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PALAEOENVIRONMENTS OF THE MANYCH VALLEY AT THE END OF LATE PLEISTOCENE BASED ON RODENT AND MOLLUSK DATA FROM SANMANYCH (ROSTOV DISTRICT, RUSSIA)

ANASTASIA K. MARKOVA[1,*], ANDREY L. CHEPALYGA[1], ANDREY YU. PUZACHENKO[1]

[1] Institute of Geography, Russian Academy of Sciences, Staromonetny per. 29, 109017 Moscow, Russia; e-mail: amarkova@list.ru, tchepalyga@mail.com, andreypuzak@gmail.com.
* corresponding author

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Abstract: A thorough consideration is given to the geological, palaeotheriological and malacological materials obtained from the Pleistocene Sanmanych locality, which is the only locality with mammal fauna in the Manych depression (46°24′53″ N, 42°36′25″ E). The brackish-water mollusk composition indicated that the bone-bearing series should be correlated to the Early Khvalynian transgression. The fossil record gives an insight into the palaeoenvironment at the time that the Caspian Sea water broke through the Manych depression into the Black Sea basin. The faunal evidence points to arid conditions and a cool climate. The rodent species composition is rather poor; it exclusively includes species indicative for an open environment, which suggests a wide spread occurrence of steppe and semi-deserts in the Manych valley during the Late Glacial (~16–12 ka BP).

Key words: Early Khvalynian transgression, Manych valley, rodents, mollusks

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Introduction

The southeastern “corner” of Europe, and the Manych valley in particular, is insufficiently known as regards to fossil mammalian and malacological faunas. The Manych valley that connected the Caspian and Black Sea basins in the past extends for 600 km from the Ergeny and Stavropol uplands to the Don River valley. Its width varies from 20–30 km to 40–50 km. The valley is filled with Quaternary deposits of various ages: Chauda-Bakinian (MIS 18), Old Euxinian (MIS 11), Early Khazarian (MIS 7), Karangatian – Late Khazarian (MIS 5e), and Khvalynian (end of MIS 2) (Popov 1982).

Until recently, Late Pleistocene mammal localities were not known in the Manych valley. It was only in 2005 that A. L. Chepalyga found there the mammal and mollusk locality known as Sanmanych with a Late Pleistocene age.

In 2007–2009 a large amount of bone-bearing deposits (about 200 kilos) were washed on the northern bank of the Manych-Gudilo Lake, 8 km south-west of the Sanmanych settlement (Orlovsky district, Rostov Region) (Text-fig. 1), within the protective zone of the Rostov Nature Reserve.

Geomorphic position of the section

The plain on the northern coast of Manych-Gudilo Lake was originally the bottom of ancient lake; it bears a system of linear ridges and hollows oriented parallel to with the general direction of the Manych valley. The depositional ridges (known under the local name of “manych”) are 10 to 25 km long, 100 to 300 m wide and about 20–25 m high. The ridges are separated by valleys 100–200 m wide, with a bottom elevated 8–10 m above the lake level.

The studied section is located west of the Gruzskkaya Ridge (up to +37 m a.s.l.), at its transition to a lower surface (linear valley). The Gruzskkaya Ridge is composed of marine deposits exposed at a coastal scarp to a depth of 20 m below the surface; it is attributed to the Khvalynian series (Abeskunian layers). In the west it adjoins the lower surface of the inter-ridge valley (local name “podmanok”). At that specific point the sequence with a bone-bearing horizon was studied. The horizon wedges out towards the Gruzskkaya Ridge.

The Sanmanych section

The sequence of horizons exposed in the coastal scarp of the Manych-Gudilo Lake is as follows (thickness of horizons is given in brackets):

