



# On the importance of the representatives of the genus *Elasmotherium* (Rhinocerotidae, Mammalia) in the biochronology of the Pleistocene of Eastern Europe



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## ABSTRACT

Along with the elephants of the mammoth line, the representatives of the genus *Elasmotherium* have been entered into the biostratigraphical scale of the Pleistocene as a chronospecies. This work considers the questions of the correlation of faunistic complexes of Eastern Europe and the fossil faunas of Western Europe.

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## 1. Introduction

The biostratigraphic scale of [Cromov \(1948\)](#) is used in the stratigraphy of Eastern Europe. It is built on the principle of a comprehensive study of the stratigraphic units of faunistic complexes of mammals. For the Early and Middle Pleistocene, the following faunistic complexes are highlighted: Khapry, Psekups, Taman, Tiraspol, Khazar, and Upper Paleolithic (mammoth fauna). Later, the independent Syngil complex was placed between the Tiraspol and Khazar complexes ([Alekseeva, 1977](#)). In the taxonomic characterization of complexes, a leading role belongs to the chronospecies/subspecies of the mammoth line. The span of each complex corresponds to the biozone of one of the members of this line. Along with other animals, the representatives of the genus *Elasmotherium* are important for the paleontological characterization of the faunistic complexes because all species have clear diagnostic features, lived during very short times, and every species corresponds with only one biozone of the mammoth line. The modern level of knowledge suggests the representatives of the genus *Elasmotherium* as the guiding forms in mammalian biochronology of Eastern Europe. The representatives of the genus *Elasmotherium* appear in the Early Pleistocene and began to die out by the time of the maximum development of the Dnieper

glaciation. Their existence may have extended to the Late Pleistocene ([Kosintsev, 2014](#)).

## 2. Materials and methods

This work includes only members of the genus *Elasmotherium*, because more ancient *Elasmotheriini* in Eastern Europe have not been found. The material for this study is based on the serial collections on the elasmotherians from a number of research institutions in Russia: the Paleontology, Zoology, and Geology Institutes, Russian Academy of Sciences; the V.I. Vernadsky Geological Museum of Russian Academy of Sciences; the Rostov museum of local lore; the G.N. Prozritev and G.K. Prave Stavropol Museum-Preserve, and the I.I. Schmalhausen collections of the Paleontological Museum of Odessa State University and the National Museum of Science and Natural History of Ukraine. In total, the author has studied about one thousand bone remains and teeth of elasmotherians.

When considering the bone remains, special attention has been focused on the study of the parameters of the dental system. There is a great variability in the teeth of these rhinos, which is connected with the individual age of the animals ([Shvyreva, 1995, 1997](#)). The second upper and lower, strongly worn molars were chosen for the study because they show the details of the teeth most consistently. Also used were the astragalus, which have clear diagnostic signs. In processing the osteological and odontological materials, the

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morphological and morphometric method offered by Gromova (1959) for the rhinos was used.

The lower boundary of the Quaternary at 2.6 million years is used (Wangengeim, 2010; Shkatova, 2012). In this paper, the author adheres to the biostratigraphic scale of Gromov (1948) with minor changes for the Psekups and Taman faunistic complexes (Fig. 1). They have arisen in connection with the new faunistic studies in the Taman stratoregion (Tesakov and Titov, 2013).

