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SIBLING SPECIES OF MICE FROM EASTERN EUROPE: TAXONOMY, DIAGNOSTICS AND DISTRIBUTION

(Presented by Academician of the NAS of Ukraine V. A. Topachevskii)

Mouse-like rodents in East-European fauna include two groups of sibling-species: group «Apodemus sylvaticus» (auct.) is presented by three species — S. sylvaticus L., S. arianus Blanf., and S. uralensis Pall.; group Mus musculus (auct.) is presented by two species, M. musculus L. and M. spicilegus Pet. Type samples of all East-European taxa are revised, and lists of species synonyms are compiled (among them, microps Krat. et Ros. = S. uralensis Pall., fulvipectus Ogn. & falzfeini Mezh. et Zag. = S. arianus Blanf., sergii Valh = Mus spicilegus Meh., hortulanus Nordm. = M. musculus L.). Species geographical ranges are described, and key to their diagnostics using morphological characters are proposed. General trends in geographical distribution as well as in ways of taxonomic and morphological differentiation of the groups are discussed.

The investigation deals with the two groups of related species regarded traditionally as the taxa of specific rank, namely, «*Apodemus sylvaticus*» and «*Mus musculus*» sensu lato. Progress in the taxonomy of these groups has been achieved by comparative genetic analysis. It appears that both groups are represented in Eastern Europe by several genetically distinct forms. In accordance with the concept of biospecies, these forms should be considered reproductive isolated species. The further investigations demonstrated that the «*sylvaticus*» group includes three taxa of specific rank: *sylvaticus* (s. str.), *microps*-like species and a new species described as «*A. falzfeini*» [1]. The «*musculus*» group also consists of a few forms («house», «steppe», and «mound» mice), and is divided into two species: *M. musculus* and *M. «hortulanus»* [2]. Other representatives of these groups, namely, *Mus domesticus* among commensal house mice and *Sylvaemus alpicola* among Carpathian populations of wood mice, were not recorded in the studied region [3, 4].

Plenty of the described and mentioned forms, wide morphological variability and complicated structure of their taxonomic relations as well as the extremely intricate taxonomic history of both groups have required many private investigations stated in a number of special publications. The aim of the present paper is to synthesize and to make more precise modern data on sibling mice species taxonomy, morphology, and biogeography.

Materials and methods. Collection materials preserved in the museums of Kyiv, Tartu and Moscow Universities, Institutes of Zoology in Kyiv, Brno and Krakow as well as own collections were examined in the course of our investigations. The primary stage of the study includes accumulation of genetically (electrophoresis) identified material and its comparative morphological analysis. The following stage deals with the revision of both original and museum collections and with the determining species ranges. All species characteristics (measurements, coloration) were taken from adult specimens; the measurement scheme included 4 external and 8 cranial measurements following [5]. Mean values of all measurements and their standard deviations ($M \pm SD$) were calculated for each sample. The Mayr's coefficient of divergence (*CD*) was applied to statistical comparison of the samples (see [5]). Geographical areas of the species were underlined by their marginal records. Only the names of East-European taxa were mentioned in the synonymy.

Taxonomy

Checklist of East-European taxa. Problems of supraspecific taxonomy as well as comments to the original descriptions of the East-European Muridae were presented earlier [6]. The list of East-European forms traditionally included into «*Apodemus sylvaticus*» and «*Mus musculus*» (s. lato) are given in Table 1. Type specimens of the analyzed taxa are deposited in the Ukrainian Natural History Museum (UNHM), Zoological Institute of Russian AS (ZIN) and Zoological Museum of Moscow University (ZMMU). Results of their identification are given in Table 1. Type series of «*Mus sylvaticus* Lin.» (Swed. Mus. Nat. Hist., Stockholm), «*Apodemus microps* Krat. et Ros.» (former Inst. Syst. Ecol. Biol., Czech AS, Brno), «*Mus arianus* (= *erythronotus*) Blanf.» (Brit. Mus. Nat. Hist., London) and «*A. falzfeini* Mezh. et Zag.» (UNHM) were used as the standard. Because of the lack of type materials (types unknown) of *Mus musculus* Lin. and *M. spicilegus* Pet., identification of the forms from these groups was carried out by means of their comparison with genetically typed samples.

