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ABBREVIATIONS

AAR	Analecta Archaeologica Ressoviensia (Rzeszów)
ActaArch	Acta Archaeologica (Leiden)
ActaArchHung	Acta Archaeologica Academiae Scientiarum Hungaricae (Budapest)
ActaMusPapensis	Acta Musei Papensis. A Pápai Múzeum Értesítője (Pápa)
Agria	Agria. Az Egri Múzeum Évkönyve (Eger)
AJPA	American Journal of Physical Anthropology (New York)
Alba Regia	Alba Regia. Annales Musei Stephani Regis (Székesfehérvár)
AnB	Analele Banatului. Buletinul Muzeului din Timişoara (Timişoara)
Antaeus	Antaeus. Communicationes ex Instituto Archaeologico (Budapest)
AnthrAnz	Anthropologischer Anzeiger (München)
AnthrK	Anthropológiai Közlemények (Budapest)
Antiquity	Antiquity. A Review of World Archaeology (Durham)
AÖ	Archäologie Österreichs (Wien)
Apulum	Apulum. Acta Musei Apulensis (Alba Iulia)
AR	Archeologické Rozhledy (Praha)
ArchA	Archaeologia Austriaca (Wien)
ArchBulg	Archaeologia Bulgarica (Sofia)
ArcheoSciences	ArcheoSciences. Revue d'Archéométrie (Rennes)
ArchÉrt	Archaeologiai Értesítő (Budapest)
ArchHung	Archaeologia Hungarica (Budapest)
Archiv für Anthropologie	Archiv für Anthropologie. Völkerforschung und kolonialen Kulturwandel (Braunschweig)
ArchKözl	Archaeologiai Közlemények (Budapest)
Arrabona	Arrabona. A Győri Xantus János Múzeum Évkönyve (Győr)
ASM	Archeologické Studijní Materiály (Praha)
AUB	Annales Universitatis Budapestinensis de Rolando Eötvös Nominatae (Budapest)
AVANS	Archeologické Výskumy a Nálezy na Slovensku (Nitra)
Balcanica	Balcanica. Annuaire du Comité Interacadémique de Balkanologie du Conseil des Académies des Sciences et des Arts de la R. S. F. Y. et de l'Institut des Etudes Balkaniques (Beograd)
BAR-IS	British Archaeological Reports – International Series (Supplementary) (Oxford)
BBV	Berliner Beiträge zur Vor- und Frühgeschichte (Berlin)
bioRxiv	bioRxiv. The Preprint Server for Biology
BRGK	Bericht der Römisch–Germanischen Kommission (Berlin)
BROB	Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek (Amersfoort)
BudRég	Budapest Régiségei (Budapest)
CommArchHung	Communicationes Archaeologicae Hungariae (Budapest)
Crisia	Crisia (Oradea)
CurrAnt	Current Anthropology (Chicago)

DissArch	Dissertationes Archaeologicae ex Instituto Archaeologico Universitatis de Rolando Eötvös nominatae (Budapest)
DMÉ	A Debreceni Déri Múzeum Évkönyve (Debrecen)
DocPraehist	Documenta Praehistorica (Ljubljana)
Dolg	Dolgozatok az Erdélyi Múzeum Érem- és Régiségtárából (Kolozsvár)
Dolgozatok	Dolgozatok a Magyar Királyi Ferencz József Tudományegyetem Archaeologiai Intézetéből (Szeged)
DuDolg	Dunántúli Dolgozatok (Pécs)
DuSz	Dunántúli Szemle (Szombathely)
EJA	European Journal of Archaeology (London)
Építés- Építészettudomány	Építés- Építészettudomány. A Magyar Tudományos Akadémia Műszaki Tudományok Osztályának Közleményei (Budapest)
EurAnt	Eurasia Antiqua. Zeitschrift für Archäologie Eurasiens (Bonn)
FAM	Fontes Archaeologiae Moravicae (Brno)
FolArch	Folia Archaeologica (Budapest)
FontArchHung	Fontes Archaeologici Hungariae (Budapest)
FrK	Földrajzi Közlemények (Budapest)
FSI	Forensic Science International. Genetics
FtK	Földtani Közlöny (Budapest)
GCBI	Godišnjak Centra za Balkanološka Ispitivanja Akademije Nauka i Umjetnosti Bosne i Hercegovine (Sarajevo)
Germania	Germania. Anzeiger der Röm.-Germ. Kommission des Deutschen Archäologischen Instituts (Mainz)
Gesta	Gesta. Historical Review (Miskolc)
HHR	The Hungarian Historical Review (Budapest)
HOMÉ	A Herman Ottó Múzeum Évkönyve (Miskolc)
HungArch	Hungarian Archaeology. E-Journal (Budapest)
JAA	Journal of Anthropological Archaeology (New York)
JAHA	Journal of Ancient History and Archaeology (Cluj-Napoca)
JAR	Journal of Archaeological Research (New York)
JAS	Journal of Archaeological Science (London)
JFA	Journal of Field Archaeology (Boston)
JFS	Journal of Forensic Sciences (Chicago)
JHE	Journal of Human Evolution (New York)
JIES	The Journal of Indo-European Studies (Washington, D. C.)
JLS	Journal of Lithic Studies (Edinburgh)
JPMÉ	A Janus Pannonius Múzeum Évkönyve (Pécs)
JWP	Journal of World Prehistory
KMK	A Komárom megyei Múzeumok Közleményei (Tata)
KMMK	Komárom-Esztergom Megyei Múzeumok Közleményei (Tata)
KRMK	A Kaposvári Rippl-Rónai Múzeum Közleményei (Kaposvár)
Marisia	Marisia. Studii şi Materiale. Muzeul Judeţean Tîrgu Mureş (Tîrgu Mureş)
MatArchSlov	Materialia Archaeologica Slovaca (Nitra)
MCA	Materiale şi Cercetări Archeologice (Bucureşti)
Menga	Menga. Revista de prehistoria de Andalucía. Journal of Andalusian Prehistory (Antequera)
MFMÉ	A Móra Ferenc Múzeum Évkönyve (Szeged)
MFMÉ StudArch	A Móra Ferenc Múzeum Évkönyve – Studia Archaeologica (Szeged)

MKCsM	Múzeumi Kutatások Csongrád Megyében (Szeged)
MRT	Magyarország Régészeti Topográfiája (Budapest)
Musaica	Musaica Archaeologica. Zborník Filozofickej Fakulty University Komenského (Bratislava)
Nartamongæ	Nartamongae. The Journal of Alano-Ossetic Studies. Epic, Mythology and Language (Vladikavkaz)
OA	Opuscula Archaeologica (Zagreb)
Ossa	Ossa. International Journal of Skeletal Research (Solna)
Ősrégészeti Levelek	Ősrégészeti Levelek. Prehistoric Newsletter (Budapest)
PBF	Prähistorische Bronzefunde (München)
PLoS One	PLoS One. E-Journal (San Francisco)
PNAS	Proceedings of the National Academy of Sciences (Washington, D. C.)
Pravěk	Pravěk (Brno)
Preistoria Alpina	Preistoria Alpina (Trento)
PZ	Praehistorische Zeitschrift (Berlin)
QuaternaryInt	Quaternary International. The Journal of the International Union for Quaternary Research (Oxford – New York)
Radiocarbon	Radiocarbon. An International Journal of Cosmogenic Isotope Research (Tucson)
RégFüz	Régészeti Füzetek (Budapest)
SA	Советская Археология (Moskva)
Satu Mare	Satu Mare. Studii şi comunicări. Seria Arheologie (Satu Mare)
Savaria	Savaria (Szombathely)
SbČSA	Sborník Československé Společnosti Archeologické (Brno)
SCIV	Studii şi Cercetări de Istorie Veche (Bucureşti)
SlA	Slovenská Archeológia (Bratislava)
SMK	Somogyi Múzeumok Közleményei (Kaposvár)
Specimina Nova	Specimina Nova. Dissertationum ex Instituto Historiae Antiquae et Archaeologiae Universitatis Quinqueecclesiensis (Pécs)
SSz	Soproni Szemle (Sopron)
StComit	Studia Comitatensia (Budapest)
SzIKMK	A Szent István Király Múzeum Közleményei (Székesfehérvár)
Terra Sebus	Terra Sebus. Acta Musei Sabesiensis (Sebes)
Tisicum	Tisicum. A Jász-Nagykun-Szolnok Megyei Múzeumok Évkönyve (Szolnok)
UF	Ugarit-Forschungen. Internationales Jahrbuch für die Altertumskunde Syrien-Palästinas (Kevelaer – Neukirchen– Vluyn)
UPA	Universitätsforschungen zur prähistorischen Archäologie (Bonn)
VAH	Varia Archaeologica Hungarica (Budapest)
VetZoot	Veterinarija ir Zootechnika. A scientific journal and the Official Organ of the Veterinary Academy, Lithuanian University of Health Sciences (Kaunas)
VKT	Várak, kastélyok, templomok. Történelmi és örökségturisztikai folyóirat (Pécs)
VMMK	A Veszprém Megyei Múzeumok Közleményei (Veszprém)
VýP	Východoslovenský Pravek (Košice)
WMMÉ	A Wosinsky Mór Múzeum Évkönyve (Szekszárd)
ZalaiMúz	Zalai Múzeum (Zalaegerszeg)
ZbSNM	Zborník Slovenského Národného Múzea. Archeológia (Bratislava)
Ziridava	Ziridava. Studia Archaeologica (Arad)
ZSNM	Zbornik Slovenského Národného Múzea (Ljubljana)

FOREWORD FROM THE EXECUTIVE EDITOR

As with the previous (37th) issue of the Antaeus (Yearbook of the Institute of Archaeology), the present volume brings together a selection of research papers addressing a certain time period; the Bronze Age on this occasion. The current volume, despite containing fewer studies than the previous issues, is in line with the editorial board's ambition to publish a new volume at regular – annual – intervals, even at the expense of the overall length of the publication. With the aim to assemble a broad spectrum of Bronze Age research studies from the territory of Hungary, the current issue touches upon a wide range of themes stretching across the many hundreds of years of the Bronze Age period: from the facial reconstruction of an Early Bronze Age woman, to the domestication of horses and Middle Bronze Age dress ornaments, to the study of the large, Late Bronze Age fortified settlements. These topics cover the key issues of current European Bronze Age research, including the archaeological application of DNA analyses, and the theoretical approaches of political economies, therefore the outcomes presented here will hopefully be of wide international interest. Some of the research was carried out within the framework of the Lendület/Momentum Mobility Research Group launched in 2015, supported by the Hungarian Academy of Sciences at the Institute of Archaeology, Research Centre for the Humanities.

The paper by Ágnes Kustár and her colleagues presents the facial reconstruction of an Early Bronze Age female burial. The work serves as the first facial reconstruction study where DNA data was also considered regarding the pigmentation (eye and hair colour, skin tone) of a Bronze Age individual from present-day Hungary.

The two studies put forward by Eszter Melis and Gabriella Kulcsár as main authors, both discuss the results of micro-regional settlement investigations aimed to explore Early and Middle Bronze Age settlement structures using non-destructive methods. The settlement investigations conducted by Eszter Melis and her team focussed on the region of Nagycenk, nearby Lake Neusiedl. The data published here represents a significant piece of archaeological research as information from the region occupied by the Gáta–Wieselburg culture has been lacking in the past three decades. Furthermore, the site of Nagycenk-Kövesmező is one of the few Gáta–Wieselburg settlements investigated by a modern archaeological excavation.

Gabriella Kulcsár and her team discuss the Middle Bronze Age pit burial of a mature adult female with evidence for multiple physical trauma, from Central Hungary. The study touches upon the interpretation of pit burials in the context of the settlements of Bronze Age communities who otherwise practiced inhumation and cremation as their nominal mortuary tradition.

Géza Szabó's paper examines the so-called Tolnanémedi-type hoard horizon comprised primarily of dress ornament assemblages across to the Middle Bronze Age along with a newly discovered hoard from Mucsi in Tolna county. The publication includes the reconstruction of a costume worn by high status female members of the Transdanubian Encrusted Pottery culture and provides an interpretation of the symbolism of such ornaments.

The study by Gábor Ilon provides an overview of Bronze Age moulds and their distribution in the Carpathian Basin. The paper considers the assemblage as important evidence for local metallurgy, and sheds new light on the organisation and specialisation of bronze production.

Róbert Bozi and Géza Szabó explore the question of horse domestication within the context of Bronze Age cultures in Central and Eastern Hungary, based on the evidence of horse gear made of antler appearing first during the 2nd millennium in the Carpathian Basin. The study relies on newly discovered horse remains and their associated absolute dates.

The paper by Vajk Szeverényi and his colleagues discusses the results of their most recent excavation programme conducted at Csanádpalota; a prime example of a so-called 'mega fort' or large-scale fortified settlement typical in the Late Bronze Age in Southeast Europe. Anna Priskin in her study gives a detailed insight into the production and use of grinding stones recovered at the site.

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RÓBERT BOZI – GÉZA SZABÓ

THE BEGINNINGS OF THE USE OF EQUIDS AS WORK ANIMALS IN THE BRONZE AGE CARPATHIAN BASIN[1]

Zusammenfassung: Die wichtigste Frage in Hinsicht auf die Domestikation von Pferden lautet: Wie und wann gerieten Pferde unter menschlichen Einfluss, und welche Beweise gibt es, dass es zu solchen Tätigkeiten wahrhaftig gekommen ist. Archäologische Funde und frühe Abbildungen weisen darauf hin, dass Pferde mithilfe verschiedener Gegenstände aufgezäumt wurden, bevor sich das Konzept der Trense im Maul des Tieres etablierte. Es muss ebenso auf die Domestikation anderer Tierarten, wie zum Beispiel von Rindern (*Bos taurus*, ab 6000 v. Chr.) und von Trampeltieren (*Camelus bactrianus*, ab 3000 v. Chr.) eingegangen werden, die neben der Milchgewinnung auch für Personen- und Lastentransport herhielten, und der Domestikation von Pferden als Beispiel gedient haben können. Die völkerkundlichen Beispiele besagen, dass sich bei Rindern der Nasenring, Nasenriemen und das Zaumzeug und bei Pferden die Trense bewährten, während man bei Kamelen Holz- oder Knochennägel verwendete, um die Scheidewand in der Schnauze zu durchbohren.

Die beiden im Karpatenbecken zutage geförderten archäologischen Funde der jüngeren Vergangenheit, auf die in diesem Bericht eingegangen wird, versuchen zu belegen, welche Erfahrungen bei der Domestikation anderer Tierarten bei Pferden genutzt wurden. Der Pferdeschädel, den man im Rahmen landwirtschaftlicher Arbeiten mit weiteren Knochenbruchstücken (Tompa-3) an einem bronzezeitlichen Fundort, in Tompa (Südregion Mittelungarns) aufgedeckt hatte, verdient besondere Aufmerksamkeit. Der besagte Fund weist eine Veränderung am *Os incisivum* auf, die wahrscheinlich durch menschliche Einwirkung erfolgte (Tompa-1). Aufgrund der ^{14}C-Datierung (1870–1620 BC) und anhand der in nächster Nähe des Pferdeschädels geborgenen Keramikfunde kann der Sammelfund der Vatya-Kultur III zugeordnet werden, als der Kulturkomplex seine Vorherrschaft auch auf das Donau-Theiß-Zwischenstromgebiet ausweitete. Die am Tierkieferfragment Tompa-3 beobachtete Knochenwucherung ist offensichtlich auf die regelmäßig in das Maul des Tiers gelegte Trense zurückzuführen, während im Diastema des Exemplars Tompa-1 keine ähnliche pathologische Veränderung vorzuweisen war. Die mögliche Verwendung von Nasen- und Maultrensen im Falle der Pferdearten Tompa-1 und Tompa-3 könnten darauf hindeuten, dass im Verlauf des langwierigen Domestikationsprozesses von Pferden zahlreiche Versuche erfolgt waren, Pferde für Arbeitszwecke zu nutzen.

