Theriologia Ukrainica, **26**: 61–70 (2023)
p-ISSN 2616-7379 • e-ISSN 2617-1120
DOI: 10.53452/TU2607

MORPHOLOGICAL FEATURES OF MICE OF THE GENUS *SYLVAEMUS* UNDER CONDITIONS OF SYNTOPY IN THE EASTERN FOREST STEPPE OF UKRAINE

Oksana Markovska

Key words

Sylvaemus, morphological characters, allotopy, syntopy

doi

http://doi.org/10.53452/TU2607

Article info

submitted 04.09.2023
revised 23.12.2023
accepted 30.12.2023

Language

English, Ukrainian summary

Affiliations

V. N. Karazin National University of Kharkiv (Kharkiv, Ukraine)

Correspondence

Oksana Markovska; V. N. Karazin National University of Kharkiv, 4 Svobody Square, Kharkiv, 61022 Ukraine; Email: ksenia.markovskaia@gmail.com; orcid: 0000-0002-2573-4524

Abstract

The opinion regarding morphological changes in *S. sylvaticus* depending on being in syntopy with the competing sibling species *S. tauricus* is ambiguous. Most authors claim that allotopic and syntopic populations do not differ. Some of them indicate a tendency that the size of *S. sylvaticus* increases in allotopic populations, while others claim that such increase occurs in syntopic populations. There is an assumption that the nature of morphological changes in *S. sylvaticus* undergoes geographic variability and manifests differently in different parts of the range. Overall, the authors suggest that character change is an adaptive response of a subordinate species to the presence of a dominant competitor, so character change as a result of competitive interaction is more likely to occur in *S. sylvaticus* than in *S. tauricus*. The research was conducted in the territory of Kharkiv Oblast, Ukraine. During the observation period, from spring 2017 to autumn 2022, 666 specimens of the genus *Sylvaemus* were caught in 10 selected biotopes. Different types of oak forests, dry and floodplain meadows, riparian vegetation, steppe areas, chalk slopes, field protection forest strips, fields, as well as various ecotones were studied. According to the results of the research, being in syntopy with *S. tauricus*, *S. sylvaticus* has statistically significantly higher average values of parameters of external characters, which largely complicates the identification of these two species in the field. For the most part, confusion in identification occurs in forest biotopes, namely in dry and fresh maple-linden forests. Only two species are found in the studied oak forests in the territory of Kharkiv Oblast—*S. sylvaticus* and *S. tauricus*, whereas *S. uralensis* occurs only on forest edges. And it is in the oak forests that large specimens of *S. sylvaticus* are found, which in habitus closely resemble *S. tauricus*. In open biotopes, *S. sylvaticus* is closer in size to *S. uralensis*, often young or moulting individuals are very similar even in fur colour. Individuals of *S. sylvaticus* with a weakly expressed chest spot, and sometimes barely noticeable, are found in the steppe areas of Kharkiv Oblast. No differences in external characters were found in mice of the genus *Sylvaemus* that inhabit different biotopes, the morphospaces of the samples overlapped in all three species.

Cite as

Markovska, O. 2023. Morphological features of mice of the genus *Sylvaemus* under conditions of syntopy in the eastern forest steppe of Ukraine. *Theriologia Ukrainica*, **26**: 61–70. [In English, with Ukrainian summary]

Особливості морфології мишаків роду *Sylvaemus* в умовах синтопіїї у східному лісостепу України

Оксана Марковська

Резюме. Думка щодо морфологічних змін у *S. sylvaticus* в залежності від перебування в умовах синтопії з конкуруючим видом-двійником *S. tauricus* неоднозначна. Більшість авторів стверджують, що алотопічні та синтопічні популяції не відрізняються. Частина вказує на тенденцію збільшення розмірів *S. sylvaticus* в алотопічних популяціях, частина—на збільшення розмірів в синтопічних популяціях. Існує припущення, що характер морфологічних змін у *S. sylvaticus* зазнає географічної мінливості і проявлятися по різному в різних частинах ареалу. Загалом, автори припускають, що зміна ознак є адаптивною реакцією підлеглого виду на присутність домінуючого конкурента, тому зміна ознак в результаті такої конкурентної взаємодії, швидше за все, відбудеться в *S. sylvaticus*, ніж у *S. tauricus*. Дослідження проводили на території Харківської області України. За період спостережень, з весни 2017 р. по осінь 2022 р., було зловлено 666 представників роду *Sylvaemus* в 10 обраних біотопах. Досліджено різні типи дібров, суходільні та заплавні луки, прибережно-водна рослинність, ділянки степу, крейдяні схили, полезахисні лісосмуги, поля, а також різні варіанти екотонів. За результатами дослідження, перебуваючи в умовах синтопії з *S. tauricus*, *S. sylvaticus* має статиктично значуще більші середні значення показників екстер'єрних ознак, що значно ускладнює ідентифікацію цих двох видів в польових умовах. Здебільшого плутанина в ідентифікації виникає в лісових біотопах, а саме в сухій та свіжій кленово-липовій дібровах. В досліджених дібровах на території Харківщини, зустрічається лише два види—*S. sylvaticus* та *S. tauricus*, *S. uralensis* трапляється лише на узліссях. І саме в дібровах зустрічаються великі екземпляри *S. sylvaticus*, які за габітусом дуже нагадують *S. tauricus*. В відкритих біотопах *S. sylvaticus* за розмірами ближчий до *S. uralensis*, часто молоді або линяючі особини дуже схожі навіть за кольором хутра. В степових районах Харківщини зустрічаються особини *S. sylvaticus* зі слабко вираженою грудною плямою, а іноді й ледь помітною. Відмінностей за екстер'єрними ознаками у мишаків роду *Sylvaemus*, які заселюють різні біотопи не виявлено, морфопростори вибірок перекриваються у всіх трьох видів.