### 3. Results and discussion

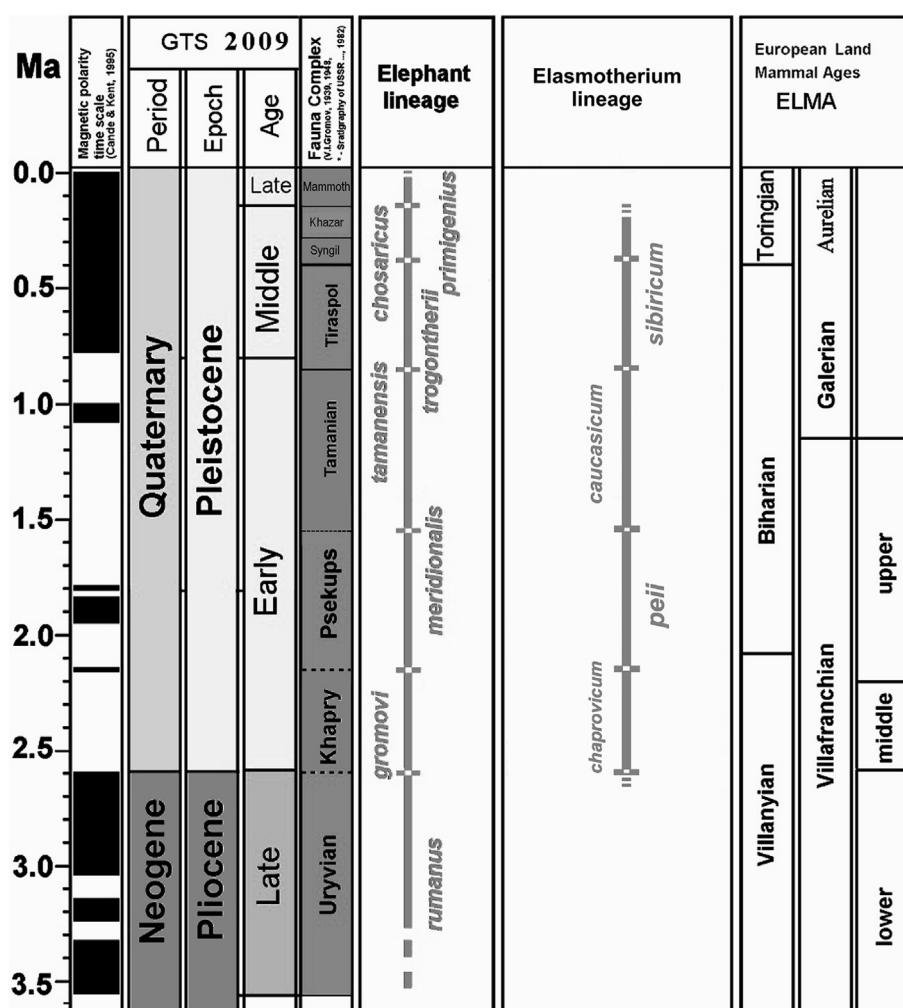
Among the numerous fossils, *Elasmotheriini* is allocated to the branch of the genus *Elasmotherium*. The members of this genus are characterized by the specifics of the structure of the skull, skeleton, and adaptations. Originating in East Asia, they quickly settled in the west (Shvyreva, 2007). The boundary of the elasmotherians in the west should be limited to Moldova (Fig. 2). The humid climate and forests were limiting factors for the elasmotherians in Western Europe.

The evolution of the elasmotherians was directed towards adaptation to rapid running in the open landscapes and to the consumption of tough plant food. In the course of the evolution they inherited some useful traits from their ancestors. The development of the dental system is expressed in the reduction of incisors and canines, the reduction in the quantity of premolars, the

increase of the length of the series of molars, the complication of the folds of the enamel, and the development of absolute hypsodontia. Improved locomotion is expressed in the overall lengthening of limbs, especially their distal segments. Four stages of speciation can be clearly seen in the evolution of the elasmotherians.

It is now recognized that the genus *Elasmotherium* is composed of *E. chaprovicum* Shvyрева, 2004, *E. peii* Chow, 1958, *E. caucasicum* Borissiak, 1914, and *E. sibiricum* Fischer, 1808 (Shvyрева, 1995, 2004; Titov, 2008). However, a number of researchers include only the two species *E. caucasicum* and *E. sibiricum* in the genus. Antoine (2002) mentions elasmotherians from Shanxi Province in China, but in the genus *Elasmotherium* he includes only *E. caucasicum* and *E. sibiricum*. Petrova (2011) finds *E. chaprovicum* and *E. peii* as junior synonyms of *E. caucasicum*. In my view, the features of structure and proportions of teeth (Tables 1 and 2), the astragalus, and some bones of the postcranial skeleton give reason to disagree with this view.

