

## *Libralces gallicus* (Cervidae, Mammalia) from the Upper Pliocene of the Northeast Azov Region

P. A. Nikolsky and V. V. Titov

Geological Institute, Russian Academy of Sciences, Pyzhevskii per. 7, Moscow, 109017 Russia  
Paleontological Institute, Russian Academy of Sciences, Profsoyuznaya ul. 123, Moscow, 117997 Russia  
Received January 10, 2000

**Abstract**—*Libralces gallicus* Azzaroli from the Khaprovian beds of the Liventsovka locality (lower course of the Don River, Middle Villafranchian) is redescribed. The proportions of the antler beams and small measurements of the lower jaw show that the elk from Liventsovka is more primitive than other Villafranchian forms of the genus *Libralces*.

### INTRODUCTION

The Khaprovian alluvial beds have yielded extensive material on Upper Pliocene mammals of southeastern Europe. It has recently been shown that the Khaprovian Fauna correlates with the Middle Villafranchian faunas from Western Europe (Nikiforova and Aleksandrova, 1987; Fejfar *et al.*, 1997). This fauna includes *Libralces gallicus* Azzaroli. This finding, along with an elk found in the Navrukho locality (Tajikistan), is the earliest form of *Libralces*.

To date, the elk from the Khaprovian beds has only briefly been described (Bajguscheva, 1971, 1982; Vislobokova, 1986, 1990). In the present study, we perform a detailed description and give figures of the elk bones from the Liventsovka locality and substantiate the assignment of this form to *Libralces gallicus*.

The Khaprovian fluvial beds are a narrow band, about 150 km long and 2 km wide, extending along the right bank of the Don River and northern coast of the Taganrog Gulf of the Sea of Azov from Rostov-on-Don to Taganrog. The beds outcrop in quarries, ravines, and natural outcrops. These deposits compose the earliest (Khaprovian) terrace at the lower course of the Don River. They overlie with erosion the Sarmatian, Meotian, and Pontian (Upper Miocene) beds and are covered with conformity by Scythian clays (uppermost Pliocene and lowermost Pleistocene) and Pleistocene coating loams.

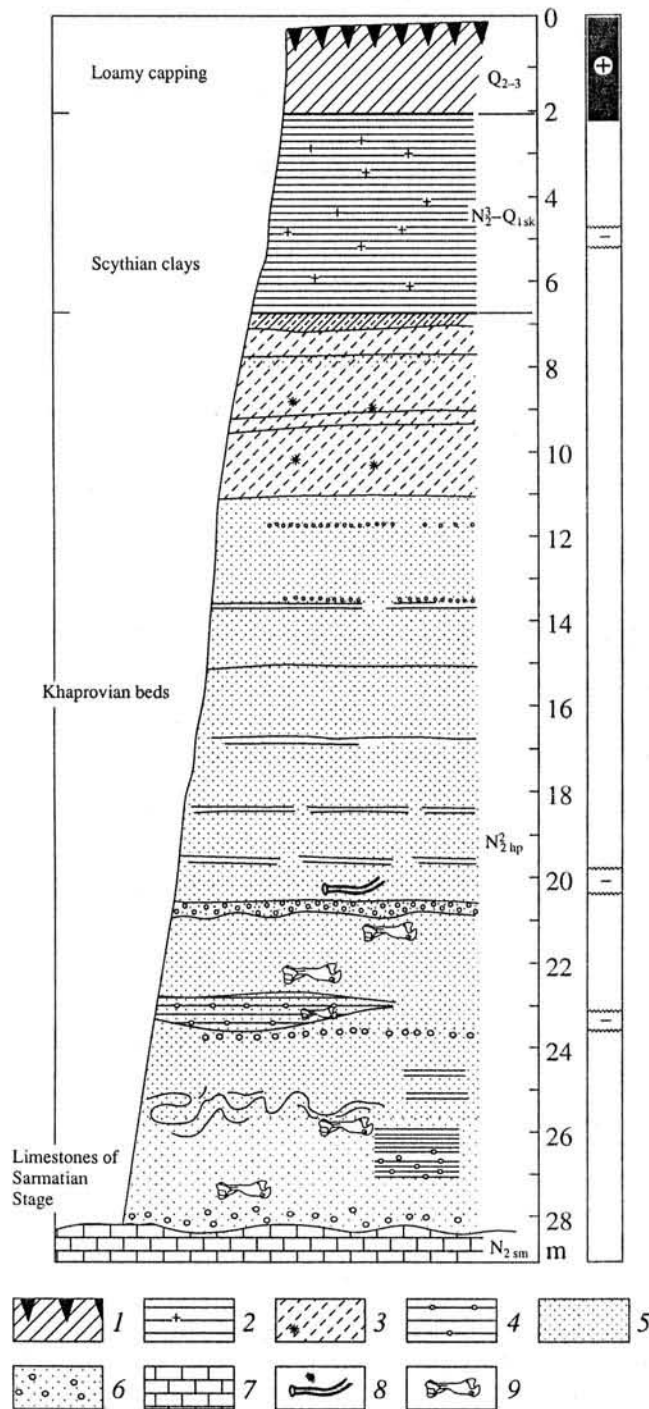
The majority of the bone specimens were collected in sand quarries at the Khapry (Gromov, 1948) and Liventsovskaya stations (Bajguscheva, 1971). Extinct elks were found only in the latter locality.