Keywords: equids, domestication, horse control, archaeozoology, Bronze Age, Carpathian Basin

Thanks to the advances of archaeological research, our knowledge regarding the domestication of horses has been transformed in the past few years. However, due to a variety of different approaches and research traditions, scientists are yet to reach common ground even in fundamental issues such as the definition of domestication. The primary aim of animal domestication was to

[1] The study was funded by the Russian Foundation for Basic Research (project number 21-59-23003), in collaboration with the Lendület Mobility Research Project. Here, we would like to express our thanks to Kornélia Bán, Annamária Bárány, Ágnes Birtalan, Claudio Cavazzuti, Tamás Hajdu, Anikó Horváth, Katherine Stevens Kanne, Viktória Kiss, István Major, János Makkay, László Palcsu, Peter Shulga, Anna Szécsényi-Nagy and to William Timothy Treal Taylor for their help and valuable advice on the text. We are grateful to the two anonymous reviewers' comments and suggestions. We thank Árpád Bozi for his photographs, Anna Tápai, László Gucsi for the graphic design, and Borbála Nyíri for the translation.

more efficiently exploit natural resources by changing the behaviour of certain species; both by inhibiting their instinctive responses and by aiding their adaptation to the anthropogenic environment.[2] The process of domestication, which spanned across several millenia, involved many twists and turns. The morphological characteristics of some animal species made them less suitable for domestication, nevertheless, individual animals could still be successfully trained to carry out specific tasks (like present-day circus animals for example). The level of domestication is generally estimated by a set of morphological characteristics (e.g. the size of teeth, horns, and volume of cranium, etc.), although, more recently the genetic modification of certain fenotypes is also being considered as indicators. Both approaches agree that the process of horse domestication took place in different geographical areas involving many – often dissimilar – stages of adaptation over several millenia. The utilisation of horses for work and transport is particularly significant, since it enhances the speed and efficiency of human mobility. Given the lengthy and multi-faceted process of domestication it might not ever be possible to pinpoint the exact location and time the domestication of horses took place. Even in the most fortuitous cases data can only be linked to a particular geographical region while it is entirely possible that similar attempts of domestication might have taken place in different areas at different times targeting other equine species.

Traces of Bronze Age horse use in the Carpathian Basin

In the middle of the 20th century – in part due to the contributions made by the Hungarian research community – it was assumed that the Carpathian Basin represented a centre or hub for horse domestication from the Early Copper Age/Eneolithic (e.g. the sites of Deszk, Kisköre-Szingehát, Kenderes-Telekhalom and Kenderes-Kulis).[3] The backdrop to equine domestication was the historical process associated with the appearance of kurgans and horse equipment north of the River Körös in northeast Hungary; a process that may also be linked to the changes occurring in the biological make-up of Central and Eastern Europe at the time.[4] The significance of horse equipment in these assemblages from Hungary, although cannot unequivocally be associated with the control or utilisation of horses as work animals, has been overrated by research since its apparent linkage to the finds discovered at Dereivka.[5] Scientists today agree that influences originating from the steppe region reached the territories of Central, Eastern and Southeastern Europe in waves from the beginning of the Eneolithic.[6] Population genetic studies link these processes between 3000 and 2500 BC to the movements of the Yamnaya pastoralist population from the direction of the Caspian–Pontic steppe region.[7] Based on these population movements, a direct correlation was assumed between the migrating population connected to the Yamnaya culture and the spread of horse domestication, however, the most recent horse genomic evidence published by the team of Ludovic Orlando outlines a situation where migrating pastoralists would have brought the know-how of horse control and transport but not their horses. According to their view the process of horse domestication carried out by the Yamnaya pastoralists was restricted to the natural habitat of these equids and did not spread into other geographical areas in the period before 2200–2000 BC – similarly to the case of the Botai horses domesticated around 3500 BC.[8] The so-called DOM2 type horses – currently regarded as the ancestors of modern domesticated

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2 *Zeder 2015* 3191.
3 *Bökönyi 1959; Bökönyi 1974; Bökönyi 1978; Greenfield 2006* 221–222.
4 *Ecsedy 1979.*
5 *Bökönyi 1959; Bökönyi 1974; Bökönyi 1978; Levine 1990; Benecke 1994; Makkay 2004.*
6 *Gimbutas 1977; Anthony et al. 1986; Anthony 2007; Szabó 2017a.*
7 *Allentoft et al. 2015; Haak et al. 2015; Goldberg et al. 2017.*
8 *Gaunitz et al. 2018.*

horses in Eurasia – are assumed to have been developed in the Volga–Don region in the second half of the 3rd mill. BC and spread towards the west with a population directly preceding the Sintashta culture.[9] These new and somewhat surprising conclusions will no doubt require further investigations as they seem to contradict current archaeological and archaeozoological observations,[10] human genetic studies.[11] It is highly likely, that if the Yamnaya population had kept domesticated horses and used them for transport and/or traction, that these horses were taken along by their owners to the new territories. However, it is entirely possible that horses were not as significant at the time as we assume, – cattle could have played a more prominent role as traction animals (as it is implied by heavy chariots with solid wheels).[12] Nevertheless, it would be unlikely that one of the most mobile and agile group of animals were left behind by the pastoralist communities. At present, compelling evidence for the domestication and utilisation of horses dates to the time when the DOM2 type horses began to distribute widely across the territories of Eurasia.[13] So far neither the archaeological investigations, nor the genetic examinations have been able to provide clear answers whether the processes of domestication and population migration were contemporaneous, and how closely were they intertwined, since the prolonged nature of such developments. Recently, however, a set of methodologies has been developed specifically for the study of horses, by identifying the changes on the metatarsals which could help to shed light on the utilisation of individual animals and could provide further details to the above assumed processes.[14]

There is increasing archaeological information which suggests that the lengthy process of domestication and utilisation of horses only began in the Early Bronze Age.[15] Horse remains and bit types *(fig. 1)* appear in different numbers within the distribution of certain archaeological cultures during the Early and Middle Bronze Age in the Carpathian Basin.

Archaeozoological data implies that in the area of distribution of the Copper Age Baden and Boleraz cultures (at the sites of Szűr, Paks, Kaposvár, Ordacsehi and Kaposújlak) horse remains are lacking. However, in the same region during the subsequent Early Bronze Age Somogyvár–Vinkovci culture (at sites of Paks, Ordacsehi and Dombóvár) and the earliest phase of the Transdanubian Encrusted Pottery culture (Ordacsehi, Kaposvár)[16] until the beginning of the Middle Bronze Age horse bones had been found, although in small numbers (2–11 fragments), producing radiocarbon dates of 2620–1880 cal BC.[17] Beside the Dunaújváros horse so far only the specimen from Kaposújlak (2560–2410 cal BC) has undergone genetic examination which indicates that this horse also belonged to ancient wild horse population of the region which has small scale genetic links pointing towards the east; to the territories of southern Thrace.[18] At the site of Dombóvár-Tesco (2570–2470 cal BC) associated with the Somogyvár–Vinkovci culture (also with links to the eastern steppe region)[19] a loose network of domestic buildings were identified suggestive of a pastoralist lifestyle of its inhabitants.[20] It would be feasible to assume that the advantages of horse domestication were utilised by these communities. However, the

[9] *Librado et al. 2021.*
[10] *Taylor – Barrón-Ortiz 2021.*
[11] *Allentoft et al. 2015; Haak et al. 2015.*
[12] E.g. Novotitarovskaya, Ostannii kurgan 1, chariot burial no. 150; *Gerling 2015* fig. 2. 5.
[13] *Hüttel 1981; Librado et al. 2021* 635–636.
[14] *Bozi – Szabó 2020.*
[15] *Levine 2004.*
[16] *Gál 2017* fig. 86.
[17] *Gál 2017* Appendix 1.
[18] *Librado et al. 2021* 635.
[19] *Szabó 2017b* 381–385.
[20] *Szabó – Gál 2013.*

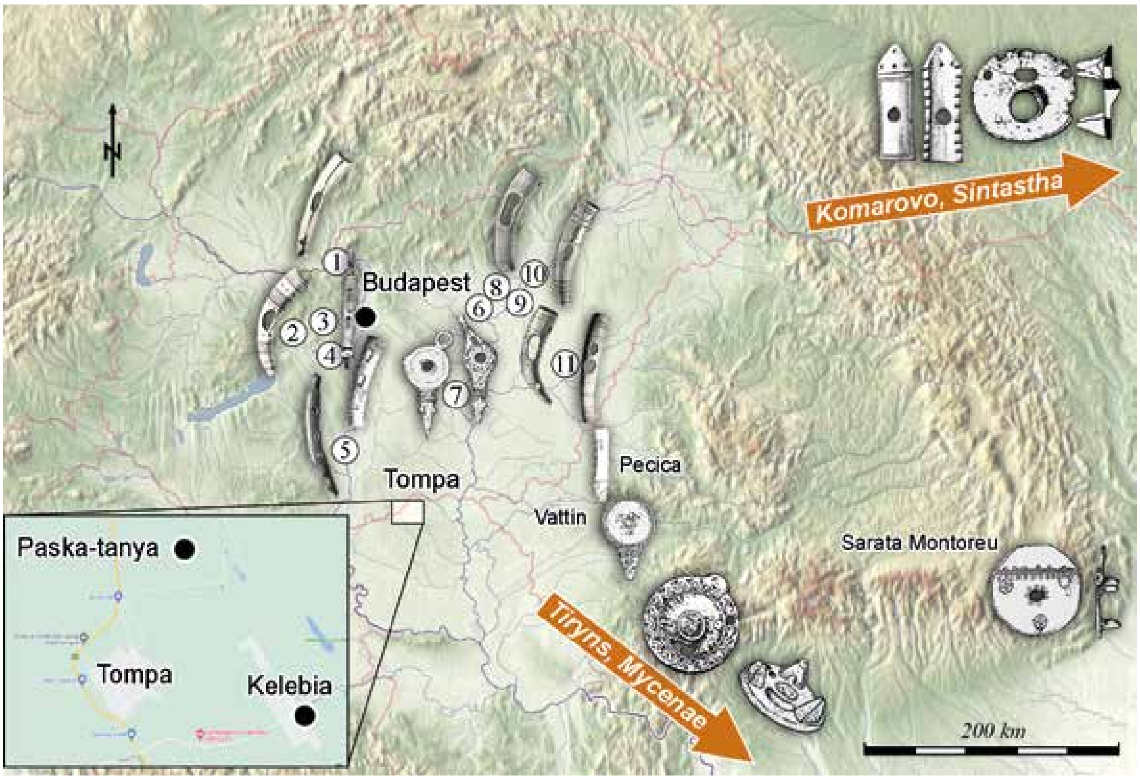


Fig. 1. Significant horse bit finds of the Carpathian Basin and their linkages. 1. Szob-Kálvária; 2. Pákozd-Várhegy; 3. Budapest-Lágymányos; 4. Százhalombatta-Földvár, Téglagyár; 5. Gerjen; 6. Jászdózsa-Kápolnahalom; 7. Tószeg-Laposhalom; 8. Füzesabony-Öregdomb; 9. Tiszafüred-Ásotthalom; 10. Mezőcsát-Pástidomb; 11. Köröstarcsa (©Géza Szabó, ©Zsolt Réti)

only two bone fragments *(radius, pelvis)* found at the site belonging to mature horses imply that horses did not play a significant role either as sources of meat/milk or as spiritual entities in the life of the local community, while the lack of horse equipment further suggests that horses were not widely used as work animals at the site in the Early Bronze Age.[21] Nevertheless, it is not impossible that individual horses were kept as pets or as prestige signifiers, and could have been trained to carry out certain tasks.

As opposed to the more scattered assemblages of Southeast Hungary, the picture is very different at the Bell Beaker sites around Budapest, where ratio of horse remains were unusually high (Bell Beaker–Csepel group: Albertfalva, Budakalász, Budapest-Békásmegyer, Csepel-Háros, Csepel-Hollandi út, Szigetszentmiklós, 2500–2200 BC). Some researchers even considered this area to be the centre of horse domestication/breeding, and assumed that horses could have spread from this original hub to other parts of Europe in the middle of the 3rd millenium.[22] However, the large number of young animals (most likely) kept for their meat seem to contradict this,[23] along with – as data from Southeast Hungary suggest – the very limited number of horse related assemblages from contemporaneous archaeological cultures *(fig. 2)*. The domesticated horse from Dunaújváros-Kosziderpadlás dating to 2139–1981 cal BC (along with the above mentioned specimen from Kaposújlak)[24] suggests that the breeding of horses was evidently taking place

[21] *Szabó – Gál 2013* 89–90.
[22] *Endrődi – Reményi 2016* 232.
[23] *Lyublyanovics 2016* 205; *Kanne 2018* 185.
[24] *Gaunitz et al. 2018* 20.

Fig. 2. Small/medium-sized horse from the Bronze Age accompanied by Nagyrév-type ceramic vessels (Soroksár-Site 1, excavated by Géza Szabó in 1999, unpublished; ©Géza Szabó)

from the Early Bronze Age in the Carpathian Basin.[25] Most recently Katherine Stevens Kanne's extensive study provided a detailed overview of horses and horse equipment from the Carpathian Basin, therefore here we shall underscore only the pieces linked directly to transport or traction.[26]

In terms of the utilisation of horses the first major change seem to have occurred during the Middle Bronze Age, when bits appear in the archaeological record, primarily in the eastern regions of the Carpathian Basin *(fig. 1).* This corresponds well with the most recent research, according to which the first securely (both genetically and morphologically) identified domesticated horse remains are known from burials in the territories of Russia and Central Asia dating to around 2000 BC.[27]

The archaeological phenomena observed in the steppe region is particularly interesting since the predecessors of Bronze Age bits occur within the distribution of the Sintashta–Poltavka culture. The first appearance of bits at Bronze Age settlements located along the Danube and the Tisza date to the Middle Bronze Age (2000/1900–1600/1500 BC).[28] However, none of these

25 It is necessary here to clarify that based on the results of the genetic examinations Gaunitz and her team made the following statement: 'Dunaújváros_Duk2 (Duk2) the earliest and most basal specimen within DOM2, was divergent to all other DOM2 members.' (*Gaunitz et al. 2018* 112). This statement was in a later interpretation (*Kanne 2018* 31) slightly modified: 'The DNA from the bones of a horse excavated from the settlement of Dunaújváros-Kosziderpadlás dating to 2139–1981 cal BC have revealed it to be ancestral to all modern domesticated horses *(Gaunitz et al. 2018)*.' Although this statement is undoubtedly flattering to Hungarian archaeology, according to the most recent studies *(Librado et al. 2021)*, it is likely to be incorrect.

26 *Kanne 2018; Kanne 2022.*

27 *Orlando 2020; Taylor – Barrón-Ortiz 2021.*

28 *Mozsolics 1953; Bándi 1963; Jaeger – Kulcsár 2013* fig. 20.

finds have secure radiocarbon dates associated with them. The available dating of the bits can only allow limited interpretation, as the chronological classification of these objects was based on largely outdated excavation methods (i.e. spits).[29] Katherine Stevens Kanne in her work mentions 14 bits dating to the Early Bronze Age and 79 to the Middle Bronze Age, all located in the eastern or northeastern regions of the Carpathian Basin. She suggests that in this area, the utilisation of horses and horse equipment was continuous since the Early Bronze Age. She associates the bridle cheekpieces with riding, the disc-shaped ones with traction/chariotry.[30] Nevertheless, so far there is not clear evidence for the use of bits from the Early Bronze Age, and the first unequivocal trace for the utilisation of horses as work animals was observed on the hereby discussed specimen of the Tompa-1 horse in the Carpathian Basin.

When it comes to the origins of the bone bits discovered in the Carpathian Basin, researchers has been divided. Some argued for their prototypes to be found in Asia Minor,[31] while others suggested links with the eastern steppe region.[32] Following the excavation of the cemetery of Sintashta,[33] it became evident that – as opposed to Asia Minor origins[34] – the disc-, or rectangular cheekpieces were in fact developed by the communities of the Sintashta–Poltavka complex in the Volga–Ural region 2000 BC. Assemblages containing chariots, bits and cheekpieces, along with rock art and other depictions testify that these objects reached territories lying west, east and south of the steppes, travelling long distances.[35] Contrary to previous views, these influences seem to have spread in the opposite direction: from the steppe region to Mycenae via the migration of early Aryan populations, while through another trajectory it reached the Carpathian Basin along with the knowledge of horse control, chariotry and equipment.[36] The insular distribution of the disc and rectangular bits in the above mentioned three regions indicate direct links between the radiocarbon dates derived from the Sintashta assemblages, depictions of Mycenae and Tiryns from the MH II period, and the second half of the Hungarian Middle Bronze Age (RBz A2a).[37] A similar picture is reflected by a map showing the distribution of various bit types.[38] Despite the close links, compared to the other two regions, the development of horse equipment appears to have taken a slightly different direction. There is so far no examples found of the rectangular bits in the territories along the Danube and the Tisza Rivers. The interior of the disc-shaped bit variants' is smooth, without spikes. Even if considered together with the so-called mixed variants, the disc-shaped bits only make up around 10% of all horse equipment in the Carpathian Basin, where the Füzesabony-type cheekpieces dominated during the Middle Bronze Age *(fig. 1).* Therefore, the two horse remains from Hungary discussed below – both with pathologies caused by the equipment – need to be examined against this historical backdrop.

