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Comparative genetic analysis of subfossil wild horses (from the Neolithic Age and Early Bronze Age) and present-day domestic horses from Bulgaria

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Abstract: This study presents the first data on the genetic diversity of Holocene wild horses of the subgenus Equus (Equus) from the period before domestication (Early Neolithic and Early Bronze Age) in Bulgaria, and with this the first data on the genetic diversity of the extinct Holocene wild horses of the subgenus in Europe. The results show the presence of the Q (in Equus germanicus from the Early Neolithic of NW Bulgaria) and G (G1) (in E. ferus from the E. Neolithic and the E. Bronze Age of Bulgaria) haplogroups. So far both haplogroups have been spread with high frequency in the Middle Asian horse breeds. This preliminary result gives ground to support the polyphyletic hypothesis for the origin of the domestic horse. All these data are interpreted in terms of the contemporary view of horse domestication and dissemination in Eurasia during the Holocene. Our results, though preliminary, can provide interesting information about the wild ancestors and the origin of domestic horses. The obtained data would contribute also to elucidating the origin and migration processes in the formation of local horse breeds. This information is directly related to the understanding of migration and the cultural-historical processes in our region.

The methodology includes: isolation of ancient DNA from bones, amplification of fragments of mitochondrial DNA, sequencing and genetic analysis.

Comparative analysis of modern breeds of horses from mountainous and flat geographic regions in Bulgaria has been performed. We found a high degree of genetic diversity and differences between mountain and planar equine populations. The established genetic profile of subfossil wild horse (E. ferus – the Tarpan) is the closest to the profile of the Danube horse, where the frequency of the haplogroup G is about 50 %.

Key words: D-loop region; ancient DNA; wild horses DNA; population horse breed structure

Introduction

The question about the time and the place of horse domestication, a process, which had huge impact on the progress of the civilizations, is disputable. According to the most widely accepted hypothesis, the earliest domestication of the horse has happened in the western parts of the Eurasian steppes, between the Northern Black Sea region and present-day Kazakhstan and Turkmenistan. It seems that it occurred not earlier than the first half and most probably during the middle (even the last third) of the fourth millennium BC (from ~ 5.5 kya; Warmuth *et al.*, 2012; Petersen et al. 2013). The next steps of

large-scale horse breeding occurred almost simultaneously in Eurasia and North Africa due to the development of the social structure of human society (Vila *et al.,* 2001; Jansen *et al.,* 2002, Lei *et al.,* 2009, Cieslak *et al.,* 2010, Lira *et al.,* 2010). On the other hand, the morphological differences between wild and domestic animals are rather vague and the genetic introgression between them is speculative.

Mitochondrial DNA (mtDNA) studies reveal several possible Eurasian domestication centres, most of them likely being secondary domestication centres. These regions have been proposed mainly because of the high frequencies of specific haplogroups. One of the centres for Western Europe is the Iberian Peninsula, where the dominant haplogroup is L (D; X1,2; see Jansen *et al.,* 2002; Cai *et al.,* 2009; Cieslak *et al.,* 2010; Achilli et al. 2012., respectively). For Northern and Central Europe, the the M (C1) haplogroup predominates along with N, B and D haplogroups (Jansen *et al.,* 2002, Cai *et al.,* 2009; Achilli *et al.,* 2012).

Another widely explored domestication centre is in the Turkmen and the Kazakh steppes (Akhal-Teke horses), where G, J, Q and A haplogroups prevail (Achilli *et al.,* 2012). An investigation of ancient DNA from Chinese and Mongolian horses has revealed the dominance of A (A) and Q (F) haplogroups (Cai *et al.,* 2009; Achilli *et al.,* 2012). Domestication in the Middle East is characterised by both a high incidence of haplogroups I and O'P, as well as a mixed genetic profile containing all known haplogroups (except for the F-haplogroup, which is characteristic of the Przivalski's horse only, a wild horse which most probably have not participated in the domestication process: Achilli *et al.,* 2012).

The first study on domestic breeds for the territory of the Balkan Peninsula and for Bulgaria in particular was conducted by Hristov *et al.* (2017a). It includes results for the mitochondrial profile in three local populations of mountain horses from Stara Planina Mts., the Rhodopes and the Rila-Pirin massif. Although these horses are known trivially under the common name of Karakachan breed, they have been differentiated on the basis of phenotypic traits as three different breeds (Petrov, 1941, Barzev *et al.,* 2005). Petrov considers as typical representatives of modern Bulgarian primitive horses three mountain breeds, Rilo-Pirinski, Staroplaninski and Karakachanski (Rhodopes), as well as two planar breeds, Deliromanski (Ludogorski, East Bulgarian) and Kamchiiski horse.

Molecular analysis of mtDNA of Bulgarian autochthonous mountain horses shows a varied genetic profile covering almost all known haplogroups (Hristov *et al.,* 2017a). The haplotypes of European origin (J, M, N and L) are predominant. A similarity was found in the Staroplaninski and Karakachanski horses due to the dominance of European haplogroups, although with a specific mitochondrial profile for Central and Western European populations (a significantly higher incidence of L-20 (20 %), J, M and N). This type of profile reveals the ancient and native background for both breeds. Unusual results are found with regard to the genetic profile of the Rilo-Pirinski horse compared to the other two populations. A high incidence of A, G, Q and C haplogroups has been established in this local domestic horse, which could be an evidence of genetic introgression of local populations with East Asian populations of the domestic horse (Akhal Teke, Kazakhstan, etc.).

One of the earliest centres of horse domestication could be the North-Eastern (Pontic) part of the Balkan Peninsula, and most likely the eastern Black Sea coast, according to the data from the sunken Early Bronze Age village of Urdoviza (Spassov & Iliev, 1997, see Spassov and others in prep.). This has provoked interest in exploring the DNA data from wild horses in the Balkan region.

This paper aims to study the genetic diversity of wild horses (before their domestication) and to make a comparative analysis with ancient and modern populations.

Materials and methods

1. Archeological samples

Four samples (bones and dental material) of wild horses from three archaeological sites: Ohoden/Valoga (Early Neolithic), Gradeshnitsa/Malo Pole (Early Neolithic) and Devetak/Karnobat (Early Bronze Age; Figs. 1 and 2) from the collection of NMNH-BAS were studied. The morphological evaluation of the material (coll. of the NMNHS-BAS) of the bone remains was performed (N.S., N.I. and L.H.) on the basis of morphological and morphometric criteria. The remains from Ohoden were insufficient for taxonomic interpretation. The metacarpal fragment of a wild horse from the early Neolithic of Gradeshnitsa -Malo Pole was determined as *E. germanicus* (a Late Pleistocene horse, survived in Bulgaria till the Holocene) by comparative analysis in previous works (Spassov & Iliev 1997; 1998). The metatarsus of a most probably wild horse from the Early Bronze Age of Devetak had the following metric data: total length – 273.8 mm; width of the diaphysis – 31.24; distal width – 46.47 and with an index

Fig. 1. Metacarpal fragment of Equus germanicus from the Early Neolithic of Gradeshnitsa Malo Pole (Vratsa) and a metatarsus of Equus ferus from the Early Bronze Age, Devetak (Karnobat).

of Brauner – 11.41. It was determined by comparison (this study) with *E. refus* using the morphometric criteria (Brauner, 1916; Gromova, 1949).

Ancient DNA isolation

The methodology includes: isolation of ancient DNA (aDNA) from bone remains, amplification of mitochondrial DNA fragments, sequencing and genetic analysis. Ancient DNA was isolated from bone and dental remains from 4 samples dating from the Early Neolithic (6th millennium BC) to the early Bronze Age (3rd millennium BC; Table 1).