In a quarry near the Liventsovskaya Station, the Khaprovian beds are 15–17 m thick; the lower layers are composed of obliquely bedded and coarse-grained sands with gravel–pebble interbeds; upsection, the layers consist of medium-grained and fine-grained sands and loams, with only weakly sloping bedding. Large

mammal bones occur in the lower beds of the section, which are 7–8 m thick (Fig. 1), whereas small mammals occur throughout the alluvial deposits. The list of large mammals from this locality includes about 30 species. *Anancus alexeevae* Bajguscheva, *Archidiskodon gromovi* Garutt et Alexeeva, *Equus livenzovensis* Bajguscheva, *Stephanorhinus ex gr. megarhinus-jeanvireti*, *Paracamelus alutensis* Stefanescu, and *Pliocrocuta perrieri* Croizet et Jobert are relatively numerous. The family Cervidae is represented by *Eucladoceros* cf. *dicranios* Nesti, *Arvernoceros* sp., *Cervus (Rusa)* cf. *philisi* Schaub, *Cervodama* cf. *pontoborealis* Pidoplichko et Flerow, and *Libralces gallicus* Azzaroli (Bajguscheva, 1971, 1994).

Small mammals from the basal Khaprovian beds include *Mimomys hintoni livenzovicus* Alexandrova, *Mimomys polonicus* Kowalski, *Dolomys milleri* Nehring, and *Pliomys ucrainicus* Topachevski et Scorik. This suggests that the formation of the bone beds began at the end of the MN 16b Subzone and beginning of the MN 17 Zone (Tesakov, personal communication, 1998). The beds located just above the bottom of the Liventsovka Section and containing gravel interbeds are characterized by the presence of megafauna and *Mimomys praepliocaenicus* Rabeder. The latter shows a correlation between these layers and the lower part of the MN 17 Zone. The upper part of Khaprovian sands contains *Borsodia* ex gr. *arankoides-fejerrvaryi*, *Mimomys* ex gr. *reidi* Hinton, *Cletrionomys kretzoi* Kowalski, and *Ellobius* sp., i.e., forms characteristic of the end of the MN 17 Zone (Tesakov, 1993; Tesakov, personal communication, 1998).

Elk remains were collected by Bajguscheva in 1964 to 1976 (housed in the Rostov Regional Museum: RRM, nos. L-1200, L-1221, L-935, and L-925) and by Alekseeva in 1959 (housed in the Geological Institute, Russian Academy of Sciences, GIN, no. 270/18). Specimen RRM, no. L-1221 was found in situ at 7–8 m from the bottom of the quarry, i.e., just above the upper



**Fig. 1.** A section of the Upper Cenozoic beds at the Liventsovskaya Station (after Vasil'ev, 1969). Designations: (1) Recent soil and loamy capping; (2) Scythian clays; (3-6) Khaprovian beds: (3) clay sand and loams; (4) clay with gravel, former river bed; (5) Khaprovian sands; (6) gravel sands; (7) Sarmatian limestones; (8) burial point of antler beam of *Libralces gallicus*, RRM, no. L-1221; and (9) burial points of large mammal bones.

gravel interbed of the lower coarse-grained sand member (Fig. 1). The stratigraphic position of other finds is uncertain; however, they most likely come from sands

enclosing gravel interbeds, since all large mammal bones found in situ occurred in these beds. Thus, all elk bones from Liventsovka come from the beds correlated with confidence with the onset of the MN 17 Zone.

