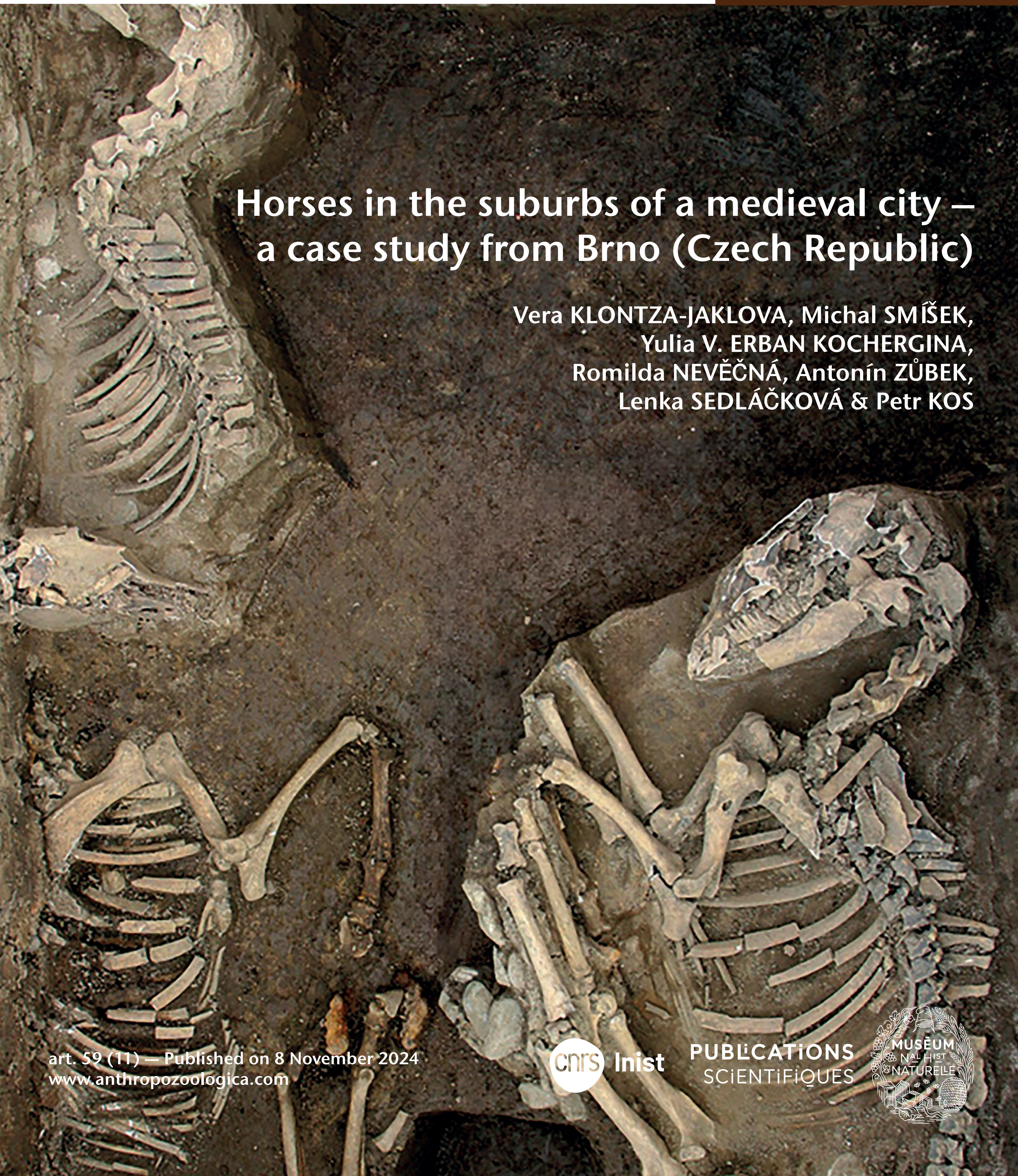
anthropozoologica

2024 • 59 • 11



Horses in the suburbs of a medieval city – a case study from Brno (Czech Republic)

Vera KLONTZA-JAKLOVA, Michal SMÍŠEK,
Yulia V. ERBAN KOCHERGINA,
Romilda NEVĚČNÁ, Antonín ZŮBEK,
Lenka SEDLÁČKOVÁ & Petr KOS

art. 59 (11) — Published on 8 November 2024
www.anthropozoologica.com

cnrs Inist
PUBLICATIONS SCIENTIFIQUES
MUSÉUM NAL HIST NATURELLE

Couverture / *Cover:*
Trnitá Street, Brno: horses T_3256, T_3257, T_3258. Courtesy of Archaia Brno.

Anthropozoologica est indexé dans / Anthropozoologica *is indexed in:*

- Social Sciences Citation Index
- Arts & Humanities Citation Index
- Current Contents – Social & Behavioral Sciences
- Current Contents – Arts & Humanities
- Zoological Record
- BIOSIS Previews
- Initial list de l'European Science Foundation (ESF)
- Norwegian Social Science Data Services (NSD)
- Research Bible

Anthropozoologica est distribué en version électronique par / Anthropozoologica *is distributed electronically by:*

- BioOne® (https://www.bioone.org)

Anthropozoologica est une revue en flux continu publiée par les Publications scientifiques du Muséum, Paris, avec le soutien du CNRS.
Anthropozoologica *is a fast track journal published by the Museum Science Press, Paris, with the support of the CNRS.*
Les Publications scientifiques du Muséum publient aussi / *The Museum Science Press also publish:* ***Adansonia***, ***Zoosystema***, ***Geodiversitas***, ***European Journal of Taxonomy***, ***Naturae***, ***Cryptogamie* sous-sections *Algologie***, ***Bryologie***, ***Mycologie***, ***Comptes Rendus Palevol***.

Diffusion – Publications scientifiques Muséum national d'Histoire naturelle
CP 41 – 57 rue Cuvier F-75231 Paris cedex 05 (France)
Tél.: 33 (0)1 40 79 48 05 / Fax: 33 (0)1 40 79 38 40
diff.pub@mnhn.fr / https://sciencepress.mnhn.fr

ISSN (imprimé / *print*): 0761-3032 / ISSN (électronique / *electronic*): 2107-0881

Horses in the suburbs of a medieval city – a case study from Brno (Czech Republic)

Vera KLONTZA-JAKLOVA
Department of Archaeology and Museology, Faculty of Arts,
Joštova 13, 60200 Brno (Czech Republic),
and Institute of Cultural and Natural Heritage, Center of Research, Rescue,
and Horsemanship Center, Nové Sady 2, 60200 Brno (Czech Republic)
vera.klontza@phil.muni.cz (corresponding author)

Michal SMÍŠEK
Department of Archaeology and Museology, Faculty of Arts,
Joštova 13, 60200 Brno (Czech Republic)
427952@mail.muni.cz

Yulia V. ERBAN KOCHERGINA
Czech Geological Survey,
Klárov 3, 11800 Prague (Czech Republic)
julie.erban@geology.cz

Romilda NEVĚČNÁ
Department of Archaeology and Museology, Faculty of Arts,
Joštova 13, 60200 Brno (Czech Republic)
romilda2.tengeriova@gmail.com

Antonín ZŮBEK
Lenka SEDLÁČKOVÁ
Archaia Brno,
Bezručova 15, 60200 Brno (Czech Republic)
azubek@archaiabrno.cz
lsedlackova@archaiabrno.cz

Petr KOS
Institute for Archaeological Heritage (ÚAPP),
Kaloudova 1231/30, 61400 Brno (Czech Republic)
kos@uapp.cz

Submitted on 11 December 2023 | Accepted on 9 July 2024 | Published on 8 November 2024

Klontza-Jaklova V., Smíšek M., Erban Kochergina Y. V., Nevěčná R., Zůbek A., Sedláčková L. & Kos P. 2024. — Horses in the suburbs of a medieval city – a case study from Brno (Czech Republic). *Anthropozoologica* 59 (11): 155-181. https://doi.org/10.5252/anthropozoologica2024v59a11. http://anthropozoologica.com/59/11

ABSTRACT

The article presents a set of horse skeletons (11 individuals) found at three excavation sites south of the city of Brno (Czech Republic), dated to the Late Medieval and Early Modern periods. The skeletons were deliberately deposited within agricultural estates and the assemblage consisted of complete or near-complete skeletons. The osteological assemblage was therefore suitable for further analysis. Firstly, the withers height and robusticity of individual equines were determined. The majority of them were slightly taller and more slender-legged than those of earlier periods and smaller than contemporary riding and draft horses. With one exception, they were determined to be males and majority died at around 7-14 years of age. Pathological findings observed on the skull and second premolars can be most likely related to the working history of those individuals. Changes to the spinal column are in most cases rather mild or absent suggesting that the horses studied were probably not used for extensive heavy work. The relatively high incidence of other pathological changes indicates poor health care, with two individuals showing signs of a possible bacterial infection. The origin and mobility of the individuals were reconstructed by strontium analyses. With one exception, all individuals were most likely born and died in the same region.

KEY WORDS
Zooarchaeology,
equine archaeology,
equine osteology,
equine pathology,
Medieval horse,
Medieval Brno,
history of horsemanship.

RÉSUMÉ

Les équidés dans les faubourgs d'une cité médiévale. Étude de cas : Brno (République tchèque).

L'article présente un ensemble de squelettes des chevaux (11 individus) découverts sur trois sites au sud de la ville de Brno (République tchèque), datés de la fin de la période médiévale et du début de la période moderne. Les squelettes ont été délibérément déposés dans des domaines agricoles. L'assemblage ostéologique contient des squelettes complets, quasi-complets ou de torses importants. Il est donc possible de l'utiliser pour une analyse approfondie. Tout d'abord, la hauteur au garrot et la robustesse des équidés ont été déterminées et il s'est avéré qu'ils étaient légèrement plus grands en taille que les équidés des périodes précédentes, mais plus petits que les chevaux de selle et de trait contemporains. Ensuite, l'âge (du poulain nouveau-né jusqu'à l'âge de 15 ans) et le sexe (à une exception, les individus adultes étaient des mâles) ont été déterminés pour chaque individu. Une analyse de l'état de santé a ensuite été effectuée en fonction des pathologies affectant les os. Tous les squelettes présentaient des modifications importantes résultant d'un travail intensif ou de conditions d'élevage inadaptées. Les résultats pathologiques observés sur le crâne et les deuxièmes prémolaires peuvent très probablement être liés à l'histoire professionnelle de ces individus. Les modifications légères ou absentes de la colonne thoraco-lombaire suggèrent que les chevaux étudiés n'ont probablement pas été utilisés pour un travail lourd et intensif. L'incidence relativement élevée des changements pathologiques observés indique plutôt des soins négligés et les os des deux individus sont marquées par les signes d'une possible infection bactérienne. L'origine et la mobilité des individus ont été reconstituées par des analyses de strontium. À une exception près, tous les individus sont probablement nés et décédés dans la même région.

KEY WORDS
Zooarchéologie,
archéologie équine,
ostéologie équine,
pathologie équine,
cheval médiéval,
Brno médiévale,
histoire de l'équitation.

INTRODUCTION

The authors present a set of horse skeletons recovered during rescue excavations realized around the medieval city of Brno (Czech Republic). Five individuals were recovered in Brno, Trnitá Street (15th-16th century), four individuals were identified in Brno, Křídlovická Street (16th-17th/18th century), and two skeletons (an adult horse and a foal) in Modřice (15th-16th century) (Fig. 1).

In the first step, the age, sex, size, and robusticity of the animals was examined. Subsequently, the size and robusticity were compared with the available data from the Czech medieval and modern sites.

In the next step, the pathological changes observed on the cranial and postcranial skeleton were recorded for each individual. These changes can be broadly characterized as those that could be directly linked to the working or riding history of the horses and those that could affect their working or riding performance. The most significant cases are presented in this article[1]. Mobility and origin of the horses were also investigated *via* strontium analyses.

Abbreviations

Bd	greatest breadth of the distal epiphysis;
GL	greatest length;
LSI	log standard index;
SD	smallest width of the diaphysis.

CONTEXT AND MATERIAL

Brno represented a significant medieval agglomeration and was among the largest royal cities of the medieval Kingdom of Bohemia (1198-1918).

1. Detail pathology analysis represent goal of the next stage of the project. Then, we will also focus on mobility (combination of Sr and O isotopes analyses), origin and relation to other equine populations (DNA analyses). In the process of analyzing (elemental analysis and reconstruction of the production ways), there are also horseshoes found *in situ.*

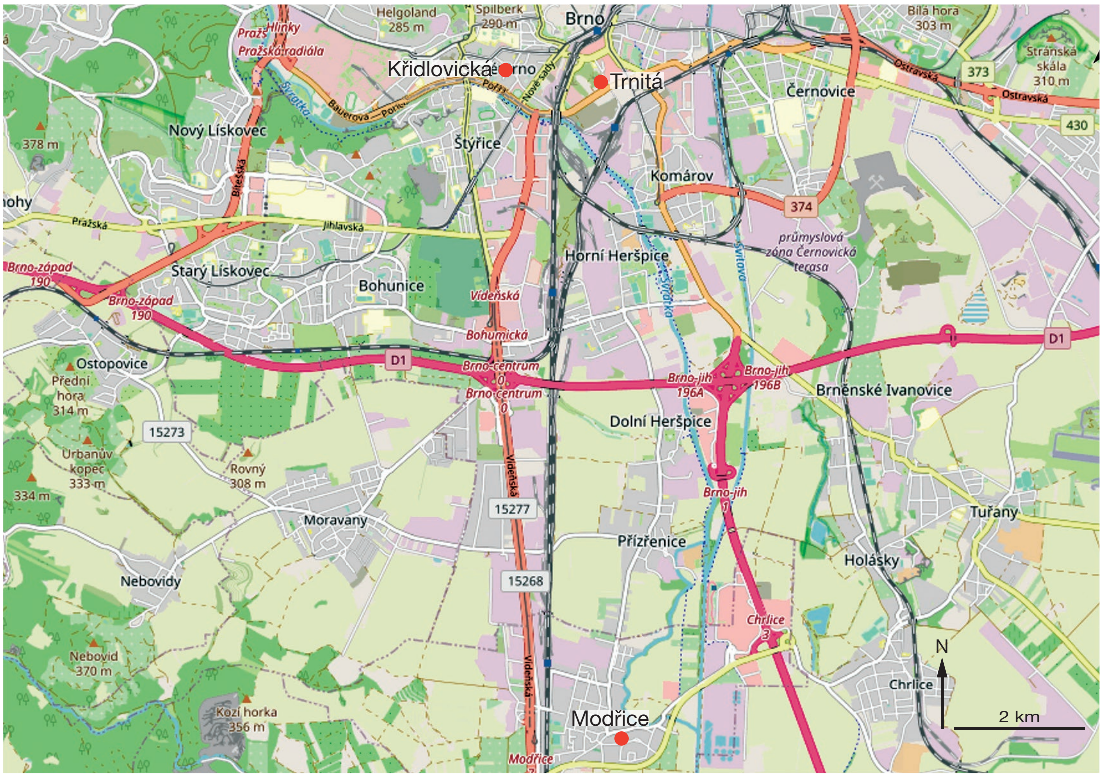


Fig. 1. — Localization of the investigated sites south of the city of Brno (Czech Republic).

Fig. 2. — Suburban villages south of Brno (Joris Hoefnagel, 1617).

Both sites analyzed here (Trnitá and Křídlovická streets) represent rural settlements connected to the urban economy. Both are referred to as so-called suburban villages, where food is produced and transported to the city markets daily. These villages lay practically immediately under the city walls (Fig. 2) (Procházka 2011; Jan 2014; Fasora & Malíř 2020). Semirural suburbs were essential to the supply and economy of the medieval urban nucleus itself (compare León & Murillo 2014).