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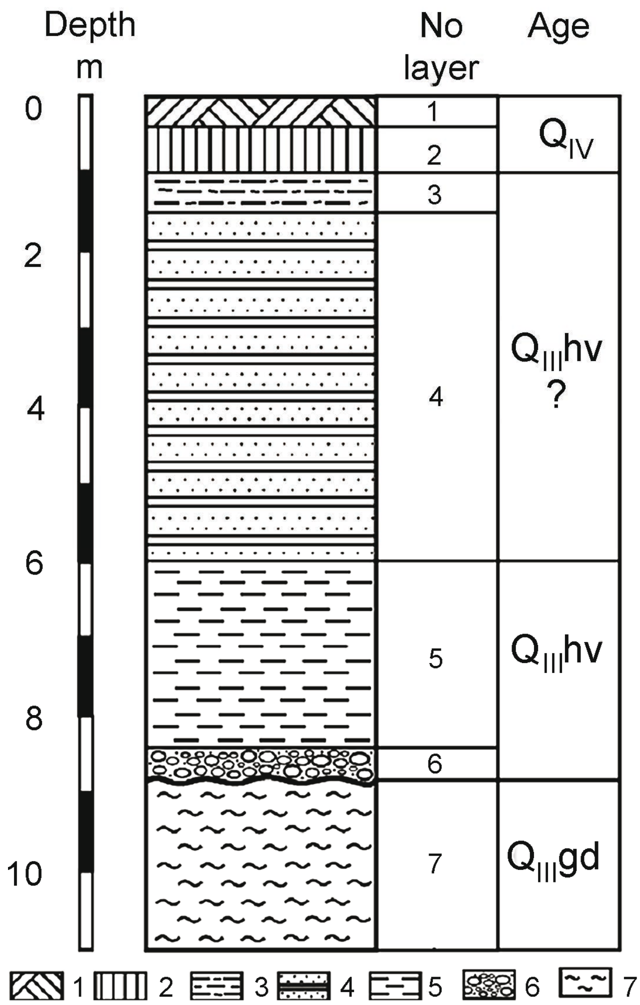
Text-fig. 1. The geographical position of Sanmanych locality.

1. Arable layer (0.1–0.2 m).
2. Meadow-chestnut soil, brown-gray loam (0.4 m).
3. Brown loam unstratified, calcareous, deposited in water (0.5 m).
4. Yellow-brown sandy loam, silty, unstratified, calcareous, subaqueous in origin, includes thin (1–2 mm) whitish lenses enriched in salts (4.5 m).
5. Gray-brown loam, horizontally stratified, with interlayers of unstratified material including blurred calcareous spots (2.2 m).
6. A lens-shaped interlayer of gravels and non-sorted sands with small and large mammal bones and mollusk shells, both marine and freshwater ones; there are alternating beds of sands, gravels and green clays, each bed a few centimeters thick (0.2–0.3 m).
7. Gray-brown clay, plastic, with interlayers and lenses of sandy clays and green clays (lacustrine clays, Gudinov layers). Apparent thickness (down to the water edge of Manych-Gudilo Lake) – 2.2 m. (Text-fig. 2).