The genetic material was isolated according to the protocol of Yang *et al.* (1998) with minor modifications (Hristov *et al.,* 2017b). To prevent contamination of the bone surface by foreign DNA, the samples were treated sequentially with sodium hypochlorite (40%), 2% hydrochloric acid and washed with ultra-clear H_2O several times. After drying for 24-48 h in UV-irradiation medium and constant air filtration, the surface layer was removed, and then a bone powder was obtained, which was further homogenized in metal mortars. Treatment of bone material for isolation of the aDNA was performed from 400-500 mg of bone powder dissolved in 5 ml of lysis buffer (0.5M EDTA, 2% Sodium dodecyl sulfate, 0.1M Tris pH8, 10 µl/ml Mercaptoethanol, 20 µl/ml Proteinase K). The samples were incubated in a hybridizer (Hybridiser HB-2D, Techne, UK) at constant rotation at 55°C for 36-48 h. The samples were centrifuged at 5000 rpm for 1 h, after which the supernatant was filtered with 0.45 µm filters and transferred to 50 ml tubes. DNA isolation was performed using silicone membrane technology, including the use of DNA isolation columns (GeneMatrix, E3520, EURx, Poland) and 5M GuSCN (Sigma-Aldrich) binding reagent V/V. The aDNA bound to the silica columns was purified twice with 70% ethanol wash solution and dissolved in ultrapure water. Isolated aDNA was stored at -20°C.

2. PCR amplification and sequencing

Five different overlapping regions were used to amplify the D-loop region (mitochondrial DNA, HVRI). Primers for amplification are listed in Table 2.

All PCR reactions were performed with 10ng/µl DNA in a final volume of 50 µl (NZYTaq Colourless Master Mix, Cat No – MB040, NZYTech, Portugal). They were performed under the following conditions: Initial denaturation at 94°C for 5 min.; 40 cycles of denaturation at 94°C for 30 seconds, hybridization – 50°C for 30 seconds, elongation at 72°C for 1 minute; end final elongation at 72°C for 10 min. The amplified fragments were separated and visualized on 2% agarose gel electrophoresis.

The successfully amplified products were purified with a PCR purification kit (Gene Matrix, PCR clean-up kit, EURx, Poland) and sequenced in both directions using a PlateSeq kit (Eurofins Genomics Ebersberg, Germany).

3. Statistical processing and analysis of sequence results

All obtained DNA sequences were manually edited and aligned with the MEGA7 program (Kumar *et al.,* 2016) using the horse reference DNA sequence X79547 (Xiufeng & Arnason, 1994). The obtained sequences (about 650 bp) were deposited in the GenBank database National Biotechnology Information Center (NCBI) under accession numbers MG420991 – MG420994.

Table 1. Studied archaeological samples.

	Periodization	Settlement	Abbreviation	Skeletal element	Product size, bp	Haplogroup	GenBank Acc. Number
1	Early Neolithic	Ohoden/Valoga	Och/Va1	*phalanx II*	641	G1	MG420992
2	Early Neolithic	Ohoden/Valoga	Och/Va2	*dens*	658	G1	MG420993
3	Early Neolithic	Gradeshnitsa-Malo Pole	G/MP1	*metacarpus*	257	Q2'3?	MG420994
4	Early Bronze	Devetak/Karnobat	Dev1	*metatarsus*	651	G1	MG420991

Table 2. Primers used for amplification of the D-loop region of mtDNA. The position of the primers is relative to the reference sequence NC_001640 (Xiufeng & Arnason, 1994).

Region	Primer sense/antisense	Sequence 5'-3'	Reference	Product size, bp
I.	f-15450	cacccaaagctgaaattctac	Hristov *et al.*, 2017a	114
	Ec1_r_15564	gacgtacataggccattcataaga	Elsner *et al.*, 2016	
II.	f-15450	cacccaaagctgaaattctac	Hristov *et al.*, 2017a	220
	Ec4_r_15670	gacttggatggggtatgcac	Elsner *et al.*, 2016	
III.	f-15450	cacccaaagctgaaattctac	Hristov *et al.*, 2017a	210
	Ec2_r_15660	gatggggtatgcacgatcaataat	Elsner *et al.*, 2016	
IV.	Ec4_f_15590	gaatggcctatgtacgtcgtg	Elsner *et al.*, 2016	190
	Ec5_r_15760	tagttgggagggttgctg	Elsner *et al.*, 2016	
V.	Ec4_f_15590	gaatggcctatgtacgtcgtg	Elsner *et al.*, 2016	488
	r-16078	ataacaccttatggttgctg	Hristov *et al.*, 2017a	

The sequences were analyzed using their polymorphic positions and the haplogroups were determined according to the nomenclature of Achilli *et al.* (2012). The obtained sequences were compared to other populations: Carpathian pony (EU093063 – EU093045), Akhal-Teke (DQ327950 – DQ327967) and Bulgarian primitive mountain horses (KU601744 – KU601624) (see McGahern *et al.*, 2006; Priskin et *al.*, Hristov *et al.*, 2017a, respectively) and mitochondrion – PopSet Acc. No. 74725290 (Achilli *et al.*, 2012) for comparing the genetic profile with the known border populations. Unpublished data were also used in interpreting the results – 57 sequences from the Danube horse breed (MG420898 – MG420955).

This modern breed is representative of lowland horses in Bulgaria created based on mares from the Eastern Bulgarian breed.

4. Protocol for working with aDNA

All experiments were performed according to standard precautions in specialized and territorially distinct laboratories for aDNA work: bone material processing, DNA isolation and PCR amplification (Paabo *et al.*, 2004; Willerslev & Cooper, 2005). Briefly, this includes establishing independent laboratories (premises and buildings) for working with aDNA, treating surfaces and solutions with UV radiation (45 W, 72 h), heat treatment (over 180°C, 12 h), acid treatment (2.5M HCl, 48 h) and/or sodium hypochlorite (40%, 48 h), washing with ultrapure water and air filtration in the premises. The dis-

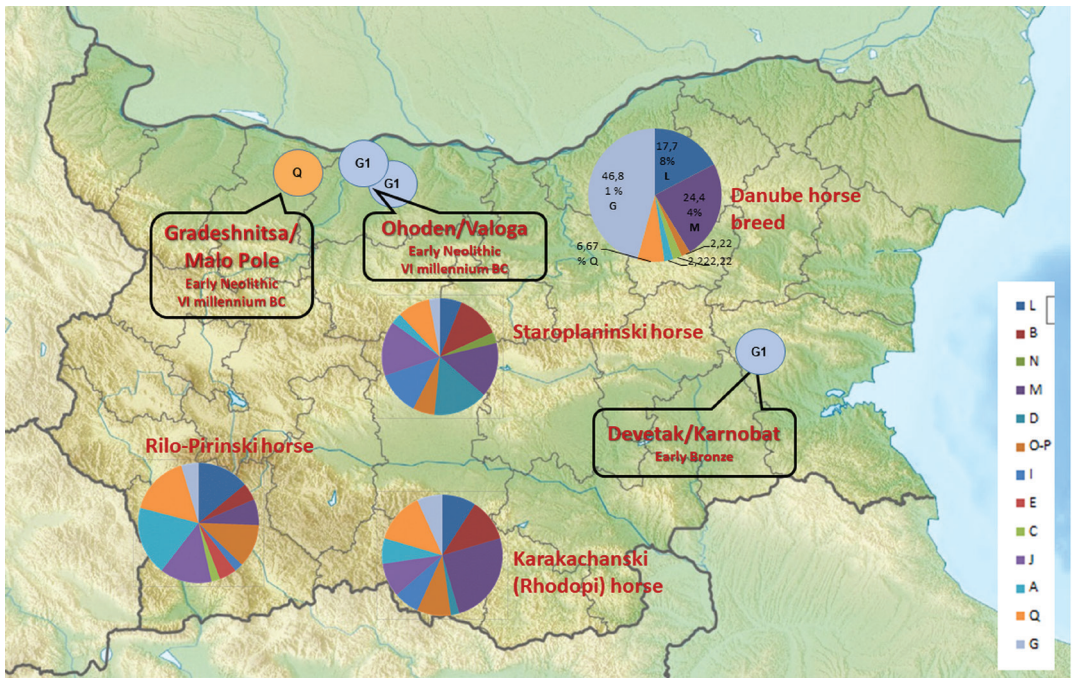


Fig. 2. Mitochondrial profile and geographic location of the studied ancient and modern horse breeds. The classification of the haplogroups is presented according to the nomenclature of Achilli et al. (2012).