The town of Modřice is located seven kilometers south of both locations mentioned above. It is conveniently located on

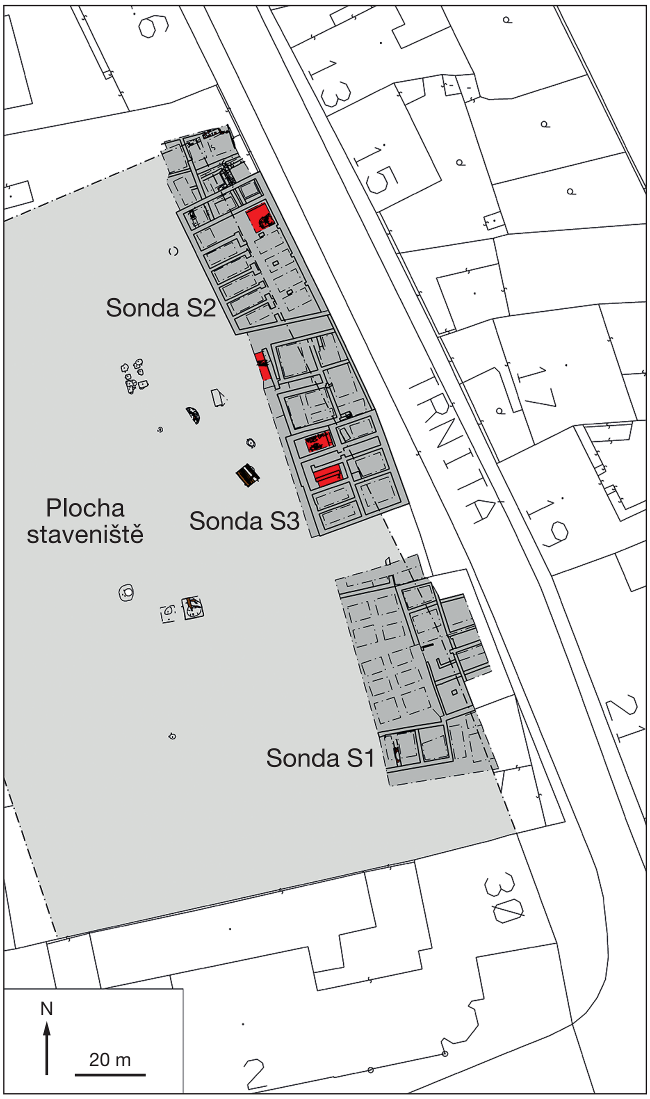


FIG. 3. — Trnitá Street, Brno: excavated plot with horse burials. Gray, excavated plot; red, trenches with horse burials. Courtesy of Archaia Brno.

TABLE 1. — Brno, Trnitá: list of horse burials

Skeleton number	Preservation	Pit description (shape, size in m, fill)	Dating	Figure
T_1490	Fragmentary cranium. Lower hindlimbs were not retrieved.	Irregular, approximately oval pit, > 2 x 1.5 x 0.5 m. Grey sandy silt with a random appearance of charcoal, pebbles, and other angular stones.	Second half of the 15th and first half of the 16th century.	4
T_3164	Complete postcranial skeleton.	Almost rectangular or oval pit. > 1.4 x 0.9 x 0.4 m. Gravel mixed of cobbles, pebbles and coarse sand.	Second half of the 15th to the first half of the 16th century.	5
T_3256	Fragmentary cranium. Anterior middle and distal phalanges were not retrieved.	Unknown shape of the pit. Depth = 0.5. Grey sandy silt with a random appearance of charcoal, cobbles, pebbles and brick fragments.	Second half of the 15th and first half of the 16th century.	6
T_3257	Fragmentary cranium and axial skeleton. Limb bones except for one femur and fragments of scapula were not retrieved.	Unknown pit shape. Depth = 0.4-0.6. Grey sandy silt with frequent lamps of yellowish clay and random appearance of charcoal, cobbles, pebbles and brick fragments.	Second half of the 15th and first half of the 16th century. Object disrupted by the pit containing individual 3258.	6
T_3258	Fragmentary cranium. Cervical vertebrae 3-7 and thoracic vertebrae 3-18 were not retrieved.	Unknown pit shape. Depth = 0.8. Grey sandy silt with frequent lamps of yellowish clay and random appearance of charcoal, cobbles, pebbles and brick fragments.	Second half of the 15th to the first half of the 16th century. The context disturbing 3257.	6

the natural connection between Brno and Vienna. Modřice also belongs to the intensively populated regions of South Moravia. The first written mentions come from the period just before the middle of the 12th century, while sources from the year 1339 speak of Modřice as a town. However, the primary economic resources were agricultural production and the processing of agricultural products (Mitáček & Procházka 2017).

BRNO, TRNITÁ STREET

The rescue excavation, linked to planned construction, took place between July 2018 and October 2019. The street is a remnant of the historical village of the same name about 300 m beyond the city walls. The village developed gradually around a farmhouse built in the mid-13th century.

Construction affected a large part of the village, particularly three plots. Archaeological research focused primarily on the construction development of those homesteads. Skeletal remains of buried animals were discovered on all three of the plots investigated, buried in the backyards, not far from the houses (Fig. 3).

Burials can be dated to the broader period from the second half of the 15th to the first half of the 17th century, and most of them can be included in the period from the second half of the 15th to the first half of the 16th century (Table 1; Figs 4-6) (Zůbek 2022).

Fig. 4. — Trnitá Street, Brno: horse T_1490. Courtesy of Archaia Brno.

Fig. 5. — Trnitá Street, Brno: horse T_3164. Courtesy of Archaia Brno.

Fig. 6. — Trnitá Street, Brno: horses T_3256, T_3257, T_3258. Courtesy of Archaia Brno.

Brno, Křídlovická street

The skeletons were uncovered during the rescue excavation from April to June 2021. The name of the street is connected with the name of the village of Křídlovice, which was located in this part of today's urban agglomeration. This village was mentioned in records dated to 1314 as a satellite village connected to Brno in the 19th century. The village was located on the north bank of the Svratka river.

The area where the horses were found was already in use in the 14th-15th centuries, more intensively from the 16th to 18th centuries (Table 2; Figs 7-10).

Modřice, nám. Svobody

Two horse skeletons (Table 3; Figs 11, 12) were found during rescue archaeological excavation in the winter of 2021-2022, on a plot, Za Humny Street. A medieval homestead with a

Table 2. — Brno, Křídlovická street: list of horse burials.

Skeleton number	Preservation	Pit description (shape, size in m, fill)	Dating	Figure
K_800	Poorly preserved fragments of scapula, humerus, thoracic vertebrae and ribs.	Pit shape is unidentified. Grey sandy silt covering the skeleton.	Second half of the 17th and first half of the 18th century.	8
K_801	Fragmentary cranium, complete appendicular skeleton. Three horseshoes *in situ*.	Rectangular, NE-SW, > 1.4 x 0.95 x 0.6. Brown-grey soil rarely contains small ceramic fragments.	16th-17th century.	9
K_802	Complete postcranial skeleton and fragmentary cranium. Four horse shoes *in situ*.	Rectangular pit, E-W, 1.93 x 0.8 x 0.45. Grey-brown sandy silt is occasionally mixed with ceramic sherds.	16th century-first half of the 17th century.	10
K_803	Fragments of mandible. Postcranial skeleton not preserved.	Found together with K_802 (intrusion).	16th century-first half of the 17th century.	–

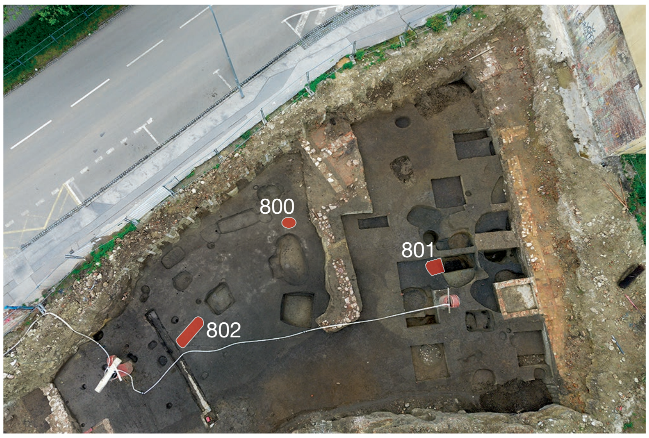


Fig. 7. — Křídlovická Street, Brno: excavated plot with horse burials. Courtesy of Archaia Brno.

Fig. 8. — Křídlovická Street, Brno: horse K_800. Courtesy of Archaia Brno.

house facing Náměstí Republiky square and a yard in the back section of the plot were explored. Various types of production and processing activities (kilns, furnaces, cellars, etc.) dated to a period spanning from the 14th century to the present were recorded in the yard. A number of buried farm animals were found in the rear tract itself.

Fig. 9. — Křídlovická Street, Brno: horse K_801. Courtesy of Archaia Brno.

OSTEOLOGICAL METHODS

The individuals were identified as horses by following the macroscopic criteria described in Hanot & Bochaton (2018). Horse skeletons were sexed based on the presence of canine teeth in male horses and pelvis shape (Sisson 1914; Daugnora & Thomas 2005). However, in some cases, the sex of the animal could not be determined due to missing bones.

The age of the horses was estimated based on tooth eruption, wear of the incisors, the crown height of the premolars/molars, and epiphyseal fusion (Silver 1969; Levine 1982; Nacarino-Meneses *et al.* 2016).

Measurements of the long bones were taken according to international standards described in Von den Driesch (1976). Size differences in the long bones of each specimen were as-

Fig. 10. — Křídlovická Street, Brno: horse K_802. Courtesy of Archaia Brno.

Table 3. — Modřice: list of horse burials

Skeleton Number	Preservation	Pit description	Dating	Figure
M_802	Postcranial skeleton and seven loose teeth (3 x I1-3, 1 x C, 2 x upper P2, 1 x upper P3). Four horse shoes *in situ*.	Oval.	15th-16th century.	12
M_803	Complete skeleton of a newborn foal.	Oval.	15th-16th century.	12

sessed using Log Standard Index (Simpson *et al.* 1960). LSI allows the comparison of different measurements by using the following formula: LSI = log (x/m), where x represents the individual measurement and m represents the standard value, which in this case derives from the average size of *Equus hemionus* Pallas, 1775 onager. *Equus hemionus* onager is one of the best-running adapted equids. A comparison of horses from Brno with the Onager standard can therefore provide insights into their adaptation to running. In addition, average proportions of limb bones of the modern Arab horses (*Equus caballus* Linnaeus, 1758), Przewalski's (*Equus caballus przewalskii* Poliakov, 1881), and draft horses were added as a reference sample (Eisenmann 2009).

Withers heights and robusticity of horses from Brno were compared with the available data from the medieval and modern contexts in Czechia (Table 4). Withers heights were estimated from Greatest Length measurements of long bones following May (1985). Robusticity was examined through metrical analysis of metapodials namely the ratios between GL and the smallest width of the diaphysis and greatest breadth of the distal epiphysis (Brauner 1916; Ameen *et al.* 2021). The modern samples for Arab (Clutton-Brock & Burleigh 1979), Przewalski's, and draft horses (Eisenmann & Beckouche 1986) were added as reference sample.

Ossification of ligaments between metapodials and in the area of nuchal ligament attachment site was scored based on criteria described in Bendrey (2007a, 2008). To determine possible bit wear, the extent of enamel/dentine exposure was examined and measured following Bendrey (2007b). Remaining pathological changes were evaluated based on comparison with relevant archaeological and veterinary literature (e.g., Baker & Brothwell 1980; Levine *et al.* 2005; Bartosiewicz & Gál 2013; Komosa *et al.* 2018).

Table 5 provides a summary of withers heights, robusticity, age, and sex of horses from Brno. Individual measurements, withers heights, and robusticity ratios used in the comparison are stored within the Pandora interference and are freely available (Smíšek *et al.* 2023-2024).

RESULTS OF OSTEOLOGICAL ANALYSIS

Age and sex

The youngest individual (Table 5; Fig. 12) of the dataset is a newborn foal M_803 from Modřice. This specimen has the third deciduous incisors still inside alveoli, which suggests an age of less than three weeks (Nacarino-Meneses *et al.* 2016: 280, fig. 1). In this case the possibility can not be excluded

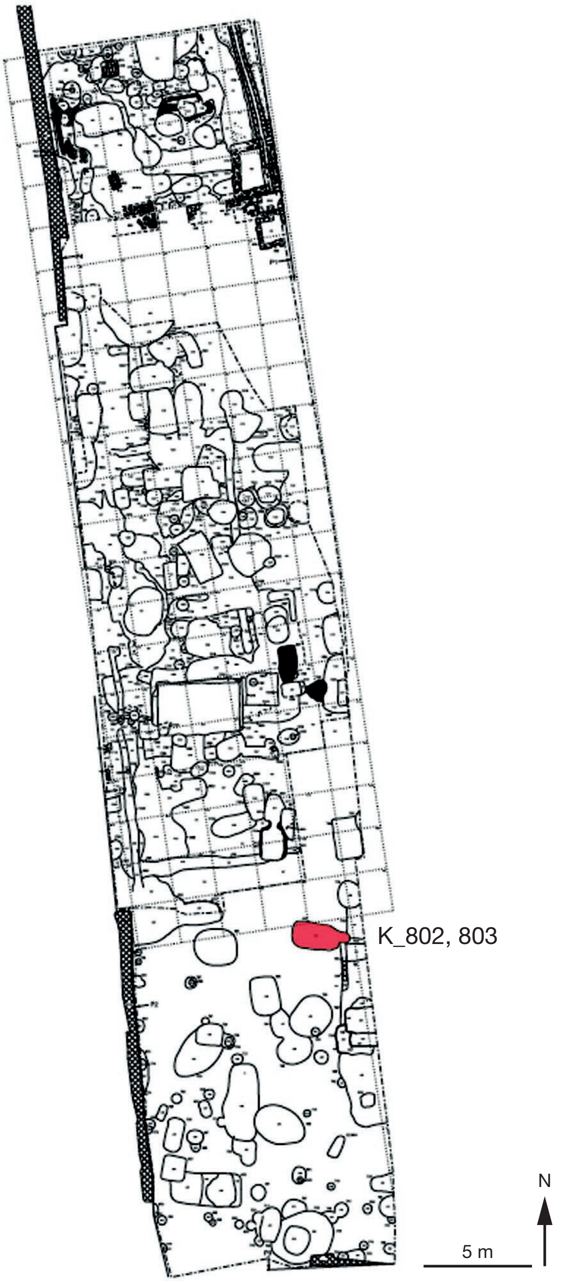


Fig. 11. — Modřice: excavated plot. Courtesy of the Institute for Archaeological Heritage, Brno.

Fig. 12.— Modřice: horses M_802, M_803.

that this animal was dead prior its birth. No teeth were available for age determination of horse K_800, but unfused proximal humerus suggests an age of less than three to three and a half years. Only the postcranial skeleton was available for the age estimation of horse T_3164. In this case, fused vertebral bodies suggest an age of more than five years. Two heavily worn deciduous premolars (dP3, dP4) coming from the horse K_801 indicate an age of approximately three to four years. The ages of the rest of the adult individuals were determined based on incisor wear and the crown height of premolars/molars. One horse appears to be slightly younger, with age estimated around seven to eight years, while the

Table 4. — Sites used in the comparison of withers height (all sites) and robusticity (excluding Vyšehrad). Abbreviation: **NMLB**, number of measured long bones included in this study.