Ключові слова: *Sylvaemus*, морфологічні ознаки, алотопія, синтопія.

Introduction

Mice of the genus *Sylvaemus* live in sympatry in most of their range. Due to their similar habitat requirements, they are not uncommon to be found in the same habitat. Being in syntopy, species compete for shelter and food resources. Thus, interspecific competition and various environmental factors can affect the morphology of wood mice, which is manifested in size variations and fur colouration [Panzironi *et al.* 1993]. The authors also suggest that the combination of these factors may cause morphological convergence in sympatric species to the extent that it leads to mutual camouflage in the same size and general habitus, which will be more adapted to escape from predators.

The value of Hutchinson's index for the group of wood mice *Sylvaemus* reaches *HK* = 1.17 for five craniometric characters of differentiation: condylobasal length of the skull, length of the upper row of molar teeth, length of the auditory bulla, length of the nasal bones, and occipital width of the skull. The Hutchinson's coefficient is below the critical value, which indicates a significant overlap of niches and the presence of competitive relationships between species [Zagorodniuk 2007].

As noted by Barciova & Macholan [2006], among the three species of wood mice (*Sylvaemus uralensis*, *Sylvaemus sylvaticus*, and *Sylvaemus tauricus*), interspecific competition is most pronounced in the *sylvaticus–tauricus* pair. *S. tauricus* is less ecologically plastic and more habitat-specific [Montgomery 1981], behaves as a dominant species [Alcantara 1991] and prefers habitats with old forest stands and dense canopy. Whereas *S. sylvaticus* occurs mostly on forest edges and in open habitats, although under allopatric conditions it is found in large numbers in forests.

For wood mice, Alcantara [1991] and Mikulova & Frynta [2001] suggested that character variation is an adaptive response of a subordinate species to the presence of a dominant competitor, so

character variation due to such competitive interaction is more likely to occur in *S. sylvaticus* than in *S. tauricus*. Changes in characters will primarily affect the general dimensions of the animal, so measurements should focus on the skull and body. In particular, it is worth paying attention to characters related to certain functions, for example, the length of the hind foot and tail in relation to movement and climbing, measurements of teeth in relation to chewing [Mikulova & Frynta 2001; Lashkova & Dzeverin 2004].

Amori & Contoli [1986] for populations from southern Italy showed that *S. sylvaticus* demonstrates an adaptive response to the conditions of syntopy with its sibling species, which is manifested in morphological changes, so that *S. sylvaticus* is potentially larger and *S. tauricus* is smaller in the absence of its competitor. Although Niethammer [1969] reports that allopatric *S. sylvaticus* in Germany and France do not differ in hind foot length, tail length, condylobasal skull length, and upper molar row length from *S. sylvaticus* in sympatry with *S. tauricus*. He also argues that sympatric *S. sylvaticus* do not tend to shift in size toward *S. tauricus*.

A comparison of syntopic and allotopic wood mouse populations was also conducted by Barciova & Macholan [2006] in the Czech Republic. The difference between the four samples (syntopic *S. tauricus*, allotopic *S. tauricus*, syntopic *S. sylvaticus*, and allotopic *S. sylvaticus*) was significant. Out of the selected cranial measurements, only five (brain case height including *bulla tympanica*, upper molar row length, *bulla tympanica* length, lower molar row length, and upper incisor thickness) showed significant differences between syntopic and allotopic populations of *S. tauricus*, with syntopic specimens having higher values than allotopic ones. No significant differences were found between allotopic and syntopic populations in *S. sylvaticus*. The same is noted for *S. sylvaticus* by Alcantara [1991], there is no difference in body size (weight, condylobasal length) between sympatric and allopatric populations of *S. sylvaticus*, but larger sizes are observed mostly in allopatric populations than in sympatric ones. Mikulova & Frynta [2001] also report no difference.

According to the results of geometric morphometry, the average centroid size of individuals from syntopic populations of *S. tauricus* was significantly larger than that of allotopic populations. However, syntopic *S. sylvaticus* were on average also larger than allotopic populations. These differences were significant for dorsal and ventral landmarks [Barciova & Macholan 2006].

The aim of this research is to find out whether the mice of the genus *Sylvaemus* differ in external characters inhabiting different habitats and depending on the level of syntopy in the studied biotopes of the eastern forest-steppe of Ukraine.

Materials and Methods

Micromammals were captured using the trap-line method [Kucheruk 1952; Numerov *et al.* 2010], using Gero traps equipped with standard bait (rye bread crust with unrefined sunflower oil). The traps were placed 5 metres apart in a line. In each habitat, 25, 50, or 100 traps were placed, and the trapping was carried out during one night. Whenever possible, the trapping was carried out three times a year: in spring, summer, and autumn.