Table 3. Haplogroups and polymorphic sites of the studied samples. (Reference sequence JN398377; Achilli et al, 2012)

No	Abbreviation	Haplogroup	Polymorphic positions
1	Och/ Va1	G1	15492,15539,15582,15594,15599,15632,15647,15663,15700,15717,15867,16028
2	Och/ Va2	G1	15492,15539,15582,15594,15599,15632,15647,15663,15700,15717,15867,16028
3	G/MP1	Q2'3	15492, 15582, 16028
4	Dev1	G1	15492,15539,15582,15594,15599,15632,15647,15663,15700,15717,15867,16028, 16072

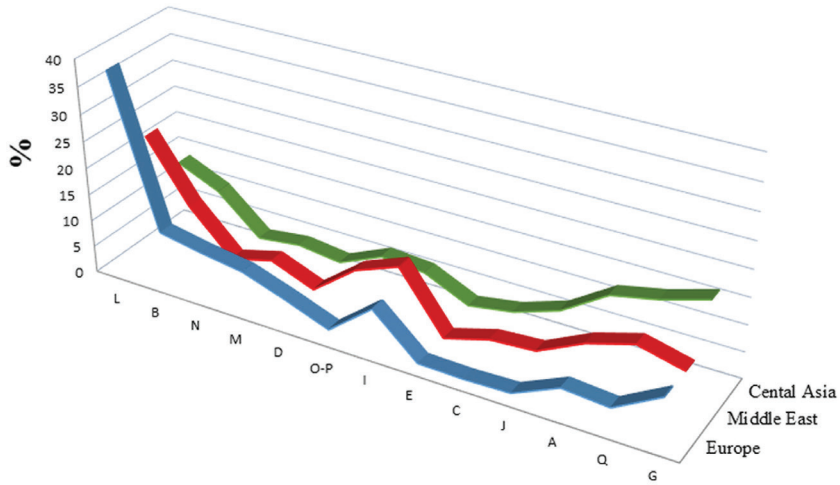
posable plastic consumables and disposable safety devices and solutions were licensed to work with human DNA.

Results and discussion

Ancient DNA was successfully amplified from all the tested samples. In the interpretation of the results after analysis of the sequenced fragments/ regions for assay, combined overlapping sequences of about 650 bp were used. The established polymorphic positions are presented in Table 3 by comparison with reference sequences X79547 (Xiufeng & Arnason, 1994) and JN398377 (Achilli *et al.*, 2012). Mitochondrial haplogroups were determined according to the latest classification of Achilli *et al.* (2012).

Three haplotypes belonging to two haplogroups, Q2'3 and G1, were identified. The dominant haplogroup was G1 (3/4, 75%) presented with two different haplotypes: Och / Va1-2 and Dev1 (transversion at polymorphic position 16072C / A; Table 3).

Haplogroup G is found in both modern and ancient horses. The results of the studies showed that the prevalence of haplogroup G was the highest in the Middle Asian horse breeds – over 16%



	L	B	N	M	D	O-P	I	E	C	J	A	Q	G
Europe	38	10	8,5	7,3	4,5	1,4	8	0,5	0,32	0,6	4,5	3,8	8,7
Middle East	22,4	11	3,1	5,2	2	8,3	11,5	0,5	3	3,6	7,8	10,4	8,3
Cental Asia	13,5	10	3	4	3	6,6	6	2,2	3,6	6,5	12	13,8	16,4

Fig. 3. Geographical distribution of the main haplogroups in Eurasia (Achili et al., 2012).

(Kazakhstan and Turkmenistan; Fig. 3). For Central and Western Europe this frequency was about two times lower. The subhaplogroup G1 is believed to be typical of the Middle Asian breed Akhal Teke from Kazakhstan (Jansen *et al.,* 2002; Cai *et al.,* 2009; Cieslak *et al.,* 2010; Achilli *et al.,* 2012). This is logical because this region is considered to be the main domestication centre and is a representative of the steppe regions. These studies, though large-scale, have a drawback in terms of "white spots" – the genetic diversity of key geographic regions of Europe, such as the Balkan Peninsula and the Northern Black Sea coast.

The first survey of populations of Bulgarian horses was only published in 2017. This study characterized the mountain type of local horses from Stara Planina Mts., the Rhodopes and the Rila-Pirin massif or over 121 samples in total (Fig. 2). The results showed a typical European mitochondrial profile in the Staroplaninski and Rhodope horses with unusually high frequencies of the European-specific groups M and D (2 to 3 times). The mitochondrial profile of the Rila-Pirin horses differed significantly from the aforementioned with high frequencies of typical Central and Eastern Asian groups, i.e. haplogroups A, G, Q, C. In this study the authors commented on this unusual genetic profile as a massive mix of Asian local horses (genetic drift or introgression).

A similar genetic drift of populations of Central Asian to Central European horses was also found for the Carpathian Mountain Horse, Hucul, and the planar Hungarian and Polish primitive horses (Czernekova, 2013; Cieslak *et al.,* 2010; Priskin *et al.,* 2010, Cieslak *et al.,* 2017). This migration is considered as a result of the "migration of the peoples" and especially the Hungarian settlements during the first millennium of the new era.

Summarizing the data on modern local Bulgarian horses, several conclusions can be made: 1) they show a heterogeneous genetic profile following their geographical localization; 2) although insufficient, the data show a significant difference between the planar and the mountain types of horses (Fig. 2); 3) the so-called Asian G1 group has a high frequency and is even a dominant haplogroup in the mountain (Rilo-Pirinski) and the planar Danube horses.

The ancient DNA data received from the subfossil bones of wild horses from Bulgaria represent a special interest: they are the first such data for the extinct wild horses of the subgenus *Equus* (*Equus*) which has been spread in the forest-steppe and steppe regions from Eastern Europe most probably till Kazakhstan in the Early and Middle Holocene. Two species of wild horses, rather different after dentition and limb proportions, existed in the Late Pleistocene of Europe and survived after paleozoological data in Eastern Europe (including Bulgarian): the massive *Equus germanicus* (= *E. latipes*) and the slender and more adapted to steppe conditions *E. ferus* (= *E. gmelini*) (the so-called Tarpan). This statement, supported by a large number of data was expressed in the papers of Spassov and Iliev (1997; 1998), remained insufficiently known to the science community. The presence of two different wild species in the probable area of the earliest domestication make the question for the wild progenitor of the do-

mestic horse (*Equus caballus*) more complicate. The existence of two different wild horse species in the Holocene of Eastern Europe, which both have been used in the process of the domestication, is supported by the presence of the haplogroup Q in the massive wild horse from the Neolithic of Gradeshnitsa-Malo Pole, determined as *E. germanicus* (Spassov & Iliev 1997), after morphological criteria, and the presence of another haplogroup (G) in the slender wild horse from the Early Bronze Age of Devetak.

In Central Asian (Kazakhstan, Turkmenistan) horses, which are ancient by origin, there is a predominance of the G and Q haplogroups, which we find in prehistoric wild horses from Bulgaria. As these Middle Asian breeds have been grown since ancient times in the region, according to today's research, especially close to the most probable primary horses' domestication centre, it could be assumed again that these haplogroups were typical of the wild horses of the Eurasian steppes and forest steppes from the Eastern Black Sea coast to the Kazakh and Iranian open spaces (here we exclude the more eastern species – the Mongolian wild horse, which did not participate in terms of genetic data in the origin of the domestic horse).

Judging by the presence of the haplogroup Q in the massive wild horse *E. germanicus*, from the Neolithic of Gradeshnica, we can assume that it has been involved in the domestication of ancient domestic horses. Haplogroup G could be the typical haplogroup for the slender wild horse of the steppes (*E. ferus*) determined in the Early Bronze Age of Devetak and well presented in the old domestic breeds in the Middle East. Further investigations and a larger sample (number of samples) are needed in order to confirm the hypotheses very hesitantly suggested here. It is not excluded that a part of the territory of Bulgaria (the Eastern Black Sea coast, judging by genetic data and the presence of the domestic horse from the Early Bronze Age of Urdoviza), represents (with the North Black Sea coast) a part of the primary centre of the domestication of the horse.