Site Number	Site	Period	NMLB	Source of osteometric data
1	Brno-Křídlovická	Early Modern	23	Present study
2	Brno-Trnitá	Late Medieval – Early Modern	55	Present study
3	Brno-Modřice	Late Medieval – Early Modern	14	Present study
4	Mikulčice	Early Medieval	316	Chrzanowska & Krupska 2003
5	Nemilany	Early Medieval	20	Dreslerová 2014
6	Pohansko	Early Medieval	27	Kratochvíl 1969; Chrzanowska & Krupska 2003; Dreslerová 2018
7	Stará Boleslav	Early Medieval	5	Kyselý 2003
8	Vyšehrad	Early Medieval	1	Kyselý 2004
9	Podolí	Migration	29	Ambros & Müller 1980
10	Záluží	Migration	6	Ambros & Müller 1980
11	Zdice	Modern	25	Diedrich 2017

rest of the specimens fall in the approximate range of nine to fourteen years.

The sex of the individuals M_803, K_800, K_801, and K_803 could not be determined due to the absence of diagnostic elements. Horse T_3258 was determined as female based on the absence of canines and the shape of the pelvis, while the remaining individuals were determined as males.

Proportions of the limb bones

Late Medieval – Early Modern horses T_3256, T_3258, and T_3164 differ most significantly from the Onager standard (Fig. 13). Their metapodials are considerably shorter relative to the proximal limb bones, and the shapes of the LSI curves resemble most modern draft horses although all come from smaller individuals. The differences in size between metapodials and upper limb bones seem to be less pronounced in the rest of the Late Medieval – Early Modern specimens from Trnitá Street, Modřice, as well as the Early Modern Křídlovická Street individuals, where the overall shape of the curves is closer to Arabs and Przewalski's horses, which are well adapted to intensive running in open landscapes.

Table 5. — Summary table providing information on dating, mean withers height, robusticity ratios, sex, and age of the horses from Brno. Abbreviations: **Bd**, greatest breadth of the distal epiphysis; **GL**, greatest length; **MC**, metacarpal; **MT**, metatarsal; **SD**, smallest width of the diaphysis; **WH**, withers height.

ID	Site	Century	Number of measured long bones	WH mean (cm)	WH (SD)	MC SD/GL x 100	MT SD/GL x 100	MC Bd/GL x 100	MT Bd/GL x 100	Sex	Age (years)
T_1490	Brno-Trnitá	15-16	10	144.7	1.2	14.8	–	21.6	–	M	10-13
T_3256	Brno-Trnitá	15-16	15	137.3	1.1	16.2	12.8	22.1	18.2	M	10-11
T_3257	Brno-Trnitá	15-16	1	142.5	–	–	–	–	–	M	7-8
T_3258	Brno-Trnitá	15-16	15	147	3.2	14.5	11.9	22.7	17.6	F	9-11
T_3164	Brno-Trnitá	15-16	14	145.5	3.5	14.4	11.6	21.8	18.6	M	> 5
M_802	Brno-Modřice	15-16	14	141.9	3.6	14.2	11.4	21.4	17.6	M	12-14
M_803	Brno-Modřice	15-16	0	–	–	–	–	–	–	?	newborn
K_800	Brno-Křídlovická	17-18	0	–	–	–	–	–	–	?	< 3-3.5
K_801	Brno-Křídlovická	16-17	9	143.7	2.7	14	10.9	20.7	17.1	?	3-4
K_802	Brno-Křídlovická	16-17	12 (14)	146.5	3.5	13.6	11.5	20.9	17.8	M	9-11
K_803	Brno-Křídlovická	16-17	0	–	–	–	–	–	–	?	9-12

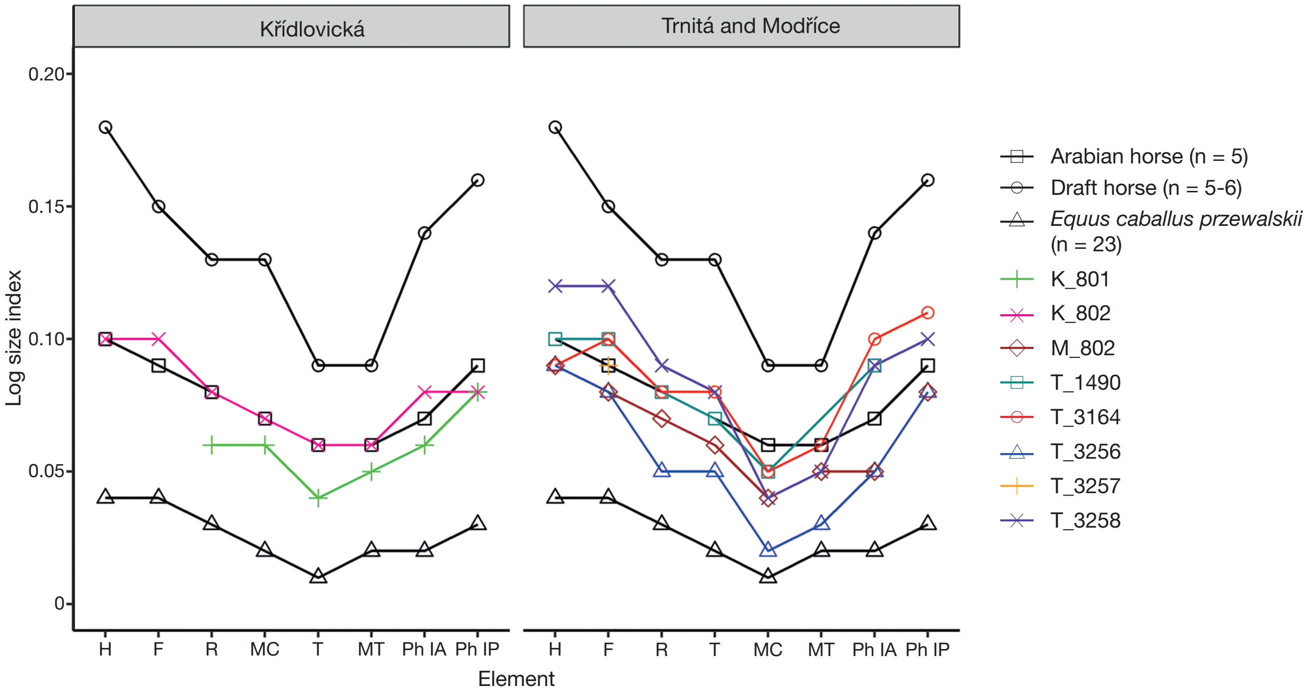


Fig. 13. — Comparison of the LSI distribution of horses from Brno and modern specimens of the Arabian horse *Equus caballus* Linnaeus, 1758, draft horse and *Equus caballus przewalskii* Poliakov, 1881 calculated from the greatest length (**GL**) of long bones and standard set of values derived from the average size of *Equus hemionus* Pallas, 1775 onager. Abbreviations: **F**, femur; **H**, humerus; **MC**, metacarpus; **MT**, metatarsus; **Ph IA**, anterior first phalanx; **Ph IP**, posterior first phalanx; **R**, radius; **T**, tibia.

Withers height

The Late Medieval – Early Modern horses (Table 6) from Trnitá Street and Modřice vary in the mean withers' height from 137.3 to 147 cm. The two individuals from Early Modern Křídlovická Street display average withers heights of 143.7 cm and 146.5 cm respectively. Modern mining horses from Zdice have an average wither height of 146.6 cm and appear to be slightly taller than horses from Late Medieval – Early Modern Brno. On the other hand, the height at the withers of Zdice horses is quite variable ($\pm 1\ \sigma = 8$) with the smallest individual reaching an average of 135.4 cm and the largest 161.3 cm respectively. Horses from the Early Medieval period vary in wither height from 120.9 to 149.5 cm with an average of 136.5 cm. Although approximately 16 sites with individual horse burials are known from the Early Medieval period in the territory of the Czech Republic, only a fraction of them have been investigated by zooarchaeologists (Dreslerová 2020). Therefore, the majority of the bones from the Early Medieval period used in the comparison come from the settlement's debris and not from individual burials so in most cases it is not possible to examine the relationships between individual bones in greater detail. The single horse burials from Mikulčice and Pohansko have average withers heights of 141.6 and 137.6 cm, and two individuals from Nemilany have 133.8 and 142.5 cm respectively.

Horses from the Migration period also appear to be slightly smaller with an average withers' height of 135.4 cm. The available sample is limited to only seven partially preserved

TABLE 6. — Comparison of the wither's height of horses from Brno with the Czech Medieval and Modern archaeological sites. Estimated withers height is given for each element together with mean withers heigh and standard deviation (**±1 σ**). Abbreviations: **F**, femur; **H**, humerus; **MC**, metacarpus; **MT**, metatarsus; **R**, radius; **T**, tibia.

ID	Period	H	F	R	T	MC	MT	Number of Measurements	Mean	±1 σ
T_1490	Late Medieval – Early Modern	142	144.2-145.3	144.7-145.1	146	145.2	–	8	144.7	1.2
T_3256	Late Medieval – Early Modern	136.9-137.3	137.6	136.1-136.5	137.7-138.5	136.1	138.3-139.4	11	137.3	1.1
T_3257	Late Medieval – Early Modern	–	142.5	–	–	–	–	1	142.5	–
T_3258	Late Medieval – Early Modern	147-148	153	146.8-147.2	150	142.2	145.1-146.2	11	147	3.2
T_3164	Late Medieval – Early Modern	138.7	143.9-144.6	142-143.9	147.2	147.1	149.8-150.4	10	145.5	3.5
M_802	Late Medieval – Early Modern	136.4-136.9	140	141.8	141.7-142.1	142.8-143.4	147.2	10	141.9	3.6
K_801	Early Modern	–	–	139.4	141.7	144-144.6	146.2	6	143.7	2.7
K_802	Early Modern	141-142	146.3	*c.* 144.7-145.5	145.6	148.3-148.9	149.8-150.4	8 (10)	146.5	3.5
	Modern	136.4-145.7	138-148.8	135.3-166.5	153.9-156.3	131.8-156.2	146.7-149.3	25	146.6	8
	Late Medieval – Early Modern	136.4-148	137.6-153	136.1-147.2	137.7-150	136.1-148.9	138.3-150.4	65	143.6	4.3
	Early Medieval	130.4-138.3	131.9-142.9	122-149	129.5-148.6	123.3-149.5	120.9-146.4	226	136.5	5.8
	Migration	128.5-134.6	127.4	135.2-138.1	131.4-139.3	132.4-137.9	135.7-144.1	25	135.4	3.6

individuals from the Brno-Podolí with the largest specimen reaching an average of 139 cm in withers and a single skeleton from Záluží with an average withers' height of 132.3 cm. In general, it seems that the average withers' height of horses gradually increased especially from the Late Medieval – Early Modern period onwards. Increased height in withers has been recently noted for post-Medieval horses from England, and Late Medieval horses from Lithuania (Ameen *et al.* 2021; Piličiauskienė *et al.* 2022).

However, in the case of horses from Czech sites, the non-homogeneous representation of sample sizes for the individual periods must be taken into account. New data may thus further modify our observations.

Robusticity

When considering the ratio (Fig. 14) between the smallest width of the diaphysis and the greatest length of the metapodials (SD/GL*100) the specimen T_3256 appears to be the most robust and is comparable in terms of robusticity to the most massive individuals from the Migration (metacarpals), and Early Medieval period (metatarsals). In contrast, the increased length of the metapodials of remaining individuals from Brno does not seem to be reflected in their greater robustness, with the horses from Křídlovická Street (K_801, K_802) appearing as the most gracile. This observation is somewhat surprising, considering that the horses from Brno came from rural estates. It seems highly likely that these horses were utilized as working animals and, if so, perhaps rather more robust individuals should be expected.

A similar pattern is present when looking at the ratio (Fig. 15) between the distal breadth and the greatest length of the metapodials (Bd/GL*100). The horses from Brno do not appear to be considerably more robust compared to horses of Migration and Early Medieval periods. Comparison with the Modern mining horses from Zdice is interesting. Horses from Zdice were hard working animals from the area of iron ore mines. Based on cranial morphology Diedrich identified "crossbreeds" of small to medium-sized mining horses and large-sized working horses (Diedrich 2017). The robusticity of these individuals is variable, with the one outlier, interpreted as a medium-sized mining horse (Sk 6), being significantly more robust, and another, interpreted as a large working horse (Sk 4), being considerably more gracile, compared with other mining horses from Zdice and Czech sites overall. The differences in robusticity may possibly be related to animal utilization or "breed" morphology (Ameen *et al.* 2021), although the latter seems more likely given the fact that the horses from Zdice were most likely used for heavy work and despite that display relatively great variability in robusticity.

Based on these observations, it seems that the robusticity of the horses from Brno was not of particular importance to their owners. Except for T_3256 (in terms of shaft width) all remaining horses from Brno appear as rather moderately robust to gracile.

Preliminary pathological observations

The study of isolated pathologies can be misleading, as pathological findings can also occur in non-working animals and may be related to ageing, the life history of the individual or be hereditary (e.g., Baker & Brothwell 1980; Bartosiewicz & Gál 2013). When assessing pathologies, it is therefore important to compare individual findings within the skeleton of an individual in order to make a comprehensive diagnosis. Therefore, the following sections describe pathological findings and their possible causes observed on the skull, dentition, thoracolumbar column, and appendicular skeleton with the aim of providing as complete information as possible about the condition of each horse from Brno.

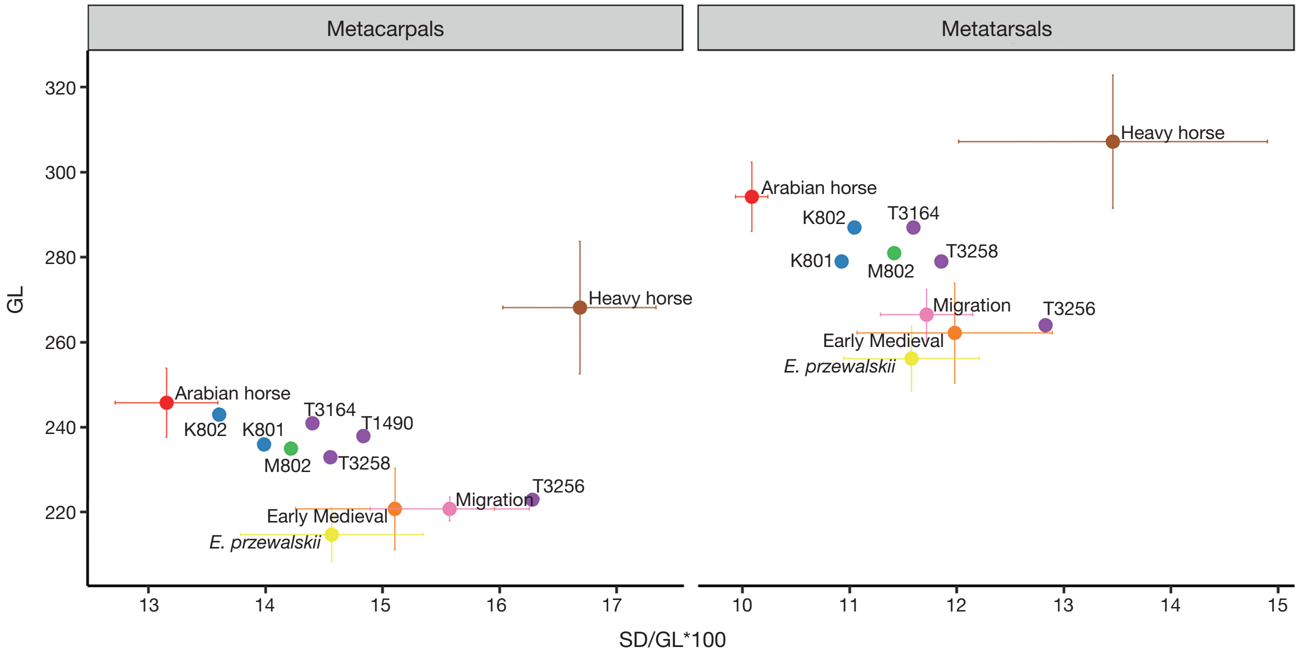


FIG. 14. — Robusticity Comparison of the ratio of measurements SD/GL*100 on horse metacarpals (left) and metatarsals (right) from Brno with the mean ratios of horses from Czech Medieval sites and modern specimens of Arabian horse, heavy horse, and *Equus caballus przewalskii* Poliakov, 1881. Abbreviations: **GL**, greatest length; **SD**, smallest width of the diaphysis.