## SYSTEMATIC PALEONTOLOGY

Family Cervidae Goldfuss, 1820

Subfamily Alcinae Jerdon, 1874

Genus *Libralces* Azzaroli, 1952

*Libralces gallicus* Azzaroli, 1952

*Libralces gallicus*: Azzaroli, 1952, p. 134, text-figs. 1 and 2, pl. 15, figs. 1-6, pl. 6, figs. 1-7.

*Libralces minor*: Azzaroli, 1953, p. 27, text-figs. 4A, 10A, 10E, and 10F.

*Libralces* sp.: Bajguscheva, 1971, p. 25; 1982, pp. 9-10; Vislobokova, 1986, pp. 239-242.

*Alces gallicus*: Kahlke, 1990, p. 83.

**Holotype.** Museum of Natural History, Lyon (France), no. not indicated, complete skeleton of a mature male; Senese, France; Late Villafranchian.

**Description.** The antler beam of specimen RRM, no. L-1200 is long and narrow, S-shaped, and slightly flattened over the entire extent. No signs of basal branches are observed. Distinct longitudinal grooves extend along the entire beam. In different parts of the beam, the axes of greatest diameters are positioned almost in parallel to each other (Fig. 2a, Table 1).

The beam of RRM, no. L-1221 is also S-shaped; however, it is much shorter than that of specimen RRM, no. L-1200. The burr is clearly outlined throughout the circumference. Proximal to the burr, the antler is irregularly ellipsoidal in cross section. The grooves covering the beam are similar to those of specimen RRM, no. L-1200. At the origin of the palmation, the beam is clearly flattened. The beam gradually passes into palmation. The greatest diameter at the antler base is positioned almost perpendicular to the greatest diameter at the origin of palmation (Fig. 2a, Table 1).

Fragmentary palmations of specimens RRM, no. L-935 and GIN, no. 270/18 are flat; the greatest thickness is 10.0-19.0 mm; the edges of the palmation are 10.0-13.5 mm thick. The antler branches vary in shape from wide and digitiform to small and pointed. The palmation surface is covered by well-pronounced grooves.

The horizontal ramus of the mandible (RRM, no. L-925) is low; on the labial side at the posterior edge of  $M_3$ , the jaw is 35.4 mm deep. At the anterior edge of  $M_2$ , the jaw is substantially lower.

The lower molars are relatively low crowned. The lower part of the tooth crowns is substantially expanded labially and forms a ridge overhanging the roots; the upper part strongly narrows to the occlusal surface. The ratios between the height and length of crown (teeth are moderately worn) in  $M_1$ ,  $M_2$ , and  $M_3$  are approximately 67.4, 61.7, and 45.5%, respectively. The lower molar row is approximately 78.3 mm long.

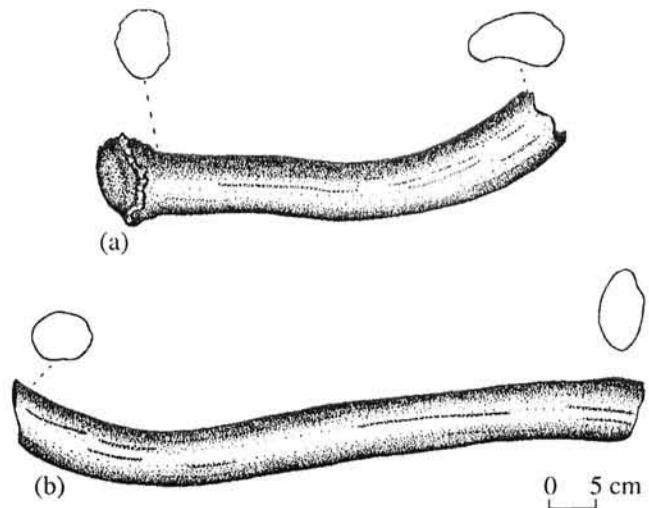
M<sub>1</sub> has the *Palaeomeryx* fold, i.e., a subvertical fold on the posterior wing of the protoconid. M<sub>2</sub> and M<sub>3</sub> also have this fold; however, it is developed to a lesser extent than the fold on M<sub>1</sub>.