Conclusion

The current study presents the first data on the genetic diversity of the Holocene wild horses of the subgenus *Equus* (*Equus)* from the early Neolithic and the Early Bronze Age in Bulgaria, and with this the first data on the genetic diversity of the extinct Holocene wild horses of this subgenus in Europe. The results show the presence of the Q (in *Equus germanicus* from the Early Neolithic of NW Bulgaria) and G (G1) (in *E. ferus* from the E. Neolithic and the E. Bronze Age of Bulgaria) haplogroups. Both G and Q haplogroups have so far been spread with high frequency in the Middle Asian horse domestic breeds. This preliminary result gives ground to support the statement of the survival of two different Late Pleistocene wild horses in the Holocene of Eastern Europe and with this to support the polyphylethic hypothesis for the origin of the domestic horse in the western part of the Eurasian steppes. Our results give some clarity about the further dispersal of the domestic horse and about its strong genetic polymorphism. The data, though preliminary, can provide interesting information about the wild ancestors and the origin of domestic horses.

Our findings would contribute also to elucidating the origin and migration processes in the formation of local horse breeds. This information is directly related to the understanding of migration and the cultural-historical processes in our region.

The established genetic profile of subfossil wild horse (*E. ferus* – the Tarpan) is the closest to the profile of the Danube horse, where the frequency of the haplogroup G is about 50 %.

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The domesticated horses from the submerged prehistoric village of Urdoviza (Kiten) on the Bulgarian Black Sea coast – among the oldest known

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Abstract: Published is the result of a preliminary study of horse bones from the sunken prehistoric village Urdoviza (Bulgaria) dated from the Early Bronze age. Large number of horse remains (about 450 ones) were determined among the rich bone sample of wild and domestic animals from the sunken prehistoric village Urdoviza. The data from the bone sample indicate that the bones must be from domestic horses. The skeleton (metatarsal, n = 2) characteristics reveal a rather robust habitus and small (129 cm of height) to medium (137 cm) size for the Urdoviza horses. Thus *Equus germanicus* could be a more probable wild ancestor of the domestic horses from Urdoviza than *Equus ferus*. The radiocarbon calibrated dates for a sample of horse bones obtained in the Oxford laboratory (Oxford Radiocarbon Accelerator Unit) show that the age of the bone remains falls at the end of the fourth and the transition of the third millennium (3340 – 2740 BC, at an average of ca 3100 BC). This age put the Urdoviza horses among the earliest domesticated horses.

Key words: earliest horse domestication; Bronze Age settlement of Urdoviza; Bulgaria;

Introduction

The earliest horse domestication problem

The question about the time and the place of horse domestication, a process, which had huge impact on the progress of the civilizations, is disputable. The horse was probably domesticated rather late and the opinion about an early domestication in the 5ft millennium B.C. (Sredniy Stog culture, Derievka) is recently strongly contested. According to the recent data, the domestication has happened probably in the western part of the Eurasian steppe, between the Northern Black Sea region, Iran and Kazakhstan. It seems that this process was developed not earlier than the first half, and most probably during the middle (even the last third) of the fourth millennium BC (from ~ 5.5 kya) (Warmuth *et al.*, 2012; Petersen et al. 2013). That is why the question about the mass horse bone remains from the sunken rarly Bronze age village of Urdoviza, which have been found together with large number of other domestic and wild animal remains (Ribarov 1991), is a matter of special interest.

The archaeological site of Urdoviza and the animal bones' material

The underwater excavations, started at 1986 at about 30 km sought of Sozopol, headed by Dr. M. Lazarov, Dr. K. Porojanov and V. Popov, reveal a sunken prehistoric settlement from the early Bronze Age on the shore of Urdoviza peninsula, at the periphery of Kiten (Porojanov, 1991). Ceramics, tools and large number of bones of wild and domesticated animals have been found there. Our data show (N. Iliev, N. Spassov – unpublished till now) that the following wild mammals and domesticated forms could be listed among the analyzed 12 800 animal remains: aurochs, wisent?, wild boar, roe deer, European red deer, fallow deer, beaver, hare, fox, wolf, brown bear, badger, wild cat, beech marten/ European pine marten, harbour porpoise, common bottlenose dolphin, Mediterranean monk seal, cattle, sheep, goat, domestic dog, domestic horse.

Fig. 1. Horse bones from Urdoviza: 1 – skull FM 3460, male; 2 – occlusal view of the check teeth of skull FM 3460; 3 – humerus FM 3445; 4 – metatarsus FM 3432; 5 – metatarsus FM 3431

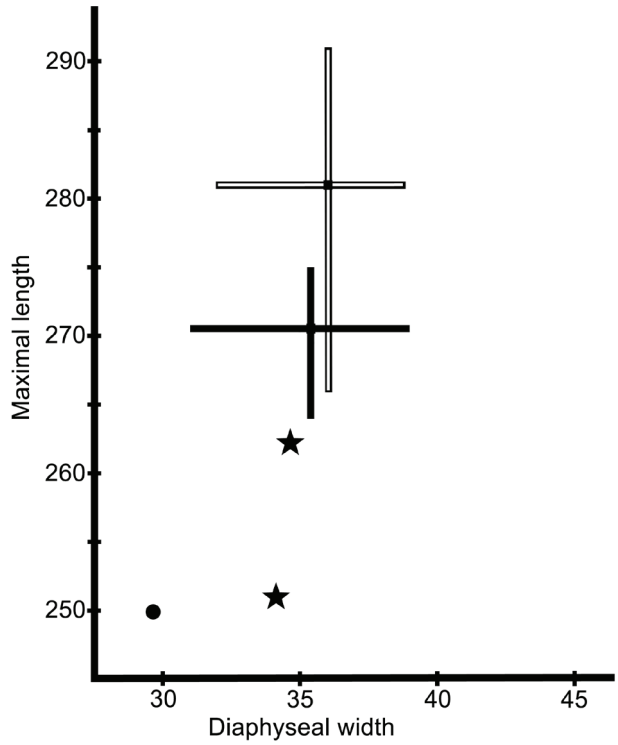

Fig. 2. Comparison of the maximal metatarsal length vs. diaphyseal width of wild horses and the horses from Botai and Urdovisa. The crossed lines represent the variation of the length and width for the samples from Botai, Kazakhstan (black line) and *E. germanicus* from the late Pleistocene of Kostenki, Ukraine (hollow line). The squares at the cross point present the mean values; black circle – the value for *E. ferus* from the Holocene of Ukraine (paralectotype); asterisks – the values for the metaposials from Urdovisa (metric data for wild horses and Botai from Kuzmina, 1997; Urdoviza – original data)

About 70% of the bones are from wild animals, among which the ones of red deer, aurochs and wild boar are prevailing. The small ruminants predominate among the bones of the domestic animals.

The horse bones' material

Of special interest are the numerous horse bones (about 450 bones/bone fragments) from individuals of different ontogenetic stages – from foals to old-adults. The large number of diverse horse bones from Urdoviza and the early age of the archaeological site (keeping in mind the data about the earliest horse domestication) could make this settlement a crucial object for studying the domestication of this so important for the development of the human civilisations animal. The precise dating of the horse bones was very important - not only because of the assumption that they could be among the oldest domesticated horses, but because of other reason: there are data about the presence during the 19 century of a stud farm in the area, which brought the doubts that the underwather horse bones accumulation could be a result of throwing recent horse carcases close or above the archaeolopgical site.

Methods. Radiocarbon dating of horse bones

The radiocarbon dating of bone samples from 5 bones have been done at Oxford Radiocarbon Accelerator Unit (ORAU) (England). The methodology of the sample processing is explained at the works of Brock et al. (2010) and Ramsey *et al.* (2004). For calibration of the obtained results was used the software Oxcal (v4.2.4 и v. 4.3.2) of C. Bronk Ramsey (2013), and the calibration curve used to preform the calibrations – the software IntCal 13 (Reimer *et al.*, 2013) (Table 1, Fig. 3).

