

The Vole Species *Microtus arvalis* and *Microtus rossiaemeridionalis* in the Urals: Hybridization in the Wild

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Many details of distribution patterns of the vole species *Microtus arvalis* Pallas, 1779, and *Microtus rossiaemeridionalis* Ognev, 1924, in their sympatry area remain unclear [1]. Until recently, the Ural region has been poorly studied in this respect [2]. However, this region is of interest in view of at least two aspects that may be important in terms of the problem of distribution of sibling species from the *M. arvalis* group with different chromosomal sets. First, the eastern border of the basic range of *M. rossiaemeridionalis* is located in the Urals or at a short distance to the east of the Urals (probably, the *M. rossiaemeridionalis* that are sporadically found in eastern Siberia and which have been brought there accidentally by trains) [1]. Second, the habitats of small mammals are considerably contaminated with radioactive and chemical pollutants in many localities of the Urals. In view of these two factors, we analyzed our own data and the data available from literature on the distribution of *M. arvalis* s. lato in the Middle and South Urals. Species were identified by their chromosomal sets. Radiometric and radiochemical analyses were conducted by SGSK Radon (the project was headed by M.A. Izyumov) and the Department of Radiochemistry, Ural State Technical University–Ural Polytechnical Institute.

In 1992–1998, we studied voles in 14 localities in the area located between 51°08' and 57°21' N, 53°28' and 61°14' E. The data on sampling localities and the number of karyotyped animals from two sibling species are shown in the table. As is seen from the table, both species were mainly sampled in open biotopes, which agrees with the data obtained by Bol'shakov and Berdyugin, who described *M. arvalis* s. lato in the southern taiga subzone of the Urals [3], as well as with the data on other regions [4]. *M. arvalis* was observed in 13 localities, and *M. rossiaemeridionalis* was only found in five localities. Malygin [5] reported on nine more localities in the area studied; *M. arvalis* and *M. rossiaemeridio-*

nal were observed in seven and three of these localities, respectively. Malygin observed one locality shared by both sibling species, and we detected four such localities. In all cases, voles belonging to different species were caught at neighboring sites.

Thus, *M. arvalis* was found in 20 out of 23 localities studied in the Urals. *M. rossiaemeridionalis* was considerably rarer, although any conclusion on its absence in many localities would be premature because too few individuals were karyotyped. Nevertheless, the available data allow us to conclude that *M. arvalis* is prevalent in the Middle and South Urals, which is likely to be related to the proximity of the eastern boundary of the *M. rossiaemeridionalis* range.

Our data confirm the tendency of both species to synanthropy, which is more marked in *M. rossiaemeridionalis* [6]. This species was only found in the localities affected by anthropogenic pressure. In most of these localities, the radiation factor is of considerable importance: a conservation site of thorium-containing wastes is located at the left bank of the Iset' River near the Biological Station of the Ural State University; Kristalka and Starobogdanovka are situated within the Totskoe zone of radioactive contamination; the radiation environment of Ozernyi is unfavorable and requires special description.

The radiation hazard of Ozernyi is primarily determined by an increase in the content of radium, thorium, and uranium (tens and hundreds times higher than the background radiation) in natural media, including soil. A high soil-air concentration of radon (up to 300000 Bq/m³) is especially important for voles, who mainly live underground. Moreover, the environs of Ozernyi are contaminated with thorium of industrial origin. The content of ⁹⁰Sr and ¹³⁷Cs in the soil did not exceed global levels. The background γ -radiation was 107 μ R/h in this sampling locality. Note that the aforementioned natural radioactive elements and some products of their decay produce α -radiation, and the incorporation of even small quantities of these elements may result in local intracellular doses of 0.5 Gy [7].