Bronze Age remains of equids from Tompa

The skull of the Tompa-1 *(fig. 3)* along with other bone fragments *(fig. 6)* horse mandible, mt. III., mammal bone were discovered during agricultural works in the Danube–Tisza Interfluve region close to the southern border of Hungary *(fig. 1).* The remains were gifted to the Bozi Ars Med.

[29] *Bándi 1963.*
[30] *Kanne 2018; Kanne 2022* 297.
[31] *Bándi 1963* 55.
[32] *Mozsolics 1960; Hüttel 1981.*
[33] *Gening – Gening – Zdanovič 1992.*
[34] *Smirnov 1961.*
[35] *Lichardus – Vladár 1996* 25–27; *Makkay 2000.*
[36] *Boroffka 1999; Penner 1998; Makkay 2006.*
[37] *Penner 1998* 161–165.
[38] *Hüttel 1981* Tab. 26.

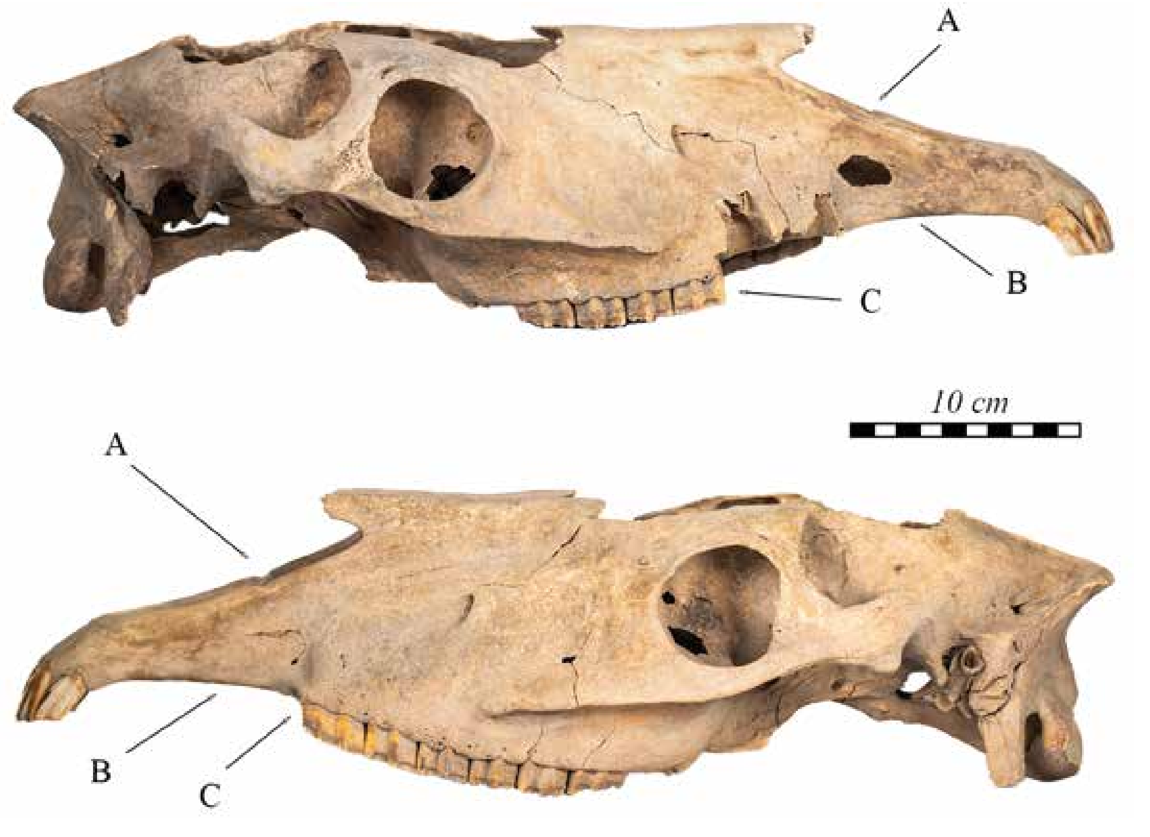


Fig. 3. Lateral view of the Tompa-1 horse cranium. A. Groove on the nasal process of the incisive bone running in a dorsal-dorsomedial direction; B. Intact interdental space *(diastema);* C. No damage visible on the exterior of the second premolar (©Árpád Bozi)

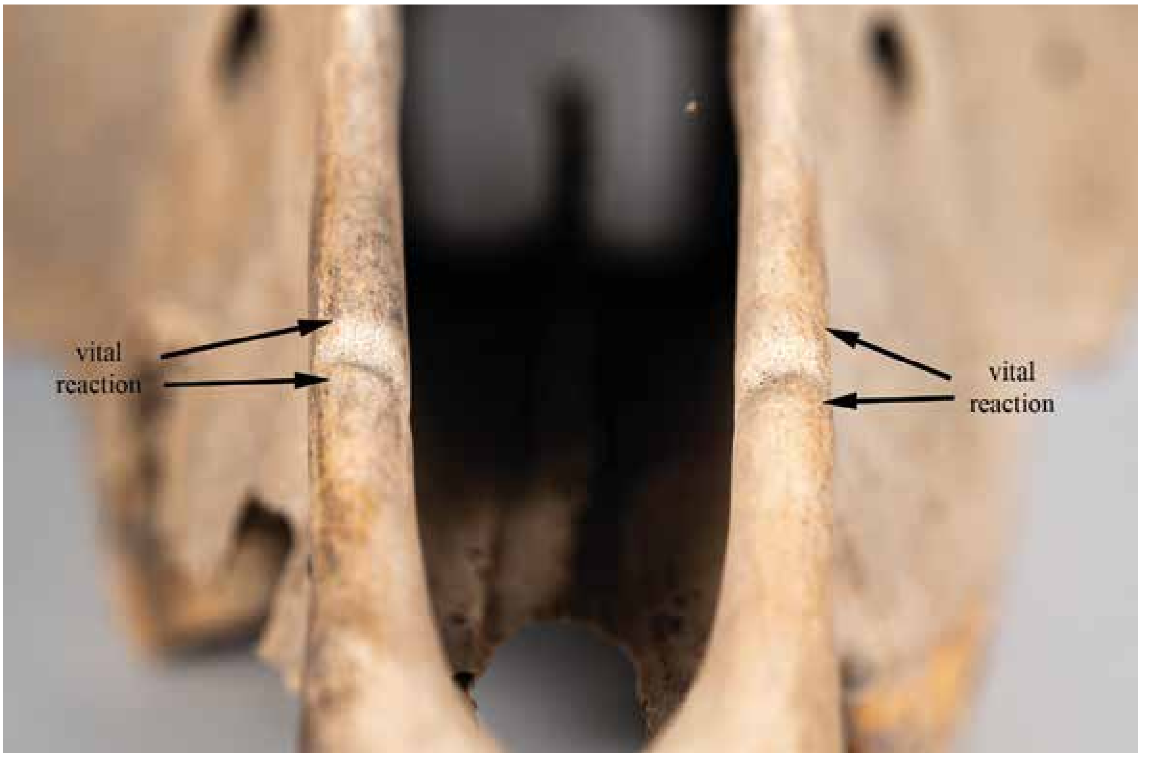


Fig. 4. Evidence for vital reaction on the nasal process of the incisive bone on the Tompa-1 horse skull (©Árpád Bozi)

Vet. Clinic in 2020, and following their examination, they were inventoried into the collection of the Museum of Agriculture, Budapest. According to the collector, the bones and the ceramic fragments accompanying the remains were found in the northern vicinity of Tompa, between the railway track and a farm. Unfortunately, the frontal bone, the larger part of the nasal bone and the mandible of the skull was already missing. Among the ceramic pieces, a bowl of dark grey colour was identified to have belonged to the Middle Bronze Age Vatya culture (see below).

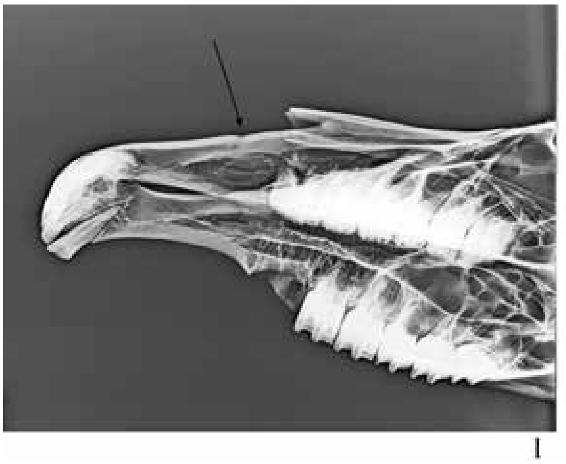
This detail raised the possibility that the skull could have belonged to a Bronze Age *Equus caballus,* which might also indicate that the remodelling observed on the *os incisivus* stands as the earliest example for a horse used for riding or transport in the Carpathian Basin. The pathologies present on the mandible fragment imply the use of a bit, therefore the two bone specimens will be discussed and interpreted together.

Tompa-1 sample (equine cranium)

The cranium is well preserved, the frontal bone, the larger part of the nasal bone and the mandible is missing. The second premolar (hereafter P^2) on the right side was removed and sampled for ^{14}C, and $^{87}Sr/^{86}Sr$ and ^{18}O tests. The piece not used for analysis was later restored into the maxilla. The examination of the incisors has shown that the specimen belonged to a mare about 8 years old, canines were missing. The remains were of light brown colour, code Dac693. The measurable characteristics of the skull and its comparison specimen (a skull fragment of an *Equus ferus* from the Pleistocene)[39] are listed in the *Appendix*. The frontal region of the Tompa-1 horse skull is shorter, the temporal/occipital/parietal area was broader, and the molars significantly smaller than that of the *Equus ferus* living in the Danube–Tisza Interfluve during the Pleistocene. The length measurements taken at the base of the skull suggest a withers height of 131.27 cm according to Ludwig Kiesewalter,[40] and 139.3 cm according to Vladimir Oskarovich Vitt.[41] In the comparative dataset the withers height measured on wild horse specimens fall within the range of 142.26–155.33 cm based on Vitt's study.[42] Therefore the measurements and the calculated withers height suggest that the Tompla-1 skull belonged to a domesticated *Equus caballus*. Out of the 11 indices of morphological measurement criteria 2 (18.18%) is characteristic of western type horses, 8 (72.72%) of eastern types and 1 (9%) index to both types. The morphological examination support the eastern type of the Tompa-1 specimen.[43]

On both sides of the incisive bone's *(os incisivum)* nasal process *(processus nasalis)*[44] a bevelling can be observed in a dorsal or dorsomedial direction *(fig. 4)*. The axis of the bevelling creates an angle of 22 degrees on the left and 21 degrees on the right side in an oral direction with the labial plane of the central incisors. The largest dorsal breadth of the bevelling on the left is 11.43 mm, on the right is 11.54 mm. The length of the bevelling is 12.41 mm on the left, and 12.18 mm on the right. The largest depth of the bevelling is 3.31 mm on the left, and 3.2 mm on the right. In both cases on the front and back edge of the bevelling flame-shaped bone spur formed, a so-called vital reaction. The width of the bone spur on the left side is 9.02 mm, its length is 8.55 mm, while the width of the bone spur on the right measures 8.08 mm, its length is 8.63 mm. The X-ray has shown evidence for osteoporosis within the area of the bevelling *(fig. 5. 1)*. The remodelling detected on the incisive bone was likely due to physical stress (e.g. pressure or pull caused by a harness). There is no trace of a bevelling or remodelling of the nasal

39 *Driesch 1976.*
40 *Kiesewalter 1888.*
41 *Vitt 1952.*
42 *Bozi – Szabó 2020.*
43 *Besskó 1906.* The DNA analysis of the remains was carried out by the Institute of Archaeogenomics at the Research Centre for the Humanities.
44 *Kovács 1967.*



1

2

Fig. 5. 1. X-ray image of the Tompa-1 cranium; 2. P^2 premolar (©Róbert Bozi)

bone or on the nasal process. Furthermore, there is no evidence for wear caused by chewing on a bit on the anterior edge and the crown of P^2 *(fig. 5. 2).* The bone surface in the interdental space *(diastema)* is intact. There was no ossification detected at the point of attachment of the large median ligament *(ligamentum nuchae)* on the occipital bone. Exterosis present at the attachment point of the large median ligament and on the occipital bone is a sign of the horse being used for traction but can also signify abnormal neck posture (bent posture, overbent neck, broken neck).[45]

Similar pathologies on the nasal process of the incisive bone have been described before and explained by various reasons: endogenous and exogenous causes. Fundamental endogenous cause for example is a prolonged O_2 deficit. The lateral muscle in the nose *(musculus nasi lateralis)* attaches to an S-shaped cartilage, which helps to lift the muscle and open up the airways when breathing in. In the case of prolonged O_2 deficiency the muscle is continuously strained, it becomes hypertrophic and presses on the nasal process of the incisive bone from a dorsomedial direction and also on the infraorbital nerve *(nervus infraorbitalis)* creating a bevelling or groove in the bone material dorsomedially and laterally.[46] A number of health conditions can result in permanent O_2 deficit. RAO (Recurrent Airway Obstruction) develops as an effect of stabling, caused by airborne particles, such as stable dust, fodder dust, fungi spores or polluting gases which induce an allergic reaction resulting in the inflammation of the airways. A disease of slow progression, does not improve.[47] IAD (Inflammatory Airway Disease) is brought on by bacteria, viruses, airborne particles, or polluting gases. It can be cured by providing a clean environment and suitable medication. Often traditional medicines can also improve the condition. Improves quickly.[48] *Laryngeal hemiplegia* is the paralysis of the recurrent laryngeal nerve *(nervus recurrens)*. Dystrophy of the left recurrent nerve occurs more commonly than the right. The left vocal fold and the *arytenoid cartilege* partially obstruct the airways. It causes some level of exercise intolerance but no shortness of breath. Occurs mainly in large racehorses and English thoroughbreds, does not affect mares.[49] A tumour in the nasal passage is a rare pathology and in most cases affects one side only.

In the case of the Tompa-1 horse, endogenous causes can most likely be excluded. RAO: archaeological evidence for the sabling of horses during the Bronze Age in the region is lacking,

[45] *Higgins 2009.*
[46] *Pérez – Martin 2001.*
[47] *Rush 1955.*
[48] *Rush 1955.*
[49] *Karsai – Vörös 1993.*

and the analysis of another mt. III. bone fragment found along with the skull has shown that the horse was pastured.[50] IAD: Stabling also plays a role in the development of the disease, but the condition improves quickly. *Laryngeal hemiplegia:* Occurs among large English thoroughbreds especially among stallions and geldings. The estimated withers height based on the base length measurement of the Tompa-1 skull implies that the specimen belonged to a horse of small-medium build. The lack of canines in the skull indicates a mare. *Tumour in the nasal passage:* most tumours can be identified as sarcomas originating from the bone membrane. Such pathologies were not detected on the Tompa-1 cranium.

Exogenous causes are always linked to contraptions placed on the head restricting the animal's movements and to facilitate its control during transport or traction. In order to achieve this reins, bridles and bits were used. The use and, consequently, the chewing of the bit results in a characteristic wear on the oral edge of the P^2, thus a diagonal wear greater than 3 mm indicates the usage of such contraption. In the diastema a bone spur can sometimes develop due to irritation by the bit. Bits made of metal and organic material can leave a distinguishable trace on the bone.[51]

The usage of the bit could have been preceded by the employment of a simple rein. During prolonged exertion the pressure caused by a tight noseband can result in a groove or bevelling on the incisive bone.[52] The sideways pressure induced by the noseband can put stress on the *nervus infraorbitalis,* which in turn could lead to the development of a lateral bone spur on the nasal process *(processus nasalis),* but still providing enough room for the nerve to branch off. Prolonged forceful breathing can also result in the development of a medial groove on the nasal process, its depth is dependent on the horse's age. The correction coefficient is 0.028 mm/year.[53] Along with these pathologies, ossification of the nuchal ligament can also occur due to exertion. The comparison between recent, domesticated horses used for traction, wild horses kept in zoos, and archaeological specimens suggest that if this pathology is present, the animal was likely to be utilised in some way, however, it is not yet possible to identify what exactly this task involved.[54] The type of work these horses were used for could be ascertained by a newly published method,[55] looking at bone cortex modification and bone tissue hyperthophy identified on the mt. III.

