

- of Geology of Pre-Urals and Trans-Urals. Perm Polytechnic Institute, Perm, pp. 125–135 (in Russian).
- Geptner, V.G., 1955. Notes on tarpan. Zoologicheskii Zhurnal 34 (6), 1404–1423.
- Grichuk V.P., 2002. Vegetation. In: Velichko A.A. (Ed.), Dynamics of Terrestrial Landscape Components and Inner Marine Basins of Northern Eurasia During the Last 130000 years. Geos, Moscow, pp. 64–89. (in Russian).
- Kosintsev, P.A., 1995. Remains of megamammals from the Lobvinsky cave. In: Smirnov, N.G. (Ed.), Materials on History of the Modern Middle Urals Biota. Russian Academy of Sciences, Ekaterinburg, pp. 58–102 (in Russian).
- Kosintsev, P.A., 1996. Large mammal fauna of the North Urals in the Late Pleistocene and Holocene. In: Smirnov, N.G. (Ed.), Materials and Research on History of the Recent Urals Fauna. "Ekaterinburg", Russian Academy of Sciences, Ekaterinburg, pp. 84–109 (in Russian).
- Kosintsev, P.A., Vorobiev, A.A., Orlova, L.A., 2003. Absolute dates on fossil bears (genus *Ursus*) of the Middle Urals. In: Orlov, V.N. (Ed.), Theriofauna of Russia and Adjacent Territories. Institute of Ecology and Evolution Problems, Moscow, pp. 174–175 (in Russian).
- Kuzmina, I.E., 1971. Forming of theriofauna of the North Urals during the Late Anthropogen. In: Vereshchagin, N.R. (Ed.), Materials on the Faunas of Anthropogen of the USSR. Proceedings of the Zoological Institute, vol. 49, Leningrad, pp. 44–122 (in Russian).
- Kuzmina, I.E., 1975. Some data on mammals of the Middle Urals in the Late Pleistocene. Bulletin of the Commission on Study of Quaternary Period 43, 63–77 (in Russian).
- Kuzmina, S.A., 2000. Faunal data from the Late Palaeolithic site Smelovskaya II in the South Urals. In: Kosintsev, P.A. (Ed.), Pleistocene and Holocene Urals Faunas. "Riphey", Chelyabinsk, pp. 137–153 (in Russian).
- Orlova, L.A., Kuzmin, Ya.V., Dementiev, V.N., 2004. A review of the evidence for extinction chronologies for five species of Upper Pleistocene megafauna in Siberia. Radiocarbon 46 (1), 301–314.
- Sinitsin, A.A., Prasolov, N.D., Svezhentsev, U.S., Sulerzhitskiy, L.D., 1997. Radiocarbon chronology of upper paleolithic of the Eastern Europe. In: Sinitsin, A.A., Prasolov, N.D. (Eds.), Radiocarbon Chronology of Upper Paleolithic of Eastern Europe and Northern Asia. Institute of History of Material Culture, Saint Petersburg, pp. 21–66 (in Russian).
- Smirnov, N.G., Bolshakov, V.N., Kosintsev, P.A., Panova, N.K., Korobeinikov, U.J., Olshwang, V.N., Erokhin, N.G., Bykova, G.V., 1990. Historical ecology of animals of the South Urals. The Ural Branch of the USSR Academy of Sciences, Sverdlovsk, pp. 1–244 (in Russian).
- Stuart, A.J., Kosintsev, P.A., Higham, T., Lister, A.M., 2004. Pleistocene to Holocene extinction dynamics in giant deer and woolly mammoth. Nature 431, 684–689.
- Svezhentsev, Yu.S., Popov, S.G., 1993. Late paleolithic chronology of the East European Plain. Radiocarbon 35 (3), 495–501.



Late Pleistocene and Holocene small- and large-mammal faunas from the Northern Urals

Olga Bachura*, Pavel Kosintsev

Institute of Plant and Animal Ecology, Russian Academy of Sciences, 202 Marta 8 St., 620144 Ekaterinburg, Russia

Available online 4 December 2006

Abstract

Data from the mammal fauna of the North Urals during the Late Pleistocene and Holocene are synthesised. Analysis of differentiation the degree of small- and large-mammal faunas during this time has been undertaken. Only differences of mammal species composition were significant between the Late Pleistocene and Holocene complexes, and within these complexes, the distinction between faunas was insignificant. The transition from the Late Pleistocene to the Holocene complex small-mammal faunas occurred in the Middle Late Valdai due to expansion of the forest species. In large-mammal faunas, the process was recorded later (in Dryas 3-Early Holocene) because of the extinction of some species and others that changed their areas of occupation.

© 2006 Published by Elsevier Ltd.

1. Introduction

The Northern Urals extend from 64°N to 59°N. A series of investigations have examined the Late Quaternary mammal faunas of the Northern Urals region, including Kuzmina (1971), Kosintsev and Borodin (1990), Kosintsev (1996), Smirnov (1996), Smirnov et al. (1999b), Borodin et al. (2000), Kosintsev et al. (2000), Bachura and Strukova (2002), Teterina (2002, 2003), Bachura and Plasteeva (2005) and Kosintsev and Bachura (2005). These articles describe both the small- and large-mammal faunas of separate periods during the Late Pleistocene and Holocene.

In the present work mammal faunal evidence from the Late Pleistocene and Holocene from the Northern Urals is summarised. Analysis of the differentiation between the small- and large-mammal fauna assemblages during this time has been undertaken.

2. Materials and methods

Data collected from mammalian assemblages from 10 alluvial, 23 cave and 5 archaeological sites provide the basis for this synthesis (Fig. 1). The radiocarbon dates, the evolutionary stages of individual species, and archaeologi-

cal artifacts allow the combination of these local faunas to 8 faunal groups, and are assigned to chronological periods (Tables 1 and 2; Appendix Tables A1 and A2):

1. Early Valdai (Early Weichselian; MIS4)—EW; 3 local faunas (Zhiliche Sokola—2, Usolcevskaia and Shaitanskaya caves).
2. Middle Valdai (Middle Weichselian II; Late MIS3; 34–24 kyr BP)—3 local faunas (Cheremukhovo pit 1, 2, 4).
3. Late Valdai 1 (LGM; Late Weichselian I; Early MIS2; 24–15 kyr BP)—5 local faunas (Medvezhaya, Studenaya and Shaitanskaya caves, Cheremukhovo pit 2, 4).
4. Late Valdai 2 (LGE; Late Weichselian II; Late MIS2; 15–12.4 kyr BP)—1 local fauna (Shaitanskaya cave).
5. Bølling-Allerød (Late Weichselian II; Late MIS2; 12.4–10.9 kyr BP)—3 local faunas (Medvezhaya and Shaitanskaya caves, Kakva-4).
6. Early Holocene (Early MIS1; 10.2–8.0 kyr BP)—4 local faunas (Medvezhaya and Shaitanskaya caves, Cheremukhovo pit 1, Kamen' Pisany).
7. Middle Holocene (Middle MIS1; 8.0–2.5 kyr BP)—11 local faunas (Zhiliche Sokola—1, Cheremukhovo pit 1, Burmantovo—1, Burmantovo—2, Shaitanskaya and Ushminskaya caves, Ivdel'—2, Lisia, Kamen' Pisany, Kaninskaya and Uninskaya caves).

*Corresponding author.

E-mail address: olga@ipae.uran.ru (O. Bachura).

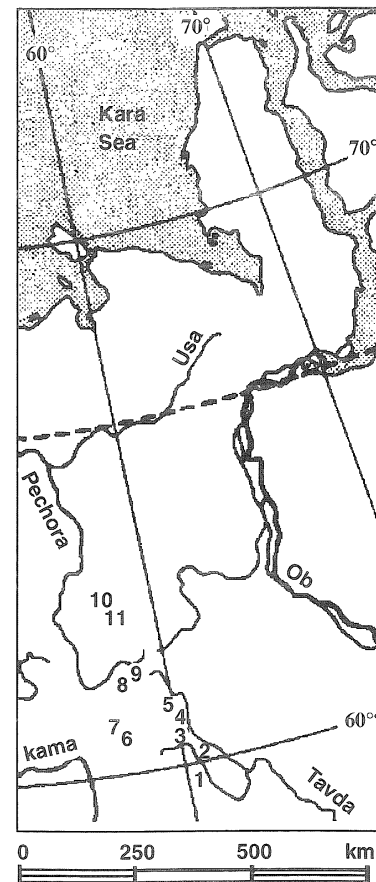


Fig. 1. Fossil fauna localities in the Northern Urals. 1—Zhiliche Sokola, Kakva-4; 2—Cheremukhovo; 3—Usolcevsckaya cave; 4—Shaitanskaya cave; 5—Burmantovo; 6—Kamen' Pisany; 7—Dyrovaty Kamen'; 8—Kaninskaya cave; 9—Uninskaya cave; 10—Medvezhaya cave; 11—Arka.