Supplementary stylids between the protoconid and the hypoconid of M<sub>1</sub>–M<sub>3</sub> (ectostylids) are well developed. In addition, M<sub>3</sub> has a weakly developed stylid between the hypoconid and the talonid. The stylids are located close to the anterior lobe. The stylids are narrowed oval in cross section. The stylids and ribs on the lingual surface of conids are rounded and well developed. The enamel is wrinkled.

**Comparison.** The elk beams from Liventsovka (specimens RRM, nos. L-1221 and L-1200) are shorter than those of the holotype from Senese; however, their length falls into the variation range of *L. gallicus*. At the same time, the beams of specimens RRM, nos. L-1221 and L-1200 are smaller in diameter than all previously known *L. gallicus* (Table 1). Based on the relatively long and narrow antler beams, double curvature, and gradual transition from the beam to the palmation, the specimens from Liventsovka can be assigned to *L. gallicus*.

Specimen RRM, no. L-1200 from Liventsovka differs from antler of *L. gallicus* from Navrukho (Tajikistan) by somewhat longer and narrower beam (Table 1).

In specimen RRM, no. L-1221, the beam is shorter and narrower than the beam from Navrukho (Table 1). In both antlers from Liventsovka, the beam is curved to a lesser extent than in the specimen from Navrukho,



**Fig. 2.** Antler beams of *Libralces gallicus* Azzaroli from the quarry near the Liventsovskaya Station; Middle Villafranchian. General appearance and cross sections of (a) RRM, no. L-1221 and (b) RRM, no. L-1200.

whereas the transition from the beam to the palmation is as gradual as in the latter specimen (Vislobokova, 1986; Vislobokova, 1988). Thus, elk antlers from Liventsovka are similar in morphology and measurements to the antler from Navrukho; the differences are insignificant. Therefore, we believe that elk remains from both localities should be assigned to the same taxon, *L. gallicus*.

**Table 1.** Antler measurements in members of the genus *Libralces*

No.	Measurement, mm	Liventsovka		Senese (Azzaroli, 1953)	East Runton (Azzaroli, 1953)	Navrukho (Tajikistan) (Vislobokova, 1986)	Kumertau (Ural Mountains) (Yakhimovich, 1965)
		RRM, no. L-1221	RRM, no. L-1200	no. not available	M 6554	PIN, no. 3120-600	no. not available
1	Length of fragmentary antler	290	390				539
2	Beam circumference above burr	124	132	230		154.7	180
3	Minimal beam diameter above burr	37.8	39	66	52		55
4	Greatest beam diameter above burr	41.5	45				62
5	Beam circumference at palmation origin	135	124				177
6	Minimal beam diameter at palmation origin	35.4	30				47
7	Greatest beam diameter at palmation origin	47	47.3				62
8	Beam circumference at midpoint	116	117				
9	Minimal beam diameter at midpoint	35	34.5				
10	Greatest beam diameter at midpoint	35.2	37.5				
11	Beam length from burr to palmation	290	390	584	388	330	429