The interval of existence of the genus *Elasmotherium* in Eastern Europe spans approximately 2.5 million years. The earliest representative of the elasmothere *Elasmotherium chaproicum* Shvyreva is fixed in the composition of the Khapry faunistic complex in the sites in North Caucasus and Moldova (Shvyreva, 2004). According to paleomagnetic data, the development of the Khapry faunistic



**Fig. 1.** Stratigraphic position of the representatives of genus *Elasmotherium*.

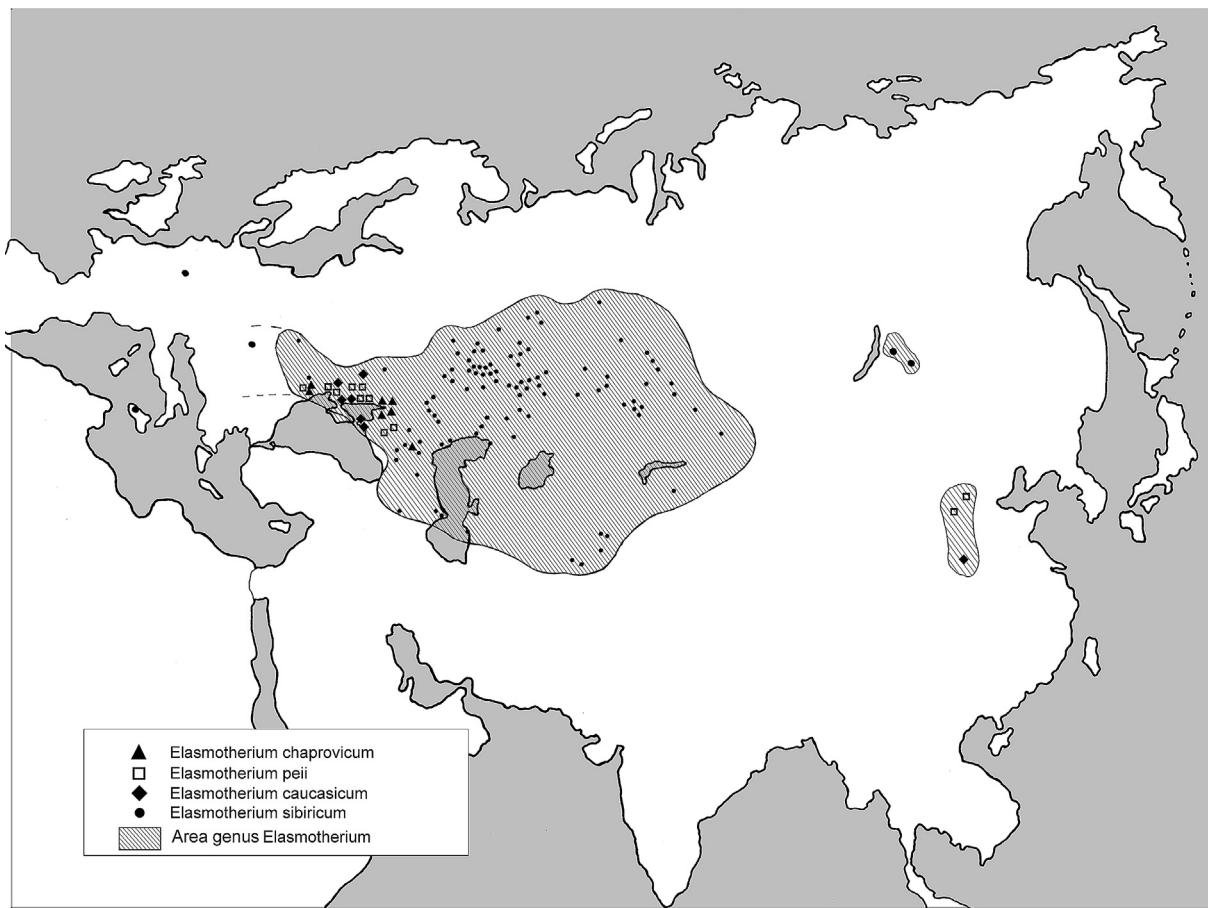


Fig. 2. Area of the elasmotherians.

complex occurred in the early part of the Matuyama. The lower boundary is at the very top of the Gauss chron. The upper boundary occurred before the Olduvai episode of the Matuyama (Wangengeim et al., 2005; Tesakov and Titov, 2013).