The research was conducted from 2017 to 2022. With an effort of 16 510 trap-nights, 666 mice of the genus *Sylvaemus* were caught. Small mammals were captured in four districts (raions) of Kharkiv Oblast of Ukraine, in the vicinities of eight settlements: Bohodukhiv Raion (Guryev Kozachok, and Kolomak), Krasnohrad Raion (Vlasivka, Rozsokhuvata), Chuhuiv Raion (Haidary), and Kupyansk Raion (Krasne Pershe, Nesterivka, and Novomlynsk).

Three metric external characters were selected for analysis: hind foot length (*P*), body length (*L*), and tail length (*C*) [Zagorodniuk 2002]. Ear length (*Au*) was not taken into account in the study as a measurement with a large measurement error and therefore not recommended by the authors for use in the analysis [Barciova & Macholan 2006].

Species diagnostics of the captured specimens was carried out using metric methods with the measurement of a complex of external and craniological characters. Initial identification was based on visual assessment of fur colour, presence and shape of the chest spot, eye diameter, and measurements of body, tail, and hind foot length.

The next step was to measure the length of the upper molar row and the greatest length of the skull [Markovska 2023]. The selected set of characters is usually sufficient for field identification of wood mice [Barkaszi 2018]. The specimens that were questionable were checked in more detail according to a set of significant odontometric and craniological characters [Markovska 2023].

Results and Discussion

During the research period, from spring 2017 to autumn 2022, 666 mice of the genus *Sylvaemus* were caught in 10 studied habitats in Kharkiv Oblast (Table 2): *S. uralensis*—344, *S. sylvaticus*—188, *S. tauricus*—134.

The features of external characters of species in different habitats

The first task was to find out whether mice of the genus *Sylvaemus* that inhabit different biotopes (Table 1) differ in external characters: hind foot length (*P*), body length (*L*), and tail length (*C*) (Table 3). According to the results of the discriminant analysis, the external characters of each species contributed to the distribution in different ways (Table 4):

L > P > C in *S. uralensis*, P > C > L in *S. sylvaticus*, P > L > C in *S. tauricus*.

The correctness of the classification of wood mice by external characters in the studied biotopes in general is 42% for *S. uralensis* (the highest for DM 93%), 37% for *S. sylvaticus* (the highest for FMLF 79%, DM 61%, RV 60%), and 45% for *S. tauricus* (the highest for DMLF 93%, MMLF 50%).

The least variable external characters were: in the RV/FM, RF in *S. uralensis*, in the RV in *S. sylvaticus*, in the MMLF in *S. tauricus*. The morphospaces of the samples in the studied habitats, according to the distribution of external characters, overlap in all three species (Figs. 1–3).

Variability of external characters of species under conditions of syntopy

The next task was to find out whether the external characters of mice of the genus *Sylvaemus* differ depending on the level of syntopy in the studied habitats, that is, depending on the number of species found in the same habitat (one, two, or all three) (Table 5).

Table 1. Investigated biotopes in the vicinities of settlements in Kharkiv Oblast, in which mice of the genus *Sylvaemus* were recorded

Таблиця 1. Досліджені біотопи в околицях населених пунктів Харківської області, в яких зафіксовані мишаки роду *Sylvaemus*

Biotope*	Location**						
	GK	K	V	R	H	D	N
DM	–	21	–	127	25	10	18
RF	–	–	–	–	–	–	37
RV/FM	1	3	9	2	22	33	21
RV	–	16	13	52	–	–	–
DMLF	–	26	23	–	40	14	–
FPS	4	7	–	88	–	1	–
FMLF	–	3	–	–	31	–	–
MMLF	–	–	–	–	4	–	–
DCF	–	–	15	–	–	–	–
Total	5	76	60	269	122	58	–

* *Biotopes*: DM—dry meadows; RF—ravine forest; RV/FM—riparian vegetation/floodplain meadows; RV—riparian vegetation; DMLF—dry maple-linden-oak forest; FPS—field protective forest strip; FMLF—fresh maple-linden-oak forest; MMLF—moist maple-linden-oak forest; DCF—dry coniferous forest.

** *Location*: GK—Guryev Kozachok, K—Kolomak, V—Vlasivka, R—Rozsokhuvata, H—Haidary, D—Dvorichansky National Nature Park (Krasne Pershe, Novomlynsk), N—Nesterivka.

Table 2. The number of caught specimens of the genus *Sylvaemus* in the studied biotopes of Kharkiv Oblast

Таблиця 2. Кількість зловлених представників роду *Sylvaemus* в досліджених біотопах Харківської області

Biotope*	*S. uralensis*	*S. sylvaticus*	*S. tauricus*	Total
DM	150	43	8	201
RF	15	3	19	37
RV/FM	65	20	6	91
RV	39	40	2	81
DMLF	15	29	59	103
FPS	55	27	18	100
FMLF	–	16	18	34
MMLF	–	–	4	4
DCF	5	10	–	15
Total	344	188	134	666

* Biotope designations as in Table 1.

