Horse size and domestication: Early equid bones from the Czech Republic in the European context

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ABSTRACT
We collected and evaluated, by the 'logarithmic size index' (LSI) method, all available postcranial equid bones found in the Czech Republic from the Neolithic to the Early Bronze Age. Material from the Upper Paleolithic (Magdalenien) and Bohemian Late Bronze Age (Knovíz culture) was also included. Two different species of equids were documented: *Equus hydruntinus* Regalia, 1907 and *Equus ferus* Boddaert, 1785. The variation in the size of true horses was compared with data published for neighbouring countries. In most periods, the horses are found to be larger in the eastern part of Central Europe than in the western part. The Czech lands appear to span the border of two worlds: the Pannonian plains and the western, geomorphologically diverse regions. The status of horses in the Neolithic Lengyel period from Moravia remains disputable. However, a high size variability in Eneolithic Funnel Beaker culture (TRB, 3800-3350 BC) together with a non-homogeneous distribution in Řivnáč culture (3100-2800 BC) and a significant increase in size between Lengyel and Baden-Řivnáč horizons (probably already in TRB) combined with the occasional occurrence of unexpectedly large individuals probably indicate the importation of tamed or even domesticated horses as early as the times of TRB culture, which is earlier than claimed in other recent studies, and possibly reflect multiple origins of the horse population. The large variability and repeated diminution in size of horses in the Early Bronze Age (Únětice culture, 2200-1700 BC) could indicate advanced domestication or multiple origins of the populations (or both). The persistence of wild horses in the Early Bronze Age cannot be proved osteometrically, but the presence of domesticated horses is considered certain.

KEY WORDS
Horse (*Equus*),
E. hydruntinus,
osteometry,
domestication,
Czech Republic,
Bohemia,
Neolithic,
Copper Age,
Bronze Age,
LSI.

RÉSUMÉ

La taille et la domestication des chevaux : ossements équins préhistoriques de République Tchèque dans le contexte Européen.

Nous avons collecté et évalué par la méthode LSI (index détaillé logarithmique) tous les ossements équins postcraniaux retrouvés en République Tchèque depuis le Néolithique jusqu'à l'Âge du Bronze. Les matériaux du Paléolithique Supérieur (magdalénien) et de l'Âge du Bronze Récent (culture Knoviz) ont également été inclus. Deux espèces différentes d'équidés ont été étudiées : *Equus hydruntinus* Regalia, 1907 et *Equus ferus* Boddaert, 1785. La variation dans la taille des 'vrais' chevaux a été comparée avec les données publiées pour les pays voisins. Dans la majorité des périodes, les chevaux étaient plus grands dans la partie est de l'Europe Centrale que dans sa partie ouest. Les régions Tchèques semblent couvrir les frontières de deux mondes : les plaines du Pannonien et les régions ouest à géomorphologies variées. Le statut des chevaux de la période du Néolithique Lengyel reste discutable. Néanmoins, une grande variabilité de taille dans la culture chalcolithique des gobelets en entonnoir (TRB, 3800-3350 av. J.-C.) associée à une distribution non homogène dans la culture Řivnáč (3100-2800 av. J.-C.) et une augmentation significative de la taille entre les horizons Lengyel et Baden-Řivnáč (probablement déjà en TRB), combinée à une présence occasionnelle d'individus étonnamment grands, semble indiquer l'importation de chevaux apprivoisés ou même domestiqués dès la période de la culture TRB, ce qui est antérieur à ce qui est affirmé dans d'autres études récentes et reflète peut-être des origines multiples de la population de chevaux. L'importante variabilité et la diminution répétée de la taille des chevaux de l'Âge du Bronze Ancien (culture d'Únětice, 2200-1700 av. J.-C.) pourraient indiquer une domestication avancée, ou bien des origines multiples des populations (ou les deux). La persistence de chevaux sauvages dans l'Âge du Bronze Ancien ne peut pas être prouvée de facon osteométrique, mais la présence de chevaux domestiqués peut être considérée comme certaine.

MOTS CLÉS
Cheval (*Equus*), *E. hydruntinus*, osteométrie, domestication, République Tchèque, Bohême, Néolithique, Chalcolithique, Âge du Bronze, LSI.

INTRODUCTION

The Czech Republic is divided into Bohemia (west) and Moravia (east). We apply the regional terminology on archaeological chronology taken from Jiráň & Venclová (2013). For the inter-regional synchronisation of cultures, the definition of periods, and absolute dating see Table 1.

Context and aim of the study

The history of equids, including the occurrence of the first domesticated forms (*Equus caballus* Linnaeus, 1758) in Central Europe, the history of its wild ancestor (*Equus ferus* Boddaert, 1785) and the presence of *Equus hydruntinus* Regalia, 1907 in Holocene Europe, has proved an elusive subject for dozens of authors over many decades. In central Europe, the Neolithic introduction of the main domestic species and the propagation of the domestication idea are usually combined. Theoretically, the earliest attempts at horse domestication could have occurred before 3500 BC (calibrated dating is always used in the study), which is the earliest date from which reliable evidence is available (Botai, Kazakhstan; Anthony 2007; Outram *et al.* 2009). Domestic horses are largely thought to have originated in the eastern steppes (eastern Europe, central Asia), but the existence of the skills necessary for domestication and the probable existence of local wild populations also made local domestication possible in other areas of Europe. Archaeozoological analyses, as well as analyses of DNA, support the survival of western and central European wild horse populations into the early/mid Holocene (e.g., Liesau 2005; Sommer *et al.* 2011). Local domestication in western Europe was proposed by current studies based on DNA (Warmuth *et al.* 2011; Achilli *et al.* 2012). We recall that the domestication process had gone through several stages before reaching full domestication (Zeuner 1963). Despite the fact that the centre of domestication is mainly seen in the eastern steppes, we accept that some stages of the domestication process (at least early taming) also appeared very early in Central Europe.

Within Central Europe, Bökönyi (1978, 1993), Uerpmann (1990, 1995) and Benecke (1999, 2002, 2006) are the principal authors to have published archaeozoological analyses on this subject. Further reports have been published by Milisauskas *et al.* (2006), Pucher (2006), Steppan (2006), and Czeika (2010, 2013); other recent papers also relate to this topic (e.g., Sommer *et al.* 2011; Bendrey 2012). Equid bones are rarely found in the Czech Neolithic and Eneolithic (Chalcolithic), and very few data have so far been published (Peške 1986, 1989).

This study presents a comparison in terms of size and chronology of all available postcranial bones of equids from the Czech territories from the Neolithic to the Early Bronze Age. The wider geographical context (see Discussion) and the related ecological and ethological aspects are also taken into account. New evidence from the central European region, situated between the homelands of eastern and western equid forms, together with existing results and theories on domestication, can deepen our knowledge of early horse domestication and breeding.

TABLE 1. — Schematic and simplified synchronisation of the cultures in Central Europe (based mainly on Neustupný 1969; Burger 1988; Glass 1991; Matuschik 1992; Buchvaldek *et al.* 2007). Dating and chronology within the Czech Republic updated according to Jiráň & Venclová (2013). Period codes correspond to other Tables and Figures. Periodisation and cultures in the Czech region shaded. Abbrevations: **GAC**, Globular Amphora c.; **MPC**, Moravian Painted c.; **TRB**, Funnel Beaker c.

Absolute dating of the beginning of the period cal. BC (for CR)	Period code	Periodisation in the Czech Republic (CR)		Period, culture (culture phase) [alternative acronym of the culture]						
		Period	Subperiod	Bohemia	Moravia (+ W Slovakia)	N-E/central Germany	S-E Germany (Bavaria)	Austria	Poland	Hungary
	1	Paleolithic, Mesolithic		Paleolithic, Mesolithic	Paleolithic, Mesolithic	Paleolithic, Mesolithic	Paleolithic, Mesolithic	Paleolithic, Mesolithic	Paleolithic, Mesolithic	Paleolithic, Mesolithic
5600	2	Neolithic	Early	Linear Pottery [LBK]	Linear Pottery [LBK]	Linear Pottery [LBK]	Linear Pottery [LBK]	Linear Pottery [LBK]	Linear Pottery [LBK]	Linear Pottery [LBK], Sopot
5000	2	Neolithic	Late	Stroked Pottery [STK]	Stroked Pottery [STK]	Stroked Pottery [STK]	Stroked Pottery [STK]	Stroked Pottery [STK]	Stroked Pottery [STK]	Lengyel
4800	3	Neolithic	Late	Stroked Pottery [STK]	Lengyel (I-II)/ MPC (I)	Rössen	Oberlauterbach	Lengyel	Stroked Pottery [STK]	Lengyel, Tisza
4500	4	Eneolithic	Proto-	Lengyel (IV)/ MPC (IIb)	Lengyel (III-IV)/ MPC (II)	Gatersleben, Michelsberg	Münchshöfen	Lengyel	Lengyel, Brześć Kujawski	Lengyel, Tisza
4200	5	Eneolithic	Proto-	Jordanów, Schussenried, Michelsberg	Jordanów (+ Lengyel IV)	TRB, Gatersleben, Michelsberg, Jordanów	Münchshöfen	Münchshöfen, Lengyel IIc	Lengyel, Brześć Kujawski	Tiszapolgar
3800	6	Eneolithic	Early	TRB (Baalberge, Siřem)	TRB (Baalberge)	TRB (Baalberge)	Altheim	TRB, Mondsee	TRB	Bodrogkeresztúr, Proto-Boleráz
3500	6, 7	Eneolithic	Early	TRB (Salzmünde), Boleráz	Baden, Jevišovice C, Boleráz	TRB (Salzmünde)	Altheim	TRB, Mondsee	TRB	Boleráz
3350	8	Eneolithic	Middle	Baden (classical)	Baden	TRB (Salzmünde)	Altheim	TRB, Mondsee	TRB, Boleráz	Baden
3200	8	Eneolithic	Middle	Řivnáč, GAC, Cham	Baden, Jevišovice B	GAC, Bernburg	Cham	Cham, Mondsee, Jevišovice	TRB, Baden, GAC	Baden, Kostolac, Vučedol
2800	9	Eneolithic	Late	Corded Ware	Corded Ware	Corded Ware	Corded Ware	Corded Ware	Corded Ware	Kosihy-Čaka-Makó, Vučedol
2400	9	Eneolithic	Late	Bell Beaker	Bell Beaker	Bell Beaker	Bell Beaker	Bell Beaker	Bell Beaker	Bell Beaker, Makó-Somogyvár-Vinkovici
2200	10	Bronze	Early	Únětice	Únětice, Nitra	Únětice	Straubing	Únětice, Straubing	Únětice, Mierzanowice	Nagyrév, Kisapostág, Makó