**Table 2.** Measurements of lower teeth and lower jaws of *Libralces gallicus*

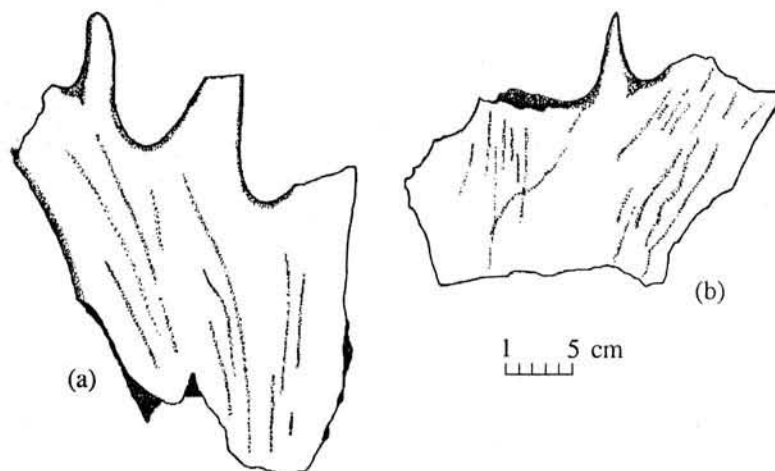
No.	Measurement, mm	Liventsovka	Senese	East Runton (Azzaroli, 1953)		
		RRM, no. L-925	PIN, cast of holotype	M 6206	M 6227	M 6210
1	P <sub>4</sub> length	>19.5	20.7			
2	M <sub>1</sub> -M <sub>3</sub> length	78.3	81	80	74	71
3	M <sub>1</sub> length	>19	24.2			
4	M <sub>1</sub> width	16.2	16.7			
5	M <sub>2</sub> length	23.5	23	23		
6	M <sub>2</sub> width	18	18.3	19	14	15
7	M <sub>3</sub> length	33	34			
8	M <sub>3</sub> width	17	17.1			
9	Width of lobe 3 of M <sub>3</sub>	11.2	11			
10	Jaw depth at M <sub>1</sub> , lingually	38.8			40.5	46.5
11	Jaw depth at M <sub>1</sub> , labially	37			45	48
12	Jaw depth at M <sub>2</sub> , labially	38				
13	Jaw depth at M <sub>3</sub> , labially	43	54			
14	Ratio between jaw depth at M <sub>2</sub> and length of molars	38				
15	Ratio between jaw depth at M <sub>3</sub> and length of molars	50			59	
16	Ratio between jaw depth at M <sub>3</sub> and length of molars	55	66.7			

The antler beams from Liventsovka differ from those found in the Kamertau Region (South Ural Mountains) by the presence of curvature and the absence of longitudinal keel on the anterior surface (Yakhimovich, 1965); in addition, the beams from Liventsovka are somewhat narrower (Table 1).

The mandible from the Liventsovka locality is similar to the previously described jaws of *L. gallicus* in

general proportions, the extent to which the angular process is developed, and in the shape of the transition region between the jaw body and the ascending ramus (Azzaroli, 1952, 1953). At the same time, the mandible from Liventsovka is relatively small.

The molars are similar in morphology to those of the holotype *L. gallicus* from Senese but somewhat smaller (Table 2).



**Fig. 3.** Fragmentary palmation of *Libralces gallicus* Azzaroli: (a) RRM, no. L-935 from the quarry near the Liventsovskaya Station, Middle Villafranchian; and (b) GIN, no. 270/18 from the outcrop near the Morskaya Station, Middle Villafranchian.