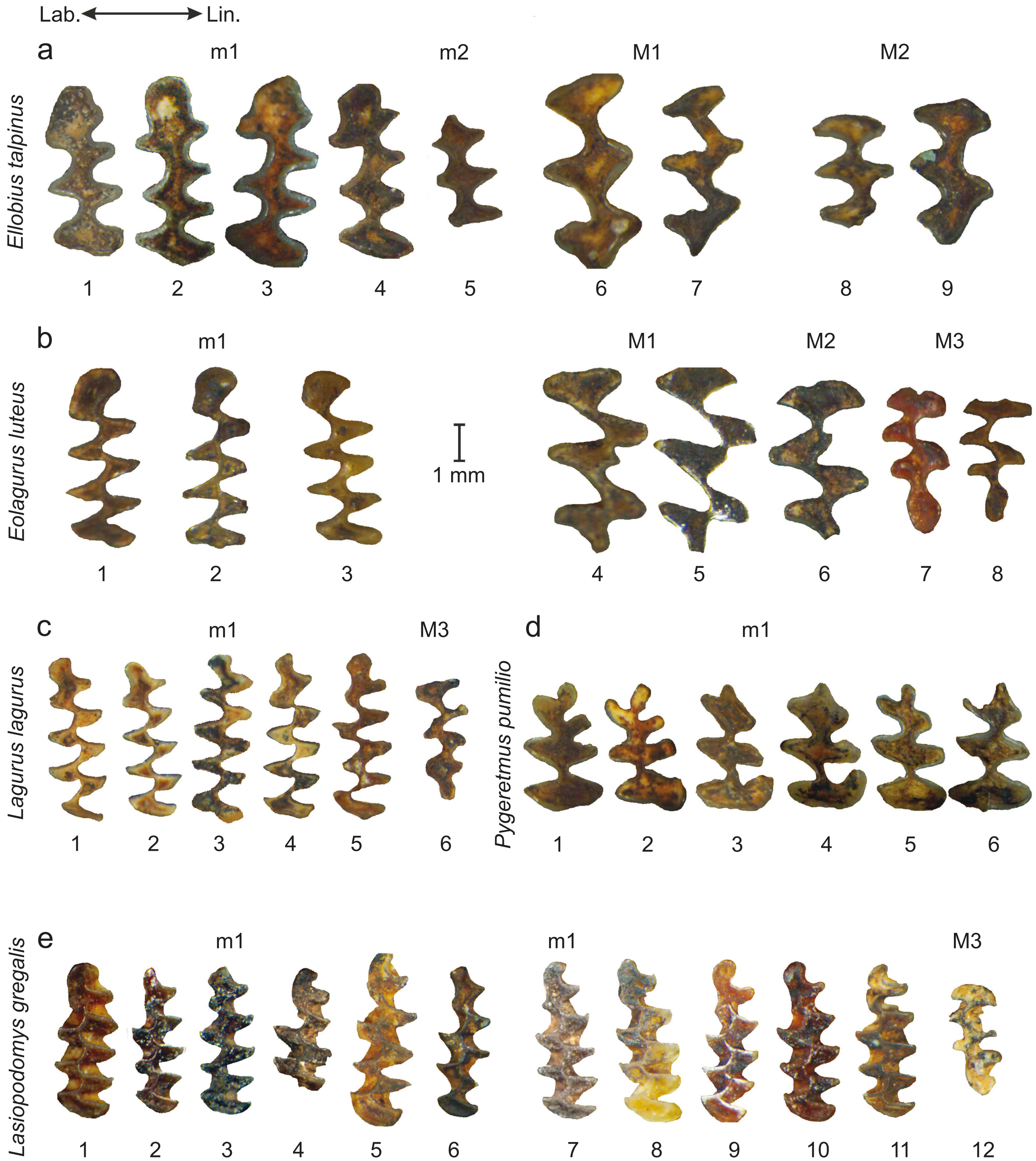
Mammal and mollusk fauna

Rodent fauna recovered from the Sanmanych section (layer 6)

At present about 20 rodent species inhabit the region of the Manych-Gudilo Lake. Among them are: little ground squirrel *Spermophilus pygmaeus*, great jerboa *Allactaga major*, dwarf fat-tailed jerboa *Pygeretmus pumilio*, three-



Text-fig 2. The geologic structure of the Sanmanych section.



Text-fig. 3. The occlusal surface of rodent teeth from Sanmanych locality.

toed jerboa *Stylodipus telum*, southern birch mouse *Sicista subtilis*, house mouse *Mus musculus*, wood mouse *Apodemus sylvaticus*, brown rat *Rattus norvegicus*, gray dwarf hamster *Cricetulus migratorius*, muskrat *Ondatra zibethicus*, water vole *Arvicola terrestris*, common vole *Microtus arvalis*, social vole *M. socialis*, northern mole vole *Ellobius talpinus*, greater mole-rat *Spalax microphtalmus* and others. Of the insectivores, there are: southern white-breasted hedgehog *Erinaceus concolor*, long-eared hedgehog *E. auritus*, bicolored white-toothed shrew *Crocidura leucodon*. The lagomorphs are represented by European hare *Lepus europaeus* (Minoranskiy et al. 2006).

In 2007 and 2009, sediment from Sanmanych section layer 6 that yielded a rich rodent fauna was washed through sieves (Tab. 1, Text-fig. 3). The bones are well weathered, though not rounded and yellowish-gray in color. Using a binocular microscope, about 400 bone remains could be identified to species level.

Among the mammal remains, 7 species of Rodentia were identified (Tab. 1). Dominant are the dwarf fat-tailed jerboa

Table 1. Taxa of fossil rodents (Mammalia, Rodentia) recorded at Sanmanych locality, Late Glacial (~16–12 ka BP).