Ecological and ethological constraints of equids in the central European environment

Modern equids are not adapted to forest or bush ecosystems and inhabit open biotopes (Moehlman 2002). Caballoid horses are well adapted especially to extensive grasslands with relatively poor habitat quality and strong seasonal variations, and thus largely inhabit steppe biotopes (Boyd & Houpt 1994; Van Asperen 2010). Moravia is theoretically connected with the eastern steppe regions near the Black Sea through the Pannonia lowlands, while the western part of the Czech Republic, Bohemia, can be considered as an isolated basin surrounded by mountains or by the large highlands towards Moravia (Fig. 1). The persistence of and changes in horse populations are closely related to changes in vegetation cover, which is reflected by environmental indicators. Despite evidence of steppe elements in malacofauna and pollen spectra and other supporting evidence for steppes in some places (for the Czech territory see Ložek 1964, 1973, 1982, 2007; Pokorný 2004; Pokorný *et al.* 2015), in central European conditions the steppe indicators in the Mid-Holocene suggest small-scale patches dominated by ecotones rather than a continuous biotope. Moreover, indicators from these categories could persist in a small-grain landscape mosaic. In bone assemblages from the Neolithic onward, red deer is a dominant element in the region under examination, followed by wild boar, roe deer, aurochs and hare (Kyselý 2005) – mammals which together tend to indicate forests rather than large open areas. True steppe elements in avifauna occurred much later (Peške 1981). However, amelioration of the climate in the Preboreal and especially the warm and

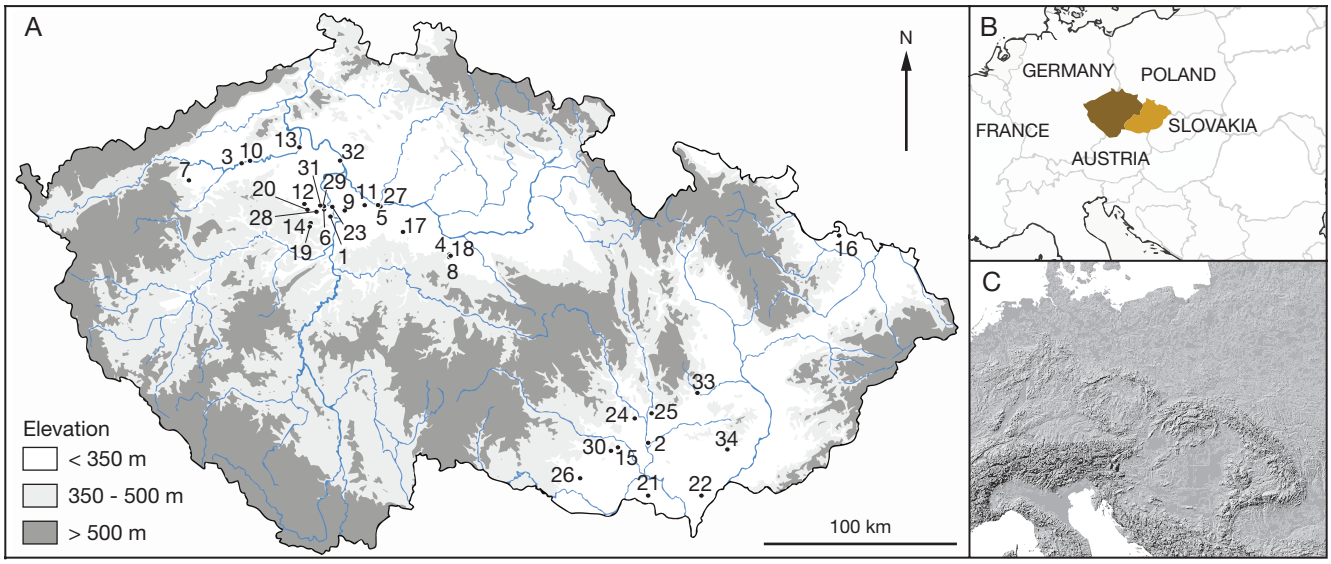

Fig. 1. — Map with Czech archaeological sites dated from the beginning of the Neolithic to EBA (Únětice c.) which provided equid bones. **A**, site locations, sorted alphabetically (chronological order in Table 2); **B**, position of the Czech Republic in Europe (**Bohemia**, dark area; **Moravia**, light area; **grey lines**, state borders); **C**, geomorphology of central Europe (http://open-data.europa.eu). Numbers: **1**, Baba (district Prague); **2**, Blučina-Cezavy; **3**, Březno; **4**, Bylany; **5**, Čelákovice; **6**, Černý Vůl; **7**, Chotěbudice; **8**, Cimburk, **9**, Ďáblice (distr. Prague); **10**, Dobroměřice; **11**, Dřevčice; **12**, Homolka; **13**, Hostěnice-Brozany; **14**, Hostivice; **15**, Jezeřany-Maršovice; **16**, Kobeřice; **17**, Kšely, **18**, Kutná Hora-Denemark; **19**, Litovice; **20**, Makotřasy; **21**, Mikulov-Jelení louka; **22**, Moravská Nová Ves; **23**, Roztoky; **24**, Starý Lískovec (distr. Brno); **25**, Stránská skála (distr. Brno); **26**, Těšetice-Kyjovice; **27**, Toušeň-Hradišťko; **28**, Tuchoměřice; **29**, Úholičky; **30**, Vedrovice; **31**, Velké Přílepy; **32**, Vlíněves; **33**, Vyškov; **34**, Žádovice.

Table 2. — List of all Bohemian and Moravian archaeological assemblages dated from the beginning of the Neolithic to Early Bronze Age, containing equid bones and teeth. Period codes correspond to other Tables and Figures, site numbers correspond to Fig. 1. Abbreviations: **abs.**, absent in other Tables and Figures (no metric data); **B**, Bohemia; **Baalb.**, Baalberge culture; **En.**, Eneolithic; **GAC**, Globular Amphora c.; **LBK**, Linear Pottery c.; **M**, Moravia; **MPC**, Moravian Painted c.; **Neol.**, Neolithic; **rev.**, revised; **STK**, Stroked Pottery c.; **TRB**, Funnel Beaker c.; *, incl. one *E. hydruntinus*; **, *E. hydruntinus* only; ***, see footnote 1.

Site number (cf. Fig. 1)	Site/sample	Region	Main period	Period code	Culture (phase), in detail	Number of equid bones used in the metric analysis/total found
30	Vedrovice	M	Neolithic	2	LBK (Ib)	1/2
4	Bylany	B	Neolithic	2	LBK (IIc)	1/1
26	Těšetice-Kyjovice	M	Neolithic	abs.	LBK (Ib-IIb)	0/3*
6	Černý Vůl	B	Neolithic	2	cf. LBK (IIc/IIIa)	1/2
7	Chotěbudice	B	Neolithic	2	LBK	2*/2
21	Mikulov-Jelení louka	M	Neolithic	2	LBK	3**/3
6	Černý Vůl	B	Neolithic	abs.	LBK+STK	0/2
23	Roztoky	B	Neolithic	abs.	STK	0/7
26	Těšetice-Kyjovice	M	Neolithic	3	Lengyel (early)/MPC (Ia)	31/57*
16	Kobeřice	M	Neol./Eneolithic	abs.	Lengyel/Eneolithic	0/1
15	Jezeřany-Maršovice	M	Proto-Eneolithic	abs.	Lengyel/MPC (IIb)	0/1
23	Roztoky	B	Proto-Eneolithic	abs.	Lengyel (late, IV)	0/9
3	Březno	B	Proto-Eneolithic	abs.	Lengyel (late, IV)	0/1
5	Čelákovice	B	Proto-Eneolithic	4	Lengyel (late, IV)	2/3
11	Dřevčice	B	Proto-Eneolithic	abs.	Lengyel (late, IV)	0/4
17	Kšely	B	Proto-Eneolithic	abs.	Jordanów (early)	0/1
28	Tuchoměřice	B	Proto-Eneolithic	5	Jordanów (early)	0/1
9	Ďáblice (K Letňanům)	B	Proto-Eneolithic	5	Jordanów (late)	1/1
9	Ďáblice (Legionářů)	B	Proto-/Early En.	5	Jordanów (late)/TRB	1/1
8	Cimburk	B	Early Eneolithic	6	TRB (Baalberge)	7/11
19	Litovice (Jeneček)	B	Early Eneolithic	abs.	TRB (Baalberge)	0/3
20	Makotřasy	B	Early Eneolithic	6	TRB (Siřem)	5/14
13	Hostěnice-Brozany	B	Early Eneolithic	6	TRB (Salzmünde)	1/2
10	Dobroměřice	B	Early Eneolithic	6	TRB	1/1
14	Hostivice (Sadová)	B	Early Eneolithic	6	TRB	1/1
19	Litovice (Nad tvrzí)	B	Early Eneolithic	abs.	TRB	0/1
25	Stránská skála	M	Early Eneolithic	6	TRB	3/5
1	Baba	B	Early Eneolithic	6	cf. TRB	2/3
8	Cimburk	B	Early/Mid En.	7	TRB (Baalb.)/Boleráz	6/11
31	Velké Přílepy (Skalka)	B	Early/Mid En.	7	TRB/Baden/GAC	3/4
19	Litovice (Nad tvrzí)	B	Mid Eneolithic	8	Baden (classical)	1/2
34	Žádovice	M	Mid Eneolithic	(8)	cf. Baden (classical)	(4/6)***

TABLE 2. — Continuation.

