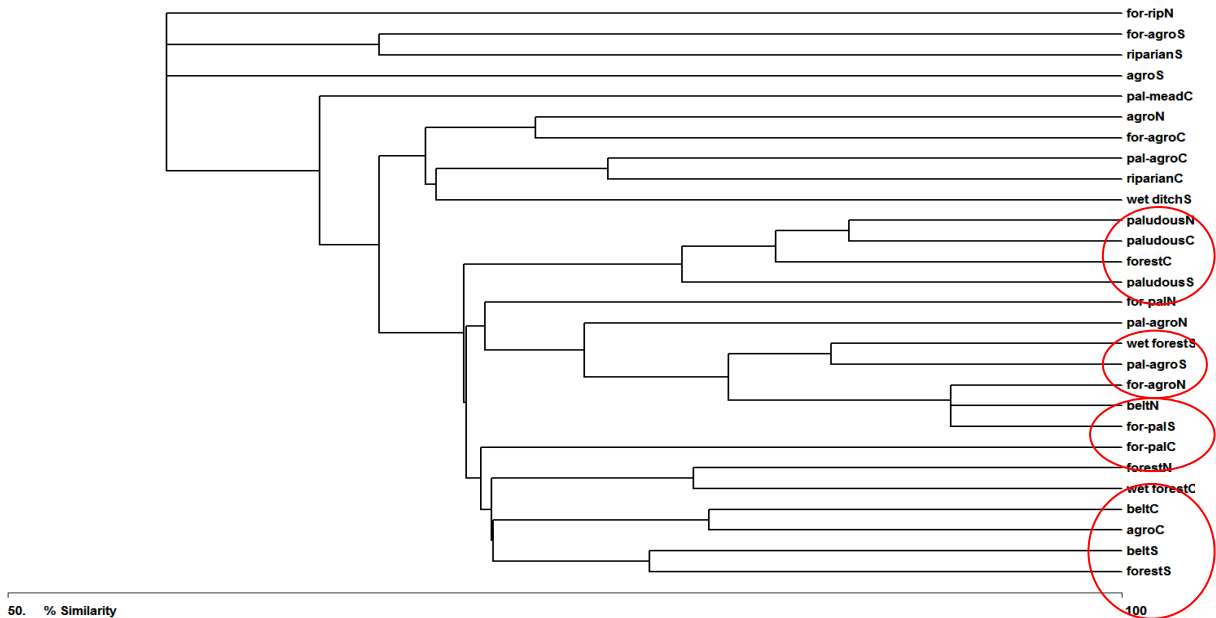


Fig. 3 – Similarity dendrogram of shrew communities in the studied biotopes (N-north, C-center, S-south)

The total zonal abundance of shrew species was assessed (fig. 4). For all the species the highest

abundance was registered in the central part due to the existence of many types of ecosystems

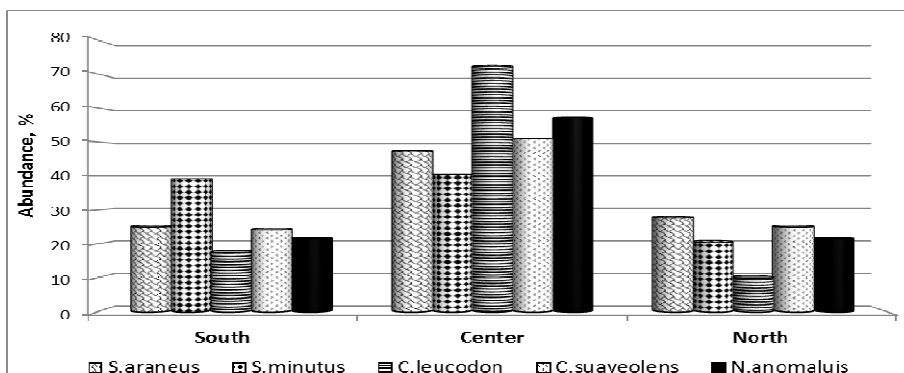


Fig. 4 – Total zonal abundance of shrew species

suitable for shrews: the Codri forest, Orhei forest, reserves, protected areas, various wet and marsh habitats, river meadows. The highest share of bicolor shrew in the center in comparison to northern and southern zones is due to the presence of many open biotopes (pastures, meadows, valleys with shrub vegetation, fallow ground) and forest ecotones. The high abundance of lesser shrew in the central part can be explained by intense studies in urban and rural environment, where this species is rather frequent. The Mediterranean shrew was recorded mostly in the central part, in wet habitats of the reserves and protected areas. In the past century it was extremely abundant in southern part, especially in Prut flooded meadow, where specific floating islands of reed and other aquatic vegetation were formed (21). The lowest abundance of all species was registered in the northern zone, where forests occupy small areas and the aquatic ecosystems are in lower amount. Also, the central part was studied more intense and more data were gathered here, which probably influenced upon the results on zonal distribution of species.

The shrews are important elements of terrestrial ecosystems and can serve as indicators of their functional stability. The rare semiaquatic species are indicators of surface water pollution and their continuously decreasing trend indicate the alarming situation of wet habitats on the entire republic territory.

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### Conclusions

During the study years 732 shrews from 5 species were collected: 304 common shrews (*Sorex araneus*), 171 pygmy shrews (*S. minutus*), 131 white-toothed shrews (*Crocidura leucodon*), 112 lesser shrews (*C. suaveolens*) and 14 Mediterranean shrews (*Neomys anomalus*). The most spread and abundant was the common shrew, the rarest – the Mediterranean water shrew. The highest diversity was registered in wet biotopes and their ecotones. The *Sorex* species have significant predilection for the ecotones of wet biotopes, *Crocidura* species – for wet biotopes, forest belts and agrocenoses, while *N. anomalus* – for wet habitats only. The Cluster analysis showed high similarity of shrew communities from paludous biotopes all over the territory of the republic and between various types of ecotones. Shrew species are good indicators of ecosystem stability, therefore they quickly react to the anthropic climatic changes.

### Rezumat

Cercetările au fost efectuate în anii 2003-2016 în diverse tipuri de ecosisteme și ecotonuri pe teritoriul republicii. În total au fost colectați 732 chițcani din 5 specii: 304 chițcani comuni (*Sorex araneus*), 171 chițcani pitici (*S. minutus*), 131 chițcani de câmp (*Crocidura leucodon*), 112 chițcani de grădină (*C. suaveolens*) și 14 chițcani de mlaștină (*Neomys anomalus*). Cea mai mare diversitate a fost înregistrată în biotopurile umede și ecotonurile acestora. Bogăția specifică este cea mai mare în habitatele riverane și șanțuri umede, unde numărul indivizilor nu este prea mare însă ei sunt repartizați mai uniform pe specii. Speciile gen. *Sorex* au predilecție semnificativă pentru ecotonurile habitatelor umede, cele ale gen. *Crocidura* – pentru habitate umede, perdele forestiere și agrocenoze, iar *N. anomalus* – doar pentru habitate umede. Analiza Cluster a arătat o similaritate mare între comunitățile de soricide din ecosistemele palustre pe tot teritoriul republicii și între cele din diverse tipuri de ecoton. Cea mai ridicată abundență a tuturor speciilor de chițcani a fost semnalată în zona centrală. Speciile de chițcani sunt buni indicatori ai stabilității ecosistemelor, reacționând rapid la modificările antropice și climatice. Trei specii (*C. leucodon*, *N. fodiens*, *N. anomalus*) sunt introduse în Cartea Roșie a Republicii Moldova.

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