Table 3. Variability of absolute values of the external characters of mice of the genus *Sylvaemus* (min–max, mean in cm, c.v.) in the studied biotopes (the smallest values of the coefficient variation are highlighted in bold)

Таблиця 3. Мінливість абсолютних значень екстер'єрних ознак мишаків роду *Sylvaemus* (min–max, mean в см, c.v.) в досліджених біотопах (жирним виділено найменші показники коефіцієнту варіації)

Character	Biotope*	*S. uralensis*	*S. sylvaticus*	*S. tauricus*
Hind foot length (*P*)	DM	1.70–2.20 1.93 (4.84%)	1.90–2.50 2.10 (6.29%)	2.30–2.70 2.45 (5.77%)
	RF	1.70–2.30 1.95 (7.49%)	–	2.30–2.70 2.56 (4.54%)
	RV/FM	1.70–2.20 1.97 (**4.64%**)	1.80–2.30 2.08 (6.12)	2.40–2.70 2.64 (**4.02%**)
	RV	1.80–2.10 1.97 (4.83%)	1.90–2.40 2.15 (5.96%)	–
	DMLF	1.80–2.00 1.91 (**4.36%**)	1.70–2.50 2.13 (12.17%)	2.30–2.80 2.54 (4.96%)
	FPS	1.60–2.20 1.93 (6.26%)	1.80–2.40 2.06 (7.53%)	2.30–2.70 2.50 (4.75%)
	FMLF	–	2.10–2.50 2.40 (**4.17%**)	2.30–2.80 2.62 (4.95%)
	MMLF	–	–	2.60–2.80 2.73 (**3.51%**)
	DCF	1.80–2.20 2.02 (10.15%)	2.10–2.20 2.13 (**2.27%**)	–
Body length (*L*)	DM	7.00–10.60 8.85 (8.15%)	7.00–10.70 9.39 (**8.24%**)	7.80–10.70 9.86 (9.93%)
	RF	7.70–9.90 8.85 (**7.56%**)	–	7.30–13.50 11.43 (13.25%)
	RV/FM	8.20–10.40 9.27 (**5.59%**)	7.10–11.10 9.57 (10.33%)	9.60–12.70 11.88 (8.51%)
	RV	6.60–9.60 8.57 (8.12%)	7.60–10.60 9.26 (**7.80%**)	–
	DMLF	7.20–9.60 8.49 (8.73%)	7.10–12.10 9.42 (13.38%)	7.90–14.00 11.22 (10.95%)
	FPS	6.10–10.20 8.64 (12.30%)	6.70–11.00 9.19 (12.17%)	9.10–12.30 10.47 (9.81%)
	FMLF	–	8.20–12.20 9.85 (9.00%)	2.30–2.80 2.62 (**4.95%**)
	MMLF	–	–	10.60–11.70 11.13 (**5.00%**)
	DCF	8.20–9.90 9.00 (8.20%)	7.30–10.60 9.25 (11.34%)	–
Tail length (*C*)	DM	4.40–9.40 7.34 (11.27%)	6.30–9.80 7.95 (10.32%)	6.10–10.60 9.29 (15.96%)
	RF	6.60–8.30 7.59 (**7.25%**)	–	7.30–12.50 10.77 (11.56%)
	RV/FM	6.30–9.00 7.63 (7.80%)	7.10–9.10 7.90 (**7.50%**)	9.20–12.60 11.09 (10.36%)
	RV	6.00–8.20 7.20 (10.28%)	6.00–8.70 7.49 (**9.31%**)	–
	DMLF	5.90–8.90 7.49 (10.09%)	6.00–10.90 8.23 (15.03%)	7.20–12.30 10.47 (**10.14%**)
	FPS	4.70–9.40 7.16 (15.09%)	5.50–10.20 7.82 (15.59%)	8.30–12.10 10.03 (12.54%)
	FMLF	–	7.20–10.50 9.14 (11.04%)	6.40–12.80 10.81 (12.79%)
	MMLF	–	–	9.30–10.60 10.00 (**5.72%**)
	DCF	6.90–8.20 7.48 (**6.84%**)	5.90–8.90 7.76 (11.89%)	–

* Biotope designations as in Table 1.

Table 4. Summary of the analysis of discriminant function of external characters of mice of the genus *Sylvaemus* in the studied biotopes (statistically significant values are highlighted in bold)

Таблиця 4. Резюме аналізу дискримінантної функції екстер'єрних ознак мишаків роду *Sylvaemus* в досліджених біотопах (жирним виділено статистично значущі значення)

Species	External character*	Wilks' Lambda	Partial Lambda	F-remove (6.331)	p-level	Toler.	1-Toler. (R-Sqr.)
S. uralensis	*P*	0.88	0.96	2.30	**p < 0.05**	0.87	0.13
	L	0.92	0.92	4.62	**p < 0.001**	0.52	0.48
	C	0.87	0.97	1.73	p > 0.1	0.52	0.48
S. sylvaticus	*P*	0.75	0.78	8.27	**p < 0.001**	0.66	0.34
	L	0.64	0.92	2.65	**p < 0.05**	0.46	0.54
	C	0.70	0.84	5.84	**p < 0.001**	0.41	0.59
S. tauricus	*P*	0.84	0.86	3.40	**p < 0.01**	0.64	0.36
	L	0.76	0.96	0.97	p > 0.1	0.40	0.60
	C	0.75	0.97	0.68	p > 0.1	0.45	0.55

* *P*—hind foot length, *L*—body length, *C*—tail length.