Site number (cf. Fig. 1)	Site/sample	Region	Main period	Period code	Culture (phase), in detail	Number of equid bones used in the metric analysis/total found
19	Litovice (Nad tvrzí)	B	Mid Eneolithic	8	Řivnáč	1/3
28	Tuchoměřice	B	Mid Eneolithic	8	Řivnáč	1/1
12	Homolka	B	Mid Eneolithic	abs.	Řivnáč	0/3
29	Úholičky	B	Mid Eneolithic	abs.	Řivnáč	0/1
27	Toušeň-Hradišťko	B	Mid Eneolithic	abs.	Řivnáč	0/2
18	Kutná Hora-Denemark	B	Mid Eneolithic	8	Řivnáč (mid-late)	7/37
31	Velké Přílepy (2002)	B	Mid Eneolithic	abs.	cf. Řivnáč	0/1
24	Starý Lískovec	M	Late Eneolithic	9	Corded Ware	1/1
33	Vyškov	M	Late Eneolithic	abs.	Bell-Beaker	0/1
34	Žádovice	M	Late Eneolithic	abs.	Bell-Beaker	0/9
2	Blučina-Cezavy	M	Early Bronze	abs.	Únětice	0/10
3	Březno	B	Early Bronze	10	Únětice	3/5
22	Moravská Nová Ves	M	Early Bronze	10	Únětice	5/8
32	Vlíněves	B	Early Bronze	10	Únětice	29/67

Site number (cf. Fig. 1)	Identification of excavation: Year	Identification of excavation: Head	Source of ostemetric data used in the study /archaeozoological publication
30	1986	A. Humpolová	Peške unpub./Nývltová-Fišáková 2004
4	1953-1967	B. Soudský, I. Pavlů, J. Rulf	Peške 1989
26	1967-2003	V. Podborský, E. Kazdová	/Dreslerová 2006, Uhlířová 2013
6	1975-1977	M. Zápotocká, I. Vojtěchovská, P. Sankot	Kyselý unpub./Kovačiková 2009 (rev.: Kyselý)
7	1973	I. Rada, R. Šumberová	Peške 1989/Kovačiková *et al.* 2012 (rev.: Kyselý)
21	1970	B. Klíma	Kratochvíl 1973, Peške unpub.
6	1975-1977	M. Zápotocká, I. Vojtěchovská, P. Sankot	Kyselý unpub./Kovačiková 2009 (rev.: Kyselý)
23	1980-1985	P. Sankot, M. Kuna	/Peške 1991
26	1967-2003	V. Podborský, E. Kazdová	Dreslerová 2006, Peške unpub./Dreslerová 2006, Kuča *et al.* 2010
16	1994	P. Martinec	Kyselý 2010
15	1976	I. Rakovský	Peške unpub./Koštuřík *et al.* 1984
23	1980-1985	P. Sankot, M. Kuna	/Peške 1991
3	1976-1977	I. Pleinerová	Peške unpub.
5	1979	J. Špaček	Kyselý 2010
11	1986	M. Kuna	/Petříčková unpub.
17	1990	P. Břicháček, M.Vávra	/Peške unpub.
28	2000	P. Sankot	Kyselý 2010/Kovačiková & Šamata 2009 (rev.: Kyselý)
9	2004	M. Kostka	Kyselý 2010
9	1999	M. Kostka	Kyselý 2010
8	1989-1990	M. Zápotocký, M. Zápotocká	Peške unpub., Kyselý 2010/Peške 2000
19	1972	V. Moucha	Peške unpub.
20	1961	E. Pleslová-Štiková	Peške unpub./Clason 1985
13	1997	M. Dobeš	Kyselý 2010/Kyselý 2013
10	1970-1972	D. Koutecký, Z. Smrž	Peške unpub.
14	2004	J. Klementová	Kyselý 2010
19	2003-2004	I. Pleinerová	Kyselý 2010
25	1981-1989	ARÚ Brno	Peške unpub./Svoboda & Šmíd 1994
1	1975-1976	J. Havel	Peške unpub.
8	1989-1990	M. Zápotocký, M. Zápotocká	Peške unpub., Kyselý 2010/Peške 2000
31	2006-2007	D. Daněček	Kyselý 2010
19	2003-2004	I. Pleinerová	Kyselý 2010
34	1986-1987	ARÚ Brno	Kyselý unpub.
19	2003-2004	I. Pleinerová	Kyselý 2010
28	2000	P. Sankot	Kyselý 2010/Kovačiková & Šamata 2009 (rev.: Kyselý)
12	1960-1961	E. Pleslová-Štiková	/Ambros 1968, Bogucki 1979
29	1994-1998	I. Vojtěchovská	/Kyselý 2010
27	1977-1982	J. Špaček	Kyselý 2010
18	1980-1989	M. Zápotocký, M. Zápotocká	Kyselý 2008b
31	2002	L. Šulová	Kyselý 2010
24	1976	J. Čizmářová	Peške unpub.
33	1958	G. Křivánek, J. Ondráček	Ondráček 1961
34	1986-1987	ARÚ Brno	Petříčková 1999
2	1983-2001	M. Salaš	Roblíčková 2003b/Roblíčková 2003a, 2004
3	1976-1977	I. Pleinerová	Peške unpub.
22	1991-1992	S. Stuchlík, J. Stuchlíková	Roblíčková 2003b/Roblíčková 2003a, 2004
32	1999-2014	P. Limburský	Kyselý unpub.

humid Atlantic period was favourable for reforestation. In the first half of the Holocene, decreasing wild populations of horses survived primarily in reduced open lands and were perhaps gradually forced to persist in more forested, unsuitable environments (Sommer *et al.* 2011), which would also have significantly reduced their reproduction rates. Generally

rare Mesolithic assemblages from this area contain or are even dominated by horses, which inevitably represent wild populations (Musil 1978; Vörös 1981; Uerpmann 1990; Benecke 1998a; Sommer *et al.* 2011). Very rare horse finds from assemblages from the beginning of the central European Neolithic are considered as non-domesticated survivors from Mesolithic populations (Peške 1986; Uerpmann 1990; Benecke 1994; Anthony 2007).

The impact of temperature on the size of a mammal's body is well known; reflected for example in the Bergmann rule. Significant change is documented between glacial and postglacial periods, including changes in horse size (Davis 1981; Vuure 2005; Nobis 1971). Studies on the correlation between archaeozoological records and a detailed climate history brought useful results, for example in a closed subalpine region (Switzerland, Schibler *et al.* 1997a, b, 2004; Schibler & Jacomet 2010). In the area under investigation here, climate history is also a focus of interest. Despite a number of attempts, however, a detailed correlation between climate trends or deviations and human behaviour still cannot be reliably reconstructed (Dreslerová 2012), and because of local specifics and significant differences between various parts of Europe (e.g., Davis *et al.* 2003), using results from other areas is problematic or even impossible. Although in the Czech lands a slight decrease in temperature and increase in humidity is suggested at the change from the Atlantic to Subboreal periods (sometime during 4th millennium BC, most probably around 3500 BC; Dreslerová *et al.* 2007; Dreslerová 2012), the climate models constructed for this territory reveal fluctuations in temperature within just 1°C and in precipitation within 100 mm in the period from the Neolithic to Bronze Age (Dreslerová *et al.* 2007; Dreslerová 2012). We do not think that such small temperature fluctuations had any direct or significant impact on horse size. Nevertheless, climatic changes can affect the environment, which could significantly influence other aspects of horse biology, including population size.

The reproduction rate of horses is relatively low (late maturity, long gestation, only one foal and not every year). Despite some theories about the migration of Paleolithic horses (hunting seasons, kill sites), we have no evidence of this behaviour, typically motivated by seasonal food shortage, in the Middle Holocene. In fact a number of recent observations indicate a high degree of horse site fidelity: for example, the 'circular' hunting of mustangs by the Comanche, demonstrating affinity to a particular place, mentioned by Levine (1999a), and analogically the nature of hunting of the last Ukrainian tarpans (Falz-Fein 1934). Feral mustangs live in unfenced reserves year-round as well as almost 'wild' ancient breeds in many sanctuaries. Also, reintroduced Przewalski's horses living now at least for 4 generations in the semi-desert steppe ecoregion of 'Dzungaria' do not exhibit any tendency to migratory behaviour and spend the whole year in restricted areas, each harem having its own territory, even though they are living in a suboptimal environment (King 2002; King & Gurnell 2005; King *et al.* 2015; U. Dorj pers. obs.). It seems that these glacial-adapted animals have no need or compulsion to move away, even in hard Mongolian winters, which applies to even the most mobile young males. These facts contradict ideas concerning the rapid expansion and repopulation of new and distant areas in a largely forested landscape.