8. Late Holocene (Late MIS1; 2.5 kyr BP—present)—16 local faunas (Zhiliche Sokola—1, Cheremukhovo pit 1, Burmantovo—1, Cheremukhovo-2, Shaitanskaya and Ushminskaya caves, Ivdel'—2, Lisia—2, Vizhay, Loz-vinsky gorodok, Atym'a—2, Atym'a—7, Kamen' Pi-sany, Kaninskaya cave, Dyrovaty Kamen', Arka).

In Tables 1 and 2 and on Fig. 2, indexes W (3W–8W) and E (1E–8E) indicate faunas of the corresponding period from the western and eastern slopes of the Northern Urals.

3. Changes of mammals species composition

Analysis of the species lists allows six species groups to be distinguished.

Group 1: Species are present in all faunal complexes including *Microtus oeconomus*, *Canis lupus*, *Vulpes vulpes*, *Ursus arctos*, *Martes zibellina*, *Gulo gulo*, *Mustela erminea*, *Mustela nivalis* and *Rangifer tarandus* (Tables 1 and 2).

Group 2: Species that have replaced each other at certain periods. On the Middle Valdai 2 and the Late Valdai 1 boundary, the large form of horse (*Equus latipes*) was

Table 1
Species composition of Late Pleistocene mammal faunas from North Urals

Species	Faunas						
	1E ^a	2E	3W	3E	4E	5W	5E
<i>Lepus tanaiticus</i> Gureev	+	+	+	+	+	+	+
<i>Ochotona pusilla</i> Pallas	+	+	+	+	+	+	+
<i>Sciurus vulgaris</i> L.	+	–	–	–	–	–	+
<i>Spermophilus</i> sp.	+	+	–	+	–	–	+
<i>Castor fiber</i> L.	+	–	–	–	–	+	–
<i>Marmota bobak</i> Müller	+	+	–	+	+	–	+
<i>Sicista</i> sp.	–	–	–	–	–	–	–
<i>Cricetulus migratorius</i> Miline-Edwards	+	+	–	+	+	–	–
<i>Clethrionomys rufocanus</i> Sundervall	+	–	–	–	+	+	+
<i>Cl. rutilus</i> Pallas	+	–	–	–	+	+	+
<i>Lagurus lagurus</i> Pallas	+	+	–	+	+	–	+
<i>Dicrostonyx gulielmi</i> Sanford	+	+	+	+	+	–	–
<i>D. torquatus</i> Pallas	–	–	–	–	–	+	+
<i>Lemmus sibiricus</i> Kerr	+	+	+	+	+	+	+
<i>Myopus schisticolor</i> Lilljeborg	+	–	+	?	+	+	+
<i>Arvicola terrestris</i> L.	+	–	–	+	+	+	+
<i>M. gregalis</i> Pallas	+	+	+	+	+	+	+
<i>M. oeconomus</i> Pallas	+	+	–	+	+	+	+
<i>M. agrestis</i> L.	–	–	–	–	+	+	+
<i>M. middendorffi</i> Poljakov	+	+	+	+	–	–	–
<i>Canis lupus</i> L.	+	+	+	+	+	+	+
<i>Alopex lagopus</i> L.	+	+	+	+	+	+	+
<i>Vulpes vulpes</i> L.	+	+	+	+	+	+	+
<i>Ursus arctos</i> L.	+	+	?	+	+	?	+
<i>Martes zibellina</i> L.	+	+	+	+	+	+	+
<i>Gulo gulo</i> L.	+	+	+	+	+	+	+
<i>M. erminea</i> L.	+	+	+	+	+	+	+
<i>M. nivalis</i> L.	+	+	+	+	+	+	+
<i>M. eversmanni</i> Lesson	+	+	+	+	+	+	+
<i>Meles meles</i> L.	+	–	–	–	–	–	–
<i>Panthera spelaea</i> Goldfuss	+	+	+	+	+	+	?
<i>Mammuthus primigenius</i> Blüm	+	+	+	+	+	+	+
<i>Equus latipes</i> Gromova	+	+	–	–	–	–	–
<i>E. uralensis</i> Kuzmina	–	–	+	+	+	+	+
<i>Coelodonta antiquitatis</i> Blumenbach	+	+	+	+	+	+	+
<i>Cervus elaphus</i> L.	+	–	–	–	–	–	–
<i>Alces alces</i> L.	+	–	–	–	–	–	–
<i>Rangifer tarandus</i> L.	+	+	+	+	+	+	+
<i>Bison priscus</i> Bojanus	+	+	+	+	+	+	+
<i>Saiga tatarica</i> L.	+	+	+	+	+	+	+
<i>Ovibos pallantis</i> H.Smith	–	–	+	+	+	+	+

^aIndices indicate faunas from the western slope (W) and eastern slope (E); N 1–5 denote numbers of faunal groups in the text.

replaced by a small form (*Equus uralensis*). During the Bølling-Allerød, *Dicrostonyx gulielmi* was replaced by *Dicrostonyx torquatus* (Smirnov et al., 1999b), and during the Middle Holocene, *Lepus tanaiticus* was replaced by *Lepus timidus* (Tables 1 and 2).

Group 3: Species that inhabited the Northern Urals during the Late Pleistocene and disappeared during the Holocene. *Spermophilus* sp. and *Mustela eversmanni* lived here until the middle part of the mid-Holocene. *Ochotona pusilla*, *Lagurus lagurus*, *Dicrostonyx torquatus*, *Lemmus sibiricus* and *Alopex lagopus* disappeared from this region during the Late Holocene.

Table 2
Species composition of Holocene mammal faunas from North Urals

Species	Faunas					
	6W ^a	6E	7W	7E	8W	8E
<i>Lepus tanaiticus</i> Gureev	+	+	+	+	–	–
<i>Lepus timidus</i> L.	–	–	–	–	+	+
<i>Ochotona pusilla</i> Pallas	+	+	–	+	–	+
<i>Pteromys volans</i> L.	–	–	–	–	+	+
<i>Sciurus vulgaris</i> L.	+	+	+	+	+	+
<i>Tamias sibiricus</i> Laxmann	–	–	–	+	+	+
<i>Spermophilus</i> sp.	+	+	–	+	–	–
<i>Castor fiber</i> L.	+	+	+	+	+	+
<i>Sicista</i> sp.	–	–	–	+	+	+
<i>Clethrionomys rufocanus</i> Sundervall	+	+	+	+	+	+
<i>Cl. rutilus</i> Pallas	+	+	+	+	+	+
<i>Lagurus lagurus</i> Pallas	–	+	?	+	–	+
<i>Dicrostonyx torquatus</i> Pallas	+	+	?	+	+	+
<i>Lemmus sibiricus</i> Kerr	+	+	?	+	+	+
<i>Myopus schisticolor</i> Lilljeborg	+	+	?	+	+	+
<i>Arvicola terrestris</i> L.	+	+	?	+	+	+
<i>M. gregalis</i> Pallas	+	+	?	+	+	+
<i>M. oeconomus</i> Pallas	+	+	?	+	+	+
<i>M. agrestis</i> L.	+	+	?	+	+	+
<i>Canis lupus</i> L.	+	+	+	+	+	+
<i>Alopex lagopus</i> L.	+	+	+	+	–	–
<i>Vulpes vulpes</i> L.	+	+	+	+	+	+
<i>Ursus arctos</i> L.	+	+	+	+	+	+
<i>Martes zibellina</i> L.	+	+	+	+	+	+
<i>Martes martes</i> L.	–	–	–	–	+	+
<i>Gulo gulo</i> L.	+	+	+	+	+	+
<i>Mustela erminea</i> L.	+	+	+	+	+	+
<i>Mustela nivalis</i> L.	+	+	+	+	+	+
<i>Mustela eversmanni</i> Lesson	–	+	–	+	–	–
<i>Meles meles</i> L.	–	–	+	+	–?	–
<i>Lutra lutra</i> L.	?	+	+	+	+	+
<i>Lynx lynx</i> L.	?	?	+	+	+	+
<i>Equus uralensis</i> Kuzmina	?	+	–	–	–	–
<i>Cervus elaphus</i> L.	–	–	–	+	–	–
<i>Capreolus pygargus</i> L.	–	–	–	–	–	+
<i>Alces alces</i> L.	+	+	+	+	+	+
<i>Rangifer tarandus</i> L.	+	+	+	+	+	+

^aIndices indicate faunas from the western slope (W) and eastern slope (E); N 6–8 denote numbers of faunal groups in the text.