Tompa-3 sample (equid mandible)

The mandible fragment of the Tompa-3 horse belonged to a domesticated equid *(fig. 6).* The size of its P_2 premolars are characteristically different from the *Equus ferus,* while the presence of canines indicate a stallion or a gelding. Based on the wear detected on the incisors, its age could

Fig. 6. Lateral view of the Tompa-3 mandible (©Árpád Bozi)

[50] *Bozi – Szabó 2020.*
[51] *Bendrey 2007.*
[52] *Taylor – Tuvshinjargal – Bayarsaikhan 2016* figs. 3–4.
[53] *Taylor – Jamsranjav – Tuvshinjargal 2015* 863.
[54] *Taylor – Jamsranjav – Tuvshinjargal 2015.*
[55] *Bozi – Szabó 2020.*

1 2

Fig. 7. Tompa-3 P_2 diastema. 1. Frontal view; 2. Plan view (©Róbert Bozi)

1 2

Fig. 8. 1. Plan view of the Tompa-3 P_2; 2. Occlusal surface of the Tompa-3 lower incisors (©Árpád Bozi)

Fig. 9. X-ray image of the Tompa-3 mandible. 1. Plan view; 2. Lateral view. The toothless part of the mandible with clearly visible the bone proliferation, caused by the bits (arrow in the image; ©Róbert Bozi)

be estimated to 14-15 years.[56] Comparing the available morphological characteristics of the Tompa-1 and 3 samples, it is evident that the two equids represent markedly different fenotypes. The interdental space *(diastema)* of the Tompa-3 equid is slightly – but not significantly – longer than in the case of the Tompa-1 specimen. In terms of teeth, *pli caballinid* cannot be detected on the P_2 (which could be due to wear on the enamel), the premolar is considerably shorter than of the Tompa-1 specimen's. This difference cannot be explained by one being a lower premolar, while the other an upper. Consequently, the row of premolars of the Tompa-3 specimen is shorter, and the animal had a somewhat longer but narrower maxillary nasal structure than the Tompa-1 horse's. This could have been the result of local selection, breeding activities or that the Tompa-3 specimen belonged to a different genetic pool or even species (e.g. donkey or hybrid species: mule) altogether. The currently ongoing archaeogenetic examinations will hopefully be able to shed more light on this aspect.

There are characteristic pathologies present on the Tompa-3 mandible caused by the use of bits and attached cheekpieces. In the diastema the bone membrane is showing signs of irritation; a dorsolateral proliferation, most likely due to pulling or yanking on the harness and the bit. The greatest length of the proliferation is 12.45 mm, extending in the middle section of the *diastema,* its greatest width measures 4.76 mm, which could be a correlated with the diameter of the mouthpiece. The back edge of the bone spur developed close to the corner of the oral cavity. Erosion of the enamel can be observed on the anterior edge of the P_2 (depth: 1.4 mm, height: 11.7 mm), most possibly due to wear. On the occlusal surface of P_2 on the protocone,

[56] *Kovácsy – Monostori 1892* 219.

and on the anterior of the hypocone the enamel had been eroded away. These pathologies do not suggest the permanent use of an elaborate mouthpiece *(figs. 7–9).*[57] The animal was most probably utilised for work, but since the metatarsals are missing, it is impossible to say what this task or tasks entailed.[58]

Absolute and relative chronology, and the natural environment of the Tompa-1 and Tompa-3 horses

In order to identify the age and habitat of the Tompa-1 horse, ^{14}C, $^{87}Sr/^{86}Sr$, $\delta^{18}O$ (phosphate) examinations have been carried out. To estimate the horse's age the root of the right P^2 premolar was sampled and analysed. The isotopic tests were carried out in the Institute for Nuclear Research, ICER Centre in Debrecen,[59] along with ^{14}C dating of the remains. The skull produced AMS dates of 3412 ± 29 BP, the 2σ calibrated range spans between 1870 and 1620 cal BC (95.4% probability), dating to the 19th–17th century BC *(fig. 10).*[60] The ^{14}C dates and the ceramic fragments found along the horse bones all indicate that the specimen date to the Vatya III period, when the cultural complex expanded its occupation to the Danube–Tisza Interfluve.[61] This era represents the second phase of the Middle Bronze Age in the Carpathian Basin, contemporaneous with the transition of the Reinecke BA2–BB periods according to the Central-European chronology,[62] with the disintegration of the Sintashta-Petrovka complex in the southern Ural region and with the period directly preceding the Mycenaean shaft graves (MH II).

The Tompa-3 mandible has been also sampled for ^{14}C, $^{87}Sr/^{86}Sr$, and $\delta^{18}O$ (phosphate) analyses in order to establish the age and habitat of the specimen. The AMS dates (DeA-31495) the Tompa-3 remains date to 3412 ± 29 BP, the 2σ calibrated range spans 1610–1450 cal BC (95.4% probability), to the 17th and 15th century BC *(fig. 10).* This complement the dating of the Tompa-1 specimen, and correspond with the late Vatya culture's Koszider phase, with the Reinecke BB1 period according to Central-European chronology, and correlate with the assemblages of the Mycenaean shaft graves exhibiting strong steppe influences.[63]

In order to establish the similarities and differences in the strontium isotope ($^{87}Sr/^{86}Sr$) signatures associated with the habitat and the place of deposition of the horse, samples were taken from the enamel of its P^2 premolar and analysed in the ICER laboratory at Debrecen as well. Tooth enamel, in contrast to bones, has been shown to be less susceptible to diagenesis and contamination from the soil than bioapatite, and does not remodel during the individual's lifetime. For this reason tooth enamel is the most common tissue targeted for $^{87}Sr/^{86}Sr$ analyses of human and animal remains. Archaeological and isotope studies of the last decades indicate that most of the food consumed by later prehistoric communities was produced on land surrounding settlements.[64] Comparative samples to establish a reference dataset of background signatures (samples of soil, grass and mollusc shells) were collected from the northern vicinities of Tompa. The isotopic rate of 0.709335 $^{87}Sr/^{86}Sr$ measured on the Tompa-1 horse is so close to rate produced by the background soil sample (0.709256) that it would strongly suggest the congruence of the

[57] *Bendrey 2008.*

[58] *Bozi – Szabó 2020.*

[59] *Major et al. 2019.*

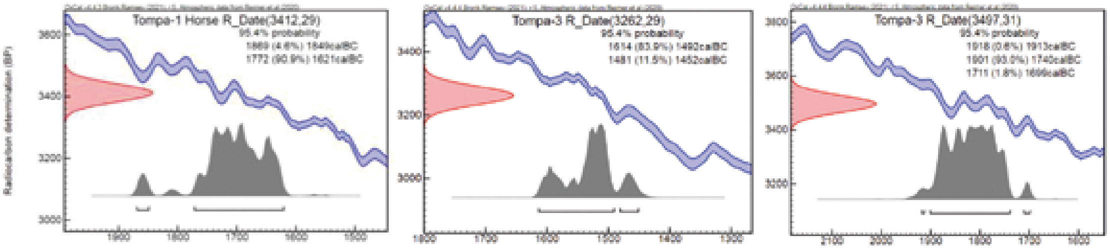
[60] The dates were calibrated with the 'OxCal' v4.3 software *(Bronk Ramsey 2009)* using the IntCal20 Northern Hemisphere radiocarbon calibration curve *(Reimer et al. 2020).*

[61] *Bóna 1975* 52.

[62] *Szabó 2017b* fig. 5; *Stockhammer et al. 2015* fig. 7.

[63] *Szabó 2017b* fig. 5; *Stockhammer et al. 2015* fig. 7.

[64] For more details of the method see *Cavazzuti et al. 2019.*



AMS ^{14}C No	HEKAL No	Sample	Type	(BP) (±1σ)	cal BC (2σ) (OxCal v4.4.3)
DeA-27707	1/2553/1	Tompa-1	Horse P^2 premolar	3412 ± 29	1869–1621
DeA-31495	1/2735/2	Tompa-3	Bone	3262 ± 29	1614–1452
DeA-31496	1/2735/3	Tompa-4 R_Date	Mammal bone	3497 ± 31	1918–1699

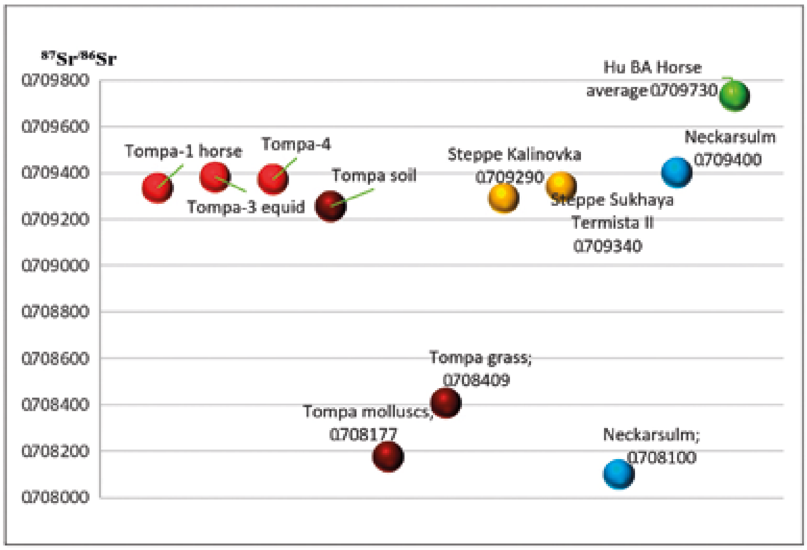
Fig. 10. ^{14}C dating of the Tompa-1, 3. samples (Institute for Nuclear Research, ICER Centre, Debrecen)

habitat and the place of deposition. Recently published archaeological fauna data from the Kelebia cemetery (2 km southeast from Tompa) with Sr ratio between 0.7091 and 0.7100 are coherent with the Tompa-1 horse and soil samples.[65] However, the ^{87}Sr/^{86}Sr isotopic signature of a recent soil sample corresponded more with a signature produced by the ancient bone than with the other two background reference samples which calls for some caution when interpreting the results.[66] The strontium isotopic signatures produced by the Tompa-1 horse barely reach the lowest values of other samples analysed from Hungary previously.[67] The situation is similar in the case of sampled Bronze Age horse teeth.[68] The closest comparable signature to the Tompa-1 horse's ^{87}Sr/^{86}Sr isotopic rates derived from samples from a Yamnaya burial at Kétegyháza-Kétegyházi tanyák site (Kurgan 3, burial 1: 0.70936) – located on the Great Hungarian Plain, characterised by largely homogenous geology.[69] When the Tompa-1 samples are compared with signatures produced by samples from regions farther west or east, it transpires that they all fall into the range measured at Neckarsulm (0.7081–0.7094: Baden-Württemberg, Germany), but the signatures measured on samples from Bulgaria and the steppe area are also close.[70] Moreover, the ^{87}Sr/^{86}Sr isotopic signatures[71] measured at several sites in the Eastern steppes fall closer to the rates measured on the Tompa-1 horse, than to the signatures produced by the background reference samples of grass or molluscs. It is particularly interesting that the ^{87}Sr/^{86}Sr isotopic signature of 0.70934 measured on a sample from the Sukhaya Termista II site associated with the Catacombe culture, and also the signature of 0.70929 produced by a bone sample (from burial no. 5)[72] from the site of Kalinovka I linked to the Poltavka culture (partially preceeding the Bronze Age Sintashta culture along the Volga) falls closer to the measurements of the Tompa-1 horse than to signatures produced by the background reference samples. Therefore, the isotopic signature of 0.709335 ^{87}Sr/^{86}Sr produced by the Tompa-1 sample would suggest a high likelyhood of the horse being of local origin, but given the archaeological context it could also have originated from territories of the present-

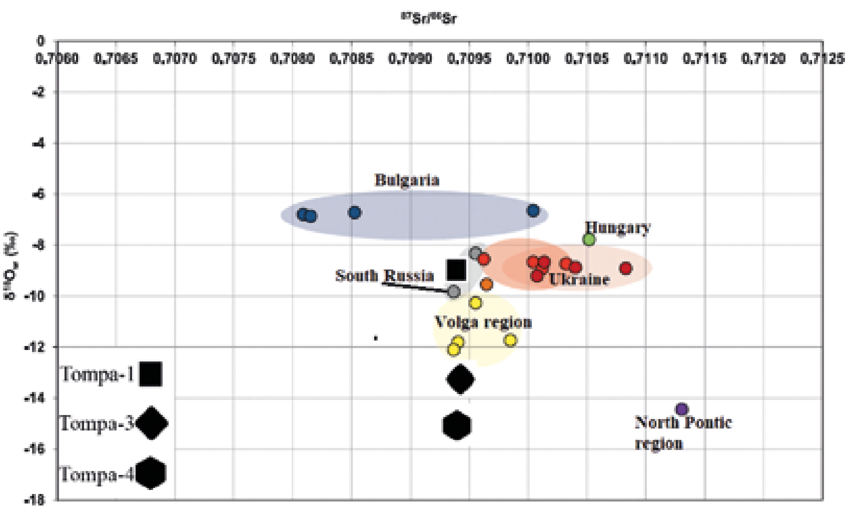
65 *Cavazzuti et al. 2021.*
66 For the possible contamination of the grass and molluscs Sr data see *Thomsen – Andreasen 2019.*
67 *Giblin et al. 2013* Tab. 1; *Gerling 2015* fig. 4. 8; *Sjögren – Price – Kristiansen 2016* 19.
68 *Kanne 2018* Tab. 5. 9.
69 *Gerling 2015* 344. See also *Depaermentier et al. 2021* fig. 5.
70 *Gerling 2014* figs. 1–2; *Sjögren – Price – Kristiansen 2016* fig. 9.
71 *Gerling 2015* 65–66, fig. 4. 21–22.
72 *Gerling 2015* 347.

HEKAL Sample No.	Sample	$^{87}Sr/^{86}Sr$	± 1σ	$\delta^{18}O$ (phosphate) vs VSMOW (‰) (±0.4‰)	On carbonates	$\delta^{18}O_w$ (‰)
I/2553/1	Tompa-1 horse	0.709335	0.000028	15.4	24.46	-9.7426
I/2553/2	Tompa grass background	0.708409	0.000029			
I/2553/3	Tompa soil background	0.709256	0.000031			
I/2553/4	Tompa molluscs background	0.708177	0.000030			
I/2735/2	Tompa-3 equid	0.709381	0.000034	11.6		-15.8
I/2735/3	Tompa-4 mammal bone	0.709372	0.000033	14.0		-13.1

A



B



Tompa-1 after converting: -9.4 and -10.6‰; Tompa-3 after converting: -16.4 and -15.2‰

C

Fig. 11. A. The $^{87}Sr/^{86}Sr$ isotopic signatures and $\delta^{18}Ow$ average of the Tompa specimens and background reference samples; B. The averages of $^{87}Sr/^{86}Sr$ isotopic signatures from Tompa compared to the averages of Bronze Age horses in Hungary (*Kanne 2018* 192) and similar values from other regions (after the chart by *Gerling 2014* figs. 1–2; *Sjögren – Price – Kristiansen 2016* fig. 9); C. The $^{87}Sr/^{86}Sr$ isotopic signatures and $\delta^{18}Ow$ averages of the Tompa specimens compared to the values derived from the Eneolithic and Bronze Age in the close region (after *Gerling 2015* fig. 4. 103; ©Géza Szabó)

day southern Germany or the eastern steppe region. In order to get a more detailed picture, the strontium isotope analyses were supplemented by $\delta^{18}O$ (phosphate) vs VSMOW examinations carried out on the same P^2 premolar at Debrecen. The measured rate of 15.4‰ (±0.4‰) produced by the Tompa sample shall be converted[73] to get the drinking water value: which is between -16.6 and -9.4‰ (considering the std. dev.), and slightly higher than the 'local range' of $\delta^{18}O$w -9.15 and -7.15‰ characteristic of Hungary according to the study by Claudia Gerling.[74] These results may suggest a possible non-local origin for the Tompa-1 horse (for more details see below).