Latin name	English name	No of specimens
Marmota bobac	Bobac marmot	6
Spermophilus sp.	Ground squirrel	7
Pygeretmus (*Alactagulus*) *pumilio*	Dwarf fat-tailed jerboa	76
Ellobius talpinus	Northern mole vole	45
Eolagurus luteus	Yellow steppe lemming	85
Lagurus lagurus	Steppe lemming	122
Lasiopodomys gregalis	Narrow-skulled vole	22

(*Pygeretmus pumilio*), the northern mole vole (*Ellobius talpinus*), the yellow steppe lemming (*Eolagurus luteus*) and the steppe lemming (*Lagurus lagurus*).

When compared with the present-day rodents inhabiting the region (Tab. 2), the species composition of the fossil assemblage differs markedly. The brown rat *Rattus norvegicus* and muskrat *Ondatra zibethicus* are absent from it – the species did not appear in the region until the Holocene. No finds of voles (*Arvicola terrestris*, *Microtus arvalis*, *M. socialis*) were recorded, nor mice remains were found.

On the other hand, there are bones such as the yellow steppe lemming found in abundance, as well as remains of the narrow-skulled vole. The distinction between the rodent species composition of rodents recovered from the Sanmanych section and the modern Rodentia inhabiting the Manych-Gudilo coast at present clearly points to a quite different landscapes and different climate at the time of deposition of layer 6.

All the fossil rodents identified in the Sanmanych section live now in a steppe and semi-desert environment only, no forest species has been found in the bone-bearing layer.

The semi-deserts (sandy, clay and loessial ones) are the preferable environment for dwarf fat-tailed jerboa and yellow steppe lemming. The following taxa are recorded:

Table 2. Comparison of rodent assemblage from Sanmanych locality (Late Pleistocene) with the living rodent assemblage from the Rostov Region.

Rodent species inhabiting the Rostov Region at present	Rodent species identified in the Sanmanych locality
Castor fiber – Eurasian beaver	–
Marmota bobac – bobak marmot	*Marmota bobac*
Spermophilus suslicus – spotted ground squirrel	–
Spermophilus pygmaeus – little ground squirel	–
–	*Spermophilus* sp. – ground squirrel
Sciurus vulgaris – red squirrel	–
Dryomys nitedula – forest dormouse	–
Allactaga major – large jerboa	–
Pygeretmus pumilio – dwarf fat-tailed jerboa	*Pygeretmus pumilio*
Stylodipus telum – three-toed jerboa	–
Spalax giganteus – giant mole-rat	–
Cricetus cricetus – European hamster	–
Mesocricetus raddei – Ciscaucasian hamster	–
Ellobius talpinus – northern mole vole	*Ellobius talpinus*
Lagurus lagurus – steppe lemming	*Lagurus lagurus*
–	*Eolagurus luteus* – yellow steppe lemming
Arvicola terrestris – water vole	–
Microtus arvalis – common vole	–
Microtus socialis – social vole	–
–	*Lasiopodomys gregalis* – narrow-skull vole
Sicista subtilis – southern birch mouse	–
Apodemus agrarius – striped field mouse	–
Apodemus flavicollis – yellow-necked mouse	–
Apodemus fulvipectus – yellow-breasted field mouse	–
Apodemus uralensis – the Ural field mouse	–
Micromus minutus – harvest mouse	–
Mus musculus – house mouse	–

Bobac marmot *Marmota bobac* (Müller, 1776) is a typical dweller of open steppe biotopes. At present it occurs in the south of Eastern Europe and in Kazakhstan. Its presence was noted in the Rostov Region where it burrows deep (up to 5 m) holes. The bobac marmot feeds on bulbs and green parts of plants. It hibernates for more than half of the year.

Ground squirrel *Spermophilus* sp. inhabits now dry steppes as well as sandy, clayey and loessial semi-deserts, and occasionally penetrates into deserts. Today it is found in the south of the Ukraine, along the Volga River, in the Northern Caucasus, Caspian Lowland and in Kazakhstan. It feeds on cereals, tulips and various bulbs. Remains of the little ground squirrel were found in the Middle Palaeolithic sites in Crimea (Markova 1999, 2005).