«Sylvaticus» group. Wood mice are regarded here as a separate genus *Sylvaemus* Ognev, 1923, contrary to *Apodemus* Kaup [6]. This point of view was first established in the original description of *Sylvaemus;* the type species of this genus must be designated as «*Mus sylvaticus* L.» sensu Ognev, 1923 = *Sylvaemus sylvaticus mosquensis* (Ognev, 1913) = *Mus sylvaticus* var. *uralensis* Pallas, 1811 = *Sylvaemus uralensis* (Pallas) [7]. The «*sylvaticus*» group is represented in Eastern Europe by three species. Our systematic revision resulted in the changing of their taxonomic status and nomenclature. According to the results of re-identification of their «subspecies», East-European «*sylvaticus*» must be designated as: Wood mice *S. sylvaticus* (s. str.) L., Pallasian mice *S. uralensis* Pall. (= *microps* Krat. et Ros.), Steppe mice *S. arianus* Blanf. (= *fulvipectus* Ogn., = *falzfeini* Mezh. et Zag.) (see: Table 1).

«Musculus» group. Being of great practical importance, this group is an object of intensive faunistic, taxonomic and experimental investigations. The traditional subdivision of the East-European *Mus* into four taxa — house «*musculus*», garden «*hortulanus*», steppe «*wagneri*», and mound «*sergii*» (the latter form is sometimes was designated as «*hortulanus*») — should be rejected. New developments in the taxonomy (see [8]) have confirmed some earlier views, especially viewpoint of Migulin [9]. All wild mice are identical to the commensal populations and only the mound mice can be considered as a distinct species [2]. The «*domesticus*»-like form (with a long tail and dark-colored belly) are most probably absent in Eastern Europe. The common name *hortulanus* Nordm. is a synonym of *M. musculus* L., according to the original description [6].

At the same time, *M. sergii* Valh is a valid name for all East-European mound mice, and this taxon should be regarded as a subspecies of *M. spicilegus* Pet. (Table 2). Thus, two *Mus* species inhabit Eastern Europe, *M. musculus* (type of genus) and *M. spicilegus* [4] (Fig. 1).

Table 1. Wood and house mice taxa from Eastern Europe and their re-determination

Year	Name	Author	Locality	Museum [1)]	Identification
«*sylvaticus*» group:					
1811	*uralensis*	Pallas	Rossia, South Ural	(UNHM)	*microps* auct.
1913	*mosquensis*	Ognev	Rossia, Moscow	ZMMU	*uralensis*
1924	*fulvipectus*	Ognev	Georgia, Dusheti	ZMMU	*arianus*
1924	*ciscaucasicus*	Ognev	N-Osetia, Vladikavkaz	ZMMU	*uralensis*
1929	*baessleri*	Dahl	Ukraine, Crimea Mts	(UNHM)	*uralensis*
1936	*charkovensis*	Migulin	Ukraine, Kharkiv	UNHM	*sylvaticus*
1936	*saxatilis*	Sviridenko	Ingushetia, Nazran	ZMMU	*arianus*
1936	*planicola*	Sviridenko	Rossia, Stavropolie	(UNHM)	*?arianus*
1938	*vohlynensis*	Migulin	Ukraine, Zhytomyr	UNHM	*sylvaticus*
1952	*microps*	Krat. et Ros.	Slovakia, Koshice	(IESB)	*uralensis*
1989	*falzfeini*	Mezh. et Zag.	Ukraine, Askania-Nova	UNHM	*arianus*
1993	*sabinae*	Zag. et Fed.	Romania, Dobrudja	UNHM	*sylvaticus*
«*musculus*» group:					
1840	*hortulanus*	Nordmann	Ukraine, Odessa	ZIN	*musculus* [2)]
1882	*spicilegus* [3)]	Petenyi	Hungary, Bucharest	—	*sergii* auct.
1912	*sareptanicus*	Hilzheimer	Rossia, Volgograd	(ZMMU)	*musculus*
1924	*borealis*	Ognev	Rossia, Kareliya	ZMMU	*musculus*
1924	*funereus*	Ognev	Rossia, Voronezh	ZMMU	*musculus*
1927	*hapsaliensis*	Reinwaldt	Estonia, Haapsalu	ZMTU	*musculus* [4)]
1927	*sergii*	Valh	Ukraine, Donetsk	UNHM	*spicilegus*
1930	*formosovi*	Heptner	Daghestan, Akhty	ZMMU	*musculus*
1934	*polonicus*	Niezabitowski	Poland, Krakow?	(ISEA)	*musculus* [4)]
1934	*nogaiorum*	Ognev	Daghestan, Kizlyar	ZMMU	*musculus*
1938	*arenarius*	Migulin	Ukraine, Gola Prystan'	(UMNH)	*musculus*