The isotopic signatures of 0.709381 $^{87}Sr/^{86}Sr$ measured on the Tompa-3 sample show a slightly higher value than the isotope ratio produced by the Tompa-1 sample, but it still falls below the average rate of $^{87}Sr/^{86}Sr$ 0.70973 characteristic to the Bronze Age horses from Hungary.[75] These signatures indicate that a local origin for the Tompa-3 horse cannot be ruled out, while if the archaeological context is being taken into account, the steppe region can also be considered as a possible place of origin. The $\delta^{18}O$ (phosphate) vs VSMOW analyses found values of 11.6‰ (±0.4‰). After conversion into drinking water values these range between -16.4 and -15.2‰, which are lower than what is considered to be a 'local range' characteristic to the Great Hungarian Plain ($\delta^{18}O$w -9.15 and -7.15‰) *(fig. 11. A–B)*.[76] The signatures produced by the Tompa-1 specimen appear to correlate more with the values measured along the Volga ($\delta^{18}O$w -12.74 and -9.56‰),[77] and southern Russia (foothills of the Caucasus) ($\delta^{18}O$w -10.4 and -8.4‰).[78] The average of the 'local range' in the latter region is slightly broader, the values fall between $^{87}Sr/^{86}Sr$ 0.7087 and 0,7095.[79] When the combination of the mentioned $\delta^{18}O$w and $^{87}Sr/^{86}Sr$ values are plotted on a chart, the Tompa-1 fall close to the Volga region, while the Tompa-3 isotopic signatures fall in the lower segment of the Hungarian dataset *(fig. 11. C)*.[80]

Tompa equid remains and their broader archaeological context

Among the ceramic fragments discovered nearby the Tompa-1 horse skull there was a fragmentary, dark grey ceramic vessel, a so-called 'Swedish helmet' type bowl *(fig. 12),* with a broad, out-curving rim and bulging lower section. Similar types of large bowls were used in the third phase of the Vatya culture as covers for burial urns. The strap handle of the bowl attaches to the rim and sits on the angled shoulder. Despite the strongly eroded exterior, the lower section of each of the bowl was decorated with four horizontal channels. Below the handle and the additional knobs sitting on the shoulder three impressed dots can be observed from which a bundle of lines (made of three strands) run towards the middle forming a cross on the lower exterior of the bowl. The centre point of the hemispherical base was emphasised by an *omphalos* surrounded by two concentrical channels. A similar type of large bowl covered the urn of burial no. 34 in the cemetery of Kelebia associated with the Vatya culture.[81] The sherds found along the horse bones can be linked to the third phase of the Vatya culture which at this time occupied parts of the Danube–Tisza Interfluve.[82]

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73 Conversion was based on *Daux et al. 2008*. WSMOW: Vienna standard mean ocean water.
74 *Gerling 2015* 161.
75 *Kanne 2018* 192, Tab. 5. 9.
76 *Gerling 2015* 161.
77 *Gerling 2015* 163.
78 *Gerling 2015* 169.
79 *Gerling 2015* 163.
80 *Gerling 2015* fig. 4. 103–104.
81 *Zalotay 1957* 21; *Bóna 1975* Tab. 67. 10.
82 *Bóna 1975* 52.

At the location specified by the collector of the finds – in the northern vicinity of Tompa village, between the western side of the Budapest–Belgrade railway track and a nearby farmyard (referred to as Tompa-Paska farm) – there had been reports of late Medieval settlement remains and traces of inhumation burials of unknown date, according to the journal of Elemér Zalotay. More recent finds brought to light by agricultural works imply that at least some of the human remains belonged to a Bronze Age burial ground. These observations are further supported by a feature clearly distinguishable on the aerial photograph taken of the site: a dark circular patch of 50 m in diameter surrounded by a band of lighter geography which strongly indicate the presence of an eroded kurgan. Within the radius of a few kilometres from the kurgan, there are several inventoried sites associated with the Vatya culture. The most significant among these is the biritual cemetery of Kelebia only 2 km south of Tompa, with 99 urn burials along with – unusually – 23 inhumations. The collagen samples taken for ^{14}C dating from the skeletal remains of this cemetery place the burials to the Vatya III and to the Koszider period (burial no. 90: 1610–1460 cal BC).[83] During the excavation of the inhumations, the leading archaeologist noted specifically that the deceased were not placed flexed on their sides but were buried upright, in a squatting position.[84] The observations made at Kelebia were further supported by a burial from Csanytelek, placed in a similar upright position also dating to the Vatya III–Vatya-Koszider period (Csanytelek-Palé burial no. 27).[85] The 'Swedish helmet' type bowl found in burial no. 79. at Kelebia proves a link with the Vatya urn and inhumation burials, but also suggest a relationship with a non-normative burial practice further afield.

Fig. 12. A so-called Swedish-helmet type bowl from Tompa (©Géza Szabó, ©Zsolt Réti)

Traces of the horse's control on the Tompa equids remains

The bone proliferation observed on the Tompa-3 mandible is evidently the effect of a bit placed in the mouth regularly, while there was no similar pathology detected in the diastema on the Tompa-1 specimen. On the anterior edge of the P_2 premolar and on the occlusal surface of the teeth there was no trace suggesting the use of a bit of either organic or inorganic material in case of the Tompa-1 equid. The development of the bit as a device of control has been experiential, its technology is still being refined even today. In the case of the Tompa-1 horse, it is possible that

83 *Kiss et al.* 2019 Tab. 4.
84 *Zalotay 1957* 62–64, fig. 10.
85 *Lőrinczy – Trogmayer 1995* Abb. 4. 4. This cemetery also contains characteristic Swedish helmet' type bowls.

instead of a more sophisticated equipment, a simple halter was used.[86] However, on the incisive bone of the Tompa-1 horse, there is no sign of lateral remodelling, and the bevelling on the nasal bone is also lacking. The absence of these two pathologies suggest that the horse was not made to wear a tight halter regularly. The only pathology indicating that this particular horse was utilised for work is the groove on the incisive bone's nasal process in a dorsal or dorsomedial direction. This is a proper groove, not a shallow bevelling. Similar grooves were described by William Taylor and his colleagues from Mongolia. However, the depth of the Tompa-1 specimen (after age corrections) is 60% greater than of the Mongolian specimens.[87] There is another key difference: In the case of the Tompa-1 horse the groove is symmetrical on both sides of the nasal process, and the bone material underneath is showing signs of osteoporosis, along with a development of a bone spur on the edges. The development of osteoporosis was due pressure applied to the bone surface, while the bone spur evolved as a result of tissue irritation. Similar pathologies can be observed around bone implants. In this case, the implant was most likely a thin, cylindrical, rod-like implement, which was placed in the animal's nasal septum. The integration of the implement was dependent on a number of factors. It was important that the device had a flexibility similar to bone, was smooth and rounded in shape; antiseptic properties were further an advantage. In the Bronze Age certain plant species, such as willow fitted these criteria.[88]

There is no proliferation of the occipital bone which would suggest lengthy periods of the neck being bent downwards, and there is no sign of stress around the site of attachment of the nuchal ligament indicating that the horse's head was not restricted in its movement. Effects of a pulling force associated with traction is not present on the cranium.[89]

Early control of animals

The key questions of equine domestication is how and when horses were brought under human control, and what kind of evidence is there to support that such activities had indeed taken place.[90] The archaeological record and early depictions indicate that a variety of implements were used for the harnessing of horses before bits placed in the animal's mouth became the dominant method. It is important to draw attention here to other domesticated species such as cattle (*Bos taurus* – from 6000 BC) and camel (*Camelus bactrianus* – from 3000 BC)[91] which, beside providing milk, were also exploited for transport and traction and could have served as examples for the domestication of horses. In most cases these large animals respond well to vocal commands, hand gestures or to a crop or cane, but in order to carry out tasks precisely sometimes a device was necessarily that would directly counteract some of the animals' instinctive reflexes. The construction of this device or implement depended on the cultural context, the abilities and character of the animal, and the task at hand. Ethnographic examples show that a nose rings, nosebands and halters worked well for cattle, bits were used for horses, whereas wooden or bone pegs piercing the membrane of the nasal passage of camels were employed. Therefore, the horse cranium exhibiting remodelling of the *os incisivum* most likely due to human interference deserves special attention *(fig. 3).*

Some early depictions portray yoked onagers with nose rings *(fig. 13. 4, B),* while other reliefs show yoked horses without nose rings and halters, but a rein attached to the left side of their heads

[86] *Taylor – Tuvshinjargal – Bayarsaikhan 2016* figs. 3–4.
[87] *Taylor – Jamsranjav – Tuvshinjargal 2015* fig. 3.
[88] *Birtalan 2008* figs. 262–266.
[89] *Bendrey 2008.*
[90] *Levine 1999; Outram et al. 2009; Taylor – Barrón-Ortiz 2021.*
[91] *Heide 2011* 360.

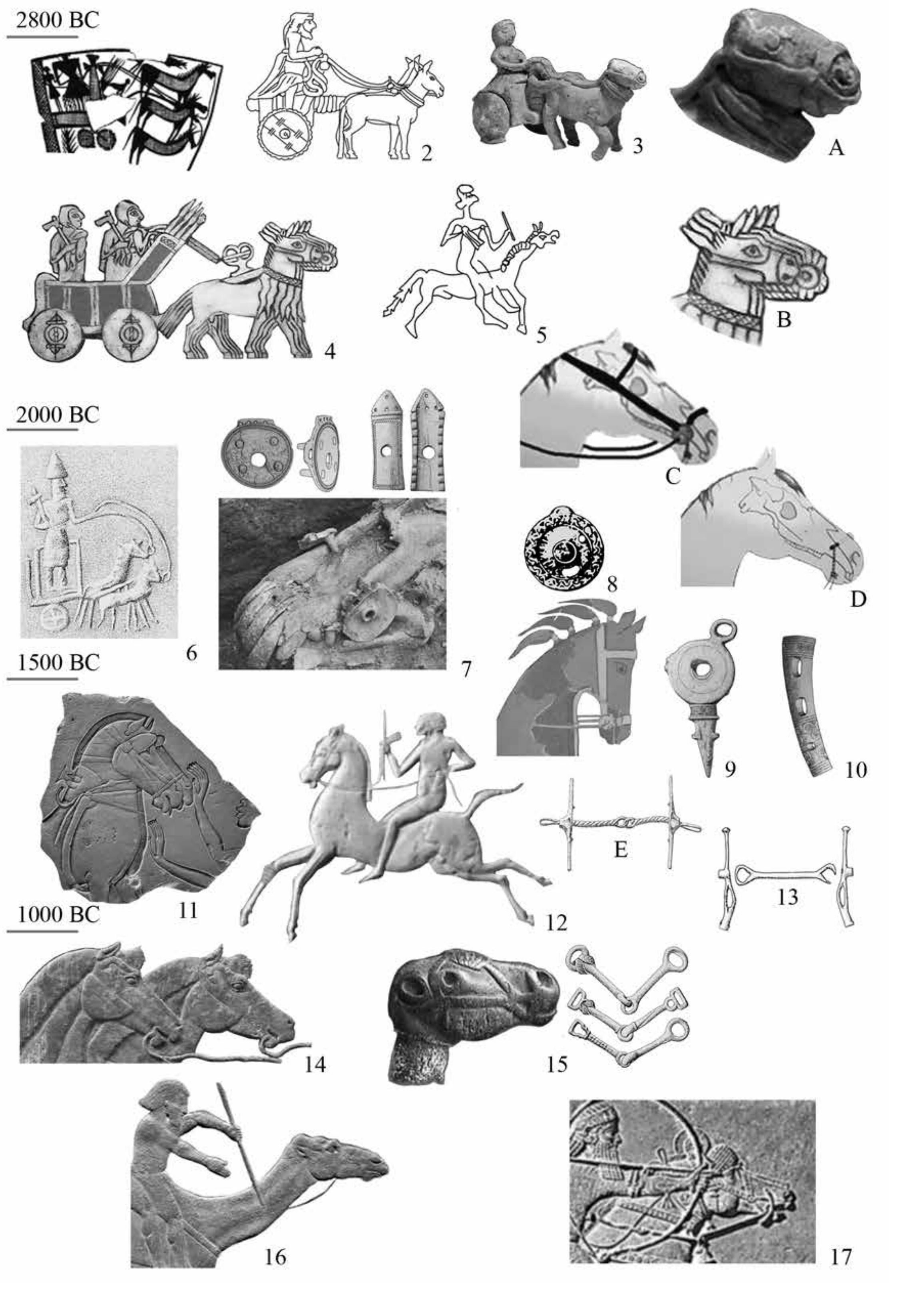

Fig. 13. Methods of control. A. Reins; B. Nose rings; C. Bits; D. Nose bit; E. Metal bits. Examples for different methods listed by species, chronological periods and geographical regions (27th–7th century BC) (©Géza Szabó, ©László Gucsi; see also note 92)

(fig. 13. 1–3, A).[92] On these depictions, the animals travel from left to right, thus the method of attachment remains unknown, but it is possible that the reins were fixed to an implement placed in the nose. Nose rings are still being used on Bovins, and in the case of camels a nose rod made of wood is widely employed even today. Wood only preserves in exceptional circumstances which could explain the absence of these artifacts in the archaeological record, and it is also possible that similar, rod-shaped bone implements from previously excavated assemblages were identified erroneously. The bits discovered in the territories of modern-day Hungary imply that horses were began to be utilised during the second half of the Middle Bronze Age in the Carpathian Basin. According to the radiocarbon dates, the Tompa-1 horse represents, so far, the earliest of horses that were utilised either for travel or traction. Of the bit cheekpieces documented from the Danube–Tisza Interfluve by Amália Mozsolics[93] and Hans-Georg Hüttel[94] neither the bridle type, nor the disc, rectangular nor the mixed type horse bits could have caused the pathology identified on the Tompa-1 horse cranium. In the case of the Tompa-1 horse this excludes all the methods of control associated with the above bits and cheekpieces, however these implements are still linked chronologically and culturally since the horse remains were found along with Vatya III ceramics. Therefore on the one hand, it is worth to provide a brief overview of methods of control here which could have resulted in the pathologies detected on the Tompa-1 skull. On the other hand, the $^{87}Sr/^{86}Sr$ isotope rates and ^{14}C dates along with the burials of the Bronze Age cemetery of Kelebia and the analogues of horse bits and cheekpieces found in the Carpathian Basin with links to the steppe and particularly towards the Volga–Ural region[95] make it reasonable to consider the wider context of the contemporaneous Sintashta culture.

The variants of nose bands, nose rings, reins and – in the case of camels – nose pegs are still in use worldwide, which testifies for the efficacy of such methods of control. Equipment made of organic materials like ropes or leather straps disintegrate with time, as opposed to the antler or bone cheekpieces and strap dividers known from the territories of the Bronze Age Sintashta–Arkaim culture (2050–1750 cal BC) from the southern Urals,[96] which– so far – are the first representatives of their kind. On the chariot model from Tell Agrab (Iraq) (*fig. 13. 2;* Early Dynastic period II, 2700–2500 BC), the rein is attached to the nose rings of the four abreast harnessed onagers through a single strap that runs along the chariot's shaft.[97] This method of chariotry is also depicted on the side of a jug from Khafajeh (Iraq) *(fig. 13. 1)* curated by the British

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[92] Fig. 13 based on images from *Anthony 2007; Kanne 2018; Gening – Gening – Zdanovič 1992:* 1. Khafajeh, 2800–2600 BC, British Museum; 2. Tell Agrab, 2700 BC; 3. Sumer, 3rd–2nd millenium BC; 4. Ur, 26th–25th century BC, British Museum; 5. The earliest depiction of a horse riding, Ur, Age of Si-sin (2037–2029 BC); 6. Karum Kanesh 20th–19th century BC; 7. Disc and rectangular cheekpieces, Sintasta culture, 20th–19th century BC; 8. Reconstruction of a harness with a buckled mouthpiece and disc-shaped cheekpieces, Tyrins, Mycenae (1600–1200 BC); 9. Composite cheekpiece, Tószeg-Laposhalom, Koszider period (17th–15th century BC); 10. Bridle type cheekpiece, Százhalombatta, Koszider period (17th–15th century BC); 11. Draught horses being controlled by reins without bits, Saqqara 18th Dynasty (1545–1291 BC), British Museum; 12. Riding horse controlled by a bit in the military camp of Horemheb (around 1292 BC) Archaeological Museum of Bologna, photo made by the authors; 13. Bronze bit mouthpiece, Mengen, Early Urnfield period, 13th century BC; 14. Horses controlled by simple mouthpieces while swimming, Ashurnasirpal II. (865–860 BC), Nimrud; 15. Depiction of a bronze bit and harness, Arsan kurgan no. 2. (9th–8th century BC); 16. Combat camel controlled by a nose peg and a single rein, Ashurbanipal (645–635 BC), British Museum; 17. Mounted royal hunt, Ashurbanipal (645–635 BC), Ninive.