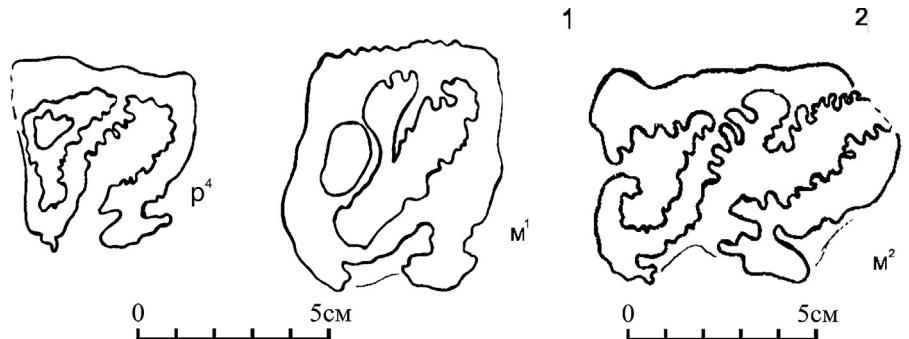
The elasmotherians of that time are characterized by relative massiveness. They have a low talus (astragalus) with a narrow trochlea of talus and a wide distal portion, with massive metacarpal and metatarsal bones. Their teeth have thick rough enamel with

**Table 1**  
Comparison of upper teeth measurements of some representatives of the genus *Elasmotherium*.

Measurements (mm)	<i>Elasmotherium</i>			
	<i>chaproscopicum</i>	<i>peii</i>	<i>caucasicum</i>	<i>sibiricum</i>
1. Length $M^2$	87.8	70.0-(82.1)-89.7	70.0-(79.33)-86.0	60.0-(67.42)-74.6
2. Width $M^2$	69.0	49.3-(56.6)-63.0	65.0-(67.6)-75.6	49.0-(60.5)-72.0
3 Length $P^4-M^3$	—	259.0-(259.5)-260.0	309.0	233.6-(255.4)-279.0
4. Length $M^1-M^3$	—	212.0-(212.5)-213.0	264.0	187.0-(207.6)-233.0
Indexes (%)				
2:1	78.59	58.77-(69.41)-84.28	78.3-(85.52)-91.4	82.66-(89.27)-96.51
4:3	—	81.85-(81.88)-81.92	85.43	77.84-(81.22)-83.51

**Table 2**  
Comparison of lower teeth measurements of some representatives of the genus *Elasmotherium*.

Measurements (mm)	<i>Elasmotherium</i>			
	<i>chaproscopicum</i>	<i>peii</i>	<i>caucasicum</i>	<i>sibiricum</i>
1. Length $M_2$	67.0	70.0-(73.0)-77.0	72.0-(79.5)-95.0	64.2-(73.1)-84.0
2. Width $M_2$	40.6	41.5-(48.5)-60.0	39.0-(43.2)-50.0	30.1-(36.48)-43.5
3. Length $P_4-M_3$	—	—	278.0-(291.1)-293.0	256.9-(272.8)-298.0
4. Length $M_1-M_3$	—	—	199.0-(210.5)-215.0	199.3-(212.0)-237.7
Indexes (%)				
2:1	60.5	59.2-(66.0)-79.2	44.2-(54/5)-60.9	47.7-(49.76)-58.8
4:3	—	—	71.1-(72.1)-73.8	72.5-(77.74)-82.9



**Fig. 3.** Teeth *Elasmotherium chaprovicum* Shvyreva from the collection of Rostov museum of local history: 1 –  $P^4$  (№ MCH-1410) and  $M^1$  (№ MCH-1409), quarry Mokriy Chaltyr; 2 –  $M^2$  (№ 1439-A) of Liventsovsky quarry.

irregular folding (Fig. 3). The Khapry faunistic complex corresponds to the biochron of the archaic elephant *Archidiskodon meridionalis gromovi*. We consistently find *Elasmotherium chaprovicum* with *Archidiskodon meridionalis gromovi* in the sites of the Khapry faunistic complex, suggesting that *E. chaprovicum* is a chronospecies of this complex.