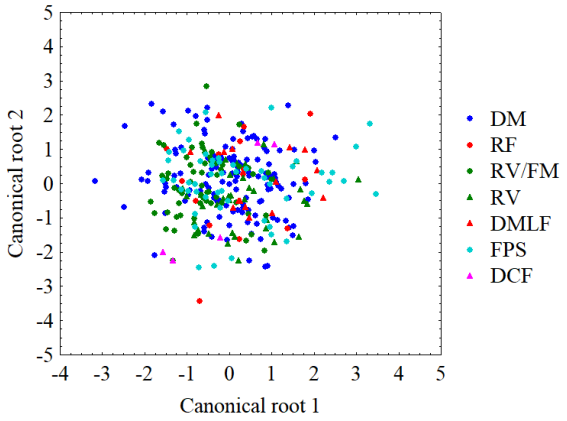

Fig. 1. Distribution of *S. uralensis* based on external characters in the studied biotopes according to the first two canonical roots.

Рис. 1. Розподіл *S. uralensis* за екстер'єрними ознаками в досліджених біотопах у просторі значень першої і другої канонічних змінних.

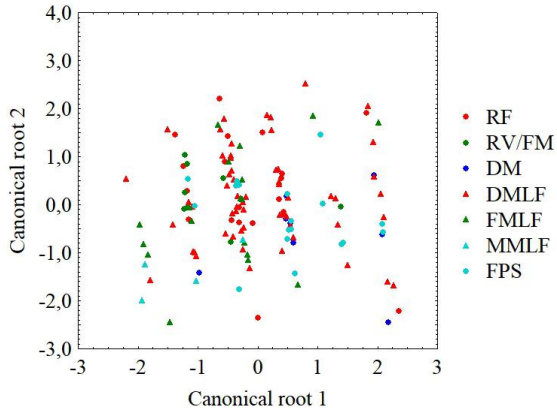

Fig. 2. Distribution of *S. tauricus* based on external characters in the studied biotopes according to the first two canonical roots.

Рис. 2. Розподіл *S. tauricus* за екстер'єрними ознаками в досліджених біотопах у просторі значень першої і другої канонічних змінних.

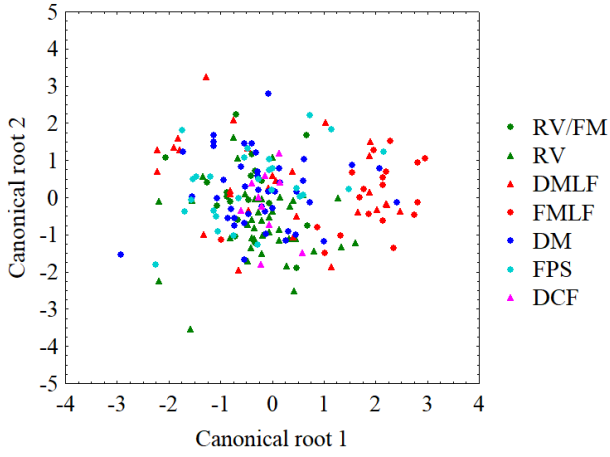

Fig. 3. Distribution of *S. sylvaticus* based on external characters in the studied biotopes according to the first two canonical roots.

Рис. 3. Розподіл *S. sylvaticus* за екстер'єрними ознаками в досліджених біотопах у просторі значень першої і другої канонічних змінних.

The external characters of each species contributed to the distribution in the same way as in the previous analysis, with the hind foot length and tail length contributing the most (Table 6). The correctness of the classification of individuals by external characters depending on the level of syntopy in the studied habitats is 46% for *S. uralensis* (the highest for US 87%), 55% for *S. sylvaticus* (the highest for SU 73%, ST 69%), 46% for *S. tauricus* (the highest for UST 97%). The least variable external characters were in the UT sample of *S. uralensis* and in the TU sample of *S. tauricus*.

Morphospaces of the samples depending on the level of syntopy in the studied habitats, according to the distribution of external characters, overlap in all three species (Figs 4–5), but in *S. sylvaticus* the ST sample stands out (Fig. 6), (Table 7).

It should be noted that the greatest confusion in identification occurs in forest habitats, namely in dry and fresh maple-linden-oak forests. In the studied oak forests in Kharkiv Oblast, only two species are found—*S. sylvaticus* and *S. tauricus*, whereas *S. uralensis* occurs only on the edges.

And it is in the oak forests that large specimens of *S. sylvaticus* are found, which are very similar in habitus to *S. tauricus*. Although the figures do not fully reflect it, in open habitats *S. sylvaticus* is closer to *S. uralensis* in absolute size, often young or moulting individuals are very similar even in fur colour. In the steppe regions of Kharkiv Oblast, *S. sylvaticus* individuals with a weakly expressed—and sometimes barely noticeable—chest spot are found. Although *S. sylvaticus* shows such trends in size changes towards *S. tauricus* and *S. uralensis*, the difference between the syntopic samples with these species is statistically significant (Table 8).