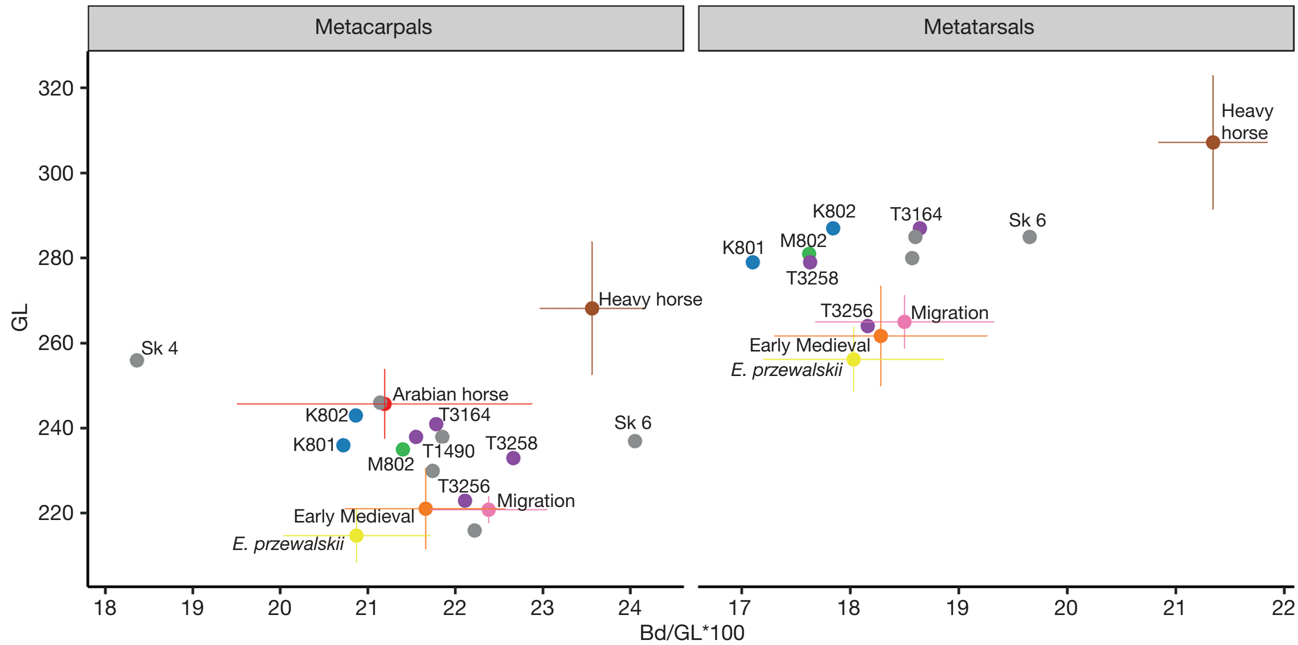


FIG. 15. — Comparison of the ratio of measurements Bd/GL*100 on horse metacarpals (left) and metatarsals (right) from Brno and Zdice (grey points) with the mean ratios of horses from Czech Medieval sites and modern specimens of Arabian horse, heavy horse, and *Equus caballus przewalskii* Poliakov, 1881. Abbreviations: **Bd**, greatest breadth of the distal epiphysis; **GL**, greatest length.

Skull and dentition

Assessing skull pathologies in this study is problematic because most of the skulls were preserved in fragmentary form (T_1490, T_3256, T_3257, T_3258, K_801, K_802) or are virtually absent (T_3164, K_800, M_802).

Ossification of the nuchal ligament attachment site (Fig. 16A-C) could be examined in three cases. Observable changes in this region are mild in horse T_3256 (score 1/2) while being significantly more pronounced in horses T_1490 (score 5) and T_3258 (score 4). Although the ossification of the nuchal ligament may occur in captive unworked animals (Bendrey 2008), a score of three or higher seems to be relatively uncommon in feral horses, while being more frequent in driven and ridden horses

Fig. 16. — **A**, Horse T_3256: Ossification of the nuchal ligament attachment site (score 1/2); **B**, horse T_3258: ossification of the nuchal ligament attachment site (score 4/4); **C**, horse T_1490: ossification of the nuchal ligament attachment site (score 5/5). Scale bars: 5 cm.

Table 7. — Measurements of enamel dentine exposure and recorded presence/absence of occlusal bevel. Abbreviations: **LDH**, height of enamel/dentine exposure; **LDW**, Enamel dentine exposure at widest point.

ID	LDH (Left)	LDW (Left)	LDH (Right)	LDW (Right)	Profile (bevel)
T_1490	1.93	3.01	No	No	Yes
T_3256	3.64	1.82	12.16	3.62	No
T_3257	13.27	5.8	15.11	5.54	No
T_3258	9.29	3.58	10.81	6.22	No
T_3164	–	–	–	–	–
K_800	–	–	–	–	–
K_801	–	–	–	–	–
K_802	13.13	6.16	10.27	7.1	No
M_802	–	–	–	–	–

(Taylor *et al.* 2015). The pronounced ossification in individuals T_1490 and T_3258 may thus indicate their utilization as working animals.

Evidence for the anterior enamel/dentin exposure of more than five millimeters (Table 7) was found in horses T_3256, T_3257, T_3258, and K_802 (Fig. 17). In addition, horse T_3256 exhibits roughening of the bone in the region of the diastema, while specimen T_1490 lacks such evidence but a significant occlusal bevel is present on both lower and upper P2s (Fig. 18).

These observations are suggestive of the use of metal bits (Bendrey 2007b).

The skull of T_3256 adds further evidence for the possible use of a bridle or halter. Pitting (Fig. 19) is present in the region of maxillary bone and proliferative periosteal lesions on mandibular bone (Fig. 20). Such lesions might be the result of chronic irritation/trauma or might have been caused by an infection (Makowiecki *et al.* 2022). In addition, two grooves are present along the dorso-medial border of incisive bone (Fig. 21). The grooves observed on the nasal process are likely related to heavy exertion and hypertrophy of the muscles involved in nasal dilation (Pérez & Martin 2001; Taylor *et al.* 2015; Taylor & Tuvshinjargal 2018).

Thoracolumbar region

Pathologies observed in the region of the thoracolumbar spine can be classified as vertebral fusion, overriding/impingement of the dorsal spinous processes, and bone proliferations on/or around articular processes. Remaining vertebral abnormalities (e.g., mild bony thickening of

Fig. 17. — Enamel/dentine exposure on the second premolar of the horse T_3257. Scale bar: 1 cm.

the articular processes), are similar to those observed on Exmoor ponies (Levine *et al.* 2005) and seem to be rather insignificant.

Spinal fusion of the last two lumbar vertebrae (L5 to L6 and in one case L4 to L5) is present in horses T_3256, T_3164, K_802, M_802. Two other individuals (T_1490, T_3258) with the preserved lumbar spine, also manifest signs of the beginning of spinal fusion of the last two lumbar vertebrae on the transverse processes. Thoracic vertebral fusion (T14 to T16) was identified only in horse T_3256 (Fig. 22). This individual has fused vertebral arches and spinous processes, which may be consistent with spondylosis ankylopoetica

Fig. 18. — Occlusal bevel on second premolars of the horse T_1490. Scale bar: 5 cm.

Fig. 19. — Pitting on the maxillary bone of the horse T_3256. Scale bar: 5 cm.

Fig. 20. — Proliferative periosteal lesions on the mandibular bone of the horse T_3256. Scale bar: 5 cm.

Fig. 21. — Horse T_3256: medial groove formation on the right nasal process of the incisive bone. Scale bar: 5 cm.

Fig. 22. — Horse T_3256: fused vertebral arches and spinous processes of thoracic vertebrae 14-16. Scale bar: 5 cm.

Fig. 23. — Horse M_802: bone proliferations on the posterior articular process of thoracic vertebra 18. Scale bar: 5 cm.

(Bartosiewicz & Bartosiewicz 2002). Bone proliferations (Fig. 23) are present in specimens T_3256 (T17 to L2 and M_802 (T18 to T19). These lesions are suggestive of osteoarthritis of the facet joints (Girodroux *et al.* 2009; Diedrich 2017).

In horses, the fusion between the last lumbar vertebrae can occur naturally (Henson 2009; Bartosiewicz & Gál 2013). On the other hand, the fusion of thoracic vertebrae and bone proliferations (T_3256, M_802), especially those located caudally, are in zooarchaeological literature usually associated with riding (Müller 1985; Levine 1999; Li *et al.* 2020) and have also been documented in draught animals (Lignereux & Bouet 2015; Diedrich 2017).

Fig. 24. — Horse T_3256: overriding/impingement of dorsal spinous processes of thoracic vertebrae 9-12. Scale bar: 5 cm.

Fig. 25. — Horse T_1490: overriding/impingement of dorsal spinous processes of thoracic vertebrae 11-15 and the lesions on the lateral portion of spinous processes of thoracic vertebrae 11-12. Scale bar: 5 cm.

Fig. 26. — Horse T_1490: lesion on the dorsal spinous process of the thoracic vertebra 10. Scale bar: 5 cm.

Table 8. — Recorded scores for the ossification of interosseous ligaments between metapodials of the horses from Brno.

		Left metacarpal		Right metacarpal		Left metatarsal		Right metatarsal	
ID	Age (years)	II-III	III-IV	II-III	III-IV	II-III	III-IV	II-III	III-IV
T_1490	10-13	0	0	0	0	–	–	–	–
T_3256	10-11	2	1b	1b	1b	0	0	0	0
T_3257	7-8	–	–	–	–	–	–	–	–
T_3258	9-11	0	0	0	0	0	0	0	0
T_3164	>5	2	0	2	0	2	0	2	0
M_802	12-14	2	1b	2	2	0	2	0	1b
K_800	<3-3.5	–	–	–	–	–	–	–	–
K_801	3-4	1c	1c	1c	0	0	0	0	0
K_802	9-11	0	0	0	0	0	0	0	0

Overriding/impingement of dorsal spinous processes (Figs 24, 25) was identified in specimens T_1490 (T5 to T15), T_3256 (T5 to T6, T9 to T12, L4 to L5), and M_802 (T4 to T11, T13 to T14). In addition, horse M_802 also has fused spinous processes of the sacrum.

Overriding/impingement of dorsal spinous processes is usually associated with riding (Haussler 2018; Li *et al.* 2020) but has been also recorded in draught animals (Diedrich 2017) and in extinct wild horses, which most likely never had additional weight placed on their backs. In the wild population, the incidence is, however, relatively low (6 % overall with only 0.3 % confirmed by radiology) (Klide 1989). In comparison, the incidence of lesions on dorsal spinous processes of horses from Brno (T_1490, T_3256, M_802; Fig. 26) varies between 28-37 %.

Other factors such as aging could contribute to recorded pathological changes as well (Clayton & Stubbs 2016) but, given the relatively young age of horses from Brno, it seems likely that observed vertebral abnormalities in horses T_1490, and T_3256 can be related to repetitive strain associated with the use of these animals by humans. The same might be true for the individual M_802, however in this case it cannot be ruled out that observed changes in the thoracolumbar region could be associated with the severity of pathological findings observed on the hind limbs (see sections Metapodials, Central and third tarsals, Navicular Bones, Distal phalanges, and Discussion) (Alvarez Gomez *et al.* 2008; Mayaki *et al.* 2019). It is also worth noting that the other two individuals with preserved thoracolumbar spine (horses T_3164, and K_802) do not exhibit any significant pathological changes.

Appendicular skeleton

Appendicular skeleton abnormalities were observed on metapodials, central and third tarsal bone, proximal phalanges, navicular bone, and distal phalanges.

Metapodials

Ossification of interosseous ligaments (so-called "splints") between metacarpal bones (Table 8; Fig. 27) was observed on horses T_3256, T_3164, M_802, and K_801, while on the metatarsal bones was found only on specimens T_3164, and M_802. In the

Fig. 27. — Horse T_3256: ossification of the interosseous ligaments (score 2) on the medial side of the left metacarpal bone. Scale bar: 5 cm.

Fig. 28. — Horse M_802: new bone formation along the left central and third tarsal bones and fusion of corresponding articular surfaces (spavin). Scale bar: 5 cm.

Fig. 29. — Horse K_802: bone proliferation and cavity on the third tarsal bone. Scale bar: 5 cm.

case of metacarpals, the pathology is more common and developed on the medial side, while metatarsals show no discernible pattern. Ossification between the metapodials could lead to equine lameness (Bertone 2011). Numerous factors such as trauma and/or movement on hard surfaces, as well as conformational faults, could contribute to this condition (Marković *et al.* 2015). It was described as the most prevalent pathological finding in the 280 archaeological skeletons from Lithuania among horses from four to 16 years of age. Similar to the Brno horses, it was more common in metacarpals than metatarsals and appears to have begun on the medial side (Daugnora & Thomas 2005). The same pattern was noted for the modern captive specimens of *E. Przewalskii* (Bendrey 2007a).

Central and third tarsals

Spavin', osteoarthritis of the distal intertarsal and tarsometatarsal joints (Fig. 28) is present in horse M_802. This individual exhibits severe exostoses along the left central and third tarsals, which are fused. In individual K_802, bone proliferations (Fig. 29) were observed around the proximal articular surface of the third (left and right) tarsal bone and a small cavity is present on the proximal articular surface of the left third tarsal. Spavin is known from wild fossil horses (Rooney 1997). It usually causes only a relatively mild degree of lameness and if the condition is not too extensive the joint will ankylose, and the animal may be used for slow work (Baker & Brothwell 1980). In addition, bony reactions on corresponding articular surfaces of central and third tarsal bones (Fig. 30) were observed in individuals T_3256, T_3258, T_3164, and K_801. A similar pathological condition was noted in modern mining horses from Zdice (Diedrich 2017), and Galo-Roman horses from Iwuy (Lignereux & Bouet 2015).

Proximal phalanges

Changes in the form of bilateral enthesopathy at the point of insertion of collateral ligaments (Fig. 31) were observed on proximal phalanges. Those changes are rather mild/moderate, except for horse T_3258, which displays severe exostoses on posterior proximal phalanges that extend toward the proximal end, and on the left phalanx, the exostoses are also present on the dorsal aspect of the distal end.

Enthesophytes were observed on the proximal phalanges of wild fossil horses, which indicates that this is a naturally occurring phenomenon (Rooney 1997), although this condition might also be possibly exacerbated by work (Bendrey 2007c; Marković *et al.* 2014, 2015; Albizuri *et al.* 2019).

Navicular bones

Both posterior navicular bones (Fig. 32) of horse M_802 are partly degraded. Widened vascular channels were observed in individuals M_802, T_3256, and T_3258 (Fig. 33). One posterior navicular bone of individual T_3258 has an irregular shape and surface with severe exostoses. Observed degenerative changes are indicative of navicular syndrome (podotrochlosis) (Komosa *et al.* 2018), which usually affects the forelimbs, but was also recorded in the hindlimbs of modern horses (Meijer & Rijkenhuizen 1999). Navicular syndrome is often associated with lameness. However, it is rarely reported in zooarchaeological literature since the navicular bones are usually not recovered during excavations (Baker & Brothwell 1980).

Fig. 30. — Horse K_801: bony reactions on corresponding articular surfaces of central and third tarsal bone. Scale bar: 5 cm.