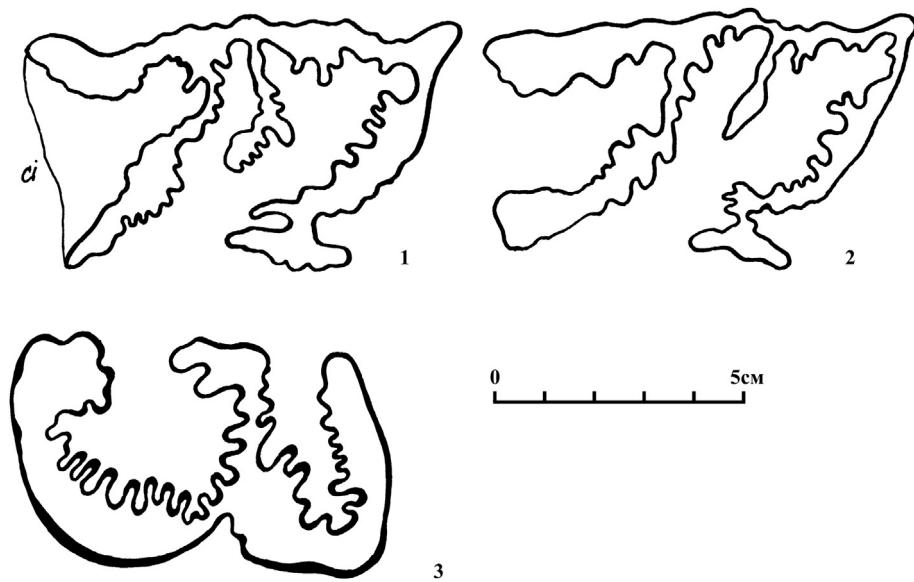
The taxonomic composition of the fauna has a resemblance to faunas of the middle Villafranchian of Italy (Wangengeim and Zazhigin, 1982). The interval of existence of the Khapry faunistic complex of mammals spanned from 2.6 to 2.2 Ma.

The Psekups faunistic complex is known from many sites of the Northern Black Sea, Moldova, and Northern Caucasus (Shvyreva, 1988; Eremeyko, 2002). The Formation of the Psekups faunistic complex is correlated with the middle of the Matuyama epoch. The lower boundary of this complex is somewhat lower than the Olduvai episode. The Upper limit lies below the Jarillo episode. This complex corresponds to the biozone *Archidiskodon meridionalis meridionalis*. In sites of the Psekups faunistic complex, *Elasmotherium peii* Chow is found in combination with the southern elephant, close to the typical form of the Upper Valdarno in Italy. *Elasmotherium peii* was first described in China (Chow, 1958), and then was discovered in southeast Europe. The teeth of *Elasmotherium peii* have early closure of the roots, the prolonged existence of an open

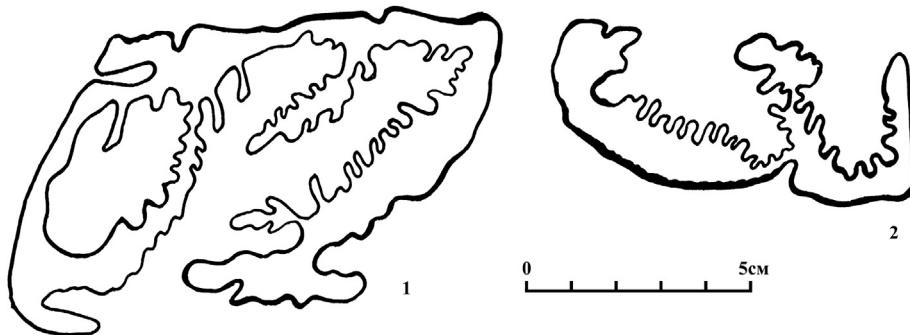
postfossette, the presence of a collar on the back wall of the tooth, a strong, drawn back of transversal protoloph and metoloph, and a clear differentiation of the crown and root (Fig. 4). The Psekups fauna corresponds to the stages of development of the Tasso and Olivola faunas of the Upper Villafranchian from Italy (Azzaroli, 1977; Wangengeim et al., 1990). The interval of development of the Psekups complex is from 2.2 to 1.1 Ma.

Currently on the Taman Peninsula, numerous sites of the Taman faunistic complex are being opened. The progressive form of the southern elephant *Archidiskodon meridionalis tamanensis*, *Equus süssenbornensis* and *Bison* sp. are the typical forms of this complex. The characteristic form of this complex is *Elasmotherium caucasicum* Boriss. This species of the elasmotherere was found also in Nihevan, China (Deng and Zheng, 2005). Compared with the more ancient forms of elasmotherians, the teeth of *Elasmotherium caucasicum* have lost the collar, have a more pronounced prismatic shape, as well as later closure of the pulp cavity and of postfossette, disorderly growth, and greater tortuosity of enamel (Fig. 5). Judging by the size of the teeth and astragalus, *Elasmotherium caucasicum* inherited its large size from its ancestors.