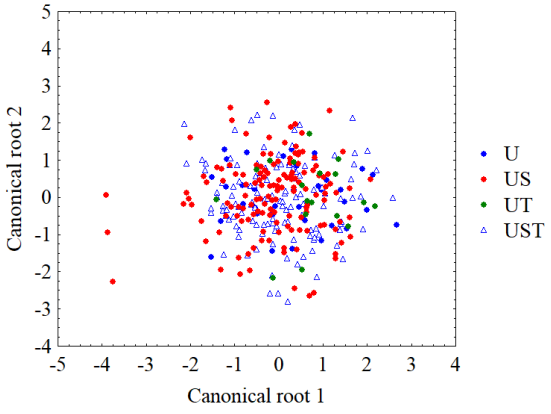

Fig. 4. Distribution of *S. uralensis* based on external characters depending on the level of syntopy according to the first two canonical roots.

Рис. 4. Розподіл *S. uralensis* за екстер'єрними ознаками в залежності від рівня синтопії у просторі значень першої і другої канонічних змінних.

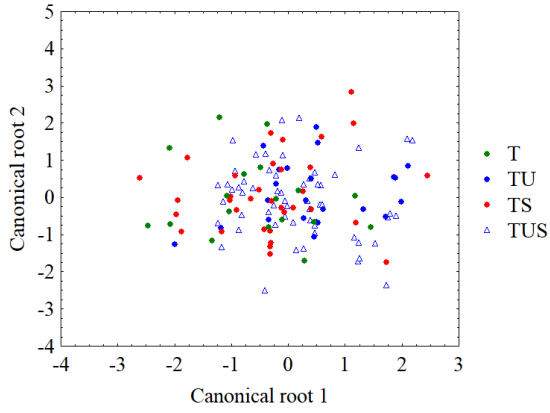

Fig. 5. Distribution of *S. tauricus* based on external characters depending on the level of syntopy according to the first two canonical roots.

Рис. 5. Розподіл *S. tauricus* за екстер'єрними ознаками в залежності від рівня синтопії у просторі значень першої і другої канонічних змінних.

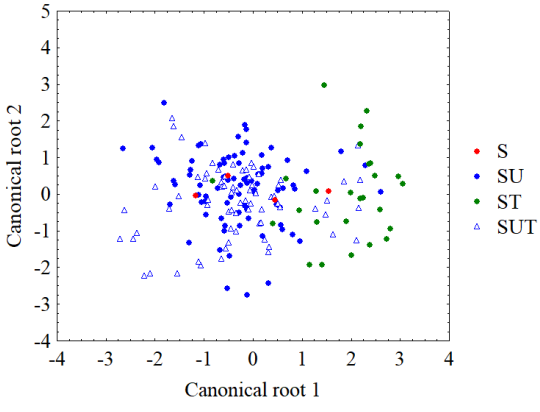

Fig. 6. Distribution of *S. sylvaticus* based on external characters depending on the level of syntopy in the studied biotopes according to the first two canonical roots.

Рис. 6. Розподіл *S. sylvaticus* за екстер'єрними ознаками в залежності від рівня синтопії в досліджених біотопах у просторі значень першої і другої канонічних змінних.

Table 5. Variability of absolute values of the external characters of mice of the genus *Sylvaemus* (min–max, mean in cm, c.v.) depending on the level and combination of syntopy in the studied biotopes

Таблиця 5. Мінливість абсолютних значень екстер'єрних ознак мишаків роду *Sylvaemus* (min–max, mean в см, c.v.) в залежності від рівня і варіантів синтопії в досліджених біотопах

Character	Syntopy*	*S. uralensis*	*S. sylvaticus*	*S. tauricus*
Hind foot length (*P*)	U, S, T	1.60–2.20 1.93 (6.60%)	2.00–2.30 2.10 (6.73%)	2.40–2.80 2.62 (4.82%)
	US, SU, TU	1.70–2.20 1.94 (4.88%)	1.80–2.50 2.10 (6.47%)	2.30–2.80 2.50 (5.39%)
	UT, ST, TS	1.80–2.00 1.93 (**3.07%**)	2.10–2.50 2.40 (**4.33%**)	2.30–2.80 2.59 (**4.79%**)
	UST	1.70–2.30 1.95 (5.66%)	1.70–2.40 2.09 (8.19%)	2.30–2.70 2.53 (5.00%)
Body length (*L*)	U, S, T	6.10–10.10 8.73 (11.08%)	8.90–9.70 9.25 (**3.69%**)	9.10–14.00 11.46 (11.80%)
	US, SU, TU	7.40–10.60 8.93 (**7.59%**)	7.00–11.10 9.46 (9.20%)	9.10–12.70 10.98 (**9.28%**)
	UT, ST, TS	7.30–9.90 8.44 (8.43%)	8.10–12.20 9.99 (10.41%)	7.90–13.10 11.41 (9.65%)
	UST	6.60–10.40 8.85 (9.27%)	6.70–11.00 9.11 (10.43%)	7.30–13.50 10.92 (12.36%)
Tail length (*C*)	U, S, T	4.70–8.50 7.32 (11.73%)	7.10–9.30 8.40 (11.21%)	8.90–12.60 10.63 (9.40%)
	US, SU, TU	5.10–9.40 7.40 (11.09%)	5.90–10.20 7.90 (**10.11%**)	8.20–12.20 10.35 (**8.94%**)
	UT, ST, TS	5.50–8.90 7.34 (**10.90%**)	7.20–10.90 9.12 (12.16%)	6.40–12.80 10.63 (12.04%)
	UST	4.40–9.20 7.35 (11.14%)	5.50–10.30 7.65 (12.88%)	6.10–12.50 10.33 (13.20%)

* U—*S. uralensis*; S—*S. sylvaticus*; T—*S. tauricus*.