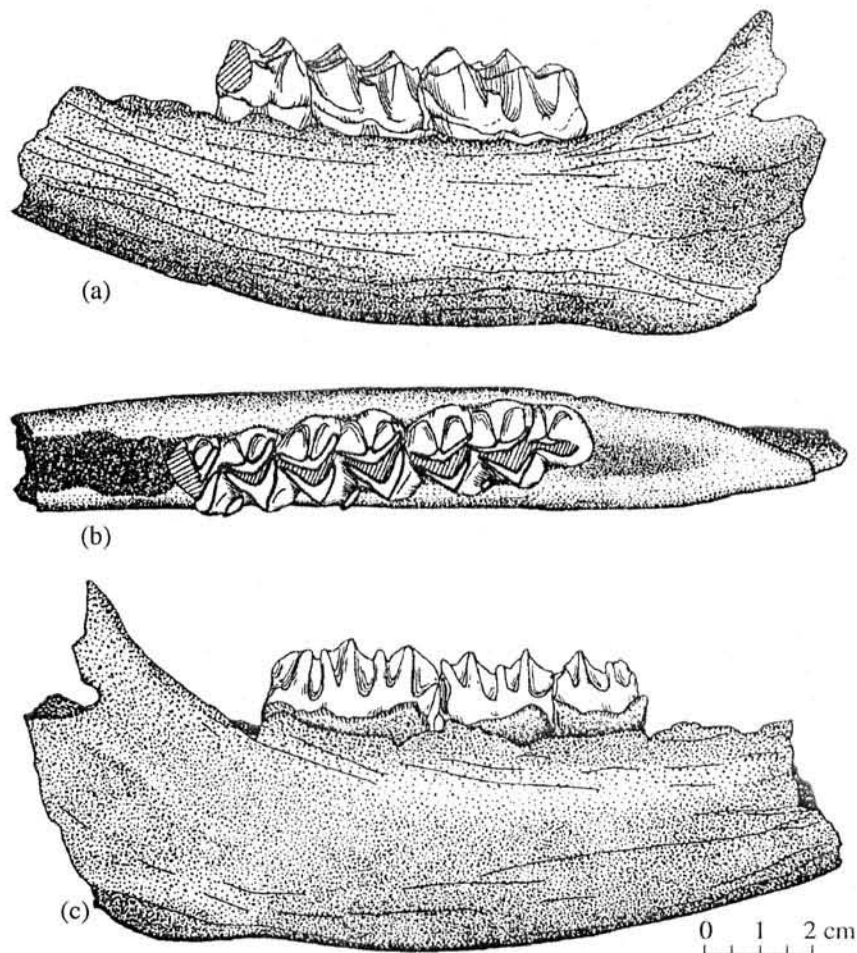


Fig. 4. Fragmentary lower jaw of *Libralces gallicus* Azzaroli, RRM, no. L-925 from the quarry near the Liventsovskaya Station, Middle Villafranchian: (a) labial, (b) dorsal, and (c) lingual views.

**Remarks.** The features of the dental system and the shape and measurements of antler beams allow us to assign elk fossils from the Upper Pliocene of the Azov Region to *Libralces gallicus*. However, the following two points demand further comment.

(1) All elk bones from Liventsovka are smaller than those from the other Villafranchian localities of Europe and Asia. In the present paper, we exclude from consideration the extremely fragmentary fossils of deer resembling elk and recently described from the Lower Villafranchian Udunga locality (Transbaikalia), since the genus to which this form belongs is uncertain (Vislobokova *et al.*, 1995).

(2) The antler beam of specimen RRM, no. L-1200 is substantially longer than that of specimen RRM, no. L-1221.

Relatively small measurements of elk bones from Liventsovka, indicated by Bajgusheva (1982), cannot be reduced to individual or age variation. These distinctions are more likely accounted for by an earlier geological age of *L. gallicus* from the Khaprovian beds.

This inference follows from the well-known fact that, at the end of the Pliocene and beginning of the Pleistocene, elk showed a clear trend to an increase in skeletal measurements.

It is worth noting that a series of *Libralces* specimens described from the Late Villafranchian Forest Bed locality included relatively small forms. Based on dentition, Azzaroli (1953) described a small member of *Libralces*, *L. minor*. Subsequently, Azzaroli (1979) assumed that the distinctive features of this form are attributable to individual or sexual variation and regarded *L. minor* as a synonym of *L. gallicus*. The specimens from the Forest Bed locality were redeposited (Lister, 1993b). Therefore, the differentiation in sizes among Forest Bed elk can be a result of different geological ages; i.e., the relatively small form probably comes from earlier beds.

A characteristic feature of elk evolution is a decrease in the length of the antler beam and an increase in relative diameter (Lister, 1993a). The other important feature is the fact that in early elk, the antler-beam length varies to a greater extent and the beam