Group 4: Species that inhabited the Northern Urals only during the Late Pleistocene. *Ursus spelaeus* disappeared from this area at the end of the Middle Valdai 2. Also included are *Panthera spelaea*, *Coelodonta antiquitatis*, *Bison priscus*, *Ovibos pallantis* and *Mammuthus primigenius*, that died out at the end of the Pleistocene (Table 1). The occupation areas of *Marmota bobak* and *Saiga tatarica* shifted southward and that of *Microtus middendorffi* shifted northwards from the Northern Urals at the end of the Pleistocene.

Group 5: Species which appeared during the Northern Urals in the Holocene: *Lutra lutra* appeared in the Early Holocene, *Tamias sibiricus*, *Sicista* sp. and *Lynx lynx* appeared in the Middle Holocene, while *Pteromys volans* and *Martes martes* appeared in the Late Holocene.

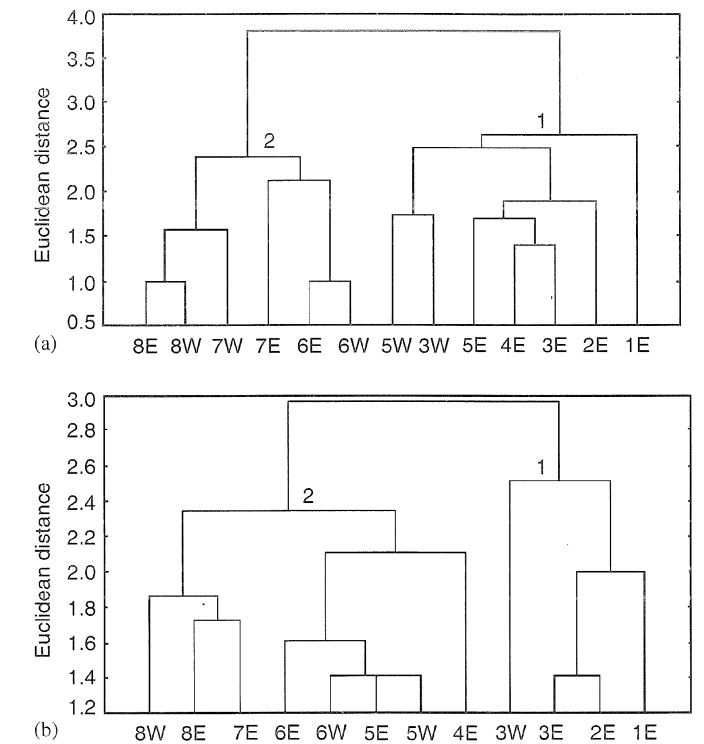


Fig. 2. Dendrogram of large- (a) and small-mammal faunas (b) Indices indicate faunas from the western slope (W) and eastern slope (E); N 1–8 denote numbers of faunal groups mentioned in the text.

Group 6: Species that occur episodically in faunal assemblages. In the Late Pleistocene they were: *Sciurus vulgaris*, *Castor fiber*, *Cricetulus migratorius*, *Clethrionomys rufocanus*, *Clethrionomys rutilus*, *Myopus schisticolor*, *Arvicola terrestris*, *Microtus agrestis*, *Mustela lutreola*, *Meles meles* and *Cervus elaphus*. In the Holocene they were: *Meles meles*, *Cervus elaphus* and *Capreolus pygargus*.

Faunal assemblages from the western and eastern slopes of the Northern Urals show geographical distinctions. On the western slope, remains of *Marmota bobak*, *Lagurus lagurus*, *Cricetulus migratorius* and *Spermophilus* sp. were absent during the Late Pleistocene, while on the eastern slope, no remains of *Ursus spelaeus* are known. The times of the disappearance of some species in the two regions were different: *Panthera spelaea* died out on the eastern slope at the beginning of Dryas 1, while on the western side this species remained until the end of the Pleistocene. Likewise, *Ochotona pusilla* disappeared from the eastern slope in the Late Holocene, and *Mustela eversmanni* disappeared during the Middle Holocene. On the western side, pika disappeared from the fauna during the Late Holocene, whilst the steppe polecat is absent after the Early Holocene.

4. Analysis of faunas

Cluster analysis of mammal species lists was undertaken to determine character changes in the small-mammal faunas that occurred during the Late Quaternary to allow

comparison with that of the large mammals. Various cluster analysis methods (complete linkage, UPGM, Ward's method) have shown a stable amalgamation of faunas into two clusters in both cases (Figs. 2a and b). The distance between the objects in these plots is the Euclidean distance.

In the analysis of the large-mammal faunas, the first cluster includes all faunas of Late Pleistocene age from Northern Urals, whilst the second includes all faunas from the Holocene (Fig. 2a). In first cluster, the Early Valdai fauna stands apart from others. Other faunas of the Late Pleistocene are combined in two geographical variances: western and eastern. In cluster 2, Holocene faunas are united in two chronological variances: Early and Late. The Middle Holocene fauna of the western slope was similar to the Late Holocene fauna. The Middle Holocene fauna of the eastern slope was similar to the Early Holocene fauna, because it included a significant amount of Pleistocene species.

Thus, during the Holocene there were more significant changes in the large-mammal composition of the fauna than during the Late Pleistocene.

In the analysis of small-mammal faunas, cluster structures differ from those seen for the large mammals (Fig. 2b). Cluster 1 consists of faunas of Early Valdai, Middle Valdai and the Late Valdai 1. Cluster 2 includes faunas from the Bølling-Allerød and the Holocene. Thus, rearrangement of the North Urals small-mammal faunas occurred during the transition from the Late Valdai 1 to Late Valdai 2. The small-mammal faunas were represented by two geographical variants, one on the western and the other on the eastern slopes during the Late Pleistocene. Cluster 2 includes two chronological variants of the faunas: Bølling-Allerød (Late Valdai)–Early Holocene, and Middle Holocene–Late Holocene (Fig. 2b).

Thus cluster analysis has shown that differences in mammal-species composition were significant between the Late Pleistocene and Holocene complexes, but within these complexes distinction between faunas was insignificant. The transition from the Late Pleistocene to the Holocene complex in the small-mammal fauna took place at the boundary of the Late Valdai 1 and Late Valdai 2 due to an expansion of forest species. The same process in the large-mammal fauna occurred later (in Dryas 3–Early Holocene) when some species died out and others changed their distributions.

5. Discussion

Comparison of Late Pleistocene mammal species composition of the Northern Urals with that of North Eurasia was undertaken (Table 3). Mammal fauna of the North Urals during Late Pleistocene was a northern variant of the periglacial mammal-fauna in the North Eurasia. The mammal faunas of the Polar Ural and adjacent territories of Eastern Europe and Western Siberia included 27 species (Kuzmina, 1977; Smirnov, 1986; Kochev, 1993; Smirnov

Table 3
Species composition of the Late Pleistocene mammal faunas from the Northern Urals and adjacent territories