MATERIAL

The study covers archaeozoological discoveries of the past 40 years. We evaluated all available equid bones from the Czech Republic, from the period *c.* 5600-1800 BC, that is, from the beginning of the Neolithic (LBK) to the Early Bronze Age (Únětice c.). The archaeological contexts of all bones were carefully evaluated, and in many instances discussed with archaeologists, in order to verify or specify particular dating. Where feasible, the bones were re-examined. The dataset consists mostly of osteometric data collected and partly published by L. Peške (1986, 1989) and new, as yet unpublished osteometric data collected during an in-depth study of the Eneolithic period (Kyselý 2010, 2012a). We also included data from studies of EBA (Roblíčková 2003a, b; Kyselý pers. obs.). Altogether we have collected data from 45 assemblages (34 sites), from which 123 postcranial bones were analysed osteometrically (123 breadths or depths and 33 lengths are used in the graphs). The material used is presented in Table 2 and the sites are shown in the map (Fig. 1).

For comparison, Magdalenien material from south Moravia (Hadí cave site, 16 bone finds; Musil 1961), representing purely wild horses, and Late Bronze Age (Knovíz c.) material from Bohemia (10 sites, 56 bone finds; L. Peške pers. obs.), representing surely domestic horses, was used. For interregional relationships, the data from sites cited in the figure captions were used. Our comparisons include Przewalski's horse (*Equus przewalskii* Poliakov, 1881) as a basic reference (see Fig. 3 for source). *Equus hydruntinus* is included in Fig. 2, which shows size relations.

METHODS

Abbreviations and terms

BC	Before Christ, calibrated;
c.	archaeological culture;
CR	Czech Republic;
EBA	Early Bronze Age;
Eneolithic	Copper Age, Chalcolithic;
Knovíz	Bohemian LBA culture (*c.* 1300-1100 BC);
LBA	Late Bronze Age;
LSI	Logarithmic size index;
LBK	Linear Pottery c.;
Řivnáč	Bohemian Eneolithic culture derived from Baden c. (*c.* 3100-2800 BC);
TRB	Funnel Beaker c.;
Únětice	EBA culture (*c.* 2200-1700 BC).

In this study, only extremity bone elements were used for size comparisons. Since the material is highly fragmented, the length of a long bone could be measured in only one case (metatarsus, Vlíněves) from material older than the

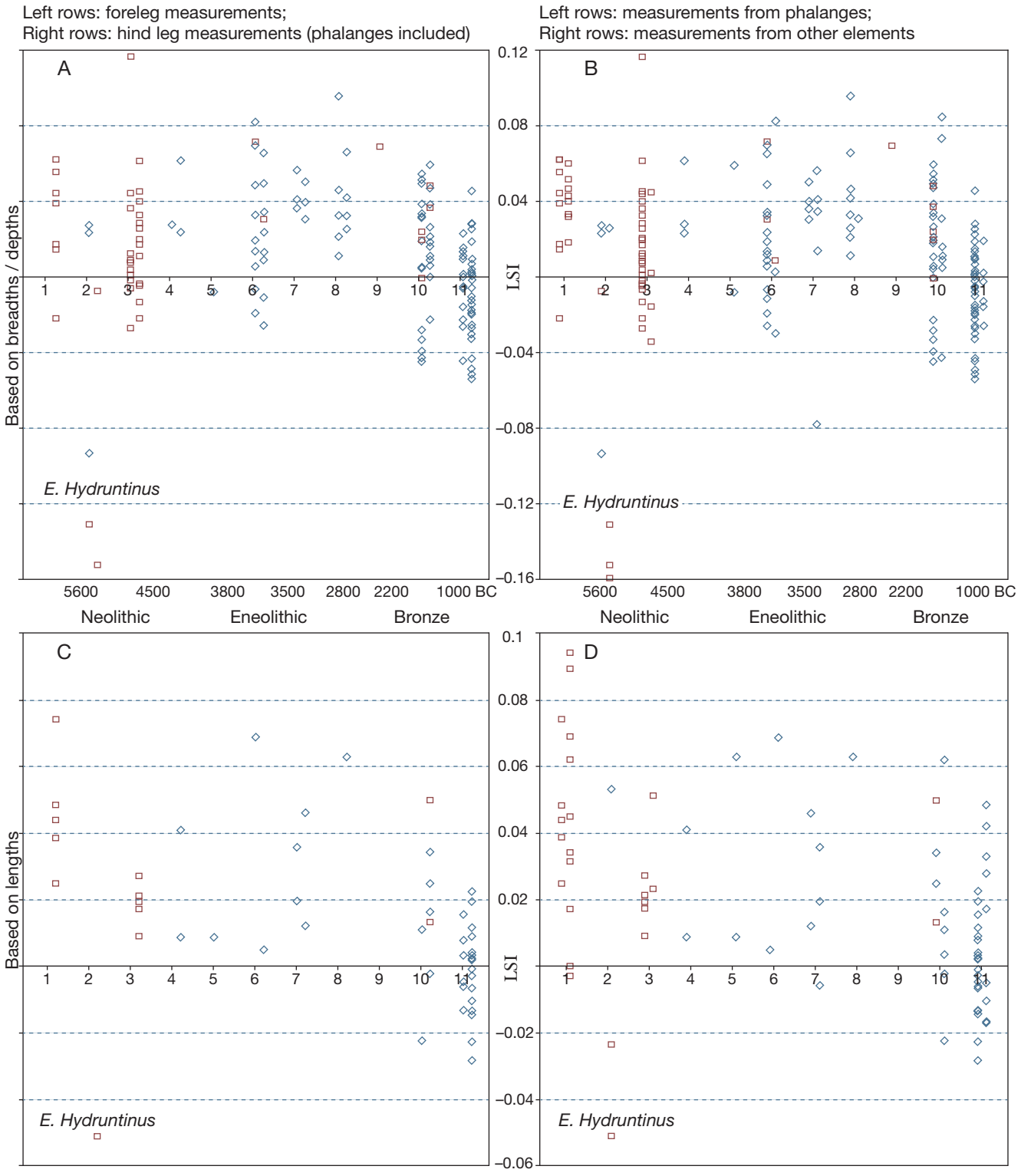

FIG. 2. — Size of equids in the Czech Republic, incl. *E. hydruntinus*. **Y axes**, individual LSI values calculated from breadth/depth (A, B) and length (C, D); **X axes**, individual periods from the Magdalenien to Late Bronze (period codes 1-11 as in Tables 1-6 and Figs 3, 4). In each period the values are separated into the left and right rows based on the anatomical position (see top of the figure). Values for periods 2-10 calculated from material in Table 2; period 1 based on Musil 1961; period 11 compiled from ten Knovíz assemblages (L. Peške pers. obs.). Standard (zero level) for LSI transformation – EQ42 (Uerpmann 1990, see Methods). ◇, Bohemia; □, Moravia.

Late Bronze Age; the used lengths originate from phalanges, calcanei and tali. Rarely found bones of juvenile individuals were eliminated. We exclude *a priori* the effect of sex ratio since the difference in size between mares and stallions is considered to be small (less than 5 % according to Ambros & Müller 1980).