[1)] names of museum in parenthesis mean that type specimens are unknown, and just topotypes were analysed; [2)] the name «*Mus nordmanni* Keys. et Blas.» is the objective synonym; [3)] Petenyi describes in the same article 5 other species of *Mus* (see [4]); [4)] both taxa are established as subspecies of *M. spicilegus*.

Table 2. Taxonomy and synonymy of the East-European wood and house mice

Sylvaemus sylvaticus (sensu lato)			*Mus musculus* (sensu lato)		
S. sylvaticus (s. str.)	*S. uralensis* (= microps)	*S. arianus* (steppe)	*M. musculus* (commensal)	*M. musculus* (wild)	*M. spicilegus* (mound)
1. *charkovensis*	1. *mosquensis*	1. *fulvipectus*	1. *borealis*	1. *hortulanus*	1. *sergii*
2. *vohlynensis*	2. *baessleri*	2. *saxatilis*	2. *funereus*	2. *sareptanicus*	
3. *sabinae*	3. *ciscaucasicus*	3. *?planicola*	3. *hapsaliensis*	3. *formosovi*	
	4. *microps*	4. *falzfeini*	4. *polonicus*	4. *nogaiorum*	

Diagnostics

"Sylvaticus" group. East-European species of this group are characterized by a small body and skull size, when compared to all other *Sylvaemus* (*tauricus*, *alpicola*, *ponticus*, *hyrcanicus,* etc.). Moreover, East-European populations of these species have the smallest body and skull size in respect to the conspecific populations from other regions: *S. sylvaticus* increases in size westward, *S. uralensis* and *S. arianus* eastward. Some measurements of East-European *Sylvaemus* are given in Table 3. Diagnostic characters of the «*sylvaticus*» group are the following. Body length is usually 80 to 100 mm; foot length is less than 23,5 mm, the boundary between back and belly coloration is vague, skull length up to 24 mm, teeth row length up to 4.0 mm, chest spot is small (tie-like) or absent; the key to their diagnostics is given below.

"Musculus" group. *Mus spicilegus* never lives in houses; in contrary, *M. musculus* never builds mounds. The former species has a smaller body and skull size and is characterized by some juvenile peculiarities. Additional diagnostic characters were revealed by the investigation of the skull fine morphology [2, 7]. Among the different measurements, body and feet lengths seem to be the most demonstrative (Table 3). Investigation of genetically marked samples allows us to found new non parametric characters with high diagnostic value [4]. Among them, the inclination of M^1 to diastema as well as the relative size of M^3 should be mentioned.