Species	Territories		
	1	2	3
<i>Lepus tanaiticus</i> Gureev	+	+	+
<i>Ochotona pusilla</i> Pallas	+	+	+
<i>Spermophilus</i> sp.	–	+	+
<i>Castor fiber</i> L.	–	+	+
<i>Marmota bobak</i> Müller	–	+	+
<i>Allactaga jaculus</i> Pallas	–	–	+
<i>Apodemus sylvaticus</i> L.	–	–	+
<i>Apodemus flavicollis</i> Melchior	–	–	+
<i>Allocretullus eversmannii</i> Brandt	–	–	+
<i>Cricetulus migratorius</i> Miline-Edwards	–	+	+
<i>Cricetus cricetus</i> L.	–	–	+
<i>Clethrionomys rufocanus</i> Sundervall	?	+	+
<i>Cl. ex gr. rutilus-glareolus</i>	+	+	+
<i>Lagurus lagurus</i> Pallas	–	+	+
<i>Eulagurus luteus</i> Eversmann	–	–	+
<i>Dicrostonyx gulielmi</i> Sanford	+	+	+
<i>D. torquatus</i> Pallas	–	+	–
<i>Lemmus sibiricus</i> Kerr	+	+	+
<i>Myopus schisticolor</i> Lilljeborg	–	+	?
<i>Arvicola terrestris</i> L.	+	+	+
<i>M. gregalis</i> Pallas	+	+	+
<i>M. oeconomus</i> Pallas	+	+	+
<i>M. agrestis</i> L.	+	+	+
<i>M. arvalis</i> Pallas	–	–	+
<i>M. middendorffi</i> Poljakov	+	+	–
<i>M. hyperboreus</i> Vinogradov	+	–	–
<i>Canis lupus</i> L.	+	+	+
<i>Alopex lagopus</i> L.	+	+	+
<i>Vulpes vulpes</i> L.	+	+	+
<i>Ursus arctos</i> L.	+	+	+
<i>Ursus spelaeus</i> Rosenmüller et Heinroth	–	+	+
<i>Martes ex. gr. martes-zibellina</i>	+	+	+
<i>Gulo gulo</i> L.	+	+	+
<i>M. erminea</i> L.	+	+	+
<i>M. nivalis</i> L.	+	+	+
<i>M. eversmanni</i> Lesson	?	+	+
<i>Meles meles</i> L.	–	+	+
<i>Crocuta spelaea</i> Goldfuss	–	–	+
<i>Panthera spelaea</i> Goldfuss	+	+	+
<i>Mammuthus primigenius</i> Blüm	+	+	+
<i>Equus ex. gr. latipes-uralensis</i>	+	+	+
<i>Coelodonta antiquitatis</i> Blumenbach	+	+	+
<i>Cervus elaphus</i> L.	–	+	+
<i>Alces alces</i> L.	–	+	+
<i>Rangifer tarandus</i> L.	+	+	+
<i>Bison priscus</i> Bojanus	+	+	+
<i>Saiga tatarica</i> L.	+	+	+
<i>Ovibos pallantis</i> H.Smith	+	+	+

*1—Polar Urals and adjacent territories of the East Europe and West Siberia.

2—North Urals and adjacent territories of the East Europe and West Siberia.

3—Middle Urals and adjacent territories of the East Europe and West Siberia.

et al., 1999a; Borodin and Kosintsev, 2001; Ponomarev, 2003). The mammal faunas of the Northern Urals and adjacent territories of Eastern Europe (Kochev, 1993; Ponomarev, 2003) and Western Siberia (Borodin and

Kosintsev, 2001; Bobkovskaya, 2002) included 39 species. The mammal faunas of the Middle Urals (Smirnov, 1993; Kosintsev, 2003; Fadeeva, 2003; Razhev et al., 2005) and adjacent territories of Eastern Europe (Yakovlev, 2003) and Western Siberia included 44 species. Consequently, by species abundance mammal fauna of the North Urals during the Late Pleistocene differed from that of the Polar Urals, and was similar to the Middle Urals.

The large-mammal faunal composition of the Late Pleistocene at the North Urals was similar to that of the Central Russian Plain (Markova et al., 1995; Sablin, 2001) and the Central Yakutia (Lazarev et al., 1998). The mammal faunas of North Urals and Central Russian Plain mainly differed by small-mammal species assemblages. *Desmana moschata*, *Sicista subtilis*, *Allactaga major*, *Eolagurus luteus* and *Microtus arvalis* were not present in the Northern Ural and *Myopus schisticolor*, *Martes zibellina*, *Ursus spelaeus* in the Central Russian Plain.

The fauna of Yakutia differed from that of the North Urals in three ways. Ural and Yakutia faunas are characterized by the presence of species which are ecological vicariates. *Ochotona pusilla*, *Marmota bobak*, *Microtus middendorffi*, *Equus latipes* and *Equus uralensis* existed in the North Urals and *O. hyperborea*, *M. camtschatica*, *M. hyperboreus* and *E. lenensis* in Yakutia. Secondly, the fauna of Yakutia included less 'steppe species' than the fauna of the North Urals. *Lagurus lagurus* and *Cricetulus migratorius* did not inhabit Yakutia. Finally, one European species (*Ursus spelaeus*) was absent from Yakutia, and one Asiatic species (*Ovis nivicola*) was absent from the North Urals (Markova, et al., 1995).

Mammal faunas of the North Urals and northern regions of Central and Western Europe differ in much greater degrees. The species list of large-mammal fauna of the Northern Urals during the Late Pleistocene was significantly longer than that of the northern Scandinavian peninsula (Hufthammer, 2001) and significantly shorter than that of northern regions of Europe and Great Britain (Stuart, 1982; Musil, 1985; Turner, 1991; Kahlke, 1994; van Kolfschoten, 2001; Stewart et al., 2003). The greatest differences were in small-mammal fauna. In the North Urals, Insectivora are represented by 1–2 species and Chiroptera are absent, as well as Hystricidae, Gliridae, Dipodidae, Spalacidae and Muridae. The Family Cricetidae included only representatives of subfamilies Cricetinae (1 species) and Arvicolinae (11 species). The differences in large-mammal fauna were not so significant. Order Carnivora included 17 species in northern Europe and 12 species in the Urals; order Proboscidea—2 and 1 species; order Perissodactyla—4 and 2 species; and order Artiodactyla—13 and 6 species. The degree of these differences varied during the Late Pleistocene. The differences were maximal during interglacial and minimal during glacial periods. The majority of warmth-requiring species: insectivores, bats, mice, dormice, roe deer, wild boar, aurochs, and others were absent in faunas during cold periods. This species group was comparatively numerous in northern

European fauna and absent from the North Urals during the interglacial.

Changes of the fauna composition and structure probably began simultaneously in Europe and the North Urals. However, the rates of these changes were different.

The transition from the Pleistocene to Holocene occurred at a greater rate in Europe than in the North Urals (Aaris-Sørensen, 1992; Coard and Chamberlain, 1999; Street and Baales, 1999). The Pleistocene relicts (*Ochotona pusilla*, *Lagurus lagurus*, *Dicrostonyx torquatus* and *Lemmus sibirica*) lived until the Sub-Atlantic in the North Urals. A similar phenomenon is found in Yakutia (Boeskorov, 2006).

6. Conclusion

Species composition of mammal faunas from the North Urals revealed significant differences between the Late Pleistocene and Holocene complexes. These distinctions were the result of two processes: extinction and distributional changes in some species. Reorganisation of the small-mammal fauna occurred at the end of the Pleistocene, whilst that of the large-mammal fauna occurred at the transition from the Pleistocene to Holocene. Such distinctions may be related to ecological factors for both the small and large mammals. Small-mammal populations require specific biotopes, whereas the character of landscapes is more important for large-mammal populations. At the end of the Pleistocene, during deglaciation of the Eurasian ice sheet in the Northern Urals, areas of forest vegetation increased, resulting in expansion of species which were connected to such biotopes. A great rearrangement of environment took place later, at the Pleistocene–Holocene boundary. This process caused changes of the structure and composition of large-mammal fauna.

Species composition of the Late Pleistocene mammal fauna from the North Urals was similar to that of the Central Russian Plain and Yakutia. Faunas of these regions were a northern variant of the mammoth fauna of the periglacial zone of North Eurasia. This variant differed significantly from northward arctic and from northern Europe and Great Britain faunas.

Acknowledgements

Research on mammals at the North Urals was supported by RFBR Grant N 05-04-48675. We are grateful to archaeologists S.E. Chairkin, P.Y. Pavlov and A.F. Melnichuk. We are also grateful to L.A. Orlova, A.J. Stuart, and A.M. Lister for radiocarbon dates.

Appendix A

Radiocarbon age determined on collagen from fossil mammal bones from the Northern Ural is given in Table A1.