Results and discussion

The radiocarbon calibrated dates for the sample of horse bones from Urdoviza, obtained in the Oxford laboratory (Oxford Radiocarbon Accelerator Unit) show that the age of the bone remains falls at the end of the fourth and the transition of the third millennium (3340 – 2740 BC, at an average of ca 3100 BC).

Table 1. Absolute dating of the horse bones from Urdoviza

Sample	Lab number	Date BP	Calibrated data BC
humerus FM 3450	OxA-35213	4449,31	3139 - 3010
humerus FM 3451	OxA-35214	4471,32	3340 - 3205
radius FM 3452	OxA-35215	4398,34	3104 - 2911
metacarpus III FM 3453	R_combine OxA-35216 и OxA-35217	4449,24	3128 – 3017
femur FM 3454	OxA-35218	4221,33	2814 - 2740

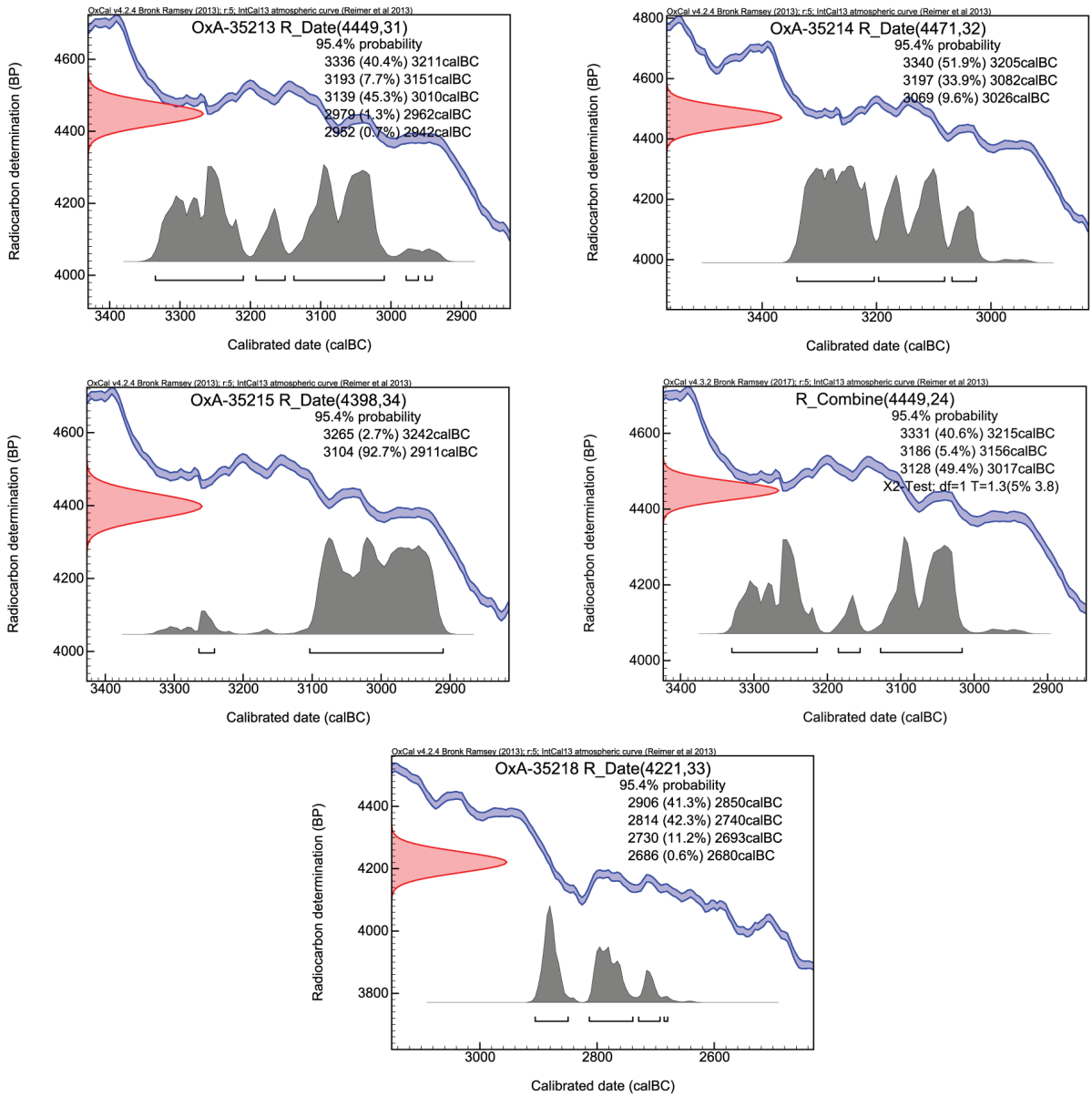

Fig. 3. Calibrating curves for the bone samples from Urdoviza

The horse bone remains from the site are from all parts of the skeleton. As it was noted above they represent individuals from all ontogenetic stages. Some of the bones bear traces of butchering and thermal treatment. The male animals dominate among the skull remains. This is the most impressive amount of horse bones found at prehistoric site in Bulgaria. Their significant number is a sign that they represent domestic, not wild horses, which is supported also by the metric comparison (Fig. 2) with wild horses and with the Botai horse, considered as the probably old domesticated horse (Outram et al. 2009). The wild

horses have been found with single finds only (as a rare and hard for hunting objects) in small number of prehistorical (Holocene) sites from Bulgaria and from some other localities in Europe (Spassov & Iliev, 1997; 1998). The estimated height at the shoulder (according to the tables of O. Vit) of the horses from Urdoviza, after two complete metatarsals, one radius and one tibia varies rather strongly (which is typical for domestic, primitive breeds of horses): 137 cm, 129 cm, 128 cm and respectively – 132 cm. The size of 137 cm fall among the medium sized horses, and all other – among less than medium sized horses after the classification of O. Vit (Vit, 1952). The Browner index (Brauner, 1916), calculated on the two fully preserved metatarsals (13.24 and 13.55), classify the horses as "with semi-massive-leggs" after his classification. Horses with slender legs ("narrow-hoofed") after the values of this index are such horses as the Arabian one (value of the index ~ 11.0) and other recent saddle horses of Eastern origin, as well as the wild horse of the East European steppe – the so called tarpan (*Equus ferus*) (index value – 11.9 after Gromova, 1949). This is an indication for affinities and probable origin from another than *Equus ferus* wild ancestor, survived the Pleistocene – the broad hoofed *Equus germanicus* (see Spassov & Iliev, 1997; 1998; Ribarov, 1991). This conclusion is supported also by the metric comparison (Fig. 2)

Conclusions

The average age of the bones fall at the end of fourth and the transition toward the third millennium BC, (i.e. about the end of the first phase of the classical Bronze age: prof. V. Nikolov, pers. comm. The presence of the first phase in Urdoviza was only supposed, till now, after archaeological data: M. Hristov: pers. comm.). Therefore we could say that the horse bones from Urdoviza could belong to domesticated horses, and probably represent a strongly diminishing in size, (in the domestication process) population, which has its origin from the broad-hoofed wild horse *Equus germanicus*. The Urdoviza horses are among the oldest domesticated horses known, and the oldest known to the west of the Northern peri-Pontic area.