Table 6. Summary of the analysis of discriminant function of external characters of mice of the genus *Sylvaemus* depending on the level of syntopy in the studied biotopes (statistically significant values are highlighted in bold)

Таблиця 6. Резюме аналізу дискримінантної функції екстер'єрних ознак мишаків роду *Sylvaemus* в залежності від рівня синтопії в досліджених біотопах (жирним виділено статистично значущі значення)

Species	Exterior character*	Wilks' Lambda	Partial Lambda	F-remove (6.331)	p-level	Toler.	1-Toler. (R-Sqr.)
S. uralensis	*P*	0.97	1.00	0.32	p > 0.1	0.86	0.14
	L	1.00	0.97	3.70	**p < 0.05**	0.51	0.49
	C	0.98	0.99	1.40	p > 0.1	0.51	0.49
S. sylvaticus	*P*	0.76	0.80	15.54	**p < 0.001**	0.74	0.26
	L	0.63	0.95	3.28	**p < 0.05**	0.50	0.50
	C	0.64	0.94	4.12	**p < 0.05**	0.47	0.53
S. tauricus	*P*	0.96	0.93	3.40	**p < 0.05**	0.63	0.37
	L	0.90	0.99	0.37	p > 0.01	0.38	0.62
	C	0.90	0.99	0.29	p > 0.1	0.42	0.58

* *P*—hind foot length, *L*—body length, *C*—tail length.

The opinion on morphological changes in *S. sylvaticus* depending on syntopy with the competing sibling species *S. tauricus* is ambiguous. Most authors argue that allotopic and syntopic populations do not differ [Niethammer 1969; Alcantara 1991; Mikulova & Frynta 2001; Barciova & Macholan 2006]. Some point to a tendency to increased size in allotopic populations [Amori & Contoli 1986], others to increased size in syntopic populations. There is an assumption that the nature of morphological changes in *S. sylvaticus* is subject to geographical variability and manifests itself differently in different parts of the range. It is also worth remembering that the pair of *sylvaticus*–*tauricus* is characterised by opposite clinal size variability, which also leaves its mark on the nature of morphological changes [Filippucci *et al.* 1989].

In this study, *S. sylvaticus* tended to increase in size in syntopic populations with *S. tauricus*, as observed in oak forests. The ST samples were statistically significantly different from the others in terms of the mean values of all external characters, especially in the hind foot length (Table 7). In terms of body and tail length, only the difference with the allotopic sample was not statistically significant. In European syntopic populations of *S. sylvaticus*, changes also occur in body and skull measurements, especially hind foot length, tail length, and tooth length [Mikulova & Frynta 2001].

Table 7. Mahalanobis distances (D_M) among the syntopic samples of *S. sylvaticus* by external characters

Таблиця 7. Дистанції Махаланобіса (D_M) між синтопічними вибірками *S. sylvaticus* за екстер'єрними ознаками

Exterior character D_M / p-values	Sample	S	SU	ST	SUT
Hind foot length (*P*)	Mean	2.10 cm	2.10 cm	2.40 cm	2.09 cm
	S	–	0.9876*	0.0002	0.9424*
	SU	0.0001	–	0.0000	0.8550*
	ST	4.0372	4.0694	–	0.0000
	SUT	0.0014	0.0009	4.1880	–
Body length (*L*)	Mean	9.25 cm	9.46 cm	9.99 cm	9.11 cm
	S	–	0.6581*	0.1371*	0.7735*
	SU	0.0514	–	0.0111	0.0199
	ST	0.6433	0.3309	–	0.0000
	SUT	0.0219	0.1405	0.9026	–
Tail length (*C*)	Mean	8.40 cm	7.90 cm	9.12 cm	7.65 cm
	S	–	0.2880*	0.1466*	0.1158*
	SU	0.2972	–	0.0000	0.0971*
	ST	0.6129	1.7638	–	0.0000
	SUT	0.6582	0.0708	2.5415	–

* $p > 0.1$.