Table A1

Radiocarbon age determined on collagen from fossil mammal bones from the Northern Urals

Sites	Date ^a	±: (>) infinite dates	Laboratory No. ^b	Lat °N	Long °E	Species	Dated object
Cheremukhovo, pit 1 (stratum 5)	4930	75	SOAN-5137	60.24	60.03	Mammal	Bones
Lisia cave	5073	173	IEMEG-1339	60.25	60.05	Mammal	Bones
Lisia cave	7213	60	IEMEG-1338	60.25	60.05	Mammal	Bones
Cheremukhovo, pit 2 (stratum 1-2)	8030	120	SOAN-5138	60.24	60.03	Equus sp.	Bone
Kakva - 4 (horizons 7)	10 555	65	SOAN-5140	59.35	60.00	Mammal	Bones
Shaitanskaya cave, pit 2 (stratum 5b)	11 220	200	SOAN-5305	60.42	60.22	Bison priscus	Metatarsal
Medvezhaya cave (grey loamy soil)	11 840	50	GIN-8400	62.20	59.0	Rangifer tarandus	Bone
Medvezhaya cave (greyish-brown "A" loamy soil)	12 230	100	LE-3059	62.20	59.0	Mammal	Bones
Kakva - 4 (horizon 8)	12 630	80	SOAN-5141	59.35	60.00	Mammal	Bones
Medvezhaya cave (grey loamy soil)	12 670	90	GIN-8398	62.20	59.0	Rangifer tarandus	Bone
Kakva-4 (horizon 4)	12 800	300	GIN-9444	59.35	60.00	Mammal	Bones
Medvezhaya cave (greyish-brown "A" loamy soil)	13 260	230	T-13476	62.20	59.0	Mammal	Bones
Shaitanskaya cave, pit 1 (stratum 2)	14 480	650	SOAN-2212	60.42	60.22	Equus, Rangifer tarandus	Bones
Medvezhaya cave (greyish-brown "B" loamy soil)	16 130	150	LE -3060	62.20	59.0	mammal	Bones
Medvezhaya cave (greyish-brown "B" loamy soil)	17 980	200	LE-3061	62.20	59.0	Mammal	Bones
Medvezhaya cave (greyish-brown "B" loamy soil)	18 700	180	GIN-8399	62.20	59.0	Rangifer tarandus	Bones
Cheremukhovo, pit 4 (stratum 1)	18 780	379	IEMEG- 1259	60.24	60.03	Mammal	Bones
Cheremukhovo, pit 1 (stratum 9)	18 900	320	SOAN-4531	60.24	60.03	Mammuthus primigenius	Femur
Shaitanskaya cave, pit 1 (stratum 2)	19 050	200	SOAN-5225	60.42	60.22	Bison priscus	Humerus
Shaitanskaya cave, pit 1 (stratum 2)	19 140	205	SOAN-5224	60.42	60.22	Coelodonta antiquitatis	Tibia
Shaitanskaya cave, pit 1 (stratum 2)	22 650	670	SOAN-4529	60.42	60.22	Mammuthus Primigenius	Tibia
Cheremukhovo, pit 2 (stratum 1-2)	24 580	355	SOAN-5223	60.24	60.03	Coelodonta antiquitatis	Humerus
Cheremukhovo, pit 1 (stratum 10)	25 150	500	SOAN-5302	60.24	60.03	Coelodonta antiquitatis	Pelvis
Cheremukhovo, pit 1 (stratum 10)	26 480	840	OxA-10926	60.24	60.03	Coelodonta antiquitatis	Thoracic vertebra
Cheremukhovo, pit 1 (stratum 9)	27 000	710	AA-36471	60.24	60.03	Mammal	Bones
Cheremukhovo, pit 4 (stratum 2)	27 350	255	SOAN-5139	60.24	60.03	Mammal	Bones
Cheremukhovo, pit 4 (stratum 2)	28 140	350	SOAN-5303	60.24	60.03	Coelodonta antiquitatis	Scapula
Medvezhaya cave, Inner gallery	28 390	890	SOAN-4799	62.20	59.0	Ursus spelaeus	Bone
Cheremukhovo, pit 1 (stratum 12)	28 520	840	AA-36469	60.24	60.03	Mammal	Bones
Cheremukhovo, pit 1 (stratum 9)	29 120	230	OxA-10894	60.24	60.03	Panthera spelaea	Metacarpal
Cheremukhovo, pit 2 (stratum 3)	30 140	240	OxA-10895	60.24	60.03	Panthera spelaea	Tooth
Cheremukhovo, pit 1 (stratum 10)	31 500	1200	AA-36470	60.24	60.03	mammal	Bones
Cheremukhovo, pit 2 (stratum 2)	33 650	600	OxA-10891	60.24	60.03	Coelodonta antiquitatis	Bone
Cheremukhovo, pit 1 (stratum 12)	> 34 140	—	GIN-101152	60.24	60.03	Mammal	Bones
Shaitanskaya cave, pit 1 (stratum 3)	34 310	580	SOAN-5304	60.42	60.22	Bison priscus	Tibia
Cheremukhovo, pit 2 (stratum 2)	42 700	800	OxA-10911	60.24	60.03	Mammuthus primigenius	Femur
Zhiliche Sokola, pit 2	> 50 000	—	GIN-8500	59.35	60.00	mammal	Bones
Shaitanskaya cave, pit 1 (stratum 3)	54 500	2600	OxA-10907	60.42	60.22	Panthera spelaea	Bone

^aUncalibrated dates.^bLaboratory codes for dates: AA—University of Arizona, Tucson, USA; GIN—Geological Institute, Russian Academy of Sciences (RAS), Moscow; IEMEG—Institute of Animal Evolution Morphology and Ecology, RAS, Moscow; LE—Institute of Archeology, Leningrad Branch (currently Institute of the History of Material Culture), St.—Petersburg; OxA—Oxford Accelerated, University of Oxford, UK; SOAN—Institute of Geology and Geophysics, Siberian Branch RAS, Novosibirsk; T—Trondheim, Radiological Dating Laboratory, Norway.

Appendix B

Mammal-species composition and remain numbers from sites in the Northern Ural are given in Table A2.

Table A2

Mammal-species composition and remain numbers from sites in the Northern Urals

Species	Late pleistocene												Holocene														
	Early Valdai			Middle Valdai			Late Valdai 1			Bølling-Allerød			Early Middle			Late											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
<i>Ochotona pusilla</i>	9	—	—	163	1	985	269	101	—	9	43	—	1	10	6	22	5	—	—	3	—	1	—	—	—	—	—
<i>Lepus tanaïticus</i>	764	400	78	283	109	1254	4343	345	209	194	386	188	—	48	76	161	187	32	34	53	—	—	—	—	—	—	—

Table A2 (continued)

Species	Late pleistocene												Holocene															
	Early Valdai			Middle Valdai			Late Valdai 1			Bølling-Allerød			Early Middle			Late												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
<i>Lepus timidus</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Pteromys volans</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Sciurus vulgaris</i>	1	—	—	—	—	—	—	—	—	—	—	4	—	1	41	371	1801	1051	15	16	72	2288	68	1205	13	19	28	95
<i>Tamias sibiricus</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	5	—	—	—	—	—	—	—	—	—	—	
<i>Spermophilus sp.</i>	1	2	—	1	—	1	—	3	—	—	—	34	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Castor fiber</i>	2	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Marmota bobak</i>	26	2	1	2	4	2	—	—	—	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Sicista sp.</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Cricetulus migratorius</i>	1	—	—	10	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Clethrionomys rufocanus</i>	1	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Cl. rutilus</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Clethrionomys sp.</i>	2	13	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Lagurus lagurus</i>	6	—	—	34	10	46	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Dicrostonyx gulielmi</i>	35	372	—	4304	1130	6795	146	4245	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Dicrostonyx torquatus</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Lemmus sibiricus</i>	30	410	—	711	529	4428	20	1096	—	—	—	42	23	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Myopus schisticolor</i>	—	—	—	—	—	—	—	—	—	—	—	2	68	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Arvicola terrestris</i>	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>M. gregalis</i>	28	253	—	404	125	4400	27	1539	—	—	—	51	89	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>M. oeconomus</i>	7	159	—	2	—	177	—	205	—	—	—	10	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>M. agrestis</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>M. middendorffi</i>	15	23	—	49	5	800	1	229	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Canis lupus</i>	79	52	4	4	—	27	208	—	—	—	—	5	32	11	1	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Alopex lagopus</i>	513	125	14	92	75	297	1003	42	16	74	1507	11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Vulpes vulpes</i>	50	—	2	—	—	8	10	1	—	—	—	1	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Ursus arctos</i>	338	62	8	—	—	3	—	5	—	—	—	13	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Martes zibellina</i>	1	4	—	—	3	20	9	19	1	—	—	5	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Gulo gulo</i>	—	—	2	—	—	—	—	—	—	—	—	11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Mustela lutreola</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Mustela eversmanni</i>	18	1	—	—	—	—	—	—	—	—	—	2	21	2	1	2	10	—	—	—	—	—	—	—	—	—	—	
<i>Mustela erminea</i>	28	3	—	16	1	86	32	54	—	—	—	4	184	9	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Mustela nivalis</i>	26	1	—	15	—	49	18	32	—	—	—	2	136	2	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Meles meles</i>	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Lutra lutra</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Lynx lynx</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Panthera spelaea</i>	—	—	1	2	29	1	6	—	—	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Equus latipes</i>	84	23	154	40	16	166	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Equus uralensis</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Coelodonta antiquitatis</i>	13	4	67	13	4	47	77	—	—	—	—	12	12	—														