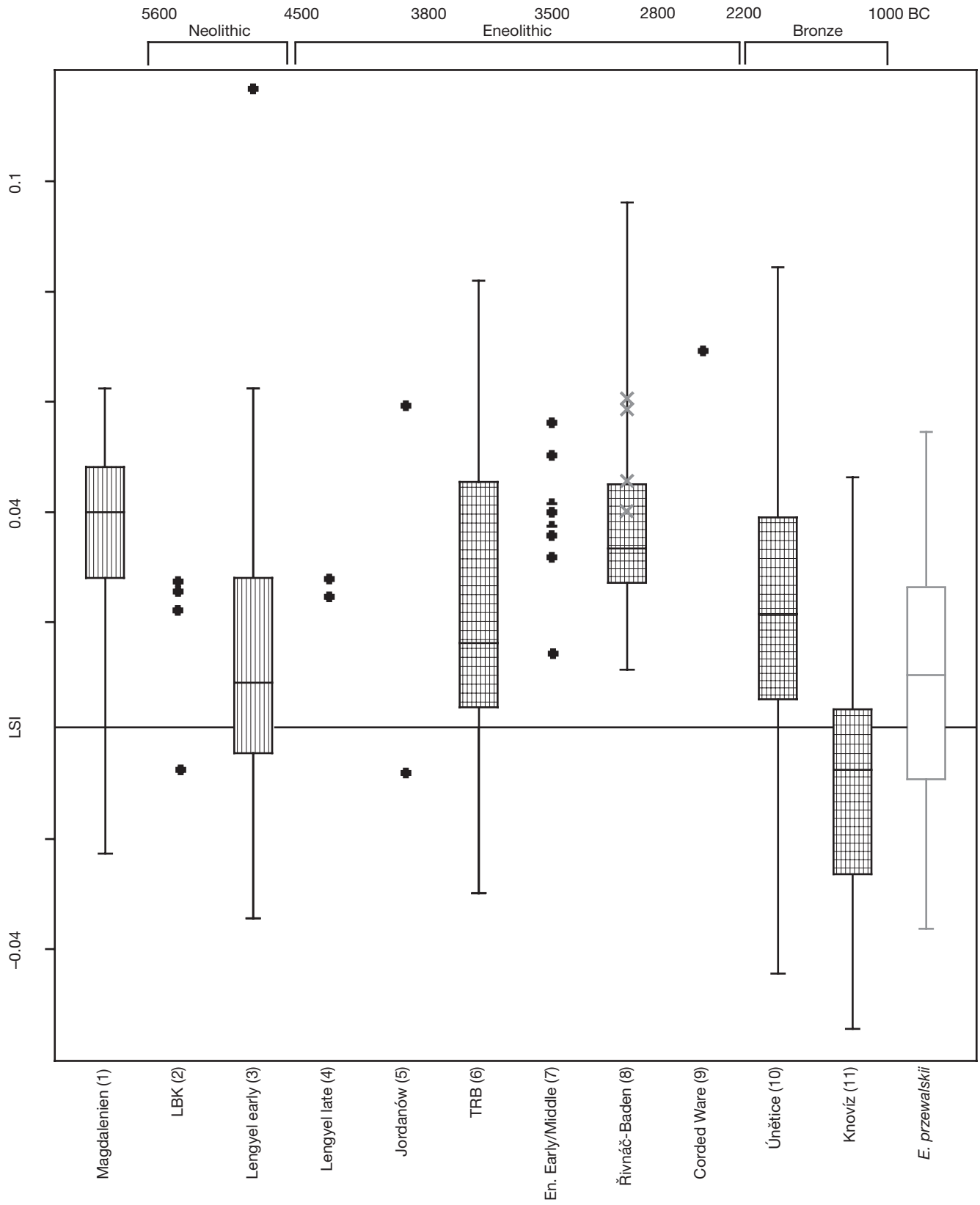

Fig. 3. — Size of horses in the Czech Republic (*E. hydruntinus* not incl.) compared to *E. przewalskii*. **Chequered boxes**: mostly Bohemian finds; **Hatched boxes**: only Moravian finds; **Light empty box**: recent *E. przewalskii*. LSI transformation as in Fig. 2, but only breadth/depth used. Period codes on lower X-axis (= values in brackets) correspond to codes in Figs 2, 4 and Tables 1-6, cf. main periodisation and absolute dating (BC) on upper X-axis with Table 1. Distributions of Czech horses are based on the same material as in Fig. 2 (statistics in Table 3); **×**, cf. Baden c. (Žádovice, see footnote 1). Distribution of *E. przewalskii* calculated from 58 breadth measurements from eight individuals (Gromova 1949) and other individuals (from the Institute of Archaeology in Prague, and museums in Prague and Berlin; L. Peške pers. obs.). **Box-whisker plots** show minima, maxima (line ends), 1st and 3rd quartile (box) and median (line dividing the box); **Dots**, single values and outliers. Abbreviations: **En.**, Eneolithic; **LBK**, Linear Pottery c.; **TRB**, Funnel Beaker c.

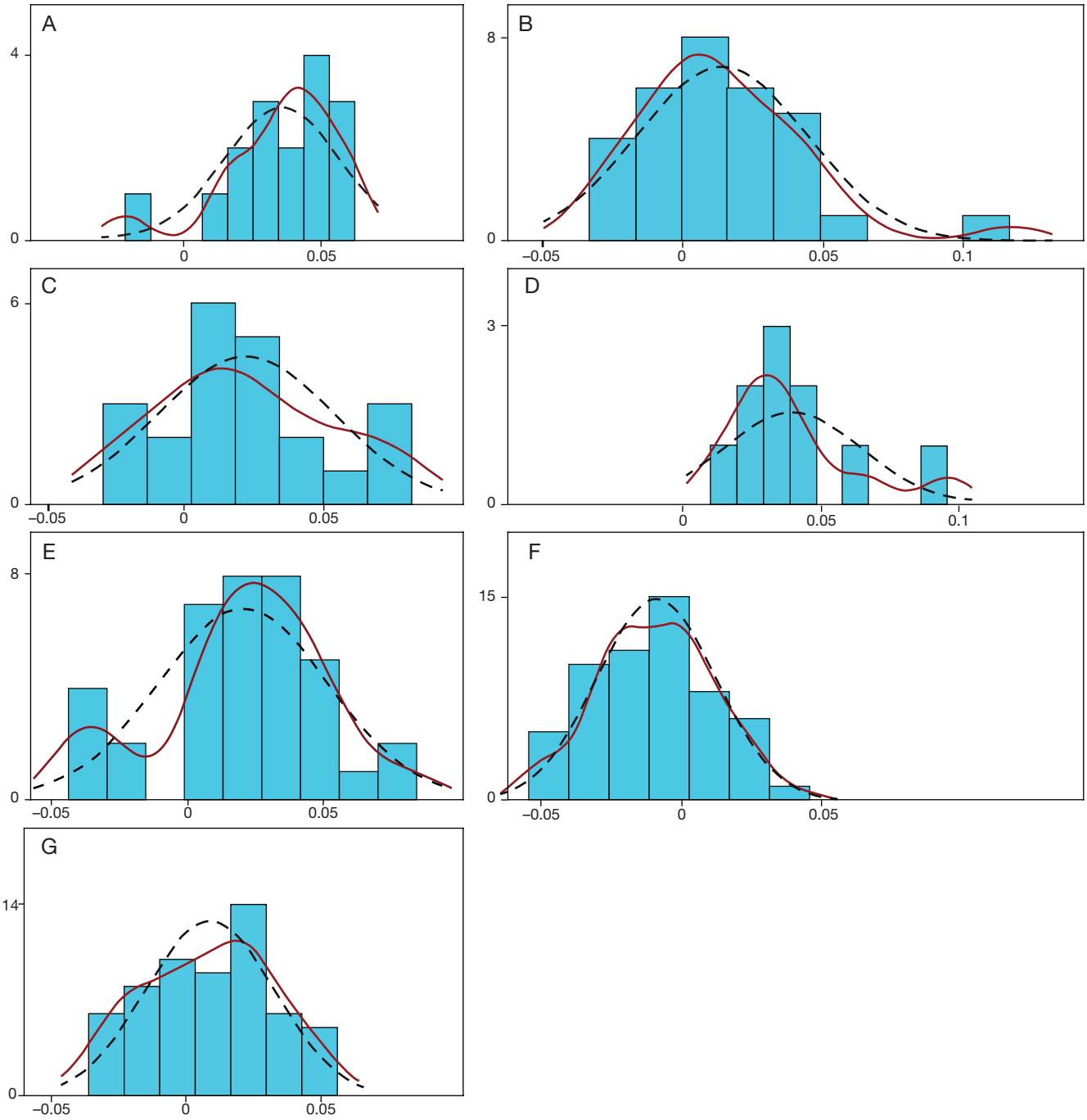

FIG. 4. — LSI distributions of *Equus* postcranial breadths/depths based on Czech datasets from selected periods and *E. przewalskii* presented by histograms. Based on the same data as in Fig. 3 (outliers incl.). Period codes correspond to other Tables and Figures. **A**, period 1 – Late Paleolithic (Magdalenien); **B**, period 3 – Early Lengyel (Těšetice-Kyjovice site); **C**, period 6 – Early Eneolithic (TRB); **D**, period 8 – Middle Eneolithic (Řivnáč culture); **E**, period 10 – Early Bronze (Únětice culture); **F**, period 11 – Late Bronze (Knovíz culture); **G**, *Equus przewalskii*; **X axes**, LSI scale; **Y axes**, frequency; **Red curve**, Kernel density; **Dotted curve**, fit (estimated) normal distribution. Analysed by Past 3.02 statistical software.

Except some cases, horse bones were found only as isolated items representing various anatomical elements and did not allow standard metrical evaluations. Like other authors (Uerpmann 1990; Meadow 1999; Benecke 1999, 2006; Benecke & Driesch 2003; Kyselý 2008a), we applied the log-ratio (logarithmic size index, LSI) method developed by Simpson *et al.* (1960) and horse skeleton EQ42 (Uerpmann 1990) as a reference. For the Czech material we present graphically both the evaluation of each primary LSI value (Fig. 2) and the overall statistics (box-whisker plots, histograms, Kernel densities: Figs 3, 4) – nevertheless only datasets containing a larger number of values are presented graphically as box-plots or histograms (all but one $n \geq 22$). The length and breadth/depth are evaluated separately in order to enable alternative views (Fig. 2). Breadth was always preferred to depth for LSI

TABLE 3. — Statistical parameters of LSI distributions of horses based on breadths/depths from individual periods and sites from the Czech Republic. Period codes correspond to other Tables and Figures. Abbreviations: **ind.**, individual site or sites; **LBK**, Linear Pottery c.; **Min.**, minimum; **Max.**, maximum; **Mean**, arithmetic mean; **Med.**, median; **MPC**, Moravian Painted c.; **n**, number of observations; **Q1**, 1st quartile; **Q3**, 3rd quartile; **S**, standard deviation; **Skew.**, skewness; **TRB**, Funnel Beaker c. Analysed by TriloByte Statistical Software.