Key to the species diagnostics

Sylvaemus sylvaticus group:

1 (2). Body size is relatively large: foot length commonly 21 to 23 mm, ear length exceeds 15 mm, foramina incisive large (5 to 6 mm), upper teeth row length 3.6 to 4.0 mm ..... *S. sylvaticus*

2 (1). Foot commonly is less than 21 mm, ear length up to 15 mm, foramina incisive length less than 5 mm, teeth row up to 3.7 mm ..... (3)

3 (4). Chest spot is absent, tail length shorter than that of body, teeth row short, 3.0–3.5 mm, postpalatine incisure rounded ..... *S. uralensis*

4 (3). Chest spot is tie-like, tail longer than body; teeth row relatively long, 3.5–3.7 mm, postpalatine incisure Π-shaped ..... *S. arianus*

Mus musculus group:

1 (2). Anterior part of the cheek-bone arc is broad, 1.5 to 2 times as wide as the zygomatic process, M^3 1.5 to 2 times as small as M^2; anterior surface of M^1 makes an obtuse angle to diastema due to outgrowth of anterior root of M^1 ..... *M. musculus*

2 (1). Both anterior cheek-bone part and zygomatic process are delicate, M^3 is a little bit smaller than M^2, anterior front of M^1 is perpendicular to diastema ..... *M. spicilegus*

Distribution

Wood mice. The taxonomic splitting of «*Apodemus sylvaticus*» into three independent species demands a revision of traditional views on the biogeography of wood mice. New investigations demonstrated that the range of *S. sylvaticus* s. str. is more limited than considered earlier: it was recorded in the Eastern Europe only for the southern Belarus', Ukraine, and Moldova [7]. In all these countries, it has an extensive sympatry zone with *S. uralensis*. The latter is widely distributed in all eastern regions traditionally included in the range of *S. sylvaticus* auct. In the steppe zone, both species are substituted by *S. arianus*. In order to demonstrate the common trends in spatial taxonomic differentiation, all species ranges are compared to those of vole's sibling species.

Table 3. Body and skull measurements of East-European species of the «*Sylvaemus sylvaticus*» and «*Mus musculus*» group (*M*±*SD*) with the levels of their distinction (*CD**)

Measurements	*Sylvaemus*					*Mus*		
	sylvaticus	*CD*	*uralensis*	*CD*	*arianus*	*musculus*	*CD*	*spicilegus*
Body:								
Body length	89.5±6.72	0.7	84.7±7.93	-0.1	85.6±5.13	83.2±7.98	**3.3**	63.3±2.86
Tail length	85.3±8.35	0.5	81.4±6.46	-1.3	89.3±5.43	66.4±5.68	1.3	60.8±2.13
Foot length	21.2±0.82	1.1	20.2±1.03	-0.3	20.4±0.41	16.9±0.88	**2.1**	15.3±0.51
Ear length	16.7±1.51	**2.3**	13.5±1.32	-0.7	14.2±0.55	12.9±0.52	1.9	11.5±0.89
Skull:								
Condylobasal length	22.9±0.84	1.6	21.7±0.64	-0.6	22.0±0.28	19.9±1.12	1.3	18.8±0.58
Zygomatic breadth	11.6±0.58	**3.0**	10.3±0.23	**-2.7**	11.3±0.47	10.4±0.48	1.9	9.7±0.28
Braincase height	9.1±0.24	**2.5**	8.5±0.24	0.5	8.4±0.15	7.2±0.15	0.7	7.1±0.15
Braincase breadth	10.8±0.31	1.8	10.3±0.23	-1.0	10.5±0.16	9.3±0.16	0.5	9.2±0.20
Molar row length	3.7±0.09	**3.4**	3.3±0.14	**-3.4**	3.7±0.09	3.2±0.08	-0.7	3.3±0.11
Diastema length	6.7±0.34	-0.6	6.9±0.35	**3.5**	5.9±0.21	5.4±0.31	1.7	5.0±0.24
Bullae length	4.8±0.13	1.5	4.6±0.14	-0.8	4.7±0.12	4.2±0.21	-0.4	4.3±0.11
Foram. incis. length	5.2±0.20	**2.5**	4.6±0.28	1.3	4.3±0.19	5.2±0.38	1.6	4.8±0.11
Specimens**	n=15	(1,8)	n=20	(1,4)	n=9	n=14	(2,0)	n=12

* *CD*>2 is bolded; ** samples: *S. sylvaticus* from the eastern Ukraine (types of *charkovensis*), *S. uralensis* from Russia (ssp. *mosquensis* from the Tver reg.), *S. arianus* from the southern Ukraine (types of *falzfeini*); *M. musculus* from the southern Ukraine (topotypes of *hortulanus*), *M. spicilegus* from the South-East of Ukraine (topotypes of *sergii*).