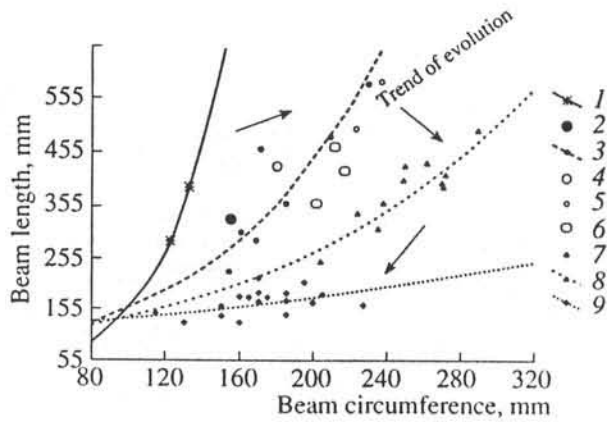


Fig. 5. Changes in the length and circumference of antler beams of elk in the course of evolution. (1) *Libralces gallicus*, Liventsovka, Middle Villafranchian, original data; (2) *Libralces cf. gallicus*, Navrukho (Tajikistan), Middle Villafranchian, original data; (3) *Libralces gallicus*, Late Villafranchian, Forest Bed (England) and Senese (France), after Lister (1993a); (4) *Libralces cf. gallicus*, Kumertau (Ural Mountains), terminal Pliocene to beginning of Pleistocene, after Yakhimovich (1965); (5) *Cervalces aff. latifrons*, primitive form, Kolyma Lowland, Eopleistocene, after Sher (1971) original and data; (6) *Cervalces latifrons*, presumable primitive form, Mosbach, (?) Eopleistocene, after Kahlke (1960); (7) *Cervalces latifrons*, advanced form, Mosbach, Early Neopleistocene, after Kahlke (1960); (8) *Cervalces latifrons*, Süßenborn, Early Neopleistocene, after Kahlke (1956); and (9) *Alces alces*, Eastern Europe, Recent, original data.

diameter varies to a lesser extent than in relatively late forms. This statement is illustrated by Fig. 5, which shows the changes of the length and circumference of antler beams in the course of elk evolution. The regression curve for the elk beams from Liventsovka shows the least inclination to the abscissa. This suggests a more primitive state of elk from Liventsovka as compared to other *L. gallicus*. At the same time, the difference in beam length between specimens RRM, nos. L-1221 and L-1200 is probably attributable to individual or age variation rather than evolutionary differentiation.

**Occurrence.** Late Pliocene to Early Pleistocene of Europe and Central Asia.

**Material.** RRM, no. L-1200, weakly rounded fragmentary antler beam; the proximal part including the burr and the distal part including the palmation are broken off; RRM, no. L-1221, nonrounded fragmentary antler broken off at the palmation; RRM, no. L-935 (Fig. 3a) and GIN, no. 270/18 (Fig. 4b), nonrounded fragmentary palmations of antlers; and RRM, no. L-925, fragmentary mandible, including left dentary ramus with  $M_1-M_3$ ; the ascending ramus and anterior region ahead of the  $P_4$  alveolus are broken off;  $P_4$  is absent (Fig. 4). The bones are strongly mineralized. The material is housed in Rostov Regional Museum and the Geological Institute of the Russian Academy of Sciences.

#### ACKNOWLEDGMENTS

We are grateful to V.S. Bajgusheva, I.A. Vislobokova, E.A. Vangengeim, and M.A. Pevzner for their help in the processing of material and preparation of this paper.

The study was supported by the Russian Foundation for Basic Research, project nos. 96-15-98069, 96-04-49557, 99-04-48636, and 99-05-64150.