[93] *Mozsolics 1953; Bökönyi 1953.*

[94] *Hüttel 1981.*

[95] *Hüttel 1981* 56–65.

[96] *Gening – Gening – Zdanovič 1992; Koryakova – Epimamakhov 2007; Čečuskov 2013; Chechushkov – Epimakhov – Bersenev 2018.*

[97] *Raulwing 2000* fig. 7. 2.

Museum.[98] There is a similar image on the standard found in burial PG 779, in the necropolis of Ur (Iraq) (*fig. 13. 4, B;* Early Dynastic period III, c. 2600 BC), however on this illustration the halter and the nose ring is clearly visible.[99] Likewise on the seals of the Assyrian merchant colony of Kültepe Kārum (Turkey); Kanesh II, 1974–1836 BC, animals are seen harnessed to a chariot with a single rein attached to their nose rings.[100] By using this method of chariotry, only one animal was being turned when changing directions which then pulls or pushes the rest of them along *(fig. 13).*

In contrast to the widespread use of chariots and carts, the first depiction of a single horse rider dates to much later, but nose rings were commonly used for riding as well, as it can be seen on the terracotta plaque found at Kis (Iraq) in Mesopotamia dating to around 2000 BC *(fig. 13. 6).* On this depiction the rider sits on the horse without a mount, holding a rein which is attached to the nose ring on both sides of the head indicating that it was possible to ride a horse this way, without the use of a bridle.[101] The nose ring as a method of horse control was given up fairly soon after this period, while more sophisticated headgear such as bridles and reins began to play a larger role. As it is shown on a Sumerian clay model of a chariot (the turn of 3000–2000 BC) a bridle with a nose- and brow-band, and a rein that ran along both sides of the head was apparently sufficient enough to control a horse *(fig. 13. 3, A).* A later and quite specific version of this bridling is depicted on a relief fragment from Saqqara (Egypt) (*fig. 13. 11;* New Kingdom, 18th Dynasty, 1550–1292 BC), where the headgear was not attached either to a nose ring or a bit.[102] It might be surprising, but there are reliefs showing chariot drivers manoeuvring horses by reins tied to their waists. As opposed to the Mesopotamian tradition, in this case both reins ran on the outer side of the harness through loops or terrets attached only to the horses on each end, thus the animals tied abreast pulled each other into the desired direction making the use of bits redundant. Such method of horse control was quite common according to the depictions of Urartu.[103] A similar method was widely utilised by native Americans in the US where a version of this type of horse control is protected by US regulation no. 6.591589 B2.[104] These methods of horse control achieved through the physical manipulation of soft tissue very seldomly leave a mark on the underlying bone structure. However, more recently William Taylor and his colleagues described pathologies connected to methods like tight harnesses.[105] The usage of bits, leaving visible marks on the horse's teeth can be linked directly to a known person: King Menua (810–786 BC) from Karmir Blur (ancient Urartu, today Armenia), where two bronze bits with curved cheek pieces were found with his inscription.[106] Metal bits began to appear in the archaeological record around the 9th–8th centuries BC south of the Caucasus, while the intricate bronze bits of Luristan become widespread in the 8th–7th centuries BC. However, given their dating, these pieces cannot be considered in relation to the pathologies detected on the Tompa-1 horse.

Methods of control developed specifically for equids were used throughout the steppe region relatively early on. Control was achieved by bits placed directly into the animal's mouth. It is so far unclear what played a more crucial role in this decision: the absence of processes similar to the Near East preceding domestication or the use of an implement that was more efficient and anatomically better suited for the horse. Several earlier assumptions about the usage of organic

[98] *Delougaz 1952* Pl. 62.
[99] *Fields 2006* 6.
[100] *Becker 1994* Abb. 4c; *Anthony 2007* fig. 15, 15b.
[101] *Becker 1994* Abb. 4b.
[102] *Fields 2006* 7.
[103] *Schachner 2007* Abb. 74–79.
[104] *Kanne 2018* 245.
[105] *Taylor – Jamsranjav – Tuvshinjargal 2015; Taylor – Tuvshinjargal – Bayarsaikhan 2016.*
[106] *Van Loon 1966* 113–114.

Fig. 14. The distribution of disc-shaped cheekpieces of the Sintastha culture and its relations (©Géza Szabó, ©Árpád Bozi)

bits in relation to Derevka and the sites of the Botai culture (3700–3100 BC) in Kazakhstan for instance,[107] turned out to be erroneous.[108] The earliest evidence for horse domestication and the use of horses for travel and/or traction is known from the territories of the Sintashta-Petrovka culture (2050–1750 cal BC) in the Southwestern Urals.[109] These included rectangular, disc and bridle cheekpieces made of antler.[110] Numerous artifacts, along with furnaces excavated in domestic structures indicated that copper mining and smelting played an important role here, something that is not generally characteristic among steppe communities. The large portion of these products were found in Central Asia in the territories of the BMAC (Bactria–Margiana Archaeological Complex), and distributed as far as Mesopotamia in the south, bringing the steppe and the Ancient Near East in closer reach. It is important to note that the domestication of the camel took place in exactly this region.

The most spectacular elements of the Sintashta culture; the horse-drawn chariot and the related equipment appear in the furthest regions of the Ancient Near East. Similar chariots are depicted on steles and seals found in Mycenaean B shaft burials (dating to around 1650 BC), while the on murals of shaft burial IV. of Mycenaea and Tiryns even the disc-shaped cheekpieces can be recognised,[111] just like in the horse burial excavated at the fortress of Buhen in Nubia dating to around 1675 BC.[112] The above mentioned artefacts draw together and contextualise these interactions between far away regions within a single timeframe testifying for the intensity and durability of these links between remote territories; marked by the Hyksos rule in Ancient Egypt, the appearance of Indo-European warriors in Mycenaean shaft burials and the exploitation of the Tompa-1 horse in the Carpathian Basin *(fig. 14)*. The latest genetic research has shown that the

[107] *Bökönyi 1968; Anthony – Brown 1991; Anthony – Brown 2011.*
[108] *Levine 1999; Taylor – Barrón-Ortiz 2021.*
[109] *Chechushkov – Usmanova – Kosintsev 2020.*
[110] *Gening – Gening – Zdanovič 1992; Chechushkov – Ovsyannikov – Usmanova 2020* 55.
[111] *Hüttel 1981* 40–48, Tab. 43. B; *Penner 1998* 30–41, Tab. 1–2.
[112] *Makkay 2004* 61; *Decker 1994* 260.

distribution of the Sintashta culture's craft products, which were the outcomes of innovations associated with the riding, chariotry and weapons, is closely linked with the migration of Indo-European populations both in Europe and in Asia.[113] It is important to mention here that the matrilinear genomic data of a woman excavated at the site of Érd of the Vatya culture (2000–1500 BC) have shown the presence of the H2a1 haplogroup,[114] similarly to the contemporaneous female burial from Kameni Ambar 5 (Russia) of the Sintashta–Arkaim culture (2050–1650 BC, female MtDNA H2a1a), and at Muradym 8 (Russia) of the Srubnaya Alakulskaya culture (female MtDNA H2a1, 1890–1750 BC), indicating a genetic link with the steppe.[115] However, beyond this link there is very little information about the contexts of these relationships.

Interpretation of the Tompa-1 and Tompa-3 finds

Nonetheless, there is one possible explanation for the pathologies present on the Tompa-1 horse cranium that would fit with contemporaneous practices of horse control; a long, thin, cylindrical nose peg was (and still is) often used on camels which could have resulted in similar pathologies detected on the Tompa-1 horse *(fig. 15).* The domestication of camels took place around the 3rd millenium BC in the Baktria–Margiana Basin,[116] therefore through the intermediary of the Sintashta culture there could have been links between the Steppe and the Carpathian Basin in the time of the Middle Bronze Age. Although such implements are insofar unknown in the archaeological record in Hungary, camels are depicted on reliefs of the Ancient Near East both as pack and combat animals. On the wall relief of the palace of Nimrud (Kalhu, Iraq) (728 BC), Assyrian riders chase a man escaping on a camel holding a rein attached to the left side of the animal's head. On the right side of the camel's head, at the level of the incisive bone there is a small, peg-like implement visible on the relief. This method of control is still being used on camels today. In Mongolia, camels are led by a peg pierced through the nasal septum *(buil)* to which a rein *(burantag)* is attached. In most cases the nose peg is made of wood, usually of willow *(burgas),* beech *(xus),* peashrub *(xargana),* or larch *(xar mod)*. Until the beginning of the 20th century wealthy camel owners were even able to afford the use of sandalwood, silver or gold nose pegs.[117] The lenght of the nose peg is around four plus one inch (4 *xurū* + 1 *yamx*, approx. 18–20 cm), depending on the camel's age and behaviour. For a camel less easy to keep in check, and which has a tendency to yank its head, a longer piece is used for more efficient control and to prevent injuries.

Fig. 15. Camel controlled by a nose peg
(Persepolis 2014, ©Géza Szabó)

Nose pegs exist in various forms: with forked ends *(acan buil)*, with circular (or hemispherical) ends *(mȫgön buil),* with a movable crescent-shaped end on one side *(tagil buil),* or with a buckle end (with a hammer-like finial on the right side – *čagtan buil*). It is apparent that the material

[113] *Penner 1998; Makkay 2000; Allentoft et al. 2015* 168–169; *Librado et al. 2021.*
[114] *Allentoft et al. 2015* ERD4, RISE483.SG/ Skel. ID 106/159 Q2.
[115] *Rondu 2021* fig. 1.
[116] *Heide 2011.*
[117] *Birtalan 2008* figs. 262–266.

used for the pegs – either organic or metal – should not irritate the skin or soft tissue, or even possess some antiseptic properties. The implement is often boiled in fat before insertion in order to sanitise it and reduce the chance of infection. The camel's nasal septum is pierced by a sharp, awl-like instrument, then the peg is inserted from the right hand side, before the ends *(šowx)* are secured by a piece of sheep or goat's hoof horn *(tūrai),* or a scrap of leather *(towx).*[118] The approx. 2.5–3 m *(2 ald)* long rein *(burantag)* is usually made of a combination of camel hair, mane hair *(jogdor),* and wool *(em nōs)* plaited twice, attached to the left side of the peg as it can be seen on the Kalhu relief. The reason for this could be that in this way the rider was able to control the camel with his left hand and could hold a weapon in the right. The length, size and placement of these nose pegs and the pathologies caused by their perpetual employment implies the use of a similar implement in the case of the Tompa-1 horse. Thus, henceforth this implement will be referred to as a nose bit. The pathologies detected on the skull of the Tompa-1 horse would strongly suggest the usage of a rod-like implement which was inserted through the nasal septum, then was used to control the horse similarly to a bit placed in the mouth. The examples currently being used on camels are often made of wood which would also explain why this artefact type is missing from the archaeological record. It is also possible that such objects made of non-perishable materials have so far not been recognised in assemblages.

The proliferation of the bone matter observed in the mandibular diastema of the Tompa-3 equid, the wearing away of the enamel on the anterior edge of the P_2 premolar, and the erosion of the enamel on the occlusal surface of the same tooth (both on the protocone and on the hypocone) indicate the prolonged use of rough bit mouthpiece. This draws further attention to the fact that despite the numerous disc-shaped and bridle cheekpieces known from the Middle Bronze Age, mouthpieces seem to appear in the archaeological record only from the Late Bronze Age. The absence of mouthpieces in the Middle Bronze Age can be explained by the use of organic materials, such as leather, rope or wood. Even in the case of Sintashta burials, only the disc-shaped cheekpieces could be found *in situ* on the horse crania which further suggest that elements of the harness and bits were constructed of organic components. The bone proliferation and the pathologies detected on the P_2 premolar of the Tompa-3 equid suggest the use of a material that could caused erosion in the oral cavity (even in a moist environment), not so much by pressure but by slipping around and creating friction in the horse's mouth. It is most likely that the mouthpiece was constructed of ropes or leather straps which when moist – especially if soiled with sand – could have caused the erosion of the enamel and the irritation of soft tissue. Therefore, based on the pathologies observed on the Tompa-3 equid, it is feasible to assume the use of a bit mouthpiece fashioned of ropes and leather straps, which could have been combined with bone and antler cheekpieces until the appearance of metal bit mouthpieces.

Summary

The potential use of the nose bit and the bit placed in the mouth in the case of the Tompa-1 and Tompa-3 equids *(fig. 16)* could further indicate that throughout the lengthy process of domestication there had been numerous attempts to utilise horses for work, and for this, experiences gained through the domestication of other animal species were actively employed. The camel is perhaps the best example for this, as in this case all possible methods of control (harness, bridle, nose ring, nose band etc.) – apart from the bit – are still being used today. As the outcome of the lengthy and diverse process of equine domestication the bit placed in the horse's mouth proved the most effective method of control, although it is certainly not the only one.

[118] *Birtalan 2008* figs. 262–266.

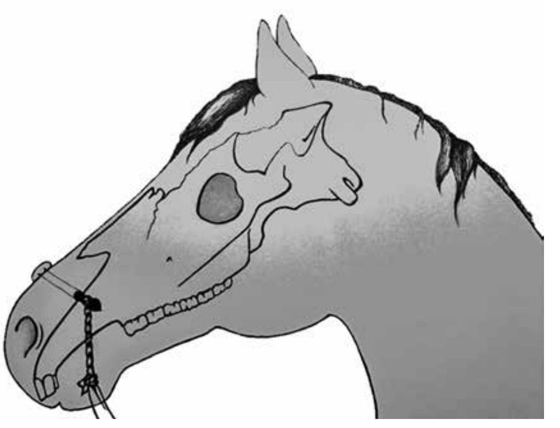

Fig. 16. Reconstruction of a nose bit based on the pathologies present on the Tompa-1 horse cranium (©Géza Szabó, ©Anna Tápai)

The over a hundred year difference between the Tompa-1 and Tompa-3 specimens and their equipment perhaps reflects technological steps in the advancing process of horse control, however it does not exclude the possibility that there had been an overlap between the use of the two bit types.

The appearance of the nose bit in the Carpathian Basin on its own around 1700 BC is difficult to interpret, however, in the broader context of the late Sintashta culture and its exchange network that span across large swathes of the steppe and the Near East,[119] it is perhaps feasible to consider that this method of horse control could have reached the Carpathian Basin from all the way of the BMC regions, where the domestication of camels took place initially. This is further supported by the hereby discussed Tompa-1 and Tompa-3 specimens and their isotopic signatures pointing towards the Volga–Ural region. Future genetic studies could reveal more about the exact location of this and the roles the Sintashta culture played in transmitting these objects and ideas further afield. However, assemblages linked to Indo-European populations during the period prior to the Mycenaean shaft burials (MH II) suggest that there is a change taking place from across the Altai region to the Danube and from Scandinavia to the Aegean at this time.[120] The Tompa-1 horse controlled by a nose bit – along with the seated burials of Kelebia – can therefore be considered as part of this process, and could be understood as evidence for steppe influences reaching the Carpathian Basin in repeated waves from the time of the Eneolithic.