Sylvaemus sylvaticus (Linnaeus, 1758) was described from Uppsala (Sweden); it includes *vohlynensis* from N-Ukraine, *charkovensis* from E-Ukraine and *sabinae* from NE-Rumania. The eastern-most records are known from Lietuva, the Minsk region of Belarus', western regions of Russia (Tver and Belgorod) and eastern Ukraine (the Kharkiv, Donetsk, Zaporozhie, Kherson regs.) (Fig. 1). The species is dominant in flood plains and agriculture fields. Generally, the type of its range is similar to that of typical «European» (nemoral) species, i. e., 52-chromosome *Terricola subterraneus* and 46-chromosome *Microtus arvalis* (s. str.).

Sylvaemus uralensis (Pallas, 1811) is well known as «*Apodemus microps*» and includes the majority of East-European «*sylvaticus*», i.e. *mosquensis* from Central Russia, *baessleri* from the Crimea, *ciscaucasicus* from the Northern Caucasus. It is the most wide-spread *Sylvaemus* species, and its range includes a great part of former Soviet Union [1]. Recently this species was identified in the Baltic region [10], Caucasus [11], and the European part of Russian Federation [10]. Contrary to the wood and steppe mice, *S. uralensis* is abundant in the forest and mountain regions; its range is similar to that of *M. rossiaemeridionalis*.

Sylvaemus arianus (Blanford, 1881) was described from the Persia and up-to-date it was considered as wood mouse subspecies [see: 12], whilst earlier Sviridenko [13] considered it a separated species, *S. fulvipectus*. Specific rank was established recently, when the species was described as a new one, «*Apodemus falzfeini*» [1]. *S. arianus* includes also *saxatilis* Svir., and probably, *planicola* Svir. The area of its distribution covers the steppe zone of Ukraine (including the Crimea) and the Northern Caucasus. The western border of its range is limited by the Dnieper. The form *falzfeini* should be regarded as the marginal westernmost subspecies distinguished by the smallest body size. Patterns of its range generally correspond to those of steppe vole, *Microtus (Sumeriomys) socialis*.