#### REFERENCES

- Azzaroli, A., La sistematica dei cervi giganti e i cervi nani delle isole, *Atti Soc. Toscana Sci. Nat. Mem., Ser. A*, 1953, vol. 59, pp. 119-127.
- Azzaroli, A., On the Occurrence of the Cervid Genus *Libralces* in the Pleistocene of Italy, *Palaeontogr. Ital.* (Pisa), 1979, vol. 71, pp. 48-54.
- Bajgusheva, V.S., A Fossil Theriofauna from the Liventsovka Quarry (Northeast Azov Region), *Tr. Zool. Inst. Akad. Nauk SSSR* (Materials on the Quaternary Faunas from the USSR), 1971, vol. 69, pp. 5-28.
- Bajgusheva, V.S., On the Elk Origin, *III s'ezd Vsesoyuznogo Teriologicheskogo Obshchestva* (III Congress of All-Union Theriological Society), 1982, vol. 1, pp. 9-10.
- Bajgusheva, V.S., On the Cranial Structure of Large Deer from the Khaprovian Assemblage, in *Paleoteriologiya* (Paleotheriology), Moscow: Nauka, 1994, pp. 236-252.
- Fejfar, O., Heinrich, W.-D., Pevzner, M.A., and Vangengeim, E.A., Late Cenozoic Sequences of Mammalian Sites in Eurasia: An Updated Correlation, *Palaeogeogr. Palaeoecol.*, 1997, no. 133, pp. 259-288.
- Gromov, V.I., Paleontological and Archeological Substantiation of the Stratigraphy of the Quaternary Continental Beds of the USSR (Mammals, Paleolithic), *Tr. Inst. Geol. Nauk, Geol. Ser.* (Moscow), 1948, issue 64.
- Kahlke, H.-D., *Die Cervidenreste aus den altpleistozänen ilmkiesen von Süßenborn bei Weimar*, Berlin: Akad. Verlag, 1956, part 1, vol. 2, no. 62.
- Kahlke, H.-D., Die Cervidenreste aus den altpleistozänen Sanden von Mosbach, *Abh. dt. Akad. Wiss., Kl. Chemie, Geol. Biol.*, 1960, no. 7, pp. 1-75.
- Kahlke, H.-D., On the Evolution, Distribution and Taxonomy of Fossil Elk / Moose, *Quartärpaläontologie*, 1990, no. 8, pp. 83-106.
- Lister, A.M., Patterns of Evolution in Quaternary Mammal Lineages, in *Evolutionary Patterns and Processes*, London: Linnean Soc., 1993a, pp. 72-93.
- Lister, A.M., The Stratigraphical Significance of Deer Species in the Cromer Forest Bed Formation, *J. Quater. Sci.*, 1993b, vol. 8, no. 2, pp. 95-108.
- Nikiforova, K.V. and Aleksandrova, L.P., Stratigraphical Chart for the Upper Pliocene and Eopleistocene Beds of European USSR, in *Granitsa mezhu neogenovoi i chetvertichnoi sistemami v SSSR* (The Boundary between the Neogene and Quaternary Systems in the USSR), Moscow: Nauka, 1987, pp. 8-13.
- Sher, A.V., *Mlekopitayushchie i stratigrafiya pleistotsena krainego severo-vostoka SSSR i Severnoi Ameriki* (Mammals and Stratigraphy of the Pleistocene of the Far Northeast of the USSR and North America), Moscow: Nauka, 1971.

- Tesakov, A.S., Late Pliocene and Early Pliocene Small Mammals from the South of Eastern Europe, *Stratigr. Geol. Koryatsiya*, 1993, vol. 1, no. 3, pp. 92–96.
- Vasil'ev, Yu.M., *Formirovanie antropogenovykh otlozhenii lednikovoi i vnednikovoi zon* (The Formation of the Quaternary Beds in the Glacial and Periglacial Zones), Moscow: Nauka, 1969.
- Vislobokova, I.A., Elk in the Pliocene of the USSR, *Quartärpaläontologie*, 1986, no. 6, pp. 239–242.
- Vislobokova, I.A., Subfamily Alcinae, in *Biostratigrafiya pozdnego plioTsena–rannego pleistotsena Tadzhikistana* (Biostratigraphy of the Late Pliocene–Early Pleistocene of Tajikistan), Moscow: Nauka, 1988, pp. 97–98.
- Vislobokova, I.A., Fossil Deer from Eurasia, *Tr. Paleontol. Inst. Akad. Nauk SSSR*, 1990, vol. 240, pp. 1–208.
- Vislobokova, I., Dmitrieva, E., and Kalmykov, N., Artiodactyls from the Late Pliocene of Udunga, Western Trans-Baikal, Russia, *J. Vertebr. Paleontol.*, 1995, vol. 15, no. 1, pp. 146–159.
- Yakhimovich, N.N., Mammalian Fossils from the Quaternary Beds of the South Ural Mountains, in *Antropogen yuzhnogo Urala* (Quaternary of the South Ural Mountains), Moscow: Nauka, 1965, pp. 229–238.
- Azzaroli, A., L'Alce di Senese, *Palaeontogr. Ital.* (Pisa), 1952, vol. 67 (N. S. 17), pp. 133–141.