Period code	Period (culture): sites	n	Logarithmic size index (LSI) Min.	Max.	Mean
1	Magdalenien: Hadí cave	16	–0.0216	0.0621	0.0356
2	Neolithic (LBK): Bylany, Černý Vůl, Chotěbudice, Vedrovice				
3	Lengyel early (MPC Ia): Těšetice-Kyjovice	30	–0.034	0.0615	0.0108
4	Lengyel late (MPC II): Čelákovice				
5	Proto-Eneolithic (Jordanów): Ďáblice				
6	Early Eneolithic (TRB): Baba, Cimburk, Dobroměřice, Hostěnice-Brozany, Hostivice, Makotřasy, Stránská skála	22	–0.0297	0.0822	0.0222
7	Early/Middle Eneolithic (mainly Baalberg/Boleráz): Cimburk, Velké Přílepy	8	0.0141	0.0565	0.038
8	Middle Eneolithic (Baden + Řivnáč): Kutná Hora-Denemark, Litovice, Tuchoměřice	10	0.0114	0.0957	0.0404
8 (ind.)	Middle Eneolithic (Řivnáč): Kutná Hora-Denemark only	7	0.0114	0.0957	0.044
10	Early Bronze (Únětice): Březno, Moravská Nová Ves, Vlíněves	37	–0.0441	0.0845	0.0204
10 (ind.)	Early Bronze: Vlíněves only	29	–0.0441	0.0845	0.023
10 (ind.)	Early Bronze: Březno and Moravská Nová Ves only	8	–0.0391	0.0483	0.0109
11	Late Bronze (Knovíz): 10 sites	56	–0.0537	0.0456	–0.0085
Equus przewalskii		58	–0.0356	0.0544	0.0085

Period code	Med.	Q1	Q3	dif. Q3-Q1	S	Skew.	Homogeneity	Values
1	0.0397	0.0283	0.0482	0.0199	0.0204	–1.172	accepted	
2								–0.0071; 0.0235 0.0258; 0.0274
3	0.0086	–0.0044	0.0277	0.0321	0.0236	0.133	rejected (1 outlier)	
4								0.0238; 0.0277
5								–0.0078; 0.0591
6	0.0165	0.0037	0.0451	0.0414	0.0314	0.247	accepted	
7	0.0381	0.0338	0.0434	0.0096	0.0119	–0.421	rejected (1 outlier)	
8	0.0328	0.0267	0.045	0.0183	0.0232	1.193	rejected (1 outlier)	
8 (ind.)	0.0327	0.0281	0.0561	0.028	0.0264	0.639	rejected (1 outlier)	
10	0.0212	0.006	0.0385	0.0325	0.0307	–0.427	accepted	
10 (ind.)	0.0212	0.0091	0.0387	0.0296	0.0304	–0.381	accepted	
10 (ind.)	0.0218	–0.0086	0.0325	0.0411	0.0302	–0.707	accepted	
11	–0.0069	–0.0257	0.0037	0.0294	0.0212	0.056	accepted	
Equus przewalskii	0.0104	–0.0087	0.0256	0.0344	0.0231	–0.067	accepted	

calculation. Each fragment is used only once in each comparison. Taking into account the scarcity of equid bones and their distribution in various features and sites, it is highly improbable that the same individual is involved in LSI-distribution more than once.

Horse types vary not only in the size of the leg bones but also in their robustness. Nobis (1971) and other palaeontologists identify four basic types based on a combination of length and width. Calkin (1969) was perhaps the first to show that in horses the width variation is related only in *c.* 30 % to the length. Therefore, the length and breadth/depth should not be mixed because they play independent roles. In inter-regional comparisons only an evaluation based on breadth/depth is used, as is the custom in similar research; respective statistics from the Czech material are in Table 3. In addition, various statistical tests are widely applied on LSI datasets (Tables 4-6, p values < 0.05 highlighted).

While a withers height correlates well with long bone lengths, a body mass tends to correspond to extremity bone breadths and depths (Meadow 1999; Kyselý 2008a). Individuals reveal a high correlation between individual breadth (or depth) measurements of extremity bones, but their body constitutions have a different effect on forelegs or hind legs (as a result of head size, Bartosiewicz 2013). Therefore, like Kyselý (2008a), we first tested, separately, measurements from forelegs and hind legs (Fig. 2A, C; Table 6). Similarly, differences between measurements of phalanges, being specific adaptable terminal elements, and remaining measurements were tested (Fig. 2B, D; Table 6).

TABLE 4. — Statistical tests evaluating the difference between LSI-distributions in individual archaeological periods based on datasets from the Czech Republic. Both the Mann-Whitney (*U*; p for adjusted Z) test (right-up, yellow) and the *t*-test (outliers excl.; left-down, red), of which P values are given in the table, were used in all of the combinations. Based on the same data as in Fig. 3. Period codes correspond to other Tables and Figures. P values < 0.05 bolded. Abbreviations: ***E. p.***, *E. przewalskii;* **n**, number of observations.

Collection (period code)	1	3	6	8	10	11	*E. p.*
n	16	31	22	10	37	56	58
1		**0.003**	0.110	0.874	**0.048**	**0.000**	**0.000**
3	**0.002**		0.279	**0.007**	0.153	**0.001**	0.667
6	0.114	0.285		0.104	0.869	**0.000**	**0.038**
8	0.897	**0.005**	0.109		0.089	**0.000**	**0.002**
10	**0.048**	0.154	0.870	0.089		**0.000**	**0.050**
11	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**		**0.000**
E. p.	**0.000**	0.604	0.112	**0.001**	**0.024**	**0.000**	

TABLE 5. — Statistical tests evaluating the difference between the averages of LSI-distributions of selected Czech (**CR**) and published European samples. The *t*-test, of which P values are given in the table, was used in all the combinations. Tarpan measurements taken from Kuzmina (1997), source for others is the same as in Figs 2-4, 6-9. Period codes correspond to other Tables and Figures. P values < 0.05 bolded. Abbreviations: **h.**, horizon; **n**, number of observations; **p**, probability (P value).

Site/collection (period code)	n	Site/collection	n	p
CR (1)	16	Lausnitz	21	**0.014**
CR (1)	16	Bärenkeller	35	**0.001**
CR (1)	16	Kniegrotte	178	**0.000**
CR (1)	16	Mirnoe	113	0.675
CR (1)	16	Szabadszállás	9	0.118
CR (3)	30	Eilsleben	9	0.090
CR (3)	30	Dereivka	50	**0.000**
CR (6)	22	Ehrenstein	21	0.964
CR (6)	22	Botai	1961	**0.000**
CR (6)	22	Unfriedhausen	71	0.545
CR (6)	22	Bronocice	19	0.972
CR (6)	22	Krautheim	97	0.620
CR (7)	8	Bronocice	19	0.093
CR (7)	8	Krautheim	97	**0.033**
CR (7)	8	Ergolding	19	0.234
CR (7)	8	Balatonőszöd (Boleráz h.)	8	0.299
CR (8)	10	Balatonőszöd (Boleráz h.)	8	0.231
CR (8)	10	Balatonőszöd (Baden h.)	12	0.180
CR (8)	10	Krautheim	97	**0.031**
CR (8)	10	Botai	1961	**0.036**
CR (8)	10	Riekofen	60	0.615
CR (8)	10	Bronocice	19	0.063
CR (8)	10	Csepel-Háros	61	0.427
Vlíněves	29	Csepel-Háros	61	**0.000**
Vlíněves	29	Rennweg	97	0.313
Rennweg	97	Csepel-Háros	61	**0.000**
Krautheim	97	Riekofen	60	**0.000**
Riekofen	60	Balatonőszöd (Baden h.)	12	0.863
Dereivka	50	*E. przewalskii*	58	**0.000**
Botai	1961	*E. przewalskii*	58	**0.000**
tarpan	40	*E. przewalskii*	58	0.913

RESULTS

1. Comparisons (Fig. 2) and statistical tests carried out for selected periods (Table 6) show no significant difference between individual anatomical subsets. Thus, the following results are not influenced by the ratio of fore-/hind legs or by the proportion of phalanges in the collection.

2. The size differences found in the Czech LBK series (Fig. 2) proves definitely the presence of at least two equid species. The considerably small size of some bones in the Czech LBK, representing bones assigned earlier to *Equus hydruntinus* Regalia, 1907 (Kratochvíl 1973; Peške 1989; see Table 2), undoubtedly confirms that species (alongside larger true horses). In the post-LBK period only one bone equates to the small size of *E. hydrutinus* (distal phalanx, Early/Middle Eneolithic; Fig. 2B) but in this case we cannot exclude natural aberration or post-depositional bias.

3. Based on our material, we conclude that the size of true horses reveal a size change from the Magdalenien to LBA (Figs 2-4). A statistically significant difference was detected between the following periods: Magdalenien vs. Lengyel; Lengyel vs. Middle Eneolithic (Baden-Řivnáč); EBA vs. LBA (Table 4). This suggests quite dynamic changes in Czech and also central European horse populations in time.

4. The analysis (Figs 2-4; Table 4) indicates a significant diminution of Czech horses between the Magdalenien and Early Neolithic-Lengyel periods. In the following time period the size increases. The horses were significantly larger in the Middle Eneolithic Řivnáč culture than in the Lengyel c., but the increase had possibly already begun in the Early Eneolithic, as indicated by LSI-distribution in TRB and supported by results of the Early/Middle Eneolithic (represented mostly by mixed Baalberge/Boleráz[1]). This increase in size seems to be followed by a decrease in EBA, which significantly continues into LBA. The described pattern based on breadth/depth is implied also in length distribution of short bones (Fig. 2).