According to faunal data, the age limit of the Taman fauna is limited to the biozone of the progressive southern elephant *Archidiskodon meridionalis tamanensis*. However, among



**Fig. 4.** Teeth *Elasmotherium peii* Chow: 1 –  $M^2$  (№ 1305-5, a collection of the Paleontological Museum of the Russian Academy of Sciences), a sand pit in the village Rasshevatskaya; 2 –  $M^2$  (№ 1784-6, a collection of the Paleontological Museum of the Russian Academy of Sciences), from Shanxi Province, China; 3 –  $M_2$  (№ 39577, a collection of the Stavropol Museum), a sand pit in the village Rasshevatskaya.

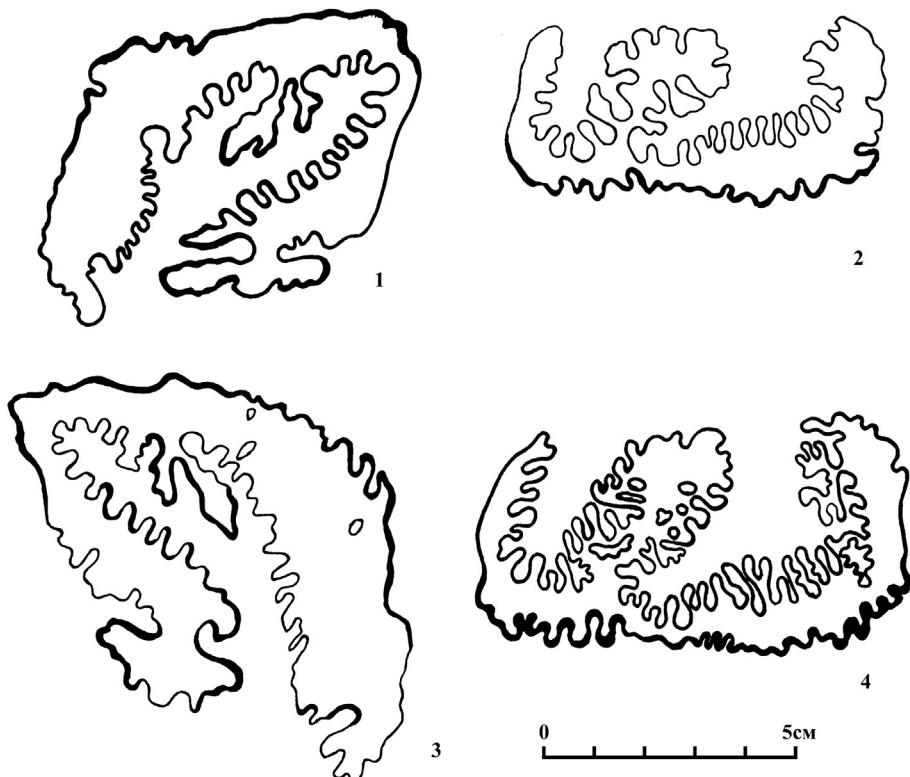


**Fig. 5.** Teeth *Elasmotherium caucasicum* Borissiac: M<sup>2</sup> (№ 1256-3) and M<sub>2</sub> (№ 1256-5) from the Sinjaja Balka (a collection of the Paleontological Museum of the Russian Academy of Sciences).

researchers there is still no consensus on the exact geological age of the Tamanian faunistic complex. According to [Wangengeim and Pivzner, 1991](#), the time interval of its development is from 1.1 to 0.8 million years. The Tamanian complex is positioned in the paleomagnetic scale between the Jaramillo episode and the Matuyama/Brunhes inversion. The probable analogues of the Taman fauna are transitional faunas between Villafranchian and Galerian according to the scheme of [Azzaroli \(1983\)](#).

Several researchers ([Titov et al., 2012](#); [Tesakov et al., 2013](#)) proposed to lower the lower boundary of the Taman faunistic complex based on the composition of rodents, and determine the age limits of this complex at between 1.55 and 0.85 Ma. This corresponds to the second half of the Late Villafranchian and the greater part of the Biharian (with *Allophaiomys plioaenicus*). In the author's opinion, such an approach is justified.