Yellow steppe lemming *Eolagurus luteus* (Eversmann, 1840) completely disappeared by now from Eastern Europe, its present-day range confined to the Zaisan basin, Mongolia, and China. Judging from palaeontological data, however, the yellow steppe lemming and its ancestral forms were widely spread over the central and southern East European Plain and in the Crimea during the Pleistocene. The species was typical for the so-called "mixed" or "no-analog" periglacial faunas at the time of the Valdai glacial period and earlier ice ages (Markova 2004). The yellow steppe lemmings standing at different evolutionary levels and attributable to various species and subspecies were also recovered from interglacial faunas of the Early, Middle and Late Pleistocene (Markova 1982a, 2004, Agadjanian and Markova 1983, Rekovets 1994). The range of *Eolagurus luteus* was still vast in the Holocene. Even in the 20th century it occurred in the lower reaches of the Volga and in Kazakhstan. The shrinking of the range resulted both from changes in climate and due to intensive soil cultivation (Text-fig. 3).

Steppe lemming *Lagurus lagurus* (Pallas, 1773), which is nowadays practically absent from the region, was recovered in abundance from layer 6. That species, as well as its ancestral forms, is a typical dweller of various open landscapes, including periglacial steppes and forest-steppes, as well as zonal steppes during interglacial epochs (Rekovets 1994, Markova 2004). During the Valdai glacial time the steppe lemming was widely spread in Northern Eurasia far north and west beyond its present-day range. Bone remains of that species have been found in the Late Pleistocene deposits as far as the British Isles. *Lagurus lagurus*, as well as the yellow steppe lemming and the narrow-skulled vole, are typical representatives of the mammoth-steppe faunal assemblage (Text-fig. 3).

Narrow-skulled vole *Lasiopodomys* (*Stenocranius*) *gregalis* (Pallas, 1779) inhabits at present various types of open landscapes (steppe and tundra). This rodent is practically indifferent to low temperatures. During the Valdai glacial time the range of the narrow-skulled vole was vast. It was a permanent member of the mammoth-steppe faunal assemblage (Markova 1982b, Baryshnikov and Markova 2002). After the Valdai ice sheet decayed and the forest zone restored in Northern Eurasia, the range of the narrow-skulled vole broke into two parts: a tundra and a steppe one. Its presence in the Sanmanych fauna suggests the cooling and a periglacial steppe expansion over the region (Text-fig. 3).

Northern mole vole *Ellobius talpinus* (Pallas, 1770) is a typical inhabitant of open landscapes, mostly of steppes and forest-steppe, with a well-developed soils; it occurs also in semi-deserts. At present it is commonly found in the south of the East European Plain, in the north of the Crimean Peninsula, in steppes of the Northern Caucasus. In the east the range of the northern mole vole spreads as far as the Aral Sea. It is a burrower and feeds mostly on plant roots (Gromov and Erbaeva 1995) (Text-fig. 3).

Dwarf fat-tailed jerboa *Pygeretmus* (*Alactagulus*) *pumilio* (Kerr, 1792) inhabits deserts at present, solonchak soils and takyrs (a specific type of flat relief occurring in the Central Asia deserts) being most hospitable for it. In spring it feeds mostly on plant bulbs, later – on green leaves and stems, and in autumn it eats seeds. The present-day range of *Pygeretmus pumilio* includes the south of the East European Plain (preferably in the lower reaches of the Don and Volga rivers) as well as Kazakhstan and Central Asia (Text-fig. 3).