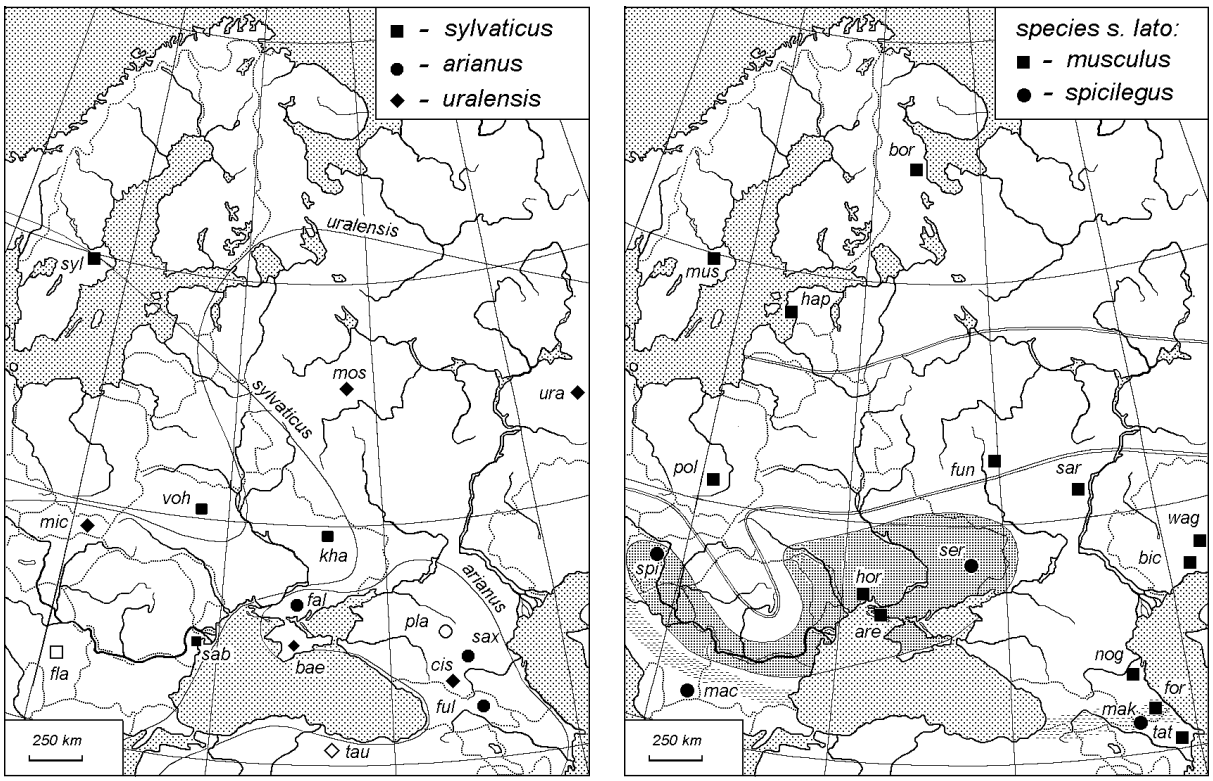

Fig. 1. Geographic distribution of *Sylvaemus* (left) and *Mus* (right; after [4]) species in Eastern Europe. Type locality names are abbreviated with three first characters of the taxa names.

***A**: «sylvaticus»* group: taxa — *baessleri, falzfeini, flaviventris, fulvipectus, kharkovensis, microps, mosquensis, sabinae, ciscaucasicus, saxatilis, sylvaticus, tauricus* (B.-H.), *uralensis, vohlynensis*.

***B**: «musculus»* group: northern border of *musculus* seasonal and round-the-year exoanthropic populations (double lines), zone of *musculus—domesticus* intergradation (shaded area), and area of mound mouse distribution (i. e. *Mus spicilegus* s. str., excl. pair *Mus macedonicus+makovensis* which is considered an independent species); taxa — *bicolor*, *borealis*, *formosovi*, *funereus*, *hapsaliensis*, *hortulanus*, *macedonicus*, *makovensis*, *musculus*, *nogaiorum*, *polonicus*, *sareptanicus*, *sergii*, *spicilegus*, *tataricus*, *wagneri*.

House mice are the most common representatives of Muridae in many regional faunas, either wild or synanthropic. Wild populations are known from southern regions of Eastern Europe, where both species form a wide sympatry zone and often occur in the same biotope, especially in agriculture lands [14].

Mus musculus Linnaeus, 1758 was described from Uppsala (Sweden) and includes *funereus* from the Voronezh region of Russia, *hapsaliensis* from Lietuva and *hortulanus* from the Odessa reg. of Ukraine (see Table 1). This species is widely distributed all over Eastern Europe, but only in the South (first of all in the Crimea), in deltas of the large rivers (Danube, etc.) and rice fields it forms really wild populations.

Mus spicilegus Petenyi, 1882 was described from the Pannonian Lowland in Hungary. The species is represented in the studied region by the subspecies *sergii* Valh described from the Donetsk reg. of Ukraine. It is distributed in the steppe zones of Moldova and Ukraine, northward to the Chernivtsy, Vinnitsia, Cherkassy, Poltava and Kharkiv reg.; eastward up to the Donetsk reg.; southward to the Black and Azov seas coast, including the steppe part of the Crimea. It is recorded also in the Rostov reg. of Russia near the boundary of Ukraine [15]. In Eastern Europe, *M. spicilegus* is spatially separated from *M. macedonicus* (the latter inhabits the Transcaucasia and the Balkans). New mounds may not be built every year.