5. The horses from the Czech territory were somewhat larger than wild Przewalski's horses in all periods from the Magdalenien to EBA, especially in the Magdalenien and Middle Eneolithic (Figs 2-4). On the other hand, Late Bronze Age horses are smaller than Przewalski's horse. However, size span in any period did not reach the small size of *E. hydruntinus*, as known in La Tène. The withers height calculated on the basis of a complete metatarsus (270.2 mm) from the EBA site Vlíněves is 144 cm (after both, Kiesewalter 1888, and non-linear regression by May 1985). This metatarsus is in the upper part of Early Bronze Age LSI distribution.

6. The size variability (standard deviation, quartiles) in the Lengyel period is somewhat greater than in wild Magdalenien horses. But only later, in the TRB, is the variability significantly larger than in a wild population such as Magdalenien or recent Przewalski's horses (Table 3; Fig. 5). Also, the variability in EBA is greater than in Magdalenien material. On the other hand, the variability in LBA horses is relatively small. In Lengyel culture, the occurrence of a very large horse individual, which statistically clearly falls outside the dataset,

1. These results are strongly supported by recently analysed material from feature No. 168 in the Moravian site Žádovice (Table 2, bones not included in statistics, boxplots and statistical tests) dated to the Baden or Bell Beaker culture. Like the almost contemporaneous Řivnáč c. in Bohemia, the finds from Žádovice that very probably originated in the Baden horizon of the feature represent quite large horses. So far we have obtained the following LSI values based on breadths: 0.040, 0.046, 0.059, 0.062 (cf. Fig. 3).

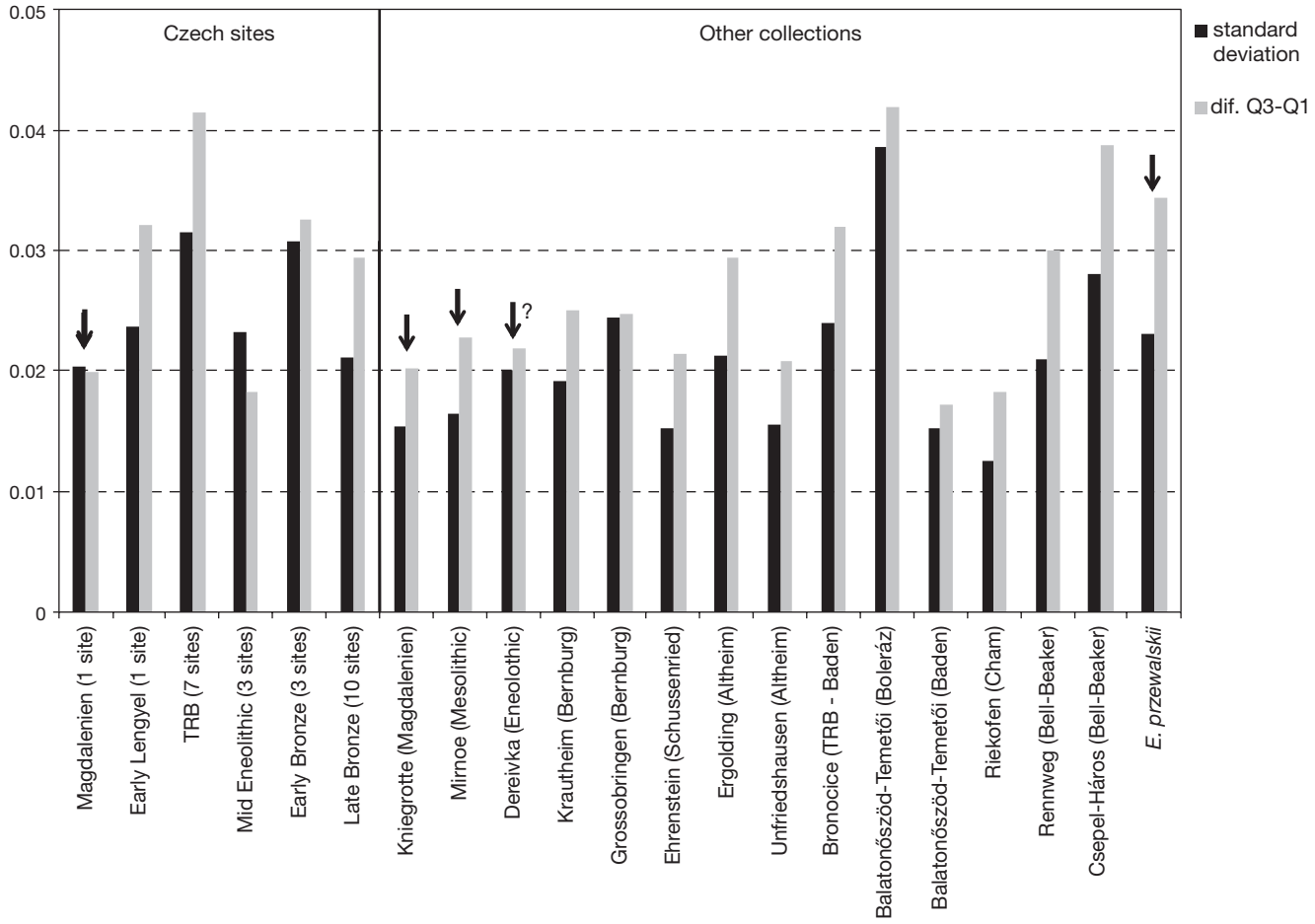

Fig. 5. — Comparison of standard deviations and quartile differences based on horse size distribution from the Czech sites (left) and selected collections from other regions (right). Based on the same sources as in Figs 3, 4, 6-9. **Arrows**, wild populations; **Dif. Q3-Q1**, interquartile range.

Table 6. — Statistical tests evaluating the difference between LSI-distributions with regard to anatomical positions based on selected datasets from the Czech Republic. Others as in Table 4. Abbreviations: **n1**, sample size 1; **n2**, sample size 2; **t**, *t*-test; **p**, P value; **U**, Mann-Whitney test.

Period	Phalanges vs non-phalanges						Foreleg vs hind leg					
code	n1	n2	t	p	U	p	n1	n2	t	p	U	p
3	24	4	1.156	0.258	30	0.251	14	11	–0,801	0.431	62	0.427
6	10	4	0.682	0.508	15	0.525	10	9	0.736	0.472	37	0.540
10	24	8	–0.325	0.748	91	0.845	19	14	–1.246	0.222	111	0.434
11	43	11	0.274	0.785	220	0.731	31	14	–0.577	0.567	191	0.532

was detected. The size distribution of horses in Řivnáč culture also appears to be statistically non-homogeneous, involving the occurrence of large individual(s). In TRB the distribution has secondary peak(s) (three-peaked histogram, Fig. 4). Unlike in later periods, the distribution in the Magdalenien is notably skewed (Fig. 4; Table 3).

DISCUSSION AND INTER-REGIONAL COMPARISONS

The pattern of size development in the analysed territory based on both breadths and lengths (though lengths based on short bones only) seems to be generally similar (Fig. 2). Thus we expect that the course described above (Results: point 4) shows general changes in size, not only changes in the robustness of the horses.

Magdalenien and Mesolithic (15000-5600 BC)

Magdalenien horses from south Moravia are significantly larger than contemporaneous finds from Germany (Lausnitz, Kniegrotte, Bärenkeller), but comparable with eastern Mesolithic horses from Szabadszállás-Tözegtelep and Mirnoe (Fig. 6A; Table 5). This finding is surprising since non-forested and easily penetrable terrain is expected at this time. However, taking into account the supposed site fidelity and horses' limited tendency to make long-distance translocations, this could be a result of a geographical cline even in such small distances as those within central