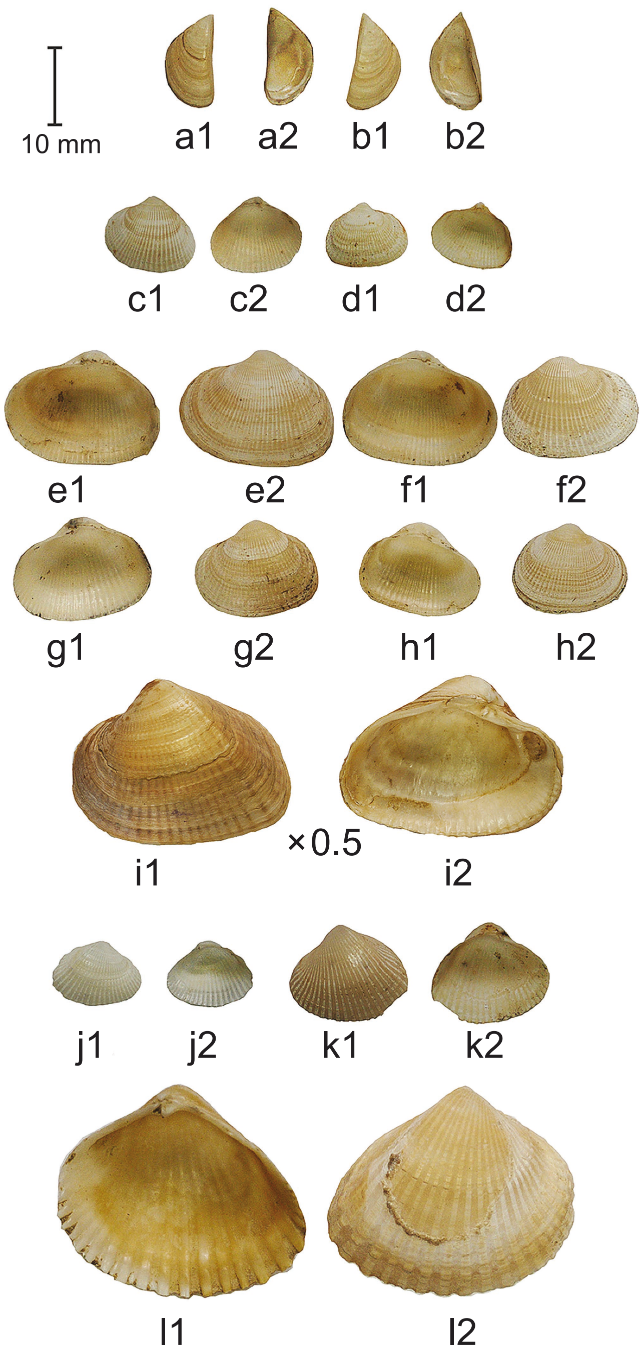
The rodent fauna recovered from Layer 6 of the Sanmanych section includes only inhabitants of open arid landscapes. No bones of animals living in forests, near water, nor Subarctic cold-tolerant species such as *Dicrostonyx* and *Lemmus* have been found. The absence of widespread species such as the water vole – *Arvicola terrestris*, commonly found near water bodies, strongly suggests that the climate was not only dry, but also rather cool. Quite probably, a high salinity of the water in the Manych Strait was unsuitable for the water vole. Another evidence of a cooler climate is the abundant presence of narrow-skulled vole remains. In general, the small mammal Sanmanych fauna is somewhat peculiar and differs widely from the modern one (Tab. 2). A large number of fossil remains reveal a low diversity of rodent species; that may be considered as an indirect sign of the climate cooling, as the species richness is well known to be reduced drastically with growing severity of climate. Judging from the small mammal fauna composition and species diversity, one may well suppose strongly arid and rather cool environments in the region at the time of deposition of Sanmanych section, layer 6.

Large mammal fauna

Large mammal remains are present in the section as numerous bone fragments, mostly of tubular bones, as well as teeth and horns. They have been identified as belonging to *Alces* sp., *Sus scrofa*, *Bison priscus*, *Equus* sp., *Saiga tatarica* (determined by E. A. Vangengeim and P. A. Nikolsky).

Brackish-water mollusk fauna

Layer 6 yielded shells of *Didacna protracta* Eichwald, 1841, *D. ebersini* Fedorov, 1953, *D.* sp. (indeterminable fragments), *Monodacna caspia* Eichwald, 1829 and *Dreissena polymorpha* (Pallas, 1771) (Text-fig. 4). The mollusk shells are partly rounded, and often present in fragments. It is a typical mollusk assemblage of the Khvalynian Caspian basin and indicates a deep penetration of the Caspian water into the Manych valley. This complex most closely resembles the fauna of the Early Khvalynian brackish-water basin. Judging from the mollusk fauna composition, the Manych palaeo-basin salinity was about 10–12 ‰, which suggests its close connection with the Khvalynian basin of the Caspian Sea. *Didacna protracta* habituates in recent Caspian Sea on the depths deeper than



Text-fig. 4. Brackish-water mollusks: a, b) left and right valves of of *Dreissena polymorpha* (inner and external view); c, d) left and right valves of *Monodacna caspia* (inner and external view); e–h) left and right valves of *Didacna protracta* (inner and external view) from bottom facies (layer 7); i) left valve of *Didacna proctracta* (inner and external view) from beach facies (layer 6); j, k) left and right valves of *Didacna ebersini* (inner and external view) from bottom facies (layer 7); l) right valve of *Didacna ebersini* (inner and external view) from beach facies (layer 6).