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Typology of Thracian horses according to osteological analysis of skeletal remains and depictions from the antiquity

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Abstract: Skeletal remains of about 15 horses from the antique Thracian mounds were compared in terms of habitus and height at the shoulders. Additional data about the habitus of the Thracian horse were received from the analysis of more than 1000 depictions of horseman and horses from the same epoch. The breeds of the Thracian horse from the recent Bulgarian territories during the antiquity (after skeletons from IV-III century B.C.) were mostly semi-thin legged to thin-legged (following the classification of Brauner, 1916). All these horses have similarity with the ancient and recent eastern breeds: relatively small-sized as a whole, frequently with slender legs (after metapodials and especially metatarsals), adapted to fast allures. The height at the shoulder varied significantly – from 125 to 150 cm. According the classification of Vit (1952), the bred horses were usually small- to medium-sized. Based on the osteological material and the studied depictions we could conclude that in general the horses from the Thracian time (including the Roman epoch) were relatively robust, with strong skeletal system and compact, embossed muscles, large head, strong neck and short, upright mane. All of these are primitive features inherited from the wild ancestors. The studied material had similarities with the Arabian horse, but in general it was a little bit more robust and its height at the shoulder was smaller than the recent Arabian horse. The most frequent images of Thracian horses from the antiquity of Bulgaria and the Balkans represent exactly this kind of horse. Such horses would be suitable for hunting, especially in the varied relief, typical for the Bulgarian/Balkan lands. Most of the Thracian horses from the studied age (judging from the sample) probably could not reach the height, the slenderness and the running ability of the recent Arabian horses, which have been selected over a long period of time. At the same time, it is important to note that the elite Thracian horses had attained the parameters of the Arabian horse, especially its height and slenderness.

Key words: Thracian horses, osteological analysis, horse height

Introduction

The horse is a subject of a particular interest since ancient times. There is no doubt that his domestication has gradually opened up new strategic options in terms of military actions, transportation and communications. The horse has also played an exceptional role in the life of the ancient Thracians. It was used in various activities: as a saddle horse in hunting or war, as a carthorse in chariots and freight cars. His role in the everyday life and culture was so important that he had become a symbol of prosperity and power and hence a symbol of cultural traditions and beliefs (Marazov, 1968, 2010; Fol, 1993; Gocheva, 2003; Izdimirski, 2006; Sakellariou, 2015). He used to be so venerated, that he even used to be buried with his owner.

The present study aimed to characterise Thracian horses based on the osteometric analysis of horse skeletons found in Thracian necropolises. It was complemented by data from analyses of ancient depictions from the same period.

Materials and Methods

Horse skeletons from the following archaeological sites have been studied:

A. Site No 9 (LOT 2), sq. G5, E-2 and E-3 along the layout of Thracia Motorway near Benkovski

Village - 2009 (antiquity). Archaeological excavations of Dr. Iliana Borissova (University of Sofia).

The material provided for examination included three horse skeletons from the pits. According to the archaeological context, their age referred to the second half of the IV century BC.

1. Horse skeleton from sq. G5 (hereafter, horse BN-1). Material: unfortunately, the skull was heavily damaged and fragmented. This did not permit its more detailed comparison with current and former races and breeds. The rest of the skeleton allowed for bone, metric analysis. The pictures of the skeleton finding during the excavations showed the particular position of the hind limbs and the unnaturally curved backwards head.

2. Horse skeleton from sq. E-2 (hereafter, horse BN-2). Material: The skeleton supplied for processing was missing the skull. The pictures of the excavations showed clearly that the skull had not been available in the dug structure in which the skeleton was revealed.

3. Horse skeleton from sq. E-3 (hereafter, horse BN-3). The pictures of the excavations revealed that the skeleton was entirely preserved. However, the material provided included only a portion of the bones.

No traces of skinning or dismemberment of the corpse were found, with the exception of the skull of horse BN-2.

Taphonomic notes: in horse BN-2 (sq. E-2) a deliberate stroke had cut the head of the skull and decapitated the animal. It appears that the head had been taken from the skeleton. In the horse from G-5 (BN-1), a blow at a similar place might have killed the animal, while the head might had been cut off at the neck and placed in a reverse position, which explains its unnatural position in the preserved remains of the skeleton. At least two of the three horses had been decapitated. It could be assumed that this deliberate beheading had a symbolic-ritual character.

B. Eastern Hellenistic necropolis of the Sboryanovo Reserve (IV-III century B.C.) near Sveshtare Village (excavations of prof. Diana Gergova, Inst. of Archaeology with museum - BAS).

The bones of five horse skeletons from the archaeological excavations of Prof. Diana Gergova were provided for studying. They were found in mounds No 30, 29, 21 and 27 from the Eastern necropolis of the Sboryanovo Reserve, IV-III century B.C.

The two skeletons of horses from sites No 30 and 29 were in a very bad condition with only a few, mostly long bones being preserved. At the same time, the horse skeleton from site (mound) No 21 and the two skeletons from site No 27 were in a relatively good condition and the bone material was almost entirely preserved. At site No 30, the skeleton of the horse was found without a skull, at site No 29 the skull was crushed, at site No 21 the skull was preserved in a very bad condition and no measurements could be made, except for the teeth and the two mandibles. At site No 27 the skulls of the two horses were also fragmented.

C. The height at the shoulder of four horses from the Thracian necropolis from Kazanlak Region (Iskra Museum collection, Kazanlak, excavations of assoc. prof. G. Kitov, Inst. of Archaeology and Kazanlak museum) were studied based on their metatarsal bones: KZ-1 - Slavchova Mound (beginning of IV century B.C.), expedition Temp 95; KZ-2 - Sarafova Mound (IV-III century B.C.), Temp 95; KZ-3 - Belchinova Mound, 2006; KH-4 – Golyama kosmatka Mound, (IV century B.C.), 2004, first chamber.

The morphological analysis were based on the comparative craniological and osteological indices of Ewart (1907) and Brauner (1916) (see also Osborn 1912) and the height classification indicators of Vit (1952), as well as on the comparative metric data for the Arabian horse and other Thracian and local horses (according to Petrov 1925; Stanchev & Ivanov 1958; 1972; Vassilev & Georgiev 1985; Iliev 2000), for the wild horses (Gromova 1949), and on other of our unpublished data. Determination of age was done following the comparative schemes of Klimov (1950) and that of sex according to Gromova's analyses (1949).

While analysing the height at the shoulder and habitus of horses, additional comparisons with more than 1000 images of Thracian horses dating B.C. and A.C. were made (based on published depictions in Opperman, 2006; Yurukova, 1992; Rabadzhiev, 2012; etc.)

Gender and Age of the Horses

A. Site Benkovski:

The gender of horse BN-1 was determined using the very small, almost rudimentary, canine teeth. The condition of the canine teeth, whose development is a manifestation of sexual dimorphism (Gromova, 1949), was an indication for female sex. The analysis of the wearing of the mandibular incisors (according to the schemes of Klimov, 1950, vol. I, p. 418) lead to the conclusion that the mare was about 8-10 years, i.e. in full mature age.

The gender of horse BN-2 (sq. E-2) could not be reliably determined based on the available skeletal

material. The comparison with the other two horses, as well as with other Thracian horses, showed a high (for its breed, see below) growth and relatively bigger mass and it could be assumed that it was probably a stallion. According to the established pelvic exostoses and the separate phalanges, we could assume it was not young: probably at least at the age of ten or perhaps more years.

The lower jaw of horse BN-3 (sq. E-3) was gracile, devoid of canine teeth. This determined the individual as a mare. The teeth were very worn out. The animal was old, at least at the age of 15. Here, it should be noted that, according to Vit (1952), the Eastern Scythians had taken special care of their elite saddle horses and some of them continued to be used for combat horses up to 18 years and even longer. The tear surface of the second premolar (the first tooth of the cheek teeth row) was heavily carved, which was likely owing to the prolonged use of a bridle with a metal mouthpiece).

B. Site Sboryanovo: Only the gender of horse SB-3 could be determined. The developed canine teeth and heavily worn-out incisors indicated that it was also an adult stallion, about 12-18 years old.

Osteometric analysis

A. Comparison of relative lengths of long bones.

1. Benkovski horses:

The relative lengths of the bones of stallion BN-2 and mare BN-1 (expressed as a percentage of the total sum of the bone lengths of the fore and hind limbs) were compared with the stallion from Kralevo, Targovishte, which was of the same epoch (IV- III century B.C.; Vasilev & Georgiev, 1985). The results for forelimb, shoulder bone, humerus (H) + radius (R) + metacarpus (Mc) and, respectively hind limb: femur (F) + large tibia (T) + metatarsal bone (Mt), are shown in Table 1.