Conclusion. Systematic revision of polytypic East-European mice species allows us to establish two sibling complexes, one among wood mice («*sylvaticus*» group, 3 species) and another among house mice («*musculus*» group, 2 species). Each polytypic group includes several species with different levels of phylogenetic and morphological distinction. Each sibling complex includes one more distinct species and a pair of allospecies: *Sylvaemus uralensis* against the *sylvaticus* + *arianus* pair, *Mus spicilegus* against the *musculus* + *domesticus* pair. Within each group, the similar trends take place: increase in body sizes, well-sculptured skull, expression of coloration, and increase in ecological flexibility (Table 4).

These rows are the followings:

uralensis < *arianus* < *sylvaticus* in «*Sylvaemus sylvaticus*» group,

spicilegus < *musculus* in «*Mus musculus*» group.

The correspondence between their ontogenesis and phylogenesis testify a predominance of acceleration in the evolution of the groups, i. e. support the views on the evolution within these groups by «anaboly type» of phylembryogenesis [2–5].

Table 4. Morphological and ecological differentiation of «*sylvaticus*» and «*musculus*» species

Characters	*Sylvaemus*					*Mus*		
	uralensis	dif	*arianus*	dif	*sylvaticus*	*spicilegus*	dif	*musculus*
Body measurements	smaller	<	middle	<	larger	smaller	<	larger
Fur coloration	non bright	<	middle	<	bright	feeble	<	intensive
Skull maturity	juvenile	<	middle	<	senile	juvenile	<	senile
Ecological flexibility	minimal	=	minimal	<	maximal	minimal	<	maximal
Taxonomic diversity	middle	=	middle	<	large	smaller	<	larger

The taxonomic history analysis has shown that all «new» species were considered earlier: all new taxonomic descriptions are synonyms of some oldest taxa. Among them, there are *sergii* (1927) = *spicilegus* (1882), *microps* (1952) = *uralensis* (1811) and *falzfeini* (1989) = *fulvipectus* (1924) = *arianus* (1881). Only a half of all known intraspecific taxa of the traditional species (i. e., *sylvaticus*, *musculus*) are identical to the Linnaean species, other forms correspond to new species. The species studied should be identified by their morphological characters, and they can not be considered as sibling species in the strong respect. All of them have distinctions in the fine morphology, skull and body measurements and fur coloration.

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Резюме

Zagorodnyuk I. V. **Sibling species of mice from Eastern Europe: taxonomy, diagnostics and distribution.** ***Reports Natl. Acad. Sci. Ukr.*** **1996. N 12. P. 166-173.**

Загороднюк І. В. **[Види-двійники мишей у Східній Європі: таксономія, діагностика та поширення] // Доповіді НАН України. — 1996. — № 12. — С. 166–173. —** У складі східноєвропейської фауни виявлено два комплекси видів-двійників мишоподібних гризунів: група «*Apodemus sylvaticus*» (auct.) представлена трьома видами — *S. sylvaticus* L., *S. arianus* Blanf., *S. uralensis* Pall.; група *Mus musculus* (auct.) — видами *M. musculus* L. та *M. spicilegus* Pet. Ревізовані типові матеріали всіх східноєвропейських форм, складено списки їх синонімів *(серед інших, microps Krat. et Ros. = S. uralensis Pall., fulvipectus Ogn. & falzfeini Mezh. et Zag. = S. arianus Blanf., sergii Valh = Mus spicilegus Meh., hortulanus Nordm. = M. musculus L.).* Описано видові ареали та запропоновано ключі для їх діагностики за морфологічними ознаками. Обговорюються загальні тенденції у географічному поширенні та напрямках таксономічної і морфологічної диференціації видів.

P.S. файл не звірено з оригіналом