The specimens presented here, as far as we are aware, represent the earliest evidence for equids utilised for work, and therefore they usher in a new era in the Bronze Age Carpathian Basin around 1700 BC. This new type of exploitation of equids increases the speed of mobility substantially, the efficacy of various human enterprises and their radius; it can be considered as a kind of ʻmotorization' which was only surpassed by the process of industrialisation in the 20th century. The different ^{14}C dating of the two specimens, their isotopic signatures, and the Tompa-3 cranium with probable evidence for the use of a bit mouthpiece, all indicate that these equids represent distinct stages of a lengthy process which was inextricably linked to the steppe region even during the 16th century BC. The picture will be no doubt detailed further by the increase of data, particularly the publication of the cemetery of Kelebia,[121] and by the outcomes of the currently ongoing genetic examinations of the Tompa-1 and Tompa-3 crania.[122]

119 *Makkay 2000.*

120 *Gerling 2015; Allentoft et al. 2015; Szabó 2017a; Librado et al. 2021.*

121 The isotopic examination of the Bronze Age burials from Kelebia has been conducted by Claudio Cavazzutti.

122 The manuscript was closed on 28 May 2021.

REFERENCES

Allentoft et al. 2015 M. E. Allentoft – M. Sikora – K.-G. Sjögren – S. Rasmussen – M. Rasmussen – J. Stenderup – P. B. Damgaard – H. Schroeder – T. Ahlström – L. Vinner – A.-S. Malaspinas – A. Margaryan – T. Higham – D. Chivall – N. Lynnerup – L. Harvig – J. Baron – P. Della Casa – P. Dąbrowski – P. R. Duffy – A. V. Ebel – A. Epimakhov – K. Frei – M. Furmanek – T. Gralak – A. Gromov – S. Gronkiewicz – G. Grupe – T. Hajdu – R. Jarysz – V. Khartanovich – A. Khokhlov – V. Kiss – J. Kolář – A. Kriiska – I. Lasak – C. Longhi – G. McGlynn – A. Merkevicius – I. Merkyte – M. Metspalu – R. Mkrtchyan – V. Moiseyev – L. Paja – Gy. Pálfi – D. Pokutta – Ł. Pospieszny – T. D. Price – L. Saag – M. Sablin – N. Shishlina – V. Smrčka – V. I. Soenov – V. Szeverényi – G. Tóth – S. V. Trifanova – L. Varul – M. Vicze – L. Yepiskoposyan – V. Zhitenev – L. Orlando – T. Sicheritz-Pontén – S. Brunak – R. Nielsen – K. Kristiansen – E. Willerslev: Population genomics of Bronze Age Eurasia. Nature 522 (2015) 167–172.

Anthony 2007 D. W. Anthony: The Horse, the Wheel, and Language. How Bronze-Age Riders from the Eurasian Steppes Shaped the Modern World. Princeton 2007.
https://doi.org/10.1515/9781400831104

Anthony – Brown 1991 D. W. Anthony – D. R. Brown: The origins of horseback riding. Antiquity 65, 246 (1991) 22–38.
https://doi.org/10.1017/S0003598X00079278

Anthony – Brown 2011 D. W. Anthony – D. R. Brown: The secondary products revolution, horse-riding, and mounted warfare. JWP 24 (2011) 131.
https://doi.org/10.1007/s10963-011-9051-9

Anthony et al. 1986 D. W. Anthony – P. Bogucki – E. Comşa – M. Gimbutas – B. Jovanović – J. P. Mallory – S. Milisaukas: „Kurgan culture," Indo-European origins, and the domestication of the horse. A reconsideration. CurrAnt 27/4 (1986) 291–313.
https://doi.org/10.1086/203441

Bándi 1963 G. Bándi: Die Frage der Riementeiler des Mittelbronzezeitlichen Pferdegeschirrs im Karpatenbeckens. ArchÉrt 90 (1963) 46–60.

Becker 1994 C. Becker: Zur Problematik früher Pferdenachweise im östlichen Mittelmeergebiet, in: B. Hänsel – S. Zimmer (Hrsg.): Die Indogermanen und das Pferd. Budapest 1994, 145–177.

Bendrey 2007 R. Bendrey: New methods for the identification of evidence for bitting on horse remains from archaeological sites. JAS 34/7 (2007) 1036–1050.
https://doi.org/10.1016/j.jas.2006.09.010

Bendrey 2008 R. Bendrey: An analysis of factors affecting the development of an equid cranial enthesopathy. VetZoot 41, 63 (2008) 25–31.

Benecke 1994 N. Benecke: Zur Domestikation des Pferdes in Mittel- und Osteuropa. Einige neue archäozoologische Befunde, in: B. Hänsel – S. Zimmer (Hrsg.): Die Indogermanen und das Pferd. Budapest 1994, 123–144.

Besskó 1906 J. Besskó: A honfoglaló magyar nemzet lovairól. Craniometriai tanulmány [About the Horses of the Hungarian Conquerors. Craniometric Study]. Budapest 1906.

Birtalan 2008 Á. Birtalan: Hagyományos mongol műveltség. 1. Anyagi műveltség (Traditional Mongolian Culture. 1. Material Culture). Wien – Budapest 2008. DVD-ROM.

Bóna 1975 I. Bóna: Die mittlere Bronzezeit Ungarns und ihre südöstlichen Beziehungen. ArchHung. Series nova 49. Budapest 1975.

Boroffka 1999 N. Boroffka: Bronze- und Früheisenzeitliche Geweihtrensenknebel aus Rumänien und ihre Beziehungen. Alte Funde aus dem Museum Für Geschichte Aiud. Teil 2. EurAnt 4 (1998) [1999] 81–135.

Bozi – Szabó 2020 R. Bozi – G. Szabó: Permanent marks left by works and the way of life on horses' metatarsus bones. Determining the use of horses in archaeology using an osteometric method. Archeometriai Műhely 17 (2020) 67–86.

Bökönyi 1953 S. Bökönyi: Reconstruction des mors en bois de cerf et en os. ActaArchHung 3 (1953) 113–121.

Bökönyi 1959 S. Bökönyi: Die frühalluviale Wirbeltierfauna Ungarns. Vom Neolithikum bis zur La Tène-Zeit. ActaArchHung 2 (1959) 39–102.

Bökönyi 1968 S. Bökönyi: Data on Iron Age Horses of Central and Eastern Europe. Cambridge 1968.

Bökönyi 1974 S. Bökönyi: History of Domestic Mammals in Central and Eastern Europe. Budapest 1974.

Bökönyi 1978 S. Bökönyi: Earliest waves of domestic horses in East Europe. JIES 6 (1978) 17–73.

Bronk Ramsey 2009 C. Bronk Ramsey: Bayesian analysis of radiocarbon dates. Radiocarbon 51 (2009) 337–360.
https://doi.org/10.1017/S0033822200033865

Cavazzuti et al. 2019 C. Cavazzuti – R. Skeates – A. R. Millard – G. Nowell – J. Peterkin – M. Bernabò Brea – A. Cardarelli – L. Salzani: Flows of people in villages and large centres in Bronze Age Italy through strontium and oxygen isotopes. PLoS One 14/1 (2019) e0209693, 1–43.
https://doi.org/10.1371/journal.pone.0209693

Cavazzuti et al. 2021 C. Cavazzuti – T. Hajdu – F. Lugli – A. Sperduti – M. Vicze – A. Horváth – I. Major – M. Molnár – L. Palcsu – V. Kiss: Human mobility in a Bronze Age Vatya 'urnfield' and the life history of a high-status woman. PLoS One 16/7 (2021) e0254360, 1–32.
https://doi.org/10.1371/journal.pone.0254360

Chechushkov 2013 И. В. Чечусков: Колесничный комплекс степей Евразии (от Днепра до Иртыша). Диссертация на соискания ученой степени к.и.н. Москва 2013.

Chechushkov – Epimakhov – Bersenev 2018 I. V. Chechushkov – A. V. Epimakhov – A. G. Bersenev: Early horse bridle with cheekpieces as a marker of social change. An experimental and statistical study. JAS 97 (2018) 125–136.
https://doi.org/10.1016/j.jas.2018.07.012

Chechushkov – Ovsyannikov – Usmanova 2020 I. V. Chechushkov – A. A. Ovsyannikov – E. R. Usmanova: On the Earliest use of plate-formed cheekpieces and the emergence of horse riding. Based on finds from the Novoilyinovskiy II cemetery in Northern Kazakhstan). Archaeology, Ethnology & Anthropology of Eurasia 48/2 (2020) 49–58.
https://doi.org/10.17746/1563-0110.2020.48.2.049-058

Chechushkov – Usmanova – Kosintsev 2020 I. Chechushkov – E. Usmanova – P. Kosintsev: Early evidence for horse utilization in the Eurasian steppes and the case of the Novoil'inovskiy 2 cemetery in Kazakhstan. JAS. Reports 32 (2020) 102420.
https://doi.org/10.1016/j.jasrep.2020.102420

Daux et al. 2008 V. Daux – C. Lécuyer – M. A. Héran – R. Amiot – L. Simon – F. Fourel – F. Martineau – N. Lynnerup – H. Reychler – G. Escarguel: Oxygen isotope fractionation between human phosphate and water revisited. JHE 55 (2008) 1138–1147.
https://doi.org/10.1016/j.jhevol.2008.06.006

Decker 1994 W. Decker: Pferd und Wagen in Ägypten, in: B. Hänsel – S. Zimmer (Hrsg.): Die Indogermanen und das Pferd. Budapest 1994, 259–270.

Delougaz 1952 P. Delougaz: Pottery from the Diyala Region. Chicago 1952.

Depaermentier et al. 2021 M. L. C. Depaermentier – M. Kempf – E. Bánffy – K. W. Alt: Modelling a scale-based strontium isotope baseline for Hungary. JAS 135 (2021) 105489.
https://doi.org/10.1016/j.jas.2021.105489

Driesch 1976 A. von den Driesch: A Guide to the Measurement of Animal Bones from Archaeological Sites. Peabody Museum Bulletin 1. Cambridge 1976.

Ecsedy 1979 I. Ecsedy: The People of the Pit-Grave Kurgans in Eastern Hungary. FontArchHung. Budapest 1979.

Endrődi – Reményi 2016 A. Endrődi – L. Reményi (eds.): A Bell Beaker Settlement in Albertfalva, Hungary (2470–1950 BC). Budapest 2016.

Fields 2006 N. Fields: Bronze Age War Chariots. Osprey New Vanguard 119. Oxford – New York 2006.

Gál 2017 É. Gál: Animals at the Dawn of Metallurgy in South-western Hungary. Relationships between People and Animals in Southern Transdanubia during the Late Copper to Middle Bronze Ages. Budapest 2017.

Gaunitz et al. 2018 C. Gaunitz – A. Fages – K. Hanghøj – A. Albrechtsen – N. Khan – M. Schubert – A. Seguin-Orlando – I. J. Owens – S. Felkel – O. Bignon-Lau – P. de Barros Damgaard – A. Mittnik – A. F. Mohaseb – H. Davoudi –

S. Alquraishi – A. H. Alfarhan – K. A. S. Al-Rasheid – E. Crubézy – N. Benecke – S. Olsen – D. Brown – D. Anthony – K. Massy – V. Pitulko – A. Kasparov – G. Brem – M. Hofreiter – G. Mukhtarova – N. Baimukhanov – L. Lõugas – V. Onar – P. W. Stockhammer – J. Krause – B. Boldgiv – S. Undrakhbold – D. Erdenebaatar – S. Lepetz – M. Mashkour – A. Ludwig – B. Wallner – V. Merz – I. Merz – V. Zaibert – E. Willerslev – P. Librado – A. K. Outram – L. Orlando: Ancient genomes revisit the ancestry of domestic and Przewalski's horses. Science 360(3684) (2018) 111–114.
https://doi.org/10.1126/science.aao3297

Gening – Gening – Zdanovič 1992 V. F. Gening – V. V. Gening – G. B. Zdanovič: Sintashta. Archaeological Sites of the Aryan Tribes of the Ural–Kazakhstan Steppe. Čeljabinsk 1992.

Gerling 2014 C. Gerling: A multi-isotopic approach to the reconstruction of Prehistoric mobility and economic patterns in the West Eurasian steppes 3500 to 300 BC. JAS 3 (214) 1–21.

Gerling 2015 C. Gerling: Prehistoric Mobility and Diet in the West Eurasian Steppes 3500 to 300 BC. An Isotopic Approach. Topoi. Berlin Studies of the Ancient World / Topoi. Berliner Studien der Alten Welt 25. Berlin – Boston 2015.
https://doi.org/10.1515/9783110311211

Giblin et al. 2013 J. Giblin – K. J. Knudson – Zs. Bereczki – Gy. Pálfi – I. Pap: Strontium isotope analysis and human mobility during the Neolithic and Copper Age. A case study from the Great Hungarian Plain. JAS 40/1 (2013) 227–239.
https://doi.org/10.1016/j.jas.2012.08.024

Gimbutas 1977 M. Gimbutas: The first wave of Eurasian steppe pastoralists into Copper Age Europe. JIES 5 (1973) 277–338.

Goldberg et al. 2017 A. Goldberg – T. Günther – N. A. Rosenberg – M. Jakobsson: Ancient X chromosomes reveal contrasting sex bias in Neolithic and Bronze Age Eurasian migrations. PNAS 114/10 (2017) 2657–2662.
https://doi.org/10.1073/pnas.1616392114

Greenfield 2006 H. Greenfield: The social and economic context for domestic horse origins in Southeastern Europe. A view from Ljuljaci in the Central Balkans, in: S. L. Olsen – M. A. Littauer – I. Rea (eds.): Horses and Humans. The Evolution of Human-Equine Relationships. BAR-IS 1560. Oxford 2006, 221–244.

Haak et al. 2015 W. Haak – I. Lazaridis – N. Patterson – N. Rohland – S. Mallick – B. Llamas – G. Brandt – S. Nordenfelt – E. Harney – K. Stewardson – Q. Fu – A. Mittnik – E. Bánffy – C. Economou – M. Francken – S. Friederich – R. Garrido Pena – F. Hallgren – V. Khartanovich – A. Khokhlov – M. Kunst – P. Kuznetsov – H. Meller – O. Mochalov – V. Moiseyev – N. Nicklisch – S. L. Pichler – R. Risch – M. A. Rojo Guerra – C. Roth – A. Szécsényi-Nagy – J. Wahl – M. Meyer – J. Krause – D. Brown – D. Anthony – A. Cooper – K. W. Alt – D. Reich: Massive migration from the steppe is a source for Indo-European languages in Europe. Nature 522 (2015) 207–211.
https://doi.org/10.1038/nature14317

Heide 2011 M. Heide: The domestication of the camel. Biological, archaeological and inscriptional evidence from Mesopotamia, Egypt, Israel and Arabia, and literary evidence from the Hebrew Bible. UF 42 (2011) 331–382.

Higgins 2009 G. Higgins: How your Horse Moves. A Unique Visual Guide to Improving Performance. Newton Abbot 2009.

Hutyra – Marek 1923–1924 F. Hutyra – J. Marek: Állatorvosi belgyógyászat 1–2 [Veterinary Internal Medicine 1–2]. Budapest 1923–1924.

Hüttel 1981 H. Hüttel: Bronzezeitliche Trensen in Mittel- und Osteuropa. Grundzüge ihrer Entwicklung. PBF 16. 2. München 1981.

Jaeger – Kulcsár 2013 M. Jaeger – G. Kulcsár: Kakucs-Balla-domb. A case study in the absolute and relative chronology of the Vatya culture. ActaArchHung 64/2 (2013) 289–320.
https://doi.org/10.1556/AArch.64.2013.2.2

Kanne 2018 K. S. Kanne: Becoming Equestrian. People and Horses in Bronze Age Hungary. Manuscript. Dissertation for the degree Doctor of Philosophy. Evanston, Illinois 2018.

Kanne 2022 K. Kanne: Riding, ruling, and resistance. Equestrianism and political authority in the Hungarian Bronze Age. CurrAnt 63/3 (2022) 289–329.
https://doi.org/10.1086/720271

Karsai – Vörös 1993 F. Karsai – K. Vörös: Állatorvosi belgyógyászat [Veterinary Internal Medicine]. Budapest 1993.

Kiesewalter 1888 L. Kiesewalter: Skelettmessungen am Pferde: als Beitrag zur Theoret. Grundlage der Beurteilungslehre des Pferdes. Leipzig 1888.

Kiss et al. 2019 V. Kiss – M. Csányi – J. Dani – K. P. Fischl – G. Kulcsár – I. Szathmári: Chronology of the Early and Middle Bronze Age in Hungary. New results. Studia Hercynia 23/2 (2019) 173–197.

Koryakova – Epimakhov 2007 L. N. Koryakova – A. V. Epimakhov: The Urals and Western Siberia in the Bronze and Iron Ages. Cambridge 2007.
https://doi.org/10.1017/CBO9780511618451

Kovács 1967 Gy. Kovács: Háziállatok anatómiájának atlasza [Anatomy Atlas of Domestic Animals]. Budapest 1967.

Kovácsy – Monostori 1892 B. Kovácsy – K. Monostori: A ló és tenyésztése [The Horse and its Breeding]. Kassa 1892.

Levine 1990 M. Levine: Dereivka and the problem of horse domestication. Antiquity 64(245) (1990) 727–740.
https://doi.org/10.1017/S0003598X00078832

Levine 1999 M. Levine: Botai and the origins of horse domestication. JAA 18/1 (1999) 29–78.
https://doi.org/10.1006/jaar.1998.0332

Levine 2004 M. Levine: Exploring the criteria for early horse domestication, in: M. Jones (ed.): Traces of Ancestry. Studies in Honor of Colin Renfrew. Cambridge 2004, 115–126.