The stratotype of the Tiraspol faunistic complex is located in the outskirts of the town of Tiraspol (Kolkotova Balka). The chronospecies of this complex is *Mammuthus trogontherii* (= *Elephas wüsti*). *Elasmotherium sibiricum* Fischer is present in sites of the Tiraspol fauna in Eastern Europe. This elasmotherium displays a shortening of dental formula by reduction of the amount of premolars. Its molars, despite great wear, have open roots. The enamel of the upper and the lower teeth are thinner with strong folding (Fig. 6). For this species, the early closure and disappearance of the postfossette is typical. All teeth have a slightly curved shape of the prism, the differentiation of the crown and the root not being traced. There is reason to believe that the *Elasmotherium sibiricum* from the Tiraspol faunistic complex was larger than their relatives from the Syngil and Khazar faunistic complexes ([Table 3](#)). For example, the third metacarpal bone is larger and more massive



**Fig. 6.** Teeth *Elasmotherium sibiricum* Fischer from a collection of Stavropol Museum: 1 and 2 – M<sup>2</sup> and M<sub>2</sub> (№ 19900), village Gaevskaya; 3 and 4 – M<sup>2</sup> and M<sub>2</sub> (№ 19901) Zelenokumsk city.

**Table 3**

Comparison of MC III from elasmotherians.

Measurements (mm)	<i>Elasmotherium caucasicum</i>		<i>Elasmotherium sibiricum</i>	
	Nihovan. China № 20342 Deng and Zheng (2005)	Taman f.c. Blue beam, Russia AMZ № 30208/25	Tiraspol f.c. Gaevskaya village, Russia SSMR № 19900	Singil f.c. Raygorod, Russia GIN № 980
1. Length	290.5	289.0	279.2	273.2
2. Width of upper end	95.3	Ca90	100.0	93.5
3. Width of lower end	105.7	99.0	98.2	93.8
4. Width of mid-diaphysis	76.0	—	74.6	67.4
Indexes (%)				
2:1	32.8	31.14	35.8	35.5
3:1	36.38	34.25	35.1	34.3
4:1	26.16	—	26.3	25.1

than the same bone from the Syngil complex (type site Raygorod). This question is under investigation.

In the magnetochronological scale, the Tiraspol faunistic complex is placed in the uppermost Matuyama Chron, but below the Matuyama/Brunhes inversion. The development of this complex occurred before the Likhvin interglacial. The Tiraspol complex is estimated to span 0.8–0.4 Ma. An approximate analogy of the Tiraspol fauna would be the Galerian faunas of Italy.

The Syngil faunistic complex was included in the stratigraphic scale of the Eastern Paratethys in the 1960s. It was isolated between layers of Baku and the Lower Khazars based on discoveries of the fauna in deposits of the Kosozhsky and Singilsky formations. Its development is limited to the Likhvin interglacial. During the propagation of the Syngil fauna, *Palaeoloxodon antiquus* is the chronospecies. In addition, it includes the numerous finds of small form *Elasmotherium sibiricum*. Its teeth are characterized by more thin enamel and still more depth and randomness of the folds, especially on the lower teeth. Its third metacarpal bone is smaller and slimmer compared to the *E. sibiricum* from the Tiraspol faunistic complex (Gaevskaya site). The duration of the complex is estimated from 0.4 to 0.3 Ma.

In the Volga-Ural region the elasmotherians finds occur with representatives of the Khazar faunistic complex: *Camelus knoblochi*, *Bison priscus longicornis*, *Megaloceros giganteus*, *Saiga borealis*, and early mammoth *Mammuthus chosaricus*. Not all were found in situ, but the consistency of faunal combination suggests that *Elasmotherium sibiricum* was a representative of the Khazar faunistic complex. The representatives of the genus *Elasmotherium* appeared in the Early Pleistocene and began gradually to die out by the time of the maximum development of the Dnieper glaciation. The Khazar complex spans 0.3–0.2 Ma.

#### 4. Conclusions

Considering the representatives of the genus *Elasmotherium*, the specific characteristics of the structure of the skull, teeth, and astragalus are easily recognizable. We hope that the results of the study will be useful in the study of new localities of fossil fauna on the territory of Russia and neighboring countries. In the course of study, the problem of the detailed attribution of *E. sibiricum* from the Tiraspol, Syngil and Khazar faunistic complexes was discovered. Continued research is required. At this stage, the problem is in the process of study and comprehension.

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