- Bachura, O.P., Plasteeva, N.A., 2005. Holocene mammal fauna from Burmantovskiy cave deposits at the North Urals. In: Kosintsev, P.A. (Ed.), Ural and Siberia Faunas at Pleistocene and Holocene Times. Chelyabinsk, Riphey, pp. 38–55 (in Russian).
- Bachura, O.P., Strukova, T.V., 2002. Mammal bone remains from the site Chermukhovo-1 (pit 4). In: Kosintsev, P.A. (Ed.), Urals Fauna at Pleistocene and Holocene Times. Ekaterinburg University, pp. 37–56. (in Russian)
- Bobkovskaya, N.E., 2002. Pleistocene-dated megamammals in the regions around the Irtysh-river down reaches. In: Kosintsev, P.A. (Ed.), Urals Fauna at Pleistocene and Holocene Times. University Press, Ekaterinburg, pp. 56–61 (in Russian).
- Boeskorov, G.G., 2006. Arctic Siberia: refuge of the Mammoth fauna in the Holocene. Quaternary International 142–143, 119–123.
- Borodin, A.V., Kosintsev, P.A., 2001. Mammals of the Western Siberia. In: Rozanov, A.Yu. (Ed.), Mammoth and Its Environment: 200 Years of Investigations. Geos, Moscow, pp. 244–252 (in Russian).
- Borodin, A.V., Kosintsev, P.A., Strukova, T.V., Nekrasov, A.E., 2000. Mammals, birds and fish from the site Chermukhovo-1 (pit 2). In: Kosintsev, P.A. (Ed.), Pleistocene and Holocene Urals Faunas. Chelyabinsk, Riphey, pp. 59–81 (in Russian).
- Coard, R., Chamberlain, A.T., 1999. The nature and timing of faunal change in the British Isles across the Pleistocene/Holocene transition. The Holocene 9, 372–376.
- Fadeeva, T.V., 2003. Small mammals in the Perm Pre-Urals during the Late Pleistocene and Holocene periods. In: Smirnov, N.G. (Ed.), Quaternary Paleozoology in the Urals. Uralskiy Universitet, Ekaterinburg, pp. 133–146 (in Russian).
- Hufthammer, A.K., 2001. The Weichselian (c. 115,000–10,000 B.P.) vertebrate fauna of Norway. Bollettino della Societa Paleontologica Italiana, Modena, Giugno 40 (2), 202–208.
- Kahlke, R.D., 1994. Die Entstehungs-, Entwicklungs-, und Verbreitungsgeschichte des oberpleistozänen Mammuthus-Coelodonta-Faunenkomplexes in Eurasien (Großäuger). Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft 546, 1–164.
- Kochev, V.A., 1993. Pleistocene Rodent of the North-East Europe and Their Stratigraphical Importance. Nauka, Saint-Petersburg, pp. 1–112 (in Russian).
- Kosintsev, P.A., 1996. Large mammal fauna of the North Urals in the Late Pleistocene and Holocene. In: Smirnov, N.G. (Ed.), Materials and Research on History of The Recent Urals Fauna, pp. 84–109 (in Russian).
- Kosintsev, P.A., 2003. Late Pleistocene and Holocene mega-mammals of the Urals. In: Smirnov, N.G. (Ed.), Quaternary Paleozoology in the Urals. Uralskiy Universitet, Ekaterinburg, pp. 55–72 (in Russian).
- Kosintsev, P.A., Bachura, O.P., 2005. New Holocene sites of large mammals remains at the North Urals. In: Kosintsev, P.A. (Ed.), Ural and Siberia Faunas at Pleistocene and Holocene Times. Riphey, Chelyabinsk, pp. 148–168 (in Russian).
- Kosintsev, P.A., Borodin, A.V., 1990. Teriofauna of the eastern slope of the North Urals in the Late Pleistocene and Holocene. In: Kuzmina, I.E., Barishnikov, G.F. (Eds.), Fauna of Mammals and Birds from Late Pleistocene and Holocene of the USSR. Leningrad, pp. 120–134 (in Russian).
- Kosintsev, P.A., Mamyachenkova, M.V., Bachura, O.P., 2000. Large mammals from the deposits in cave "Lisia". In: Kosintsev, P.A. (Ed.), Pleistocene and Holocene Urals Faunas. Riphey, Chelyabinsk, pp. 123–137 (in Russian).
- Kuzmina, I.E., 1971. Forming of theriofauna of the North Urals during the Late Anthropogene. In: Vereshchagin, N.R. (Ed.), Materials on the Faunas of Anthropogene of the USSR. Proceedings of the Zoological Institute, vol. 49, Leningrad, pp. 44–122 (in Russian).
- Kuzmina, I.E., 1977. About origin and history mammal fauna of the Siberian Arctic. In: Skarlato, O.A. (Ed.), Fauna and Flora of the Anthropogene of the North-East Siberia. Nauka, Leningrad, pp. 18–46 (in Russian).
- Lazarev, P.A., Boeskorov, G.G., Tomskaya, A. I., Garutt, N.V., Vassiliev, E.V., Kasparov, A.K., Rodionov, G.N., 1998. Mammals of the Anthropogene of Yakutia. Yakutsk, Yakut Scientific Centre, Russian Academy of Sciences, pp. 1–168 (in Russian).
- Markova, A.K., Smirnov, N.G., Kozharinov, A.V., Kazantseva, N.E., Simakova, A.N., Kitaev, L.M., 1995. Late Pleistocene distribution and diversity of mammals in Northern Eurasia (Paleofauna database). Paleontologia I Evolucio 28–29, 5–143.
- Musil, R., 1985. Palaeobiogeography of terrestrial communities in Europe during the Last Glacial. Sbornik Národního Muzea v Praze 41B, 1–84.
- Ponomarev, D.V., 2003. Late Pleistocene and Holocene fauna of megamammals in the European north-eastern regions of Russia. In: Smirnov, N.G. (Ed.), Quaternary Paleozoology in the Urals. Uralskiy Universitet, Ekaterinburg, pp. 123–132 (in Russian).
- Razhev, D.I., Kosintsev, P.A., Ulitko, A.I., 2005. Large mammal fauna of the Late Pleistocene and Holocene from cave Bobilek (Middle Urals). In: Kosintsev, P.A. (Ed.), Ural and Siberia Faunas at Pleistocene and Holocene Times. Riphey, Chelyabinsk, pp. 190–211 (in Russian).
- Sablin, M.B., 2001. New date about the fauna of the large late Wurm mammals from central Russian Plain, the dynamics of relative quantity of some species. In: Rozanov, A.Yu. (Ed.), Mammoth and Its Environment: 200 Years of Investigations. Geos, Moscow, pp. 262–265 (in Russian).
- Smirnov, N.G., 1993. Small-mammals of the Middle Urals in Late Pleistocene and Holocene. Nauka, Ekaterinburg, pp. 1–64 (in Russian).
- Smirnov, N.G., 1996. Diversity of small mammals in the North Urals during the Late Pleistocene and Holocene time. In: Smirnov, N.G. (Ed.), Materials and Research on History of the Recent Urals Fauna, pp. 39–84 (in Russian).
- Smirnov, N.G., Andreicheva, L.N., Korona, O.M., Zinoviev, E.V., Golovachov, I.B., Pavlov, P.Yu., Hufthammer, A.K., 1999a. Materials to characterize the biota of the Pre-Ural Subarctic during the Holocene Optimum time. In: Smirnov, N.G. (Ed.), Biota of the Pre-Urals Subarctic in Late Pleistocene and Holocene, pp. 23–60 (in Russian).
- Smirnov, N.G., Kuzmina, E.A., Kourova, T.P., 1999b. New data on rodents of the Late Glacial time in the North Urals. In: Smirnov, N.G. (Ed.), Biota of the Pre-Urals Subarctic in the Late Pleistocene and Holocene, pp. 68–77 (in Russian).
- Stewart, J.R., van Kolfschoten, T., Markova, A., Musil, R., 2003. The mammalian faunas of Europe during Oxygen Isotope Stage Three. In: Van Andel, T.H., Davies, W. (Eds.), Neanderthals and Modern Humans in the European Landscape During the Last Glaciation, McDonald Institute Monographs. McDonald Institute for Archaeological Research, Cambridge, pp. 221–231 Chapter 7.
- Street, M., Baales, M., 1999. Pleistocene/Holocene changes in the Rhineland fauna in northwest European context. In: Benecke, N. (Ed.), The Holocene History of the European vertebrate Fauna. Modern Aspects of Research; Workshop, 6th to 9th April 1998, Berlin. Rahden/Westf. Leidorf, pp. 9–38.
- Stuart, A.J., 1982. Pleistocene Vertebrates in the British Isles. Longman, London and New York, 212pp.
- Teterina, A.A., 2002. Fossil micromammal faunas from North Urals. In: Kosintsev, P.A. (Ed.), Urals Fauna at Pleistocene and Holocene Times. Ekaterinburg, pp. 111–136 (in Russian).
- Teterina, A.A., 2003. Late and Holocene history of small mammals in the North Urals. In: Smirnov, N.G. (Ed.), Quaternary Paleozoology in the Urals. Ekaterinburg, pp. 147–157 (in Russian).
- Turner, E., 1991. Pleistocene stratigraphy and vertebrate faunas from the Neuwied Basin region of Western Germany. Cranium 8, 21–34.
- Van Kolfschoten, T., 2001. Pleistocene mammals from the Netherlands. Bollettino della Societa Paleontologica Italiana, Modena, Giugno 40, 209–215.
- Yakovlev, A.G., 2003. Studies of fossil micromammals of the neo-Pleistocene and Holocene time in the South Pre-Urals and western macro-slope of the South Urals. In: Smirnov, N.G. (Ed.), Quaternary Paleozoology in the Urals. Uralskiy Universitet, Ekaterinburg, pp. 116–122 (in Russian).