Librado et al. 2021 P. Librado – N. Khan – A. Fages – M. A. Kusliy – T. Suchan – L. Tonasso-Calvière – S. Schiavinato – D. Alioglu – A. Fromentier – A. Perdereau – J.-M. Aury – C. Gaunitz – L. Chauvey – A. Seguin-Orlando – C. Der Sarkissian – J. Southon – B. Shapiro – A. A. Tishkin – A. A. Kovalev – S. Alquraishi – A. H. Alfarhan – K. A. S. Al-Rasheid – T. Seregély – L. Klassen – R. Iversen – O. Bignon-Lau – P. Bodu – M. Olive – J.-C. Castel – M. Boudadi-Maligne – N. Alvarez – M. Germonpré – M. Moskal-del Hoyo – J. Wilczyński – S. Pospuła – A. Lasota-Kuś – K. Tunia – M. Nowak – E. Rannamäe – U. Saarma – G. Boeskorov – L. Lõugas – R. Kyselý – L. Peške – A. Bălășescu – V. Dumitrașcu – R. Dobrescu – D. Gerber – V. Kiss – A. Szécsényi-Nagy – B. G. Mende – Zs. Gallina – K. Somogyi – G. Kulcsár – E. Gál – R. Bendrey – M. E. Allentoft – G. Sirbu – V. Dergachev – H. Shephard – N. Tomadini – S. Grouard – A. Kasparov – A. E. Basilyan – M. A. Anisimov – P. A. Nikolskiy – E. Y. Pavlova – V. Pitulko – G. Brem – B. Wallner – C. Schwall – M. Keller – K. Kitagawa – A. N. Bessudnov – A. Bessudnov – W. Taylor – J. Magail – J.-O. Gantulga – J. Bayarsaikhan – D. Erdenebaatar – K. Tabaldiev – E. Mijiddorj – B. Boldgiv – T. Tsagaan – M. Pruvost – S. Olsen – C. A. Makarewicz – S. Valenzuela Lamas – S. Albizuri Canadell – A. Nieto Espinet – M. Pilar Iborra – J. Lira Garrido – E. Rodríguez González – S. Celestino – C. Olària – J. L. Arsuaga – N. Kotova – A. Pryor – P. Crabtree – R. Zhumatayev – A. Toleubaev – N. L. Morgunova – T. Kuznetsova – D. Lordkipanize – M. Marzullo – O. Prato – G. Bagnasco Gianni – U. Tecchiati – B. Clavel – S. Lepetz – H. Davoudi – M. Mashkour – N. Ya. Berezina – P. W. Stockhammer – J. Krause – W. Haak – A. Morales-Muñiz – N. Benecke – M. Hofreiter – A. Ludwig – A. S. Graphodatsky – J. Peters – K. Yu. Kiryushin – T.-O. Iderkhangai – N. A. Bokovenko – S. K. Vasiliev – N. N. Seregin – K. V. Chugunov – N. A. Plasteeva – G. F. Baryshnikov – E. Petrova – M. Sablin – E. Ananyevskaya – A. Logvin – I. Shevnina – V. Logvin – S. Kalieva – V. Loman – I. Kukushkin – I. Merz – V. Merz – S. Sakenov – V. Varfolomeyev – E. Usmanova – V. Zaibert – B. Arbuckle – A. B. Belinskiy – A. Kalmykov – S. Reinhold – S. Hansen – A. I. Yudin – A. A. Vybornov – A. Epimakhov – N. S. Berezina – N. Roslyakova – P. A. Kosintsev – P. F. Kuznetsov – D. Anthony – G. J. Kroonen – K. Kristiansen – P. Wincker – A. Outram – L. Orlando: The origins and spread of domestic horses from the Western Eurasian steppes. Nature 598 (2021) 634–640. https://doi.org/10.1038/s41586-021-04018-9

Lichardus – Vladár 1996 J. Lichardus – J. Vladár: Karpatenbecken-Sintašta-Mykene. Ein Beitrag zur Definition der Bronzezeit als Historischer Epoche. SlA 44 (1996) 25–93.

Lőrinczy – Trogmayer 1995 G. Lőrinczy – O. Trogmayer: Birituális temető Csanytelek-Palén (Birituales Gräberfeld der Vatya-Kultur in Csanytelek-Palé). MFMÉ StudArch 1 (1995) 49–90.

Lyublyanovics 2016 K. Lyublyanovics: Animal bones from the Bell Beaker settlement of Albertfalva, Budapest, in: A. Endrődi – L. Reményi (eds.): A Bell Beaker Settlement in Albertfalva, Hungary (2470–1950 BC). Budapest 2016, 204–216.

Major et al. 2019 I. Major – J. Dani – V. Kiss – E. Melis – R. Patay – G. Szabó – K. Hubay – M. Túri – I. Futó – R. Huszánk – A. J. T. Jull – M. Molnár: Adoption and evaluation of a sample pretreatment protocol for radiocarbon dating of cremated bones at HEKAL. Radiocarbon 61/1 (2019) 159–171. https://doi.org/10.1017/RDC.2018.41

Makkay 2000 J. Makkay: The Early Mycenaean Rulers and the Contemporary Early Iranians of the Northeast. Tractata Minuscula 22. Budapest 2000.

Makkay 2004 J. Makkay: Lovak és őshazák avagy Szelídíteni kell az elvadult házilovakat [Horses and ancestral homes, or wild domestic horses must be tamed]. Tractata Minuscula 35. Budapest 2004.

Makkay 2006 J. Makkay: The Miracle Stag in Ancient Greek Mythical Stories, and their Indo-Iranian Counterparts. Tractata Minuscula 48. Budapest 2006.

Mozsolics 1953 A. Mozsolics: Mors en bois de cerf sur le territoire du Bassin des Carpathes. ActaArchHung 3 (1953) 69–111.

Mozsolics 1960 A. Mozsolics: Die Herkunftsfrage der ältesten Hirschgeweihtrensen. ActaArchHung 10 (1960) 125–135.

Orlando 2020 L. Orlando: The evolutionary and historical foundation of the modern horse. Lessons from ancient genomics. Annual Review of Genetics 54 (2020) 563–581. https://doi.org/10.1146/annurev-genet-021920-011805

Outram et al. 2009 A. K. Outram – N. A. Stear – R. Bendrey – S. Olsen – A. Kasparov – V. Zaibert – N. Thorpe – R. P. Evershed: The earliest horse harnessing and milking. Science 323/5919 (2009) 1332–1335. https://doi.org/10.1126/science.1168594

Penner 1998 S. Penner: Schliemanns Schachtgräberfund und der europäische Nordosten. Studien zur Herkunft der frühmykenischen Streitwagenausstattung. Saarbrücker Beiträge zur Altertumskunde 60. Bonn 1998.

Pérez – Martin 2001 W. Pérez – E. Martin: An explanation of a groove found on the nasal process of the equine incisive bone. Anatomia Histologia Embryologia 30/6 (2001) 357–358. https://doi.org/10.1046/j.1439-0264.2001.00348.x

Raulwing 2000 P. Raulwing: Horses, Chariots and Indo-Europeans. Foundations and Methods of Chariotry Research from the Viewpoint of Comparative Indo-European Linguistic. Budapest 2000.

Reimer et al. 2020 P. J. Reimer – W. E. N. Austin – E. Bard – A. Bayliss – P. G. Blackwell – C. Bronk Ramsey – M. Butzin – H. Cheng – R. L. Edwards – M. Friedrich – P. M. Grootes – T. P. Guilderson – I. Hajdas – T. J. Heaton – A. G. Hogg – K. A. Hughen – B.Kromer – S. W. Manning – R. Muscheler – J. G. Palmer – C. Pearson – J. van der Plicht – R. W. Reimer – D. A. Richards – E. M. Scott –

J. R. Southon – C. S. M. Turney – L. Wacker – F. Adolphi – U. Büntgen – M. Capano – S. M. Fahrni – A. Fogtmann-Schulz – R. Friedrich – P. Köhler – S. Kudsk – F. Miyake – J. Olsen – F. Reinig – M. Sakamoto – A. Sookdeo – S. Talamo: The IntCal20 Northern Hemisphere radiocarbon age calibration curve (0–55 cal kBP). Radiocarbon 62 (2020) 725–757. https://doi.org/10.1017/RDC.2020.41

Rondu 2021 M.-O. Rondu: MtDNA H2a1 Dispersion Map, March 2021. Paris 2021.

Rush 1955 B. Rush: Veterinary Manual. Recurrent Airway Obstruction in Horses. Heaves, Chronic Obstructive Pulmonary Disease. Kansas 1955.

Schachner 2007 A. Schachner: Bilder eines Weltrechs. Subartu 20. Brepols – Turnhout 2007.

Sjögren – Price – Kristiansen 2016 K.-G. Sjögren – T. D. Price – K. Kristiansen: Diet and mobility in the Corded Ware of Central Europe. Plos One 11/5 (2016) e0155083, 1–36. https://doi.org/10.1371/journal.pone.0155083

Smirnov 1961 К. Ф. Смирнов: Археологические данные о древних всадниках поволжско-уральских степей. SA 1961/1, 47–72.

Stockhammer et al. 2015 P. W. Stockhammer – K. Massy – C. Knipper – R. Friedrich – B. Kromer – S. Lindauer – J. Radosavljević – F. Wittenborn – J. Krause: Rewriting the Central European Early Bronze Age chronology. Evidence from large-scale radiocarbon dating. Plos One 10/10 (2015) e0139705, 1–32.

Szabó 2017a G. Szabó: Eastern myth elements in the West in light of the Nart sagas and the archaeological finds of the Carpathian Basin. Nartamongæ 12/1–2 (2017) 85–109.

Szabó 2017b G. Szabó: Caught Between the pincers of Eastern influences. Bronze Age cultures in Southern Transdanubia, in: G. Kulcsár – G. V. Szabó – V. Kiss – G. Váczi (eds.): State of the Hungarian Bronze Age Research. Ősrégészeti Tanulmányok / Prehistoric Studies 2. Budapest 2017, 371–393.

Szabó – Gál 2013 G. Szabó – E. Gál: Dombóvár-Tesco kora bronzkori település térhasználatának előzetes vizsgálata az archaeozoológiai megfigyelések tükrében (Die vorläufige Untersuchung der Raumnutzung TESCO Dombóvár an der frühbronzezeitlichen Siedlung im Überblick von archäozoologischen Beobachtungen). WMMÉ 35 (2013) 7–119.

Taylor – Barrón-Ortiz 2021 W. Taylor – C. Barrón-Ortiz: Rethinking the evidence for early horse domestication at Botai. Nature Scientific Reports 11 (2021) 7440. https://doi.org/10.1038/s41598-021-86832-9

Taylor – Jamsranjav – Tuvshinjargal 2015 W. Taylor – B. Jamsranjav – T. Tuvshinjargal: Equine cranial morphology and the identification of riding and chariotry in Late Bronze Age Mongolia. Antiquity 89/346 (2015) 854–871. https://doi.org/10.15184/aqy.2015.76

Taylor – Tuvshinjargal – Bayarsaikhan 2016 W. Taylor – T. Tuvshinjargal – J. Bayarsaikhan: Reconstructing equine bridles in the Mongolian Bronze Age. Journal of Ethnobiology 36/3 (2016) 554–570. https://doi.org/10.2993/0278-0771-36.3.554

Thomsen – Andreasen 2019 E. Thomsen – R. Andreasen: Agricultural lime disturbs natural strontium isotope variations. Implications for provenance and migration studies. Science Advances 5 (2019) eaav8083. https://doi.org/10.1126/sciadv.aav8083

Van Loon 1966 M. van Loon: Urartian Art. Its Distinctive Traits in the Light of New Excavations. Istanbul 1966.

Vitt 1952 В. О. Витт: Лошади Пазырыкских Курганов. SA 16 (1952) 163–205.

Zalotay 1957 E. Zalotay: Kelebiai bronzkori temető [Bronze Age cemetery at Kelebia]. RégFüz 6 (1957).

Zeder 2015 M. A. Zeder: Core questions in domestication research. PNAS 112/11 (2015) 3191–3198. https://doi.org/10.1073/pnas.1501711112

Appendix A.

Skull dimensions according to *Driesch 1976*
Tompa-1, *Equus ferus*

Location of the recorded size	**Tompa-1 mare (mm)**	***Equus ferus* stallion (mm)**
Profile length: A-P	528	
Condylobasal length	510	
Basal length	487	
Basilar length	483	
Short scull length: B-P	355	
Basicranial axis: B-H	229	
Basifacial axis: H-P	356	
Neurocranium length : B-N	-	
Viscerocranium length: N-P	324	
Upper neurocranium length: A-S	187.50	
Facial length: S-P	352	
Basion-most oral point of the facial crest on one side	278	
Most oral point of the facial creston one side-Prosthion	228	
Short lateral facial length: En-P	308	
Length of braincase: O-Ec	193	
Lateral facial length: Ec-P	368	
Greatest length of the nasals	-	
Basion-Staphylon	224	
Median palatal length: S-P	260	
Palatal length	253	
Dental length: Postdentale-Prosthion	293	
Lateral length of the premaxilla: N-P	171	174.73

Location of the recorded size	Tompa-1 mare (mm)	*Equus ferus* stallion (mm)
Length of the diastema (P^2-I^3)	102.60	
Length of the cheek tooth row (measured along the alveoli	159.30	
Length of the cheek tooth row (measured near the biting surface)	155.30	
Length of the molar row (measured along the alveoli on buccal side)	76.00	
Length of the molar row (measured near of biting surface)	74.24	
Length of the premolar row (measured along the alveoli on buccal side)	85.77	
Length of the premolar row (measured near the biting surface)	84.30	
Length and breadth P^2	L: 33.86, B: 22.16	
Length and breadth P^3	L: 26.08, B: 23.89	
Length and breadth P^4	L: 25.40, B: 25.11	L: 29.11, B: 29.96
Length and breadth M^1	L: 21.91, B: 24.63	L: 26.42, B: 29.04
Length and breadth M^2	L: 23.96, B: 24.38	L: 26.74, B: 29.12
Length and breadth M^3	L: 28.46, B: 23.65	
Greatest inner length of the orbita Ec.-En.	62.65	
Greatest inner height of the orbita	56.90	
Greatest mastoid breadth: Otion-Otion	114.07	
Greatest breadth of the occipital condyles	82.50	
Greatest breadth at the bases of the paroccipital -processes	102.68	
Greatest breadth of the foramen magnum	35.20	
Height of the foramen magnum: Basion-Opisthion	37.60	
Greatest neurocranium breadth: Euryon-Euryon	121.00	123.00
Least frontal breadth	90.50	79.00
Least breadth between the supraorbital foramina	143.30	136.81
Greatest breadth of skull = greatest breadth across the orbits	211.00	205.36
Least breadth between the orbits: Entorbitale-Entorbitale	148.91	
Facial breadth between the outermost points of the facial crest at the point of intersection of the maxillo-jugal suture with the facial ridge	Old horse, not measurable	
Facial breadth between the infraorbital foramina (least distance)	73.30	
Greatest breadth of snout: measured across the outer borders of alveoli of I^3	52.72	
Greatest breadth on the curvature of the premaxilla	71.72	
Least breadth in the region of the diastema	58.88	
Greatest palatal breadth: measured across the outer borders of the alveoli	125.66	
Greatest skull height	Not measurable	
Basion height	Not measurable	
Width above jaw joint (by *Besskó 1906*)	201.50	
Occipital width (by *Besskó 1906, Hutyra – Marek 1923–1924*)	65.07	

Appendix B.

Tompa-1, skull indexes according to *Besskó 1906* and *Hutyra – Marek 1923–1924*

Tompa-1 index a/b*100	West horse type	East horse type	Can belong to both type
Face width/forehead width		80.33	
Width above the jaw joint/forehead width		95.50	
Nuch width/forehead width	30.84		
Facial breadth between the infraorbital foramina/forehead width		27.91	
Forehead width/basal length		43.69	
Basal length/total length			91.45
Forehead width/total length			39.96
Entorbitale-Entorbitale/forehead width		70.57	
Greatest breadth of snout/forehead width	35.40		
Greatest breadth of snout/basal length		10.93	
Greatest inner height of the orbit/greatest inner length of the orbit		90.82	
Eurion-Eurion/basal length		25.00	

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