The difference between the percentages of the individual bones of the three horses was too small. The studied horses were practically the same in terms of proportions. This implied not only close kinship (in terms of breed), similar breeding conditions and similar terrain in which they had been used, but probably the use of these horses for the same purposes.

2. Sboryanovo horses:

The results of comparing the relative lengths of the bones of horses from Sboryanovo expressed in % of the total sum of the lengths of the most indicative bones of the fore (shoulder bone, humerus + radius + metacarpus) and, respectively, the hind limb (femur + large tibia + metatarsal bone) are presented in Table 2.

The difference between the percentages of the individual bones of the four horses, three of the necropolis from Sboryanovo: mounds 21 and 27 (horses SB 3 and SB 4-5) and the studies of the stallion from Kralevo varied within very small limits, leading practically to the same conclusions as the ones made above for the horses from Benkovski.

B. Metacarpal index. According the classification of Brauner (1916), based on the indices for the width of the diaphysis to the largest length of the metacarpal bones, the horses could be divided into the categories given in Table 3.

The comparison of the three horses from Benkovski, with data on the stallion from the Thracian

Table 1. Comparison of the relative length of the long bones of horses BN-1 and BN-2 with the long bones of the stallion from Kralevo, Targovishte area. H – humerus; R – radius; Mc – metacarpus; F – femur; T – tibia; Mt – metatarsus.

	H	R	Mc	F	T	Mt
Horse BN-1	34.70	39.50	25.71	38.50	35.46	25.97
Horse BN-2	33.71	38.38	27.90	37.82	35.56	26.90
Mean	34.21	38.97	26.80	38.19	36.01	26.41
Kralevo (BG)	35.18	38.31	26.50	39.66	34.45	25.87

Table 2. Comparison of the relative length of the long bones of horses SB-3, SB-4 and SB-5 with the long bones of the stallion from Kralevo, Targovishte area. H – humerus; R – radius; Mc – metacarpus; F – femur; T – tibia; Mt – metatarsus.

Individuals	H	R	Mc	F	T	Mt
Mound 21 – horse SB-3	34.93	39.10	25.97	39.30	34.80	25.90
Mound 27 – horse SB-4	33.36	40.03	26.60	38.14	35.69	26.73
Mound 27 – horse SB-5	34.79	39.42	25.78	39.12	34.64	26.23
Mean	34.36	39.52	26.12	38.85	35.04	26.29
Kralevo	35.18	38.31	26.50	39.66	34.45	25.87

Table 3. Distribution of the studied horses among the different categories according to Brauner's classification (Brauner, 1916)

Category	Limits of variation
Very slender	below 13.5
Slender legged	13.5 -14.5
Semi-slender legged	14.5 -15.5
Slender	15.5 -16.5
Semi-robust	16.5 -17.5
Robust	above 17.5

Table 4. Brouner's horse classification on the basis of metatarsal bones' index.

Category	Limits of variations
Slender legged	up to 12
Semi-slender legged	12 - 12.7
Semi-robust	12.8 - 13.6
Robust	above 13.7

tombstone near Kralevo Village (III century B.C., eastern type, Thracian horse) showed the following:

The mare of G5 (BN-1) with metacarpal index 15.20 and the male horse of E-2, (BN-2) with index 14.70 belonged to the semi-thin legged horses, together with the stallion of Kralevo with index 14.67. This seems to be a typical proportion for the Thracian horses, which show similarity with the eastern type of horses, but appear to have had relatively more massive metacarpi as compared to the Arab horses.

Generally, the horses from Sboryanovo have had even more massive metacarpal bones: Horse SB-3 - with index 16.92 - semi-robust; Horse CB-4 - with index 15.24 - semi-thin legged and Horse ST-5 - with index 16.48 - slender.

C. Metatarsal Index. This is one of the most pertinent indices of the horse's slenderness and running capability and, hence, of its use and purpose. This is why the metatarsal index is one of the most commonly used. The classification of Brauner based on the same proportion of metatarsal bones is presented in Table 4.

The comparison of the metatarsal index of the horses from Benkovski (mare BN-1 and stallion BN-2) is shown in Table 5 (based on Stanchev & Ivanov, 1958, Ivanov, 1972, Vassilev & Georgiev, 1985; Iliev, 2000, our unpublished data for excavations of Dr. Koleva and based on Gromova, 1949 for wild horses).

According to this index, horse BN-1 and horse BN-2 were identified as slender-legged, and together with the other Thracian horses known to date (see Table 5), they resembled the Arabian horse, i.e. referred to the eastern saddle horses with fast allures.

The horses from Sboryanovo showed a greater

Fig. 1. Metatarsal bones from the area of Sboryanovo: 1. Metatarsal bone of horse SB-1 – slender legged; 2. Metatarsal bone of horse SB-3 – semi-slender legged; 3. Metatarsal bone of SB-5 – semi robust. Scale bar = 40 mm.

variety: they ranged from semi-robust to slender-legged (Table 5).

The horses from the Kazanlak tombs varied in slenderness, but the slender-legged dominated as based on the metatarsal index (Table 5)

In general, the horses surveyed, although in many cases having the slenderness of the slender-legged and the long-selected Arabian horses, did not show such a precise selection and their characteristics varied within a wider range, thus resembling the more primitive eastern horses.

D. Determination of horse height.

The height at the withers was determined following the classification of O. Vit (1952) according to the horse height at the shoulder (Table 6). The latter was calculated using individual bones.

1. Benkovski horses:

Relationships of their heights are presented in Table 7.

The relationships of their heights confirmed the morphological data and indicated that horses No 1 and 3 were mares, while horse No 2 was a male individual.

The mares BN-1 (G5) and BN-3 belonged to the group of the medium-sized horses, to which belonged also the stallion from Kralevo and horse №1 from site 9 from the excavations of Dr. B. Koleva

Table 5. Comparison of the metatarsal index of horses from Benkovski (BN-1 and BN-2), Sboryanovo (SB-1, SB-2, SB-3, SB-4, SB-5) and Kazanluk (KZ-1, KZ-2, KZ-3, KZ-4) with wild horses.

Domestic horses	Horse BN-1	11.92
	Horse BN-2	11.54
	Horse SB-1	11.34
	Horse SB-2	12.27
	Horse SB-3	12.61
	Horse SB-4	10.92
	Horse SB-5	12.84
	Horse KZ-1	12.14
	Horse KZ-2	10.68
	Horse KZ-3	11.47
	Horse KZ-4	12.52
	Horse from Thracia motorway, site 9, antiquity (excavations of Dr. R. Koleva, 2008)	11.87
	Novi Pazar (8th century)	11.50
	Durankulak (9-10 century)	11.52
	Kralevo (4-3 century B.C., Bulgaria)	11.68
	Yankovo (4th century B.C.)	11.00
	Veliki Preslav (9-10 century)	10.58 – 12. 73
	Arabian horse breed	11.00
	Avarian horse breed	10.40
	draught horse	14. 30
Wild horses	*E. przewalskii*	11.60
	E. *ferus* (= *E. gmelini*)	11.90

Table 6. Horse height at the shoulder after the classification of O. Vit (1952)

Dwarf	under 112 см
Very small sized	112 – 120
Small sized	120 – 128
below medium size	128 – 136
Medium sized	136 – 144
Above the medium size	144-152
Large sized	152 – 160
Very large sized	160 - 168
Giants	over 168

(Thracia Motorway - 2008), also studied by us.

Noteworthy is the fact that the expectedly higher stallion from sq. E-2 (horse BN-2) seemed to have reached a height at the shoulder above the average according the classification of Vit. This specimen must have been an elite saddle horse for its time.

2. Sboryanovo horses:

Relationships of their heights are presented in Table 8.

It is noteworthy (though we did not test statistically this conclusion in order to accept it as a rule), that the horse from the 30 SB1 mound, which had been buried separately (probably a saddle horse), had height at the shoulder and slenderness typical of a modern Arabian horse, while the two carthorses SB-4 - 5 (Fig. 5) were below the average height (Table 9).

3. Kazanlak tombs horses:

The height at shoulder of the horses from the Kazanlak tombs varied greatly. Some of them reached 150 cm, a height similar to those of the present Arabian horses.