Fig. 31. — Horse T_3256: ossification of collateral ligaments on the lateral side of left posterior proximal phalanx. Scale bar: 5 cm.

Distal phalanges

Anterior distal phalanges of horse T_3256 (Figs 34; 35) manifest increased porosity of bone on the parietal surface, thinned bone around the rim, and roughened new bone on the palmar process

Fig. 32. — Degraded posterior navicular bone of the horse M_802 (top). Severe exostoses on the posterior navicular bone of the horse K_3258 (bottom). Scale bar: 5 cm.

Fig. 33. — Widening of the vascular channels observed on the navicular bones. From the top normal navicular bone of the horse K_802, and widened vascular channels in horses M_802, T_3258, T_3256. Scale bar: 5 cm.

Fig. 34. — Distal phalanges (from the top) of the horses T_3164, T_3256, and M_802. Scale bar 5 cm.

and parietal surface. Specimen T_3164 (Fig. 34) exhibits thinning of the bone around the rim of the solar surface, increased porosity, and roughened new bone on palmar processes. Both posterior distal phalanges of individual M_802 (Figs 34, 36) show severe loss of bone mass. Those pathological findings might be associated with chronic laminitis (Dyson 2011; Engiles *et al.* 2015; Bowker 2017). Laminitis is often thought to be caused by inflammatory processes, but most veterinary cases seem to be associated with pasture grazing, obesity, and insulin resistance (Johnson *et al.* 2010). Laminitis was noted in Byzantine (Onar *et al.* 2012) as well as in pre-domestic fossil horses (Wallett 2013).

T_3258

The pathological findings in horse T_3258 stand out from the others. In addition to proximal posterior phalanges and navicu-

Fig. 35. — Horse T_3256: increased porosity and the new roughened bone on the palmar process and parietal surface of the posterior distal phalanx. Scale bar: 5 cm.

Fig. 36. — Horse M_802: degraded posterior distal phalanx. Scale bar: 5 cm.

lar bone, exostoses (Figs 37-41) are present on the left posterior middle phalanx (dorsal surface), left calcaneus (tuber calcanei), both tibias (left: tuberosity, right: pronounced ossification in the area of muscular lines), both femurs (both: trochanter major, left: third trochanter), right radius (ridge of oblique groove), and right humerus (pronounced ossification in the area of teres tuberosity). Proliferative periosteal lesions (Figs 42-45) were observed on the pelvis (acetabular shaft), sacrum (dorsal surface and spinous processes), and ribs. The multicentric origin of lesions may point towards an infection that spreads via the bloodstream and subsequently results in inflammation, which eventually affected the bones (Archer *et al.* 2004; Bendrey *et al.* 2008). However, determining the cause of those pathological changes solely based on structural changes within the bone is problematic, and thus needs to be viewed as hypothetical at this point.

STRONTIUM ISOTOPE ANALYSES

Laboratory methods

Strontium isotope analyses were performed using a Triton Plus thermal ionization mass spectrometer (TIMS; Thermo Fisher) housed at the Czech Geological Survey, Prague. Sample preparation was provided using a method described in Erban Kochergina *et al.* (2022). For isotope analyses enamel from the top of the teeth, monitoring the early phases of the sampled

Fig. 37. — Horse T_3258: new bone formation located proximally on the dorsal aspect of the left posterior middle phalanx. Scale bar: 5 cm.

Fig. 38. — Horse T_3258: severe new bone formation on the medial side of the right posterior proximal phalanx. Scale bar: 5 cm.

Fig. 39. — Left calcaneus of the horse T_3258: new bone formation located on tuber calcanei. Scale bar: 5 cm.

Fig. 40. — Left femur of the horse T_3258: new bone formation located on trochanter major. Scale bar: 5 cm.

individual's life, was selected. Single-row steel drills with a diamond surface were used for drilling. Samples with weights of 25-50 mg were placed in PFA vials and sonicated in 5 ml of 5 % ultrapure acetic acid for 15 minutes. To remove potential secondary minerals and contamination, all samples were left overnight in 5 % ultrapure acetic acid at room temperature, then rinsed three times in Milli-Q water. Samples were dissolved with a mixture of 3.5 ml concentrated HF and 1.5 ml of concentrated HNO_3 at 140°C. The solution, evaporated to dryness at 60-80°C, was then treated twice with concentrated HNO_3. After evaporation, the residue was treated again with a mixture of 0.14 M HNO_3 and H_2O_2 (9:1). To dissolve the organic residuum, five drops of perchloric acid ($HClO_4$) were used. Following evaporation at 180°C, the residue was refluxed three times using 1.5 ml of concentrated HNO_3. Then, the dry sample was taken up with 1.7 ml of 2M HNO_3 and centrifuged for 10 min at 4000 rpm to check the presence of solid residues. Strontium was separated by ion-exchange chromatography using the Sr spec resin (Triskem).

Strontium isotopic ratios were measured in static mode using a single Ta filament. The $^{87}Sr/^{86}Sr$ ratios used the assumption $^{86}Sr/^{88}Sr$ = 0.1194. External reproducibility was estimated from replicate analyses of the NBS 987 ($^{87}Sr/^{86}Sr$ = 0.710265 ±01 [2σ, n = 2]) and carbonate sample NIST NBS 915b ($^{87}Sr/^{86}Sr$ = 0.708024 ±07 [2σ, n = 7]) reference standards. Repeat analyses of samples 4-B-Tr, 3-B-Tr and 1-B-Tr comprising total sample dissolution, ion-exchange chemistry and Sr isotope composition replicated within the analytical uncertainty (Table 9).

Results

Sr isotopes were analysed in the teeth of 10 individuals. Of the eight individuals, two samples were tested to cover as much as possible of the life span of each individual.

Fig. 41. — Right humerus of the horse T_3258: pronounced ossification in the area of teres tuberosity. Scale bar: 5 cm.

Fig. 42. — Horse T_3258: proliferative periosteal lesions located around dorsal surface and spinous processes of the sacrum. Scale bar: 5 cm.

Fig. 43. — Horse T_3258: proliferative periosteal lesions located on acetabular shaft. Scale bar: 5 cm.

Therefore, a molar and incisor, which crystallize at different ages, thus providing values related to different phases of an individual's life, were used. Individual K_801 provided only one testable tooth, and in the case of foal M_803, given its age, it was sufficient to analyse one tooth as well. (Table 9; Fig. 46). Also, a sample of T_3256 coffin bone was analysed for comparision. One bovine tooth (T_420) was also tested for the same reason.

Fig. 44. — Proliferative periosteal lesions on the rib of the horse T_3258. Scale bar: 5 cm.

Fig. 45. — Proliferative periosteal lesions on the rib of the horse T_3258. Scale bar: 5 cm.

Table 9. — Strontium radiogenic isotopic composition of 10 studied horses from Brno region. Abbreviations and symbols: **d**, duplicate; **2 s.e.**, two standard error; **±1 σ**, standard deviation between two enamel samples from same horse; *, fragments of mandible not included in zooarchaeological analysis.

	Lab N	Sample	ID	Tooth	$^{87}Sr/^{86}Sr$	2 s.e.	±1 σ
Brno, Trnitá							
1	4859	1-B-Tr	T_1490	M1	0.709355	±17	0.00001
	4859d	–	–	–	0.709361	±12	–
	4860	2-B-Tr	–	I	0.709375	±19	–
2	4861	3-B-Tr	T_3256	M1	0.715298	±11	–
	4861d	–	–	–	0.715262	±10	–
	4862	4-B-Tr	–	I3	0.711503	±18	–
	4862d	–	–	–	0.711506	±20	–
	5026	–	–	3rd phalanx articular surface	0.712181	±07	–
3	4863	5-B-Tr	T_3257	I3	0.711265	±11	0.00052
	4864	6-B-Tr	–	M1	0.710531	±16	–
4	4866	8-B-Tr	T_3258	M1	0.710525	±10	0.00052
	4867	9-B-Tr	–	I3	0.709787	±13	–
5	4868	10-B-Tr	T_420	M1	0.712012	±08	0.00017
	4869	11-B-Tr	–	P	0.711772	±07	–
Brno, Křídlovická							
6	4870	12-B-Kř	K_801	Dp	0.710733	±09	–
	4871	13-B-Kř	K_802	M1	0.710135	±17	0.0001
7	4872	14-B-Kř	–	I3	0.709992	±16	–
8*	4873	15-B-Kř	K_803*	M1 or M2	0.709758	±13	0.00008
	4874	16-B-Kř	–	I2	0.709874	±14	–
Modřice							
9	4875	17-Mod	M_803	I2, foal	0.711005	±14	0.00011
10	4876	18-Mod	M_802	P	0.711333	±09	0.000001
	4877	19-Mod	–	I3	0.711334	±13	–

Sr isotopic ratios of the dataset vary from 0.7094 to 0.7153. Such isotopic composition is typical for sedimentary rocks of the Moravian region. From the dataset, four horses (T_1490, M_802, and K_803) can be selected with almost identical iso-

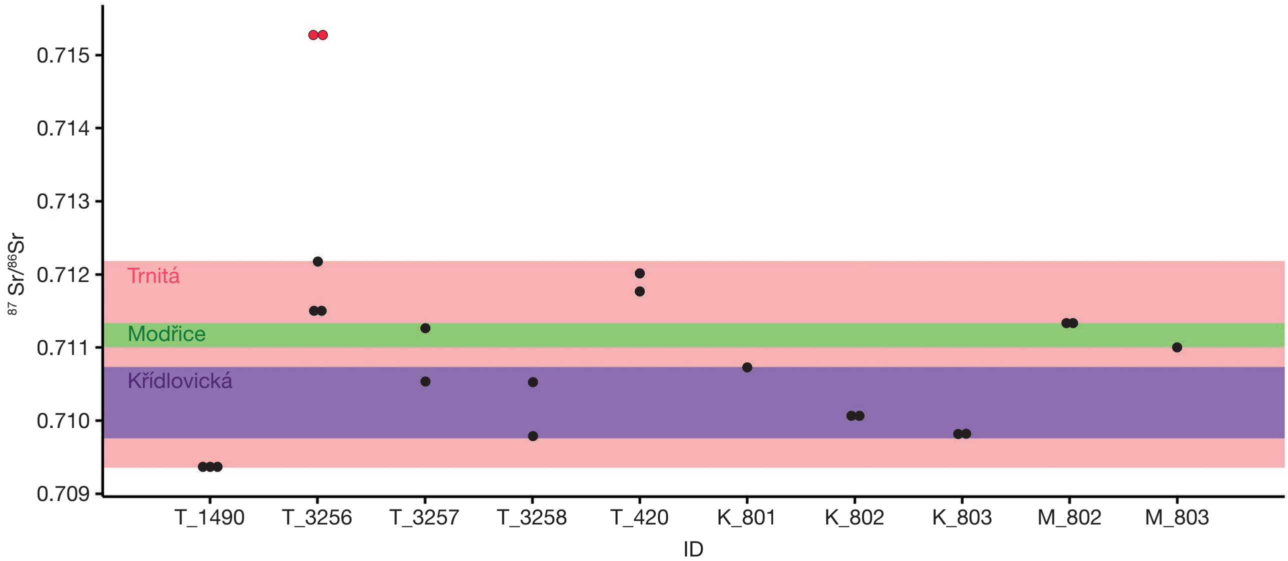


FIG. 46. — Distribution of strontium radiogenic isotopic composition for each analysed individual (**ID**). The red points represent outliers measured in first molar of individual T_3256 (duplicated measurements).

topic composition of the enamel of both teeth. The standard deviation of both measures differs in the fifth and sixth decimal places. Such minimal differences are more typical for international reference materials than for natural samples. Enamel samples of both teeth of horses K_802 and T_420 show very similar isotopic composition with standard deviation on the fourth decimal place. These differences are very small and do not indicate a change in diet or migration of these individuals. Therefore, it can be concluded that these individuals had the same diet for several years and did not migrate over longer distances. These horses likely spent their whole life with one owner on the same pasture with the same water source.

Two horses T_3257 and T_3258 show a little heterogeneity in the enamel composition of different teeth ($\pm 1\ \sigma = 0.0005$). Such differences could probably be due to a more varied diet than in the horses of the previous groups. Different water sources or slightly different pastures can easily make such a difference.

The only horse that shows signs of migration, which may not be very distant, is the T_3256 Late Medieval – Early Modern horse. The difference in Sr isotopic ratios between enamel from M1 *c.* 0.7153 and I *c.* 0.7115 is relevant as the M1 is the first permanent tooth to erupt at approximately eight to 12 months of age and the incisors between three and four years of age. Enamel layers in equine cheek teeth take longer to mineralize than had been previously assumed. The enamel continues to mineralize for approximately six to 12 months after each tooth begins to erupt (Hope *et al.* 2004). Therefore, there is a difference of several years between the mineralization of M1 and the incisors, during which the individual T_3256 most likely ate and moved in geologically significantly different regions.

This difference in the third tenth place indicates that the horse has changed its place of residence. The more radiogenic strontium corresponds more to granitic rocks, the less radiogenic ones are similar to those measured in the other horses and correspond to local sedimentary (for example) less deposits. The granitic rocks from around Brno, from the Brno Massif, are very specific and have a very primitive (less radiogenic) isotopic composition that varies from 0.703 to 0.708 (Y. V. Erban Kochergina, pers. comm.). However, there are other rocks in Central Europe, which could be a source of radiogenic Sr (Janoušek *et al.* 2020, 2022; Novák *et al.* 2020, 2023). Based on the radiogenic composition of plants and samples of highly radiogenic rocks, Erban Kochergina *et al.* (2021) proposed a simple scheme to use Sr isotopes to determine the place of origin of plants and bones. Bioavailable Sr in plants, bones and teeth (in our case) is a mixture of Sr that has entered the living organism from food and drink (if we are talking about animals and humans). The boundary that separates the two large groups of samples is the Sr isotopic composition of the rainwater (and/or sea spray), which is 0.709-0.710. If the sample under examination has an isotopic composition lower than 0.709, it probably does not come from a site that is composed of rock with an isotopic composition higher than 0.710. It works the same way in the other direction. For the horse T_3256 it could mean that it did not spend its first years of life on the territory of the extensive Czech Cretaceous Basin (87Sr/86Sr ≤ 0.708; Nádaskay *et al.* 2019) or typical for Central Europe volcanic rocks (87Sr/86Sr ≤ 0.706; Ulrych *et al.* 2011; Walther *et al.* 2016; Mysliveček *et al.* 2018; Rapprich *et al.* 2023). The Sr isotopic composition of sedimentary rocks is very heterogeneous (Waroszewski *et al.* 2021; Mach *et al.* 2021; Erban Kochergina *et al.* 2024). Therefore, if the horses come from a locality with sedimentary bedrock, it is very difficult to determine their exact origin. In time, based on more data, we will be able to determine Sr isotope ranges for individual sites. The most homogeneous Sr isotopes are samples from Modřice

($^{87}Sr/^{86}Sr$ 0.7110-0.7113) and Křídlovická $^{87}Sr/^{86}Sr$ 0.7098-0.7107). The most heterogeneous are samples from Trnitá ($^{87}Sr/^{86}Sr$ 0.7094-0.7118). However, all these isotopic ratios are typical for the Moravian region.

The isotopic composition of the coffin bone/distal phalanx gives very interesting and, in our opinion, promising results. The distal phalanx, nourished by an active hoof mechanism, intensively replenishes bone mass throughout its life. We assume that in the case of migration, the hoof will reflect the isotopic composition of the region of occurrence. The coffin bone/distal phalanx sample we studied (T_3256) has a Sr radiogenic isotopic composition of 0.7122. We presumably assume that the cofin bone thus shows a mixed strontium signal (0.7115 and 0.7153) generated throughout life, which we will focus on in the next phase of research.