QUATERNARY PERSPECTIVES



Newsletter of the International Union for Quaternary Research (INQUA)

INQUA Newsletter Volume 16, No. 2, 2007
(www.elsevier.com/locate/qp)

Editorial

Dear readers,

The next INQUA Congress is approaching rapidly and most of us are looking forward excitedly to meeting many old and new friends of the Quaternary family in Australia. The recent volume of *Quaternary Perspectives* tries to keep you up-to-date, not only of what will happen at Cairns, but also about other new developments in our field of research. We expect that many of you have followed the discussion about the status of the Quaternary as a geological time unit and, below, is a letter by the International Commission on Stratigraphy (ICS) that has been sent to the INQUA Executive Committee. Another highlight of the present issue is an overview about cosmogenic nuclide dating provided by two colleagues from ETH Zürich. Beside that, there are as usual several announcements and news, together with four conference reports.

Frank Preusser, Christian Schlüchter (Bern)

The status of the Quaternary

INQUA continues to discuss the long-standing issue of the status of the "Quaternary" in the Geological Time Scale with the International Commission on Stratigraphy (ICS). In March 2006, INQUA sent a letter to Dr. Felix Gradstein, Chair of ICS, stating that a proposal to formalize the Quaternary as a "sub-era" within the Geological Time Scale was not acceptable to our community and that the Quaternary must be a Period (System), which, in our view is, its current status. I received the following response from Professor Gradstein.

1040-6182/\$ - see front matter
doi:10.1016/j.quaint.2006.10.042

The issue of the status of the "Quaternary" will not be resolved soon, but INQUA hopes that, through continued dialogue and pressure, its position will prevail.

John Clague (INQUA President)

Letter by ICS to INQUA Executive Committee

To the INQUA Executive,

We thank INQUA for the careful consideration of the ICS recommendation to formalize Quaternary as an official unit of the international geological time scale that spans the past 2.6 Ma. The International Commission on Stratigraphy, as an IUGS commission, provides advice and recommendations to the IUGS and the International Geological Congress. The IUGS and IGC establish policy, ratify or reject definitions and nomenclatures for international stratigraphic units, approve guides for stratigraphic methodologies, and assign tasks to the ICS and its subcommissions.

Current IUGS-IGC decisions on Quaternary and on Pleistocene

The ICS and its official publications and products must conform to past decisions of the IUGS-IGC. The relevant IGC-IUGS decisions to Quaternary and Pleistocene are the following.

(1) The 1948 International Geological Congress decreed that "The Pliocene–Pleistocene (Tertiary–Quaternary) boundary

should be based on changes in marine faunas, especially in the classic area of marine sedimentation in Italy, ... and the boundary should be placed at the horizon of the first indication of climate deterioration in the Italian Neogene succession". [Prof. Vai explained to us that the *Calabrian formation incorporated into this Pleistocene definition was traditionally within the Neogene as used in Italy.*] This was a historic decision—the first time that IGC or its commissions had proposed the concept of a boundary stratotype; and this philosophy later became the principle of the GSSP. When ICS was assigned the goal of establishing GSSPs to define the international scale, the Pleistocene GSSP was retained with the same criteria as dictated by the 1948 IGC, and re-confirmed by IUGS and the IGC in 1998. Therefore, the base-Pleistocene has the unique distinction of being defined by a stable GSSP concept for the past 60 years.

(2) The 1985 GSSP for the base-Pleistocene proposed by a joint ICS-INQUA working group to IUGS explicitly stated that the boundary decision was "isolated from other more or less related problems, such as ... the status of the Quaternary within the chronostratigraphic scale". The IUGS ratified that decision. The 1998 re-ratification by IUGS of the base-Pleistocene also indicated that this was an epoch-level division of the international geological scale.

(3) The Cenozoic currently has two ratified period/system-level divisions: The Paleogene, GSSP ratified by IUGS in 1991, and the Neogene, GSSP ratified by IUGS in 1996. Tertiary and Quaternary have been consistently recognized by International Geological Congresses of the past century (the IGCs rejected proposals to abandon the

unconformity in the structurally higher areas but did not produce such clear effects in the morphologically lower sections of the Tiber Valley, where there are suggestions of either a link between eustatic effects and facies changes (Bonadonna et al., 1990), or a hiatus on a smaller scale within the Late Pliocene (Buonasorte et al., 1991; Carboni et al., 1993). The latter situation can be deduced from cores but is not visible in outcrop. Therefore, the known Acquatraversa erosive phase (or Anziate) can only be recognized where both uplift and sea-level lowering were active.

The new magnetostratigraphic and rock magnetic data indicate that at least some of the normal polarity events previously recognized at the Tini section are simply due to strong changes in magnetic mineralogy and are related to the presence of ferrimagnetic iron sulphides. Therefore they do not reflect true reversals of the geomagnetic field. The data collected during this investigation indicate that the event previously attributed to the Reunion at the Tini section is purely illusory and that new extensive and detailed studies are necessary to give a proper magnetostratigraphic control for the Plio-Pleistocene clayey successions in the Tiber valley.