The voles studied were captured within an area of 300 m² that was covered with open birch forest and weeds and was surrounded by a zone of technogenic

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Species identification and characteristics of sampling localities of the voles of the *M. arvalis* group in the Middle and South Urals (all *M. arvalis* voles belonged to form "obscurus," $2n = 46$, $NF_A = 68$)

Sampling locality	Geographical coordinates	Biotope	Species (sample size)
Visimskii Reserve, Sverdlovsk oblast	57°28' N, 59°30' E	Vegetable gardens	<i>M. arvalis</i> (two males)
Predural'e Natural Preserve, Kungur raion, Perm' oblast	57°23' N, 57°11' E	Upland meadow	<i>M. arvalis</i> (five males and one female)
Vicinity of Ozernyi settlement, Rezh raion, Sverdlovsk oblast	57°19' N, 61°14' E	Open birch forest with ruderal species	<i>M. rossiaemerdionalis</i> (two males and one fe- male) and <i>M. arvalis</i> (one male, one female, and one female of F ₁)
Vicinity of Shalya settlement, Shalya raion, Sverdlovsk oblast	57°17' N, 58°45' E	Forb-gramineous meadow	<i>M. arvalis</i> (one male and five females)
Vicinity of Talitsa village, Nizhne- serginskii raion, Sverdlovsk oblast	56°52' N, 58°45' E	Gramineous herb meadow	<i>M. arvalis</i> (two males and seven females)
Southern suburb of Yekaterinburg, Botanical Garden, Ural Division, Russian Academy of Sciences	56°48' N, 60°40' E	Wet forb-gramineous meadow with ruderal species	<i>M. rossiaemerdionalis</i> (16 males and 13 females)
Right bank of the Iset' River, Biological Station, Ural State University, Sysert' raion, Sverdlovsk oblast	56°35' N, 61°07' E	Sides of fields and field roads	<i>M. arvalis</i> (16 males and 31 females)
Left bank of the Iset' River, 5 km from the Biological Station, Ural State Uni- versity, Sysert' raion, Sverdlovsk oblast	56°37' N, 61°08' E	Forb-gramineous meadow	<i>M. arvalis</i> (one male and four females)
East Ural Reserve and its vicinities; Chelyabinsk oblast	55°47'–55°50'N, 60°55'–61°00' E	Pine plantations, aspen forest, and waste land (former village) with the predominance of ruderal species	<i>M. arvalis</i> (16 males and 23 females)
Arkaim Reserve, Chelyabinsk oblast	52°37' N, 59°33' E	Thickets of pea shrub, wild almond, and cherry on the slopes of hills	<i>M. arvalis</i> (5 females)
Kristalka village, Krasnogvardeisk raion, Orenburg oblast	53°00' N, 53°28' E	Meadows: gramineous with the presence of burdocks and forb gramineous	<i>M. rossiaemerdionalis</i> (17 males and 18 females)
Starobogdanovka village, Krasno- gardeisk raion, Orenburg oblast	52°45' N, 53°45' E	Downland forb-gramineous meadow with the presence of ruderal species	<i>M. rossiaemerdionalis</i> (two males and eight females)
Saraktash raion, Orenburg oblast	52°10'N, 56°10' E	Forb-gramineous community with honeysuckle and brier bushes	<i>M. arvalis</i> (one male)
Vicinity of Orenburg Reserve, Aituarka village, Kuvandyk raion, Orenburg oblast	51°08' N, 57°38' E	Bunchgrass steppe used as pasture	<i>M. arvalis</i> (one male and two females)
			<i>M. arvalis</i> (seven males and two females)