And the development of this part of the hoof occurred during the change of residence. Further concurrent studies of the Sr isotopic composition of horse teeth and coffin bones/distal phalanges may lead to interesting results and more precise information about animal life mobility and their individual biographies.

DISCUSSION

Horses from Late Medieval – Early Modern Brno seem to be slightly taller at the withers than the average horses from the Migration and Early Medieval periods, although by modern standards they fall into the pony category (below 148 cm) (Van de Pol & Van Oldruitenborgh-Oosterbaan 2007). The increase in withers' height, could be related to changes in animal husbandry that occurred in Europe with the arrival of the Renaissance, and ended by the Early Modern era. This period is in general characterized by the introduction of new horse types and by the increased size and productivity of domestic animals (Bökönyi 1995). Based on the proportions of the limbs and robustness, it seems that horses with a variety of conformations were bred in the suburbs of Brno. Horses from Křídlovická and Modřice appear to be relatively gracile with less pronounced differences between metapodials and other limb elements, while some individuals from Trnitá (horses T_3256, T_3258, and T_3164) resemble modern draft horses in terms of proportions of their limbs, but they are significantly smaller and, except for specimen T_3256, also less robust. The pathological changes observed on second premolars (horses T_1490, T_3256, T_3257, T_3258, and K_802) are most likely related to the use of a bit, while changes observed on the mandibular and maxillary bone of T_3256 might be related to the use of noseband. Pronounced ossification in the region of the nuchal ligament attachment site (horses T_1490, and T_3258), could also be related to the working history of the individuals. However, determining the predominant use of these animals based on observed pathological changes is challenging, due to the complex etiologies of many pathologies (Salmi & Niinimäki 2016). In addition, when considering the context of the findings, it seems reasonable to expect that these could have been multipurpose animals, utilized for driving, riding, and as pack horses. Vertebral abnormalities are virtually absent in horses T_3164, K_802 or milder (horses T_1490, T_3256, and M_802) in comparison to some rather extreme examples from literature (e. g. Janeczek *et al.* 2012; Lignereux & Bouet 2015; Marković *et al.* 2019). Moreover, compared to mining horses from Zdice, where the majority of the horses died between four to seven years of age (Diedrich 2017), most horses from Brno died between seven to fourteen years of age, which may further indicate that they were not used for such extensive heavy work. Other pathological findings observed on the appendicular skeleton, especially those on metapodials, central and third tarsals, navicular bones, and distal phalanges could have led to lameness in the deceased animals. These changes cannot be directly linked to workload, although they could be possibly exacerbated by it.

The severe loss of bone mass observed on the posterior distal phalanges of horse M_802 might indicate that the bone was affected by sepsis (Cauvin & Munroe 1998). Sepsis is usually associated with bacterial infection and can lead to the death of the individual (Taylor *et al.* 2015). In this case, it seems possible that pathological changes observed on the thoracic column, intertarsal joint, and the lateral rather than medial side of the metatarsals of the individual M_802 could be related to this condition as well. Current approaches to the horse prefer to perceive the organism as a unity where everything is related to everything else[2]. The hoof mechanism is often the "crossroads" of many problems that subsequently manifest themselves more strongly in other, even distant parts of the body. If the hoof mechanism is not working properly – usually due to improper hoof care, inappropriate diet, or overloading – restriction of metabolism, rotation of the distal phalanx, and deformation of the podotrochlear bursa follows, the horse tries to avoid pain by using so-called relief postures. This changes the forces acting on the tendon attachments and subsequently the bone. All kinds of growths or skeletal degradation begin to form (according to Wollf's law: growths in the case of excessive pressure and bone loss in the case of excessive tension). In none of the examined individuals, was degradation of the distal phalanx identified in isolation; this condition was always accompanied by other distinct pathologies in the metapodials and spine (Strasser & Kells 2001). Another example of a possible bacterial infection is represented by a horse T_3258, which exhibits multicentric lesions on both limbs, sacrum, and ribs. The extent of pathological changes observed on individuals T_3258, and M_802 suggests that the animals may not have been fit for the work for some time prior to their death.

BRNO AND MODŘICE HORSES IN CONTEXT

A logical question, arising from the finds of horse skeletons from three rural sites around the large royal city, is: How do these assemblages fit into the context of medieval horse

2. Pischinger's basic principle: every cell is related to the whole system (Pischinger 2007).

breeding and use? Domesticated horses have been present in the archaeological contexts of central Europe since the Early Bronze Age (2200 B.C.E.; Librado *et al.* 2021). The first written mention of horse breeding in Bohemia comes from Annales of Fulda from 871 and from 903. They state the customs duties charged for stallions (1/3 of solidus) and mares (1/12 of solidus) exported from Bohemia (Misař 2011: 7). From the same period (Great Moravia and the Duchy of Bohemia), the skeletal remains of horses as well as riding equipment (bridles, bridle parts, spurs, etc.) are commonly found (Měchurová 1981). Ibrahim ibn Yaqub (10th century) mentions in his chronicle that in Prague workshops they made excellent harnesses and saddles, which were exported to foreign countries together with horses (Kowalski 2022: 83).

Quality and renown for horse breeding is mentioned from the wider region. The *Report on Horse Livestock* by the knight Jan Dobrenski, probably from 1560, mentions horses from central Bohemia (Nymburk and Čáslav) (Misař 2011: 7). Quality and renowned horse breeding came from the Kingdom of Hungary (Dvořáková 2007).

Breeding has been systematized gradually since the 16th century. At that time, the horse "Bohemicus" was known, and the first stud farms were established in the territory of the Habsburg Monarchy, where local breeding was improved by Spanish and Italian stallions: 1579 – Kladruby n. Labem, 1580 – Lipica (Misař 2011: 8).

Although in Medieval and Early Modern Europe, there were no breeds in the modern sense, horses were nevertheless assigned to particular activities for which they were suited according to their constitution and temperament. The aristocratic milieu was characterized by the great destrier (Latin: *dextrarius*), a large powerful horse (Dvořáková 2007: 69). However, even its size was smaller than contemporary riding horses (Ameen *et al.* 2021). Another type was the universal equestrian horse, the palfrey (Latin: *palefridus*), at the turn of the 15th century and 16th century this was also called Gradarius. Arabian horses were referred to as badavia and the ambulator was a pacing, ambling horse (Dvořáková 2007: 70-77). But these types were available only in aristocratic environments. The production and breeding of horses for rural activities was governed by different rules, and there is considerably less information about them. The Brno horses probably belong to this category of working animals. Here it was necessary to provide animals suitable for work, i.e. primarily draft and field work. In England, the horses called affers and stotts (*affrus* et *stottus*) were in use in farms. They were smaller and cheaper than cart or riding horses (Clark 2004: 27, 28; Dvořáková 2007: 63; Claridge 2015, 2017), and their numbers were many times greater than the number of bred riding horses (Claridge 2017: 5).

The Moravian region had a slightly different tradition from the centre of the Bohemian kingdom. There was a more pronounced influence of horses of oriental origin (Misař 2011: 18, 19), as well as small hardy Hungarian horses, among which Arabian horses had been present in breeding since the 15th century, although probably only in elite settings (Dvořáková 2007: 46).

Even horses were subject to a hierarchy that resulted mainly from their availability. A peasant could not think of buying horses intended for the nobility, whose types are known from written sources. From the 13th to the 15th century, prices in Central Europe fluctuated. For example, Wiliňski (1979) states that in the 14th century in Poland, a work horse cost one to three hryvnia, a knight's or merchant's horse four to six hryvnia and an aristocratic horse seven to ten hryvnia. There were exceptions, e.g., Ladislaus IV's horse, which was purchased for 200 hryvnia. Compared to other domestic animals, an adult sow cost one golden, and a cow one to three golden. One hundred to two hundred golden could buy a whole village or a stone house in a town, 400 golden a castle. A wagon cost about 40 gold pieces. A horse was sometimes used as payment (Dvořáková 2007: 88-90).

The prices of war horses were similarly high in the Roman Empire (Byzantium). From the 13th to the 15th century, warhorse prices ranged from 20 to 100 hyperpyrones. The price of a slave rarely went over 50 hyperpyrones (Morrisson & Cheynet 2002: 840, 841, table 11; 848, table 14). A cavalry officer earned enough for two to four horses, a regular rider needed to work for a year or two for one horse (Morrisson & Cheynet 2002: 862, 863, table 17).

A horse was considered a valuable asset. Its acquisition value was relatively high and its maintenance demanding. The horse also did not add any value in the form of meat. Horse meat was rarely consumed in the kingdom of Bohemia, and this was true for Christians from the time of Pope Gregory III's decree from 732. Horses formed part of inheritances and dowries, but were also targets of thieves. The horse trade was centrally controlled. There were special market places (e.g., Wenceslas Square in Prague) and rules on the basis of which horses could be sold, who could buy and from where (Dvořáková 2007: 96, 97, 129, 130). The horse trade also had a huge international dimension (Gladitz 1997), extending from China across Central Asia to Eastern Europe, across the Near East and Arab breeders to the Mediterranean, then to Spain, Italy, across the Alps and into England. The horses of the South Moravian countryside were then in its periphery.

Therefore, the peasants made great efforts to balance the maximization of the performance of their horses with their health. They used two essential procedures: vein dropping and hot iron application. The farrier also ground and pulled teeth and made ointments and various decoctions. But healing was also done with incantations. The first account of equine medicine was the work Meister Albrant Rossarzeibuch from 1435 to 1440. The work of the Augsburg merchant Mark Fugger, who bought horses in Spain (1563), where there were already specialists in the treatment of horses (Dvořáková 2007: 118-122), was a breakthrough. The manuscripts of the Byzantine Hippiatrikas were also being transcribed and translated at this time (Klontza-Jaklová *et al.* 2023). In perhaps every aristocratic residence in the Czech

Republic, which included stables, there was literature summarizing the knowledge of horse care at that time[3]. Sources state that stallions and geldings lived to 18-20 years, rarely to 30. Mares were said to live to 40-50 years (Dvořáková 2007: 123). This is certainly not confirmed by the existing archaeological findings.

The breeders of that time were already aware of the causes of some diseases, knew about laminitis, and knew that an unsuitable diet could cause it. Descent through a vein was supposed to help. Abscesses were opened, and incense was put into them. Hot iron was then put on the distal hoof cushion. Tapered hooves, or "bad" hooves in general, were often mentioned as an acute problem. Bruised backs were covered with patches of cloth (Dvořáková 2007: 240-246). Pathological changes observed in the present study most frequently occur on lower limbs in general and in the thoracolumbar region. Those changes could impact the working performance of those individuals and might be a result of inappropriate or neglected care.

Medieval Moravia was not, however, a centre of horse breeding, unlike central and eastern Bohemia, where large breeding farms developed very early on and were subsequently transformed into aristocratic, royal and imperial breeding farms. A report from the provincial administration to the general command in Vienna in 1780 states that the unfavourable state of breeding persisted. The horses have a frame caused by inappropriate breeding in unsuitable stables, feed (high proportion of food industry waste), premature foaling, improper shoeing, large numbers of unlicensed stallions in less accessible locations. Subsequently, new studs were established, and the situation improved (Misař 2011: 19, 20). The breeding of horses and their use in the fertile areas of Moravia was certainly widespread, and horsepower was no exception. Among other things, this is evidenced by numerous toponyms reflecting the presence of horses (e.g., Kobylnice, Kobylí, Kobylá nad Vindavkou).

CONCLUSION

This study provides insights into the physical characteristics, origin, utilization, and health condition of horses from the Late Medieval to Early Modern period in the suburbs of the medieval city of Brno. Our research results suggest that horses with a variety of conformations, predominately of local origin (based on strontium analysis), were bred in the villages. The horses from Brno appear to be slightly taller in withers compared to previous periods, and there seems to be no discernible pattern indicating a preference for robust animals.

Considering our research results and archaeological context, it seems reasonable to conclude, that horses from Brno were used primarily as work animals. Pathological findings observed on the skull (T_1490, T_3256, T_3258), and second premolars (T_1490, T_3256, T_3257, T_3258, and K_802) can, most likely, be related to the working history of those individuals. Changes observed on the thoracolumbar column are rather mild (T_1490, T_3256, M_802) or almost absent (T_3164, K_800), which suggests that the horses from Brno were probably not used for extensive heavy work. On the other hand, all individuals died prior to old age, and the relatively high incidence of observed pathological changes indicates neglected care, which could have contributed to the untimely death of these animals. In addition, two individuals (T_3258, and M_802) show signs of a possible bacterial infection, but in these cases, further investigation would be necessary to confirm our hypothesis.

Strontium analyses performed to capture as long a life span as possible have shown that most horses come from Moravia's sedimentary rock region. The minimal differences in values allow us to consider that the individual horses were most likely born and died in the same village, perhaps a farmstead, and their diet did not have large fluctuations. The only exception is individual T_3256, which shows signs of migration and may come from another part of central Europe. As to the place of origin of our studied horses (except T_3256), we could exclude regions characterized by low $^{87}Sr/^{86}Sr$ isotopic ratios (e.g., volcanic, marine sediments). The pilot strontium analysis of the distal phalanx, with $^{87}Sr/^{86}Sr = 0.712$, seems to confirm mobility between two different geological areas, characterised by less radiogenic bioavailable Sr in the grass and water ($^{87}Sr/^{86}Sr$ *c.* 0.711) and more radiogenic ($^{87}Sr/^{86}Sr$ *c.* 0.715). But interestingly, this is also a different individual in terms of size (withers height 137.3 cm). This individual resembles most closely the modern draft horses in terms of limb proportions and robusticity but is significantly smaller (in withers), compared to modern draft horses as well as to other studied horses from Brno.

In order to assess the equine population in the Bohemian Kingdom in the Late Medieval and Early Modern periods, to contextualize over time, the source base needs to grow, and more, similar, collections need to be examined.

Acknowledgments

First of all, our gratitude goes to the institutions Archaia Brno and Institute for Archaeological Heritage Brno for the opportunity to examine the skeletal remains presented in this article. Prof. Alan Outram from the University of Exeter and Prof. William Taylor from the University of Colorado Boulder provided invaluable consultation and read the manuscript. For the photographs of the skeletal material we thank Sára Bergmanová, a student of classical archaeology at Masaryk University. The article was written as one of the outputs of the project "Medieval Brno residents and their horses in isotopes" supported by the grant of the Dean of the Faculty of Arts of Masaryk University no. MUNI/FF-DEAN/1574/2022.

3. See e.g., the library of the State Chateau and Hippological Museum in Slatiňany (e.g., *Kniha o koních* [*Book on Horses*], 1738, ZK SN 0734; *Hippiatria*, 1574, ZK SN 00741, *Hippiatria*, 1622, ZK SN 00752).

REFERENCES

ALBIZURI S., VALENZUELA-LAMAS S., BOSCH D., FERNANDEZ M. & LÓPEZ-CACHERO F. J. 2019. — Equid use and provision during the Early Iron Age in Can Roqueta (NE Iberian Peninsula). Zooarchaeological study and first strontium isotope result ($^{87}Sr/^{86}Sr$). *Journal of Archaeological Science: Reports* 26 (101907). https://doi.org/10.1016/j.jasrep.2019.101907

ALVAREZ GOMEZ C. B., BOBBERT M. F., LAMERS F., JOHNSTON C., BACK W. & VAN WEEREN P. R. 2008. — The effect of induced hindlimb lameness on thoracolumbar kinematics during treadmill locomotion. *Equine Veterinary Journal* 40 (2): 147-152. https://doi.org/10.2746/042516408X250184

AMBROS C. & MÜLLER H.-H. 1980. — *Frühgeschichtliche Pferdeskeletfunde aud dem Gebiet der Tschechoslowakei*. Archäologisches Institut der Slowakischen Akademie der Wissenschaften (Archaeologica Slovaca Fontes; 13), Bratislava, 183 p.