REFERENCES

- Aguirre, E. and Pasini, G. (1985). The Plio-Pleistocene boundary. *Episodes*, 8(2), 116–120.
- Arias, C., Azzaroli, A., Bigazzi, G. and Bonadonna, F.P. (1980). Magnetostratigraphy and Pliocene–Pleistocene boundary in Italy. *Quaternary Research*, 13, 65–74.
- Arias, C., Bigazzi, G., Bonadonna, F.P., Iaccarino, S., Urban, B., Dal Molin, M., Dal Monte, L. and Martolini, M. (1990). Valle Ricca Late Neogene Stratigraphy (Lazio region, Central Italy). *Paleobiologie continentale*, 17, 61–80.
- Bonadonna, F.P. (1968). Studio sul Pliocene del Lazio. La biostratigrafia di M. Mario e la "Fauna malacologica Mariana" di Cerulli Irelli. *Mem. Soc. Geol. It.*, 7, 261–321.
- Bonadonna, F.P., D'Eugenio, M.L. and Leone, G. (1990). Stable isotope record of Valle Ricca Plio-Pleistocene cores, Latium, Italy. *Paleobiologie continentale*, 17, 81–94.
- Bracci, G., Dalena, D. and Orlandi, P. (1985). La Greigite di Mentana, Lazio. *Rend. Soc. It. Miner. e Petr.*, 40, 295–298.
- Buonasorte, G., Carboni, M.G. and Conti, M.A. (1991). II substrato plio-pleistocenico delle vulcaniti sabatine: considerazioni stratigrafiche e paleoambientali. *Boll. Soc. Geol. It.*, 110, 3540.
- Cande, S.C. and Kent, D.V. (1992). A new Geomagnetic Polarity Time Scale for the Late Cretaceous and Cenozoic. *Journal of Geophysical Research*, 97, 13,917–13,951.
- Carboni, M.G., Di Bella, L. and Girotti, O. (1993). Nuovi dati sul Pleistocene di Valle Ricca (Monterotondo, Roma). *II Quaternario*, 6(1), 39–48.
- Colalongo, M.L. and Sartoni, S. (1979). Schema biostratigrafico per il Pliocene e basso Pleistocene in Italia. Nuovi Contributi alla Realizzazione della Carta Neotettonica d'Italia. *CNR Pubbl. 251* (Prog. Fin. Geodin.), 645–654.
- De Rita, D., Funicello, R., Rossi, U. and Sposato, A. (1983). Structure and evolution of the Sacrofano-Baccano caldera, Sabatini volcanic complex, Rome. *Journal of Volcanology and Geothermal Research*, 17, 219–236.
- Florindo, F. and Sagnotti, L. (1995). Palaeomagnetism and rock magnetism in the upper pliocene vallerieca (Rome, Italy) section. *Geophys. J. Int.*, 123, 340–354.
- Hilgen, F.J. (1991). Astronomical calibration of Gauss to Matuyama sapropels in the Mediterranean and implication for the geomagnetic polarity time scale. *Earth and Planetary Science Letters*, 104, 226–244.
- Iaccarino, S. (1985). Mediterranean Miocene and Pliocene planktic foraminifera. In: Bolli, H.M., Saunders, J.B. and Perch-Nielsen, K. (eds), *Plankton Stratigraphy*, Cambridge Earth Science Series, pp. 283–314.
- Locardi, E., Lombardi, G., Funicello, R. and Parotto, M. (1977). The main volcanic groups of Latium (Italy): relations between structural evolution and petrogenesis. *Geol. Rom.*, 15, 279–300.
- Lowrie, W. (1990). Identification of ferromagnetic minerals in a rock by coercivity and unblocking temperature properties. *Geophysical Research Letters*, 17, 159–162.
- Malatesta, A. (1978). La serie di Torre in Pietra nel quadro del Pleistocene Romano. *Quaternaria*, 20, 537–576.
- Mary, C., Iaccarino, S., Courtillot, V., Besse, J. and Aissaoui, D.M. (1993). Magnetostratigraphy of Pliocene sediments from the Stirone River (Po Valley). *Geophys. J. Int.*, 112, 359–380.
- Piccardi, E. (1993). Il Plio-Pleistocene in sinistra del Tevere dal Lago di Corbara a Magliano Sabina. Tesi di Dottorato, 1–281.
- Rio, D., Sprovieri, R. and Thunell, R. (1991). Pliocene-lower Pleistocene chronostratigraphy: a re-evaluation of Mediterranean type sections. *Geological Society of American Bulletin*, 103, 1049–1058.
- Shackleton, N.J., Backman, J., Zimmermann, H.B., Kent, D.V., Hall, M.A., Roberts, D.G., Schnitker, D., Baldauf, J.G., Despraires, A., Homrighausen, R., Huddlestun, P., Keene, J.B., Murray, J.W. and Westberg-Smith, J. (1984). Oxygen isotope calibration of the onset of ice rafting in DSDP Site 522A: History of glaciation in the North Atlantic region. *Nature*, 307, 620–623.
- Shackleton, N.J., Berger, A. and Peltier, W.R. (1990). An alternative astronomical calibration of the Lower Pleistocene time scale based on ODP Site 677. *Transactions of Royal Society of Edinburgh*, 81, 251–261.
- Snowball, I.F. (1991). Magnetic hysteresis properties of greigite (Fe³S₄) and a new occurrence in Holocene sediments from Swedish Lapland. *Physics of Earth Planetary Interiors*, 68, 32–40.
- Zijderveld, J.D.A., Hilgen, F.J., Langereis, C.G., Verhallen, P.J.J.M. and Zachariasse, W.J. (1991). Integrated magnetostratigraphy and biostratigraphy of the upper Pliocene-lower Pleistocene from the Monte Singa and Crotona areas in Calabria, Italy. *Earth and Planetary Science Letters*, 107, 697–714.



PLEISTOCENE MAMMAL FAUNAS FROM PONTE MOLLE (ROME)

L. Capasso Barbato, G. Di Stefano, C. Petronio and R. Sardella

Dipartimento di Scienze della Terra, Università "La Sapienza", P. le Aldo Moro 5, I-00185 Rome, Italy

THE PONTE MOLLE FAUNA

At the end of the last century, the fluvial Tiber deposits near Ponte Molle (Ponte Milvio), yielded several fossil remains referred to the Galerian by different authors. At present it is not possible to observe the stratigraphy of the area because of its intense urbanization. Thus, we tried to deduce the stratigraphy by means of the biochronological significance of the fossil species collected from the deposits. It is shown here that the 'Ponte Molle fauna' is represented by a mixed fauna in which it is possible to distinguish at least four faunal assemblages referable to the early middle Galerian, the late Middle Pleistocene, the latest Middle Pleistocene–Late Pleistocene and the Holocene.

In the second-half of 19th century a large number of fossil mammal bones was collected from the Tiber alluvial deposits in the area of Ponte Molle (today Ponte Milvio), in Rome. Authors (Ponzi, 1867, 1878; Portis, 1893; Ambrosetti and Bonadonna, 1967) referred this faunal assemblage to a single stratigraphical layer ('diluviale' in Portis, correlated to the Ponte Galeria Formation in Ambrosetti and Bonadonna).

Ponzi (1867) studied for the first time both fossils and stratigraphy. He observed in the Ponte Molle and Tor di Quinto area two different deposits: a conglomerate yielding fossil mammals and sands with a subfossil fauna. He considered the fossil mammal assemblage to be homogeneous.

Portis (1893) described the Cava D'Alessandri deposit. He noticed conglomerate and sands laying in seven irregular levels. Basal levels yielded the faunal assemblages. Ambrosetti and Bonadonna (1967) had no possibility of examining the stratigraphy of the Ponte Molle area, which had become completely urbanized since the first half of 20th century, but considered the faunal assemblage homogeneous.

Detailed analysis of the faunal assemblages recovered from the Ponte Molle deposits is the only way to test the presence of different phases of fluvial deposits in this area (Table 1).

Examination of the faunal remains confirms the presence of a Galerian fauna, which comes from the 'Ghiaie e sabbie di Ponte Molle' as deduced from the labels in the Museum of Palaeontology of the University of Rome 'La Sapienza' and is associated with volcanic minerals. This faunal association is charac-

terized by a skull with antlers of *Cervus elaphus acoronatus*, by the abundant antler remains of *Euraxis eurygonos* and by some hippopotamus remains. The antlers of *Cervus elaphus acoronatus* show with certainty the typical features belonging to this red deer subspecies (Di Stefano and Petronio, 1992). The antler remains of *Euraxis eurygonos* (= *Pseudodama farnetensis sensu Azzaroli, 1992 pro parte*) consist both of basal parts, with rose and brow tine and of terminal forks: the basal parts are characterized by a brow tine forming an obtuse angle with the beam; the terminal forks show a reduced anterior tine and a bent and longer posterior tine. These features fit the variability field of *Euraxis eurygonos*.

Hippopotamus remains consist of several fragmentary canines, teeth and bones. A definite species attribution is not possible, but morphology and dimensions of canines (disposition of the furrows on the outward surface of the tooth) seem to be closest to those of *Hippopotamus antiquus* (Petronio, 1986).

A mandibular fragment is referred to *Canis* cfr. *Canis mosbachensis* on account of its small size and, above all, of the remarkable secodonty of the teeth (Capasso Barbato and Gliozzi, 1993); however, on the basis of some new data (Di Stefano et al., 1992), it seems that this dog does not have a definite biochronological significance for it has been found in Italy even in late Middle Pleistocene (Capasso Barbato and Gliozzi, 1993) and Late Pleistocene faunas (Di Stefano et al., 1992).

Within the Ponte Molle faunal assemblage, however, several species cannot be referred to an early or middle Galerian fauna but suggest the presence of other, younger faunas. Among these species are the rhinoceros remains ascribed to *Stephanorhinus hemitoechus* and to *Stephanorhinus kirchbergensis* on the basis of their morphological characteristics (Guérin, 1980); these two species are considered to be typical elements of the 'Rianian' (last Middle Pleistocene) and younger faunal associations. However, Fortelius et al. (1993) report their first occurrence in the middle Galerian reducing in effect their biochronological significance.

Elephas antiquus, *Bos primigenius* and some carnivores do not give any biochronological information considering their wide chronological distribution. In fact, even the numerous lynx remains, do not allow taxonomical separation between the Middle