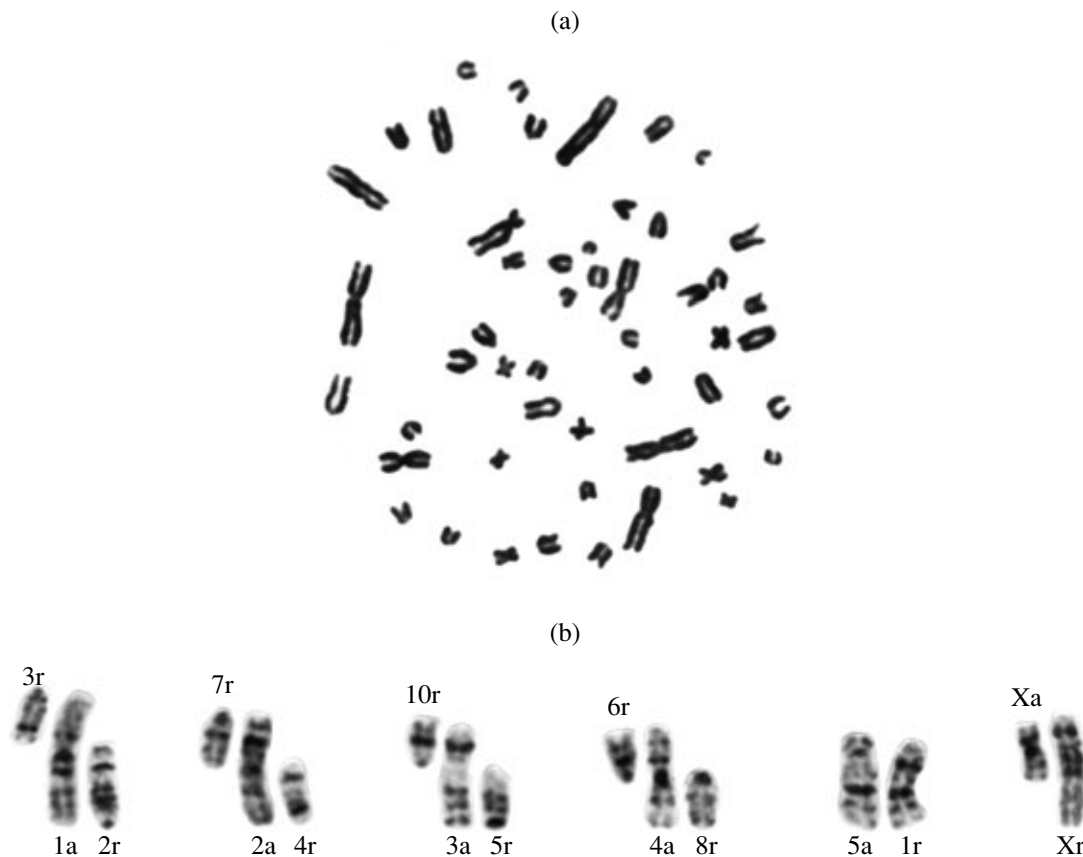


Fig. 1. Chromosomes of a hybrid female vole which was the F_1 from crossing *M. arvalis* \times *M. rossiaemeridionalis*: (a) a metaphase plate and (b) visualization of homologues in the G-banded chromosomes of the hybrid female. Designations: (a) chromosomes of *M. arvalis*; r, chromosomes of *M. rossiaemeridionalis*. The nomenclature is given in accordance with [10].

desert (800–1000 m in width). This zone was used for the preservation of thorium-containing wastes produced by a concentration plant. Both sibling species were found in this locality; in addition, an adult female with a karyotype containing 50 chromosomes was found there. The number and morphology of chromosomes suggest that this karyotype consists of haploid sets of *M. arvalis* and *M. rossiaemeridionalis* (Fig. 1a). G-banding allowed us to identify homologous chromosomes of the two parent species and confirmed the hybrid origin of this vole. Because of a comparatively high degree of spiralization, the identification of homologues of small chromosomes could only be arbitrary. Therefore, only large chromosomes are shown in Fig. 1b. This is the first documented case of hybridization between sibling vole species that was observed in the wild. Earlier, this was only observed in laboratory [8], although different authors have studied hundreds of voles from sympatry areas [1, 5]. Apparently, hybridization between *M. arvalis* and *M. rossiaemeridionalis* occurs very rarely in the wild. It is generally believed that the absence of hybridization between these species is determined by stable differences in their reproductive behavior [9]. In Ozernyi, these stable differences might have been distorted because of environmental stress,

primarily, the exposure to ionizing radiation for many generations. Probably, the exposure to radiation induced the mutations that have disturbed the mechanisms of reproductive isolation of sibling species.

In conclusion, we would like to emphasize that the hybrid female that was phenotypically almost normal had immature ovaries and womb and was sterile, as were the experimentally obtained hybrids between *M. arvalis* and *M. rossiaemeridionalis* [7]. Obviously, our observations do not give grounds to revise the generally accepted opinion that *M. arvalis* and *M. rossiaemeridionalis* are two independent species. Nevertheless, our results indicate the significance of the radiation factor, which may be considered a modifier of reproductive processes in natural populations of rodents.

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