AMEEN C., BENKERT H., FRASER T., GORDON R., HOLMES M., JOHNSON W., LAURITSEN M., MALTBY M., RAPP K., TOWNEND T., BAKER G. P., JONES L. M., VO VAN QUI C., WEBLEY R., LIDDIARD R., SYKES N., CREIGHTON O. H., THOMAS R. & OUTRAM A. K. 2021. — In search of the 'great horse': a zooarchaeological assessment of horses from England (AD 300-1650). *International Journal of Osteoarcheology* 31 (6): 1247-1257. https://doi.org/10.1002/oa.3038

ARCHER D. C., CLEGG P. D. & EDWARDS G. B. 2004. — Septic tenosynovitis of the tarsal sheath of an Arab gelding and suspected sepsis of the lateral digital flexor tendon subsequent to bacterial peritonitis. *Veterinary Record* 155 (16): 485-489. https://doi.org/10.1136/vr.155.16.485

BAKER J. & BROTHWELL D. R. 1980. — *Animal Diseases in Archaeology*. Academic press, New York, 235 p.

BARTOSIEWICZ L. & BARTOSIEWICZ G. 2002. — "Bamboo spine" in a Migration Period horse from Hungary. *Journal of Archaeological Science* 29 (8): 819-830. https://doi.org/10.1006/jasc.2001.0715

BARTOSIEWICZ L. & GÁL E. 2013. — *Shuffling Nags, Lame Ducks: the Archaeology of Animal Disease*. Oxbow, Oxford and Oakville: 302 p. https://doi.org/10.2307/j.ctvh1djdq

BENDREY R. 2007a. — Ossification of the interosseous ligaments between the metapodials in horses: a new recording methodology and preliminary study. *International Journal of Osteoarcheology* 17 (2): 207-213. https://doi.org/10.1002/oa.875

BENDREY R. 2007b. — New methods for the identification of evidence for bitting on horse remains from archaeological sites. *Journal of Archaeological Science* 34 (7): 1036-1050. https://doi.org/10.1016/j.jas.2006.09.010

BENDREY R. 2007c. — Work- and age-related changes in an Iron Age horse skeleton from Danebury hillfort, Hampshire. *Archaeofauna* 16: 73-84.

BENDREY R. 2008. — An analysis of factors affecting the development of an equid cranial enthesopathy. *Veterinarija ir Zootechnika* 41 (63): 25-31.

BENDREY R., TAYLOR G. M., BOUWMAN A. S. & CASSIDY J. P. 2008. — Suspected bacterial disease in two archaeological horse skeletons from southern England: palaeopathological and biomolecular studies. *Journal of Archaeological Science* 35 (6): 1581-1590. https://doi.org/10.1016/j.jas.2007.11.002

BERTONE A. L. 2011. — The metacarpus and metatarsus, *in* BAXTER G. M. (ed.), *Adams and Stashak's Lameness in Horses*. 6th edition. Wiley-Blackwell, Hoboken: 621-659.

BÖKÖNYI S. 1995. — The development of stockbreeding and herding in Medieval Europe, *in* SWEENEY D. (ed.), *Agriculture in the Middle Ages: Technology, Practice, and Representation*. University of Pennsylvania Press, Philadelphia: 41-61.

BOWKER R. M. 2017. — The coffin bone: how does adaptation impact the foot during laminitis?, *in NO Laminitis! Conference, Tucson, 27-29 October 2017*. ECIR – Equine Cushing's and Insulin Resistance Group, Tempe: 1-6.

BRAUNER A. A. 1916. — *Materialy k Poznaniju Zhivotnych Rossii: Loshadi Kurgannych Pogrebenij Tirapol'skogo uezda Chersonskoi Gubernii*. Vol. 1. Zapiski Imperatorskogo Obshczestva Sel'skovo Chozjajstva Juzhnoj Rossii, Odesa, 184 p.

CAUVIN E. R. J. & MUNROE G. A. 1998. — Septic osteitis of the distal phalanx: findings and surgical treatment in 18 cases. *Equine Veterinary Journal* 30 (6): 512-519. https://doi.org/10.1111/j.2042-3306.1998.tb04527.x

CLARIDGE J. 2015. — *The Trade of Agricultural Horses in Late Medieval England*. PhD thesis, School of History, University of East Anglia, Norwich, 243 p.

CLARIDGE J. 2017 — The role of demesnes in the trade of agricultural horses in late medieval England. *The Agricultural History Review* 65 (1): 1-19.

CLARK J. 2004. — *The Medieval Horse and Its Equipment,* c. *1150-*c. *1450*. Boydell & Brewer, Martlesham, 185 p.

CLAYTON H. M. & STUBBS N. C. 2016. — Enthesophytosis and impingement of the dorsal spinous processes in the equine thoracolumbar spine. *Journal Equine Veterinary Science* 47: 9-15. https://doi.org/10.1016/j.jevs.2016.07.015

CHRZANOWSKA W. & KRUPSKA A. 2003. — Pferdeknochen aus dem frühmittelalterlichen Burgwall von Mikulčice, *in* POLÁČEK L. (ed.), *Studien zum Burgwall von Mikulčice V*. Archäologisches Institut der Akademie der Wissenschaften der Tschechischen Republik Brno, Brno: 151-215.

CLUTTON-BROCK J. & BURLEIGH R. 1979. — Notes on the osteology of the Arab horse with reference to a skeleton collected in Egypt by Sir Flinders Petrie. *Bulletin of the British Museum (Natural History) Zoology* 35 (2): 191-200. https://doi.org/10.5281/zenodo.13680326

DAUGNORA L. & THOMAS R. 2005. — Horse burials from Middle Lithuania: a palaeopathological investigation, *in* DAVIES J., FABIŠ M., MAINLAND I., RICHARDS M. & THOMAS R. (eds), *Diet and health in past animal populations: Current research and future directions. Proceeding of the 9th ICAZ Conference, Durham, 2002*. Oxbow Books, Oxford: 68-74.

DIEDRICH C. G. 2017. — Pathologic historic mining horses from central Europe. *Journal of Pathology and Disease Biology* 1 (1): 8-33.

DRESLEROVÁ G. 2014. — Nemilany – hroby koní – archeozoologická analýza, *in* PŘICHYSTALOVÁ R. & KALÁBEK M. (eds), *Raněstředověké pohřebiště Olomouc – Nemilany: Katalog*. Masarykova univerzita, Brno: 175-189.

DRESLEROVÁ G. 2018. — *Sociální a ekonomická stratifikace velkomoravského centra na základě archeozoologických analýz / Social and Economic Stratification of the Great Moravian Center on the Basis of Archaeozoological Analyzes*. PhD thesis, Department of Archaeology and Museology, Masaryk University, Brno, 206 p. [in Czech].

DRESLEROVÁ G. 2020. — Zvířecí kosti a kostry z raně středověkého sídliště v Brně-Medlánkách / Animal bones and skeletons from the early medieval settlement in Brno-Medlánky [in Czech]. *Přehled výzkumů* 61 (2): 43-52. https://doi.org/10.47382/pv0612-03

DVOŘÁKOVÁ D. 2007. — *Koň a človek v stredoveku. K spolužitiu človeka a koňa v Uhorskom kralovstve*. Rak, Budmerice, 293 p.

DYSON S. J. 2011. — The distal phalanx and distal interphalangeal joint, *in* ROSS M. W. & DYSON S. J. (eds), *Diagnosis and Management of Lameness in the Horse*. Elsevier, St. Louis: 349-366.

EISENMANN V. 2009. — *Withers Height Estimations* [online]. https://vera-eisenmann.com/withers-height-estimations?lang=en, last consultation on 22 October 2024.

EISENMANN V. & BECKOUCHE S. 1986. — Identification and discrimination of metapodials from Pleistocene and modern *Equus*, wild and domestic, *in* MEADOW R. H. & UERPMANN H. P. (eds), *Equids in the Ancient World*. Vol. 2. Dr. Ludwig Reichert Verlag, Wiesbaden: 117-163.

ENGILES J. B., GALANTINO-HOMER H. L., BOSTON R., MCDONALD D., DISHOWITZ M. & HANKENSON K. D. 2015. — Osteopathology in the equine distal phalanx associated with the development and progression of laminitis. *Veterinary Pathology* 52 (5): 928-944. https://doi.org/10.1177/0300985815588604

Erban Kochergina Y. V., Erban V., Novák M. & Štěpanová M. 2021. — ^{87}Sr/^{86}Sr isotope ratios in trees as an archaeological tracer: limitations of linking plant-biomass and bedrock Sr isotope signatures. *Journal of Archaeological Science* 133 (105438). https://doi.org/10.1016/j.jas.2021.105438

Erban Kochergina Y. V., Erban V. & Hora J. M. 2022. — Sample preparation and chromatographic separation for Sr, Nd, and Pb isotope analysis in geological, environmental, and archaeological samples. *Journal of Geosciences* 67 (3): 273-285. https://doi.org/10.3190/jgeosci.357

Erban Kochergina Y. V., Pavlousek P., Sanda M. & Hora J. M. 2024. — ^{87}Sr/^{86}Sr isotopic composition of wine: uses and limitations. *Oeno One* 58 (2). https://doi.org/10.20870/oeno-one.2024.58.2.7451

Fasora L. & Malíř J. (eds) 2020. — *Dějiny Brna 4: Modernizace města 1790-1918*. Archiv města Brna, Brno, 1283 p.

Girodroux M., Dyson S. & Murray R. 2009. — Osteoarthritis of the thoracolumbar synovial intervertebral articulations: clinical and radiographic features in 77 horses with poor performance and back pain. *Equine Veterinary Journal* 41 (2): 130-138. https://doi.org/10.2746/042516408X345099

Gladitz C. 1997. — *Horse Breeding in the Medieval World*. Four Courts Press, Dublin, Portland, 356 p.

Hanot P. & Bochaton C. 2018. — New osteological criteria for the identification of domestic horses, donkeys and their hybrids in archaeological contexts. *Journal of Archaeological Science* 94: 12-20. https://doi.org/10.1016/j.jas.2018.03.012

Haussler K. K. 2018. — Osseous and soft tissue pathology of the thoracolumbar spine and pelvic region, *in Proceeding of the 360°: Back Pain and Pelvic Dysfunction Meeting, June 3-6, Fort Collins*. American Association of Equine Practitioners, Lexington, 9 p.

Henson M. D. F. 2009. — *Equine Back Pathology: Diagnosis and Treatment*. Blackwell Publishing, Oxford, 266 p.

Hope K. A., Stover S. M., Pascoe J. R. & Amundson R. 2004. — Tooth enamel biomineralization in extant horses: implications for isotopic microsampling. *Palaeogeography, Palaeoclimatology, Palaeoecology* 206 (3-4): 355-365. https://doi.org/10.1016/j.palaeo.2004.01.012

Jan L. (ed.) 2014. — *Dějiny Brna* 2. *Středověké město*. Archiv města Brna, Brno, 1160 p.

Janeczek M., Chroszcz A., Onar V., Henklewski R., Piekalski J., Duma P., Czerski A. & Calkosinski I. 2012. — Anatomical and biomechanical aspects of the horse spine: the interpretation of vertebral fusion in a Medieval horse from Wroclaw (Poland). *International Journal of Osteoarcheology* 24 (5): 623-633. https://doi.org/10.1002/oa.2248

Janoušek V., Hanžl P., Svojtka M., Hora M. H., Erban Kochergina Y. V., Gadas P., Holub F. V., Gerdes A., Verner K., Hrdličková K., Daly S. & Buriánek D. 2020. — Ultrapotassic magmatism at the hay day of the Variscan Orogeny – the story of the Třebíč Pluton, the largest durbachitic body in the Bohemian Massif. *International Journal of Earth Sciences* 109: 1767-1810. https://doi.org/10.1007/s00531-020-01872-2

Janoušek, V., Erban Kochergina Y. V., Andronikov A. & Kusbach V. 2022. — Decoupling of Mg from Sr–Nd isotopic compositions in Variscan subduction-related plutonic rocks from the Bohemian Massif: implications for mantle enrichment processes and genesis of orogenic ultrapotassic magmatic rocks. *International Journal of Earth Sciences* 111 (5): 1491-1518. https://doi.org/10.1007/s00531-022-02199-w

Johnson P. J., Wiedmeyer C. E. & Ganjam V. K. 2010. — Laminitis and the equine metabolic syndrome. *Veterinary Clinics of North America: Equine Practice* 26 (2): 239-255. https://doi.org/10.1016/j.cveq.2010.04.004

Klide A. M. 1989. — Overriding vertebral spinous processes in the extinct horse, *Equus occidentalis*. *American Journal of Veterinary Research* 50 (4): 592-593.

Klontza-Jaklová V., Panagiotakis N., Tengeriová R, Smíšek M., Fernandes R. & Klontzas M. 2023. — The Cretan horse: dtill a unique breed? Part I, Equines on Crete from the Neolithic to the Ottoman Period. *Cheiron: The International Journal of Equine and Equestrian History* 3 (2): 113-182. https://doi.org/10.22618/TP.Cheiron.20233.2.216005

Komosa M., Włodarek J., Dzierzęcka M., Nienartowicz-Zdrojewska A. & Tołkacz M. 2018. — Comparison of pathological lesions in navicular bone (*os sesamoideum distale*) and analysis of remodelling capacity in warmblood and coldblood horses. *Polish Journal of Veterinary Sciences* 21 (1): 13-27. https://doi.org/10.24425/119017

Kowalski T. 2022. — *Ibrahim ibn Yaqub's Account of His Travel to Salvic Countries as Transmitted by Al-Bakri. With Contemporary Commentaries edited by Mustafa Switat*. Peter Lang (Studies in East Asian literatures and cultures; 7), Berlin, 194 p.

Kratochvíl Z. 1969. — *Die Tiere des Burgwalles Pohansko*. Academia, Praha, 39 p.

Kyselý R. 2003. — Savci (Mammalia) z raně středověkého hradu Stará Boleslav (střední Čechy), *in* Boháčová I. (ed.), *Stará Boleslav. Přemyslovský hrad v raném středověku*. Archeologický ústav AV ČR (Mediaevalia archaeologica; 5), Praha: 311-334.

Kyselý R. 2004. — Zvířecí kosti z archeologických výzkumů na Vyšehradě, *in* Nechvátal B. (ed.), *Kapitulní chrám svatého Petra a Pavla na Vyšehradě – Archeologický výzkum*. Archeologický ústav AV ČR, Praha: 478-577.

León A. & Murillo J. F. 2014. — Advances in research on Islamic Cordoba. *Journal of Islamic Archaeology* 1 (1): 5-35. https://doi.org/10.1558/jia.v1i1.5

Levine M. A. 1982. — The use of crown height measurements and eruption–wear sequences to age horse teeth, *in* Wilson B., Grigson C. & Payne S. (eds), *Ageing and Sexing Animal Bones from Archaeological Sites*. BAR Publishing (BAR British Series; 109), Oxford: 223-250.

Levine M. 1999. — The origins of horse husbandry on the Eurasian steppe, *in* Levine M. A., Rassamakin Y. Y., Kislenko A. M. & Tatarintseva N. S. (eds), *Late Prehistoric Exploitation of Eurasian Steppe*. McDonald institute, Cambridge: 5-58.

Levine M., Whitwell K. & Jeffcott L. B. 2005. — Abnormal thoracic vertebrae and the evolution of horse husbandry. *Archaeofauna* 14: 93-109.