Table 8. Comparison of external characters of mice of the genus *Sylvaemus* by Student's *t*-test in syntopic samples US–SU (top of the table) and ST–TS (bottom of the table)

Таблиця 8. Порівняння екстер'єрних ознак мишаків роду *Sylvaemus* за *t*-критерієм Стьюдента в синтопічних вибірках US–SU (верхня частина таблиці) та ST–TS (нижня частина таблиці)

External character	Mean US	Mean SU	t-value	df	p	Std. Dev. US	Std. Dev. SU	F-ratio Variances	p Variances
P	1.94	2.10	-10.37	234	**p < 0.001**	0.09	0.14	2.05	0.0001
L	8.93	9.46	-5.20	234	**p < 0.001**	0.68	0.87	1.65	0.008
C	7.40	7.90	-4.51	234	**p < 0.001**	0.82	0.80	1.06	0.79
External character	Mean ST	Mean TS	t-value	df	p	Std. Dev. ST	Std. Dev. TS	F-ratio Variances	p Variances
P	2.40	2.59	-6.47	58	**p < 0.001**	0.10	0.12	1.43	0.36
L	9.99	11.41	-5.06	58	**p < 0.001**	1.04	1.10	1.12	0.78
C	9.12	10.63	-4.78	58	**p < 0.001**	1.11	1.28	1.33	0.46

P—hind foot length, *L*—body length, *C*—tail length. Statistically significant values are highlighted in bold.

Conclusions

1. No differences in external characters were found in mice of the genus *Sylvaemus* inhabiting different habitats; the morphospaces of the samples overlap in all three species.

2. Depending on the level of syntopy in the studied biotopes, according to the distribution of external characters, the sample of *S. sylvaticus* in syntopy with *S. tauricus* stands out noticeably.

3. Being in syntopy with *S. tauricus*, *S. sylvaticus* has statistically significantly higher mean values of body measurements.

Acknowledgements

I sincerely thank I. Zagorodniuk for discussing research materials and editing the manuscript. This study was carried out as part of the doctoral research project 'Peculiarities of relationships and the problem of determining the species affiliation of wood mice of the genus *Sylvaemus* in conditions of sympatry.'

References

Alcantara, M. 1991. Geographical variation in body size of the wood mouse Apodemus sylvaticus L. *Mammal Review*, **21**: 143–150. CrossRef

Amori, G., L. Contoli. 1994. Morphotypic, craniometric and genotypic diversification in Apodemus flavicollis and Apodemus sylvaticus. *Italian Journal of Zoology*, **61** (4): 353–357. CrossRef

Barciova, L., M. Macholan. 2006. Morphometric study of two species of wood mice Apodemus sylvaticus and A. flavicollis (Rodentia: Muridae): traditional and geometric morphometric approach. *Acta Theriologica*, **51** (1): 15–27. CrossRef

Barkaszi, Z. 2018. Sibling mice species of the genus Sylvaemus Ognev, 1924 (Mammalia, Rodentia) in the Ukrainian Carpathians. *The Journal of V. N. Karazin Kharkiv National University. Series Biology*, **31**: 59–71.

Filippucci, M. G., S. Simson, E. Nevo. 1989. Evolutionary biology of the genus Apodemus Kaup, 1829 in Israel. Allozymic and biometric analyses with description of a new species: Apodemus hermonensis (Rodentia, Muridae). Italian *Journal of Zoology*, **56** (4): 361–376. CrossRef

Kucheruk, V. V. 1952. Quantitative registration of the most important species of harmful rodents and shrews. *Methods of Accounting for the Number and Geographical Distribution of Terrestrial Vertebrates.* USSR Academy of Sciences, Moscow, 9–46. [In Russian]

Lashkova, E. I., I. I. Dzeverin. 2004. The possible role of interspecific competition in the formation of specific geographic ranges in wood mice Sylvaemus (Rodentia, Muridae). *Vestnik zoologii*, **38** (6): 41–46. [In Russian]

Markovska, O. 2023. Identification of species of the genus Sylvaemus of north-eastern Ukraine by metric characters. *Theriologia Ukrainica*, **25**: 68–86. CrossRef

Mikulova, P., D. Frynta. 2001. Test of character displacement in urban populations of Apodemus sylvaticus. *Canadian Journal of Zoology*, **79**: 794–801. CrossRef

Montgomery, W. I. 1981. A removal experiment with sympatric populations of Apodemus sylvaticus (L.) and A. flavicollis (Melchior) (Rodentia, Muridae). *Oecologia*, **51**: 123–132. CrossRef

Niethammer, J. 1969. Zur frage der introgression bei den walmäusen Apodemus sylvaticus und A. flavicollis (Mammalia, Rodentia). *Zeitschrift für Zoologische Systematik und Evolutionsforschung*, **7**: 77–127. CrossRef

Numerov, A. D., A. S. Klimov, E. I. Trufanova. 2010. *Field studies of Terrestrial Vertebrates.* Voronezhsky State University, Voronezh, 1–301. [In Russian]

Panzironi, C., G. Cerone, M. Cristaldi, G. Amori. 1993. A method for the morphometric identification of southern Italian populations of Apodemus (Sylvaemus). *Hystrix, the Italian Journal of Mammalogy*, **5** (1–2): 1–16.

Zagorodniuk, I. 2002. *Field Key to Small Mammals of Ukraine.* National Museum of Natural History, NAS of Ukraine, Kyiv, 1–60. (Series: Proceedings of the Theriological School; Vol. 5). [In Ukrainian]

Zagorodniuk, I. 2007. Conflict through coincidence of niches in sibling species: estimation using Hutchinsonian ratio. *Scientific Bulletin of Uzhhorod University, Series Biology*, **20**: 5–13. [In Ukrainian]