Discussion

The relatively well-preserved skull of SB-3 identified this horse as belonging to the eastern oriental horses, to which belonged also the Thracian horses. That was suggested by the feature defined by the line drawn through the back edge of the hard palate (according to the signs defined by Franck, 1875). In Horse SB-3, it went towards the rear edge of M2, which was typical of the Eastern horses. The robust, western type of horses probably has originated in Rome during a later era, and has later spread in Byzantium. One such a horse with scars of carrying heavy weight was identified by us among the horse remains from the First Bulgarian Kingdom in Preslav (N.I., N.S.).

Table 7. Height at the shoulder of the horses from Benkovski, calculated after different bones: . H – humerus; R – radius; Mc – metacarpus; F – femur; T – tibia; Mt – metatarsus.

	H	R	Mc	F	T	Mt	Mean height
Horse BN-1	137.2	137.6	134.7	134. 4	141.3	136	137.86
Horse BN-2	138.40	146.80	149	140.80	148	149.83	145.47
Horse BN-3				134.80	138.80		136.80

Table 8. Height at the shoulder of the horses from Sboryanovo calculated after different bones: H – humerus; R – radius; Mc – metacarpus; F – femur; T – tibia; Mt – metatarsus.

Individuals	H	R	Mc	F	T	Mt	Mean height
Mound 30 – horse SB-1					147	150	148.50
Mound 30 – horse SB-2	135	136			133	132	134
Mound 30 – horse SB-3	138	136	135	141	146	139	138.16
Mound 30 – horse SB-4	130	136	135	128	134	121	132.39
Mound 30 – horse SB-5	131	130	129	128	128	129	129.16

Fig. 2. Marble relief from Ginina mound tomb – Sveshtari (second quarter of 3th century B.C.) (source: http://uspiavamevbulgaria.com/)

For comparison, data on Thracian horses bred on our land from IV B.C. until I A.C. and the beginning of II century (including Roman times) were provided. Horses from an adjacent area, the village of Akandjievo, Pazardzhik (IV-II B.C.) (Kovachev & Gigov, 1987), were with small and medium growth. Studies of a number of Thracian tombs indicated that the height at shoulder and habitus of Thracian horses varied (see Ninov, 1997).

Based on the studied material of bone marrow horses with small to medium size prevailed. In our country, the most frequent depictions of Thracian horses from the antiquity represented such a horse. The numerous depictions of horses varied in their proportions and depended on the style and skill of the craftsman, on the material and method of making (drawing, embossed image), the area provided for the depiction, etc. Regardless, certain generalisation about the habitus of the horses could be made based on these numerous depictions. Generally, it is noticeable that they were usually small-sized, as compared to the present saddle horses, usually with a

Fig. 3. Thracian horseman (end of 1-2 century). Marble relief from Thessaloniki. İstanbul Arkeoloji Müzeleri; Inv. No. 31 T. Cat. Mendel 492.

Fig. 4. Coin of the Thracian ruler Mozes, (475 – 465 B.C.) (after Yurukova, 1922)

Table 9. Horse height at the shoulder of the horses from Kazanluk, calculated by the metatarsal bones measurements.

Individuals	height at the dhoulder
Horse KZ-1	131
Horse KZ-2	142
Horse KZ-3	147
Horse KZ-4	150

height at the withers of about 125-130 (135) cm (according to a number of comparisons with the people beside them), with a strong body, powerful necks and croup, short and protruding mane - characteristics typical of primitive and wild horses (Figs. 2-4).

Judging by the size of individual horses (BN-2 and SB-1, two of the four horses from the Kazanlak tombs), it could be concluded that some elite horses had a height above average, between 145-150 cm, which is the height of the present Arabian horses. The usual height of the modern selected, saddle Arabian horse is within the range of 146-150 cm (Vit, 1952). The Arabian horse is more elegant (with slightly more slender metapods) than the primitive ancient (so-called eastern) horse and belongs to the group of the horses with height above the average.

The slab of Shapladere (Fig. 5) presents carthorses harnessed in a massive, heavy wagon and a high saddle horse. According to our comparisons, the saddle horse probably had a height of about 150 cm, while the carthorse was slightly shorter but also a bit more massive. Probably these heights and proportions were not accidental in this very realistic image and reflected selection of horses for heavy carts and riding (elite horse). Height up to 148-150 cm could have been reached by the largest horses from the Scythian Pazyryskiy mound (Altai). Two height categories of horses were defined there by O. Vit, 1952 using a mass material: more robust, up to 130 cm tall and more slender with a height of 148-150 cm. For instance, it could be estimated based on the frieze of the tomb in Xanthos, Antalya (6 - 5th century B.C.), that the elite Assyrian saddle horse depicted there likely had a height of about 150 cm.

Conclusions regarding the growth, physical type and breed of the Thracian horses according to osteological data and depictions

The analysis showed that the Thracians of the surveyed epoch predominantly cultivated semi-slender and slender-legged horses used for cart and sad-

Fig. 5. Slab from Shapladere, Maritsa River outfall (V-III century B.C.), the earliest depiction of a chariot in Thracia (after RABADJIEV, 2012).

Fig. 6. Horses from the chariot of mound 27, Sboryanovo, near Sveshtari (excavations of prof. Diana Gergova; see Gergova, 2014)

dle animals. All of these horses had similarities with past and modern eastern breeds: in general, they were relatively small, most often with slender limbs (metatarsi) that were adapted for fast allures. More individuals need to be compared in order to determine whether horses with specific skeletal parameters, such as the horses studied here, have been used primarily for riding or for a cart (Fig. 6), or could have been used simultaneously for both. Larger and slender horses might have been used for riding from a higher-standing social stratum. The qualities of the horses likely depended on the skills of their keepers and the horses that had parameters above the average were highly appreciated. The height varied greatly: from 125 until 150 cm. (Table 10). These conclusions, based on osteological data, were confirmed by image analyses (comparisons of proportions of horse/ rider). In terms of height, the horses usually were small-

Fig. 7. Image of a hobbled horse. Detail on a vase from the mound of Chertomlykskiy (fourth century B.C.), Dnepropetrovsk, Ukraine (source: http://www.pslava.info/)

Table 10. Height at the shoulders of the horses from Benkovski, Sboryanovo and Kazanluk and their constitutional type after the metatarsal index.

Horse	Size Category	Constitutional types after metatarsals (classification of Brauner, 1916)
BN-1	medium sized	slender legged
BN-2	above the medium size	slender legged
SB-1	above the medium size	slender legged
SB-2	below the me dium size	semi slender legged
SB-3	medium sized	semi slender legged
SB-4	below the medium size	slender legged
SB-5	below the medium size	semi robust
KZ-1	below the medium size	semi robust
KZ-2	medium sized	slender legged
KZ-3	above the medium size	slender legged
KZ-4	above the medium size	semi slender legged

to medium-sized. The mass-bred horse was rather thickset, with a sturdy skeletal system and a dense, embossed musculature. The neck was stout, the head - large, with powerful jaws, short mane (often like bristles, rarely with longer straight forelocks), as seen from hundreds of detailed depictions. These are all primitive characteristics that practically did not differentiate them from the wild horses. The horse was usually more massive and shorter than the modern Arabian horse. According to osteological data, it was similar in height (and in its variability) to Scythian horses, but perhaps it used to be a bit more massive if judged by the depictions (Fig. 7). It differed from the ancient Akhal-Teke horse from Turkmenistan by its shorter body, its massive head and neck, the shorter and powerful body. The most frequent depictions of Thracian horses from the antiquity in Bulgaria were represented by such a horse (Figs. 2-4). Such horses would have been suitable for hunting, especially in the varied relief that characterises our lands. Most Thracian horses of the surveyed epoch (according to the study of the bone sample) were unlikely to have reached the height, slenderness and running abilities of the long-selected modern Arabian horse. At the same time, we have to pay attention to the fact that the elite Thracian horses (judging by osteological data, as well as some depictions) had already reached the parameters of the purebred Arabian saddle horses - their height and slenderness.

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