Li Y., Zhang C., Taylor W. T. T., Chen L., Flad R. K., Boivin N., Liu H., You Y., Wang J., Ren M., Xi T., Han Y., Wen R. & Ma J. 2020. — Early evidence for mounted horseback riding in northwest China. *Proceedings of the National Academy of Sciences* 117 (47): 29569-29576. https://doi.org/10.1073/pnas.2004360117

Librado P., Khan N., Fages A., Kusliy M. A., Suchan T., Tonasso-Calvière L., Schiavinato S., Alioglu D., Fromentier A., Perdereau A., Aury J.-M., Gaunitz C., Chauvey L., Seguin-Orlando A., Der Sarkissian C., Southon J., Shapiro B., Tishkin A. A., Kovalev A. A., Alquraishi S., Alfarhan A. H., Al-Rasheid K. A. S., Seregély T., Klassen L., Iversen R., Bignon-Lau O., Bodu P., Olive M., Castel J.-C., Boudadi-Maligne M., Alvarez N., Germonpré M., Moskal-del Hoyo M., Wilczyński J., Pospuła S., Lasota-Kuś A., Tunia K., Nowak M., Rannamäe E., Saarma U., Boeskorov G., Lõugas L., Kyselý R., Peške L., Bălășescu A., Dumitrașcu V., Dobrescu R., Gerber D., Kiss V., Szécsényi-Nagy A., Mende B. G., Gallina Z., Somogyi K., Kulcsár G., Gál E., Bendrey R., Allentoft M. E., Sirbu G., Dergachev V., Shephard H., Tomadini N., Grouard S., Kasparov A., Basilyan A. E., Anisimov M. A., Nikolskiy P. A., Pavlova E. Y., Pitulko V., Brem G., Wallner B., Schwall C., Keller M., Kitagawa K., Bessudnov A. N., Bessudnov A., Taylor W., Magail J., Gantulga J.-O., Bayarsaikhan J., Erdenebaatar D., Tabaldiev K., Mijiddorj E., Boldgiv B., Tsagaan T., Pruvost M., Olsen S., Makarewicz C. A., Valenzuela Lamas S., Albizuri Canadell S., Nieto Espinet A., Iborra M. P., Lira Garrido J., Rodríguez González E., Celestino S., Olària C., Arsuaga J. L., Kotova N., Pryor A., Crabtree P., Zhumatayev R., Toleubaev A., Morgunova N. L., Kuznetsova T., Lordkipanize D., Marzullo M., Prato O., Bagnasco Gianni G., Tecchiati U., Clavel B., Lepetz S., Davoudi H., Mashkour M., Berezina N. Y., Stockhammer P. W., Krause J., Haak W., Morales-Muñiz A., Benecke N., Hofreiter M., Ludwig A., Graphodatsky A. S., Peters J., Kiryushin K. Y., Iderkhangai T.-O., Bokovenko N. A., Vasiliev S. K., Seregin N. N., Chugunov K. V., Plasteeva N. A., Baryshnikov G. F., Petrova E., Sablin M., Ananyevskaya E., Logvin A., Shevnina I., Logvin V., Kalieva S., Loman V., Kukushkin I., Merz I., Merz V., Sakenov S., Varfolomeyev V., Usmanova E., Zaibert V., Arbuckle B., Belinskiy A. B., Kalmykov A., Reinhold S., Hansen S., Yudin A. I., Vybornov A. A., Epimakhov A., Berezina N. S., Roslyakova N., Kosintsev P. A., Kuznetsov P. F., Anthony D., Kroonen G. J., Kristiansen K., Wincker P., Outram A. & Orlando L. 2021. — The origins and spread of domestic horses from the Western Eurasian steppes. *Nature* 598 (7882): 634-640. https://doi.org/10.1038/s41586-021-04018-9

Lignereux Y. & Bouet C. 2015. — Spinal hyperostosis and ankylosis in a Gallo-Roman horse from Iwuy 'Val-de-Calvigny' (Nord, France): 'Ankylosing spondylarthritis' (*spondylarthritis ankylopoetica*), 'deforming spondylarthrosis' (*spondylarthrosis deformans*) or 'DISH' (*hyperostosis vertebralis ankylopoetica*)? An archeozoological and comparative nosological review. *International Journal of Paleopathololog*y 9: 38-51. https://doi.org/10.1016/j.ijpp.2014.12.002

Mach K., Rapprich V., Faměra M., Matys Grygar T., Novotný T., Řehoř T. & Erban Kochergina Y. V. 2021. — Crandallite-rich beds of the Libkovice Member, Most Basin, Czech Republic: climatic extremes or paleogeographic changes at the onset of the Miocene Climatic Optimum? *Geologica Acta* 19 (11): 1-29. https://doi.org/10.1344/GeologicaActa2021.19.11

Makowiecki D., Janeczek M., Pasicka E., Rozwadowska A., Ciaputa R. & Kocińska M. K. 2022. — Pathologies of a horse skeleton from the early medieval stronghold in Gdansk (Poland). *International Journal of Osteoarcheology* 32 (4): 866-877. https://doi.org/10.1002/oa.3114

Marković N., Stevanović O., Nešić V., Marinković D., Krstić N., Nedeljković D., Radmanović D. & Janeczek M. 2014. — Palaeopathological study of cattle and horse bone remains of the Ancient Roman city of Sirmium (Pannonia/Serbia). *Revue de Médecine Vétérinaire* 165 (34): 77-88.

Marković N., Janeczek M., Marinković D., Stevanović O., Krstić N., Petrujkić K. & Trailović R. 2015. — Paleopathological and radiological examination of the Avar period horse bones from central Balkans (Serbia). *Medycyna Weterynaryjna* 71 (10): 619-625.

Marković N., Stevanović O., Krstić N., Marinković D. & Buckley M. 2019. — A case study of vertebral fusion in a 19th-century horse from Serbia. *International Journal of Paleopathology* 27: 17-23. https://doi.org/10.1016/j.ijpp.2019.07.007

May E. 1985. — Widerristhöhe und Langknochenmasse bei Pferden – ein immer noch aktuelles Problem. *Zeitschrift fur Saugetierkunde* 50: 368-382.

Mayaki A. M., Intan-Shameha A. R., Noraniza M. A., Mazlina M., Adamu L. & Abdullah R. 2019. — Clinical investigation of back disorders in horses: a retrospective study (2002-2017). *Veterinary World* 12 (3): 377-381. https://doi.org/10.14202/vetworld.2019.377-381

Měchurová Z. 1981. — Kůň tažný a jezdecký v raném středověku. Das Zug- unf Reitpferd im frühen Mittelalter. Časopis Moravského Muzea – Vědy společenské. *Acta Musei Moraviae – Sciente Sociales* 66: 75-91.

Meijer M. C. & Rijkenhuizen A. B. 1999. — Navicular disease in the hind limb of a Warmblood horse. *Tijdschr Diergeneeskd* 124 (18): 536-538.

Misař D. 2011. — *Vývoj chovu koní v Čechách, na Moravě a na Slovensku*. Brázda, Praha: 360 p.

Mitáček J. & Procházka R. (eds) 2017. — *Modřice. Dějiny města*. Vlastivědná knihovna moravská, Brno, 887 p.

Morrisson C. & Cheynet J.-C. 2002. — Prices and wages in the Byzantine world, *in* Laiou A. (ed.), *The Economic History of Byzantium. From the Seventh through the Fifteenth century*. Vol. I. Dumbarton Oaks Research Library and Collection, Washington D. C.: 799-862.

Müller H.-H. 1985. — *Frühgeschichtliche Pferdeskelettfunde im Gebiet der Deutschen Demokratischen Republik. Beiträge zur Archäozoologie IV*. Weimarer monographien zur ur- und Frühgeschichte, Weimar, 79 p.

Mysliveček J., Rapprich V., Kochergina Y. V., Magna T., Halodová P., Pécskay Z. & Poňavič M. 2018. — Petrology of weakly differentiated alkaline, high-level intrusive rocks in the Zahořany-Chotiněves Belt near Litoměřice (Czech Republic). *Journal of Geosciences* 63 (4): 317-331. https://doi.org/10.3190/jgeosci.278

Nacarino-Meneses C., Jordana X. & Köhler M. 2016. — First approach to bone histology and skeletochronology of *Equus hemionus*, *in* Laurin M. & Cubo J. (eds), Progrès récents en paléohistologie : un hommage à une génération de paléohistologistes français. *Comptes Rendus Palevol* 15 (1-2): 267-277. https://doi.org/10.1016/j.crpv.2015.02.005

Nádaskay R., Kochergina Y. V., Čech S., Švábeniská L., Valečka J., Erban V., Halodová P. & Čejková B. 2019. — Integrated stratigraphy of an offshore environment influenced by intense siliciclastic supply: implications for Coniacian tectono-sedimentary evolution of the West Sudetic area (NW Bohemian Cretaceous Basin, Czech Republic). *Cretaceous Research* 102: 127-159. https://doi.org/10.1016/j.cretres.2019.06.005

Novák M., Holmden Ch., Farkaš J., Kram P, Hruska J., Curik J., Veselovsky F., Stepanova M., Kochergina Y. V., Erban V., Fottova D., Simecek M., Bohdalkova L., Prechova E., Voldrichova P. & Cernohous V. 2020. — Calcium and strontium isotope dynamics in three polluted forest ecosystems of the Czech Republic, Central Europe. *Chemical Geology* 536: 119472. https://doi.org/10.1016/j.chemgeo.2020.119472

Novák M., Andronikov A.v., Holmden C., Erban Kochergina Y. V., Veselovský F., Pačes T., Vítková M., Kachlík V., Šebek O., Hruška J., Štěpánová M., Čuřík J., Přechová E., Fottová D., Andronikova I. E., Erban V., Koubová M., Vostrá I., Housková M. & Komárek A. 2023. — δ^{26}Mg, δ^{44}Ca and ^{87}Sr/^{86}Sr isotope differences among bedrock minerals constrain runoff generation in headwater catchments: an acidified granitic site in Central Europe as an example. *Catena* 221 (A): 106780. https://doi.org/10.1016/j.catena.2022.106780

Onar V., Alpak H., Pazvant G., Armutak A. & Chrószcz A. 2012. — Byzantine horse skeletons of Theodosius harbour. 1, Paleopathology. *Revue de Médecine Vétérinaire* 163 (3): 139-146.

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

Pischinger A. 2007. — *The Extracellular Matrix and Ground Regulation: Basis for a Holistic Biological Medicine*. North Atlantic Books, Berkley, 232 p.

Piličiauskienė G., Kurila L., Ežerinskis Ž., Šapolaite J., Garbaras A., Zagurskytė A. & Micelicaitė V. 2022. — Horses in Lithuania in the Late Roman – Medieval Period (3rd-14th C AD) burial sites: updates on size, age and dating. *Animals* 12 (12): 1549. https://doi.org/10.3390/ani12121549

Procházka R. (ed.) 2011. — *Dějiny Brna 1. Od pravěku k ranému středověku*. Statutární město Brno, Archiv města Brna, Brno, 735 p.

Rapprich V., Čáp, P., Erban Kochergina Y. V., Kadlecová E., Benkó Z., Sakala J., Rodovská Z., Matějů J. & Petrash D. A. 2023. — Interactions between distal epiclastic and biochemogenic sedimentation at the foothills of a mafic alkaline volcano: the case of the Oligocene Doupovské Hory Volcanic Complex (Czech Republic). *The Depositional Record* 9 (4): 871-894. https://doi.org/10.1002/dep2.240

Rooney J. R. 1997. — Equid paleopathology. *Journal of Equine Veterinary Science* 17 (8): 430-446. https://doi.org/10.1016/S0737-0806(97)80160-8

Salmi A.-K. & Niinimäki S. 2016. — Entheseal changes and pathological lesions in draught reindeer skeletons – four case studies from present-day Siberia. *International Journal of Paleopathology* 14: 91-99. https://doi.org/10.1016/j.ijpp.2016.05.012

Silver I. A. 1969. — The ageing of domestic animals, *in* Brothwell E. & Higgs E. (eds), *Science in Archaeology*. Thames & Hudson, London: 283-302.

Simpson G. G., Roe A. & Lewontin R. C. 1960. — *Quantitative Zoology*. Harcourt Brace, New York, 440 p.

Sisson S. 1914. — *The Anatomy of the Domestic Animals*. W. B. Saunders company, Philadelphia, London, 930 p.

Smíšek M., Klontza-Jaklova V. & Tengeriová R. 2023-2024. — *Equine Biometry from Medieval and Modern sites in the Czech Republic* [online]. https://www.doi.org/10.48493/c8ck-y827

Strasser H. & Kells S. 2001. — *The Hoofcare Specialist's Handbook: Hoof Orthopedics and Holistic Rehabilitation*. Sabine Kells, Qualicum Beach, 800 p.

Taylor W. T. T., Bayarsaikhan J. & Tuvshinjargal T. 2015. — Equine cranial morphology and the identification of riding and chariotry in late Bronze Age Mongolia. *Antiquity* 89 (346): 854-871. https://doi.org/10.15184/aqy.2015.76

Taylor W. T. T. & Tuvshinjargal T. 2018. — Horseback riding, asymmetry, and changes to the equine skull: evidence for mounted riding in Mongolia's Late Bronze Age, *in* Bartosiewicz L. & Gál E. (eds), *Care or Neglected? Evidence of Animal Disease in Archaeology*. Oxbow, Oxford: 134-154.

Ulrych J., Dostal J., Adamovič J., Jelínek E., Špaček P., Hegner E. & Balogh K. 2011. — Recurrent Cenozoic volcanic activity in the Bohemian Massif (Czech Republic). *Lithos* 123 (1-4): 133-144. https://doi.org/10.1016/j.lithos.2010.12.008

Van de Pol C. & Van Oldruitenborgh-Oosterbaan S. 2007. — Measuring the height of ponies at the withers: influence of time of day, water and feed withdrawal, weight-carrying, exercise and sedation. *The Veterinary Journal* 174 (1): 69-76. https://doi.org/10.1016/j.tvjl.2006.10.023

Von den Driesch A. 1976. — *A Guide to the Measurement of Animal Bones from Archaeological Sites*. Harvard University Press (Bulletin of the Peabody Museum of Archaeology and Ethnology; 1), Cambridge MA, 136 p.

Wallett L. A. 2013. — Laminitic paleopathology: evidence from the fossil record of *Equus*. *Journal of Equine Veterinary Science* 33 (10): 840. https://doi.org/10.1016/j.jevs.2013.08.007

Walther D., Breitkreuz C., Rapprich V., Kochergina Y. E., Chlupáčová M., Lapp M., Stanek K. & Magna T. 2016. — The Late Carboniferous Schönfeld-Altenberg Depression on the NW margin of the Bohemian Massif (Germany/Czech Republic): volcanosedimentary and magmatic evolution. *Journal of Geosciences* 61 (4): 371-393. https://doi.org/10.3190/jgeosci.219

Waroszewski J., Pietranik A., Sprafke T., Kabała C., Frechen M., Jary Z., Kot A., Tsukamoto S., Meyer-Heintze S., Krawczyk M., Łabaz B., Schultz B. & Erban Kochergina Y. V. 2021. — Provenance and paleoenvironmental context of the Late Pleistocene thin aeolian silt mantles in south-west Poland – a widespread parent material for soils. *Catena* 204: 105377. https://doi.org/10.1016/j.catena.2021.105377

Wiliňski K. 1979. — Ceni koni w Polsce średniowiecznej. Acta universitatis Losziensis. Zeszyty naukowe Universztetu Lódzkiego. *Nauki humanysztyczno-spoleczenske. Seria I, Zeszyt* 57: 75-110.

Zůbek A. 2022. — *Nálezová zpráva o provedení záchranného archeologického výzkumu při stavbě "Palác Trnitá"* [*Field report on rescue excavation on "Palác Trnitá" construction*]. Report number: A59/2018. Archive of Archaia Brno, z. ú., Brno.

Submitted on 11 December 2023;
accepted on 9 July 2024;
published on 8 November 2024.