25 m, where the water temperature is significant low (Text-fig. 4). Thus, the find of *Didacna protracta* is the indicator of colder climate during the end of last glaciation.

Freshwater mollusk fauna

Numerous very small shells of freshwater mollusks of *Lymnaea* sp. and *Planorbis* sp. were recovered from Layer 6. They belong to the so-called stagnophile group indicative of stagnant, or slowly flowing, fresh water, kind of shallow lakes or freshwater swamps. The small size of the shells is indicative of oppressed development and a habitation under unfavorable conditions of the Late Glacial time.

The fact of shells of freshwater and marine mollusks being found together in layer 6 may be attributed to the malacofauna mixing when marine water of the Khvalynian transgression penetrated into the Manych valley formerly occupied by freshwater lakes.

Palaeogeographical reconstruction

The palaeontological data obtained provide the information about climate and environment that existed in the Manych valley during the Early Khvalynian transgression.

The rodent fauna recovered from Sanmanych locality includes a few species (7 taxa have been identified), all of them being at present inhabitants of open steppe and semi-desert biotopes. The fossil fauna of Sanmanych differ noticeably in the species richness from today's rodent fauna, which includes more than 20 species. The open steppe and semi-desert fossil fauna differed strongly from the modern fauna which includes some rodent species that are subaquatic (such as beaver and water vole) that completely absent from the fossil assemblages. That applies also to inhabitants of shrubberies and forested lands found in the present-day rodent fauna (*Sciurus vulgaris*, *Dryomys nitedula*, *Apodemus flavicollis* and others) (Tab. 2). So, as can be seen from the species richness and species composition of the fossil fauna recovered from the Sanmanych locality, the environments and climate at the time of the fauna existence differed essentially from those of today. The materials obtained suggest a more severe climate in the Manych basin at the time of the Early Khvalynian transgression, an episode that can be correlated with the final stages of the last glaciation. The low species diversity suggests an inhospitable environments; that is attested to by the entire absence of species such as dwellers of shrub and forest biotopes, or even those living near water. Noteworthy is the presence of species absent completely from the Manych valley at present, such as abundant remains of the narrow-skulled vole *Lasiopodomys* (*Stenocranius*) *gregalis* and the yellow steppe lemming *Eolagurus luteus*; species that are completely absent from the Manych valley at present. Both species are not only typical for steppe environments, but were also characteristic of the Late Pleistocene periglacial steppe fauna of the glacial epochs. At the glacial time in the Middle and Late Pleistocene the ranges of the narrow-skulled vole and yellow steppe lemming expanded northward and westward over vast areas of Northern Eurasia (Markova and Kolfschoten 2008). Remains of those rodents found in the Manych valley confirm the periglacial environments and cool climate characteristic of the region at that time.

Radiocarbon dating results give the age of the Early Khvalynian transgression as 16 to 12 ka BP (Chepalyga 2005, Svitoch 2009, Makshaev et al. 2015, Arslanov et al. 2016). As follows from a great volume of geological and palaeontological data collected all over Europe, the considered time follows immediately the maximum cooling of the last glacial time (Markova and Kolfschoten 2008). As shown by palaeohydrological reconstructions, it was the time of the maximum phase of flooding coinciding with the Khvalynian transgression peak and the highest overfloods in river valleys in the temperate zone of Eurasia (Sidorchuk et al. 2005, Chepalyga et al. 2007). As a result of the Cascade of Eurasian basins developed in the Late Pleistocene, the Caspian (Khvalynian) water flooded over the Manych valley and the Manych-Kerch Strait appeared. The Caspian water brought the brackish-water mollusk fauna. The Khvalynian water salinity was close to that of the Caspian Sea (10–12 ‰). The water temperature could be probably lower than at present, as suggested by the size of Khvalynian mollusk shells: they are 2–3 times smaller than the modern shells of the same species. The flow velocity (as indicated by the size of transported sediment particles) was up to 0.4–0.5 m/s. At the beginning of transgression the basin was 2–3 m deep. Later it became deeper, as seen from fine material of Layers 5 to 3 in Sanmanych section and the presence of *Didacna protracta*. The microtheriological data point to the fact that the Early Khvalynian alluvial layers were deposited under cool periglacial conditions, which confirms its chronological assignment to the end of the last ice age.

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