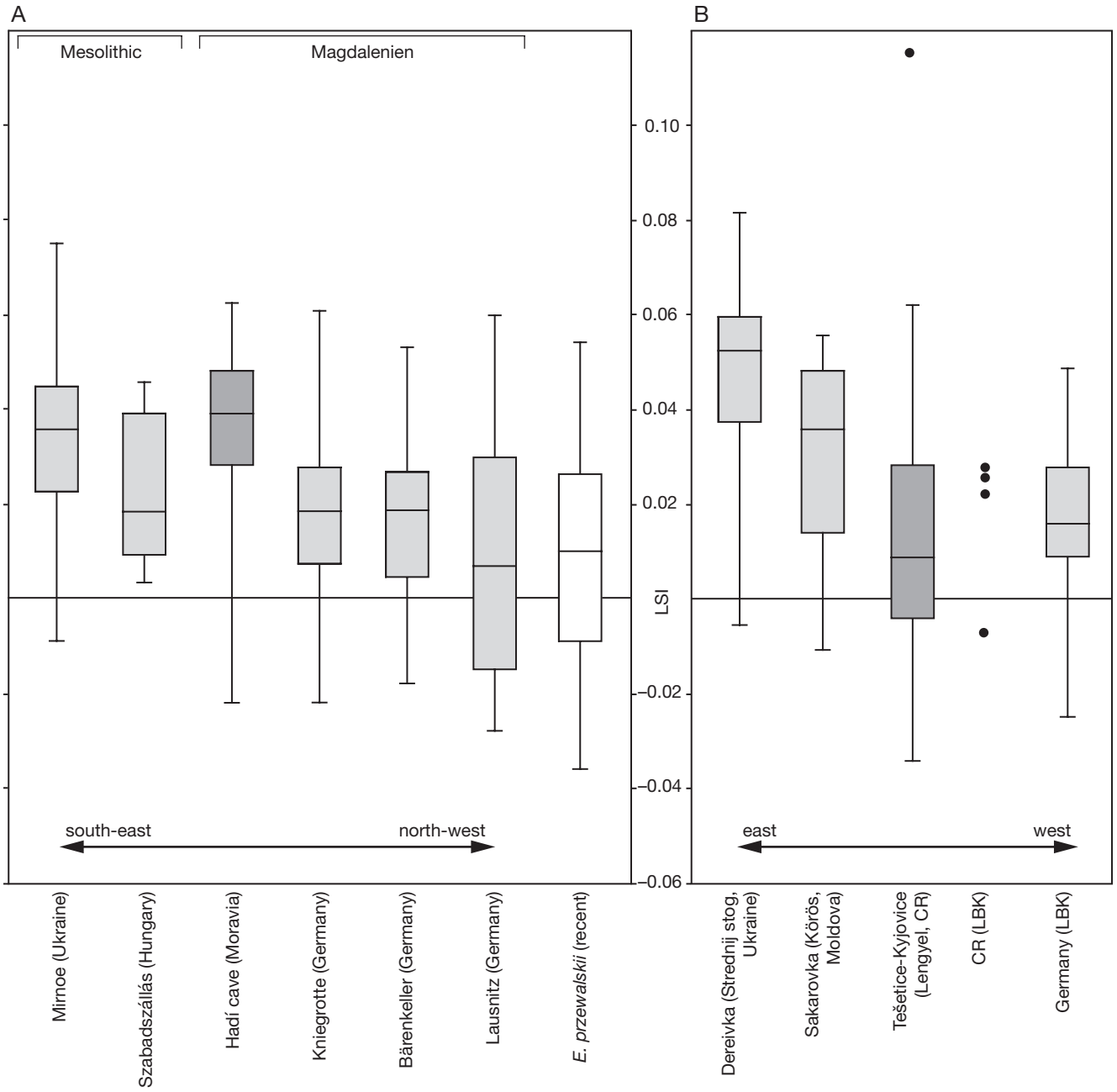

Fig. 6. — Size comparison between horses from the Czech Republic (dark boxes and dots) and adjacent regions (light boxes) within: **A**, 15000-5600 BC; **B,** 5600-4200 BC. **X-axis,** locations (in brackets: culture and/or country). Statistics for Hadí cave and Těšetice-Kyjovice based on the same data as the Magdalenien and early Lengyel, respectively (in Fig. 3; Table 3). Statistics for Mirnoe, Kniegrotte, Bärenkeller, LBK (Germany), Sakarovka and Dereivka taken from Benecke & Driesch (2003), for Lausnitz based on Teichert (1963), for Szabadszállás-Tözegtelep on Vörös (1981). Others as in Fig. 3. Abbreviations: **CR**, Czech Republic; **LBK**, Linear Pottery c.

Europe. Relatively large wild horses were also detected in material from the south Moravian site of Smolín, the only available Czech Mesolithic assemblage (not shown in Fig. 6 since only teeth measurements are available; Musil 1978). The notably skewed nature of the distribution (which is generally considered as a sign of size-change in evolution) observed in the Moravian Magdalenien (Hadí cave), is perhaps a manifestation of such a temporal body size-change in the population. A mixed population is also considered possible.

LBK–Lengyel (5600-4200 BC)

Some 7 to 11 thousand years after the Magdalenien, south Moravia hosted significantly smaller horses (Těšetice-Kyjovice, Lengyel; Fig. 6). It could be a result of the general trend towards adaptive size reduction between the glacial and Holocene periods as observed in many mammals, including the horse, aurochs and other ungulates (Nobis 1971; Davis 1981; Vuure 2005). In the Holocene, the adaptive diminution could be a natural response to the post-glacial spread of forests. Theoretically, we cannot fully exclude the possibility

that the reduction represents the common domestication trend described in most domesticated mammals (e.g., Bökönyi 1974; Davis 1981; Clutton-Brock 1999; Kyselý 2016). The immigration or even of importation theory, corresponding with early domestication status, is supported by the large extent of size-change.

At the same site (Těšetice-Kyjovice), horses are also present in LBK, a horizon dated *c.* 1000 years earlier than the Lengyel, but the share of their bones is considerably lower (Dreslerová 2006). The same difference in the abundance was observed in Roztoky, where LBK and Lengyel horizons were also present (Peške 1991). The increase in the abundance between LBK and the following Lengyel-Eneolithic period is general for the Czech Republic, which is obvious from archaeozoological quantifications (Peške 1986, 1994; Kyselý 2012a; Kovačiková *et al.* 2012). The low level of osteometric data from LBK (10 finds, of which we use four measurements; Tables 2, 3; Figs 2, 3, 6B) corresponds with the extremely low number of horse bones in LBK in central Europe in general.

The occurrence of the Mediterranean and steppe-adapted *E. hydruntinus* as far north as Chotěbudice (north Bohemia, Ohře lowlands, Elbe tributary; Peške 1989) is striking, while its occurrence in south Moravia can be explained by the connection between south Moravian lowlands and the plains of Pannonia. The Chotěbudice site is separated from true steppes in the south-east by a wide uninterrupted highland chain, which also implies a forest barrier. Peške (1989) suggested that this find could represent a type of importation, which would support the idea of the relatively early keeping and managing of equid individuals by the beginning of the Neolithic.

The somewhat greater variability in size in the Lengyel period than in the previous Magdalenien period, simultaneous evidence of a very large individual in early Lengyel material (outlier in Figs 2-4, 6B), and the presence of large horses in contemporaneous Stroked Pottery culture in neighbouring Lower Austria (Frauenhofen, *c.* 4800 BC; Pucher 1992), is supportive of the notion of the multiple origin of Lengyel horses, possibly even including tamed individuals (for further supportive evidence for the possible existence of domestic horses in the Lengyel period, see Peške 1986). Horses in the eastern European plains were, in the relevant timespan, significantly larger (Ukraine, Moldova, Fig. 6B). Therefore, a more probable origin of Lengyel horses could be western Europe or the North European Plains, which – including the constantly expanding forest – was suboptimal for horses and where smaller horses are generally detected (see below).

Some authors suggest that a new wave of wild horses migrated to the central European territories opened up (deforested) by man after the Neolithic colonisation (Benecke 1994, 2006; Sommer *et al.* 2011). According to Steppan (2006), based on the material from western Europe, the changes caused by men and agriculture created a more suitable environment for horses, and body size subsequently increased. Nevertheless, according to us, the remaining open areas, relatively small in those times, were undoubtedly occupied primarily by Neolithic people and the artificially deforested areas nearby were used mainly for their subsistence (see also below, in General discussion). Simultaneously, grasslands, and especially fields, were attractive to various animals, including forest herbivores, and had to be protected against them. This condition gives little chance for the natural dispersion of new large steppe elements such as equids. This assumption does not correspond to the idea of natural immigration. Furthermore, in unsuitable conditions the reproductive rate generally decreases, mainly as a result of lower fecundity and juvenile mortality, diseases, and inbreeding in small groups, thereby preventing rapid repopulation.

The relatively large number of Lengyel horses, variable in size and smaller on average, probably cannot represent a local development of Mesolithic populations. One of the possible explanations is artificial importation, possibly the importation of isolated individuals with symbolic value. Despite the fact that some of the arguments support the idea that tamed or domestic horses were imported to the Czech lands as early as the fifth millennium BC (see above and in Bökönyi 1978; Peške 1986), this is not confirmed by our osteometric comparisons and none of the above-mentioned possibilities can be excluded.

Proto-Eneolithic – Middle Eneolithic (4200-2800 BC)

In the timespan *c.* 4200-3400 BC (incl. Schussenried, Jordanów, Michelsberg, TRB, Althaim cultures), horses in the Czech Republic and Germany were comparable in size, while smaller horses were detected in Poland (Fig. 7). The size variability in the Czech TRB sample is remarkably greater than in most of sites (Figs 5, 7), even slightly greater than in Csepel-Háros and Vlíněves considered to be domestic (see below). The high variability is enhanced by the discovery of an extremely large old stallion skull in Stránská skála (south Moravia, TRB, Table 2; condylobasal length 557 mm, profile length 580 mm, not included in our graphs) belonging to a horse estimated to be over 168 cm (Vitt 1952), or *c.* 157 cm (Kieselwalter 1888), or *c.* 164 cm (non-linear regression, May 1985) high at the withers.[2]

Relatively larger horses were also detected in the subsequent Baden-Řivnáč horizon, in which the upper metric limit exceeds all of the analysed German, Hungarian and Polish collections (Fig. 8). Despite the fact that the median in Řivnáč culture generally corresponds to that in contemporary cultures in Germany (Bernburg, Cham), the Czech horses are significantly larger than horses in the largest dataset of the Bernburg culture (Krautheim site, Table 5). However, such a large 'jump' between the Lengyel and Middle Eneolithic horizons, as observed in the Czech territory, was not detected in Germany (see Figs 6-8). The increase in size of horses via natural processes, such as natural selection or genetic drift, is highly improbable in suboptimal conditions in such a short

2. Radiocarbon dating of this important find is 4608±24 BP, 3498-3348 cal. BC (p = 97) (Czech Radiocarbon Laboratory, CRL-15242), which fully come under absolute dating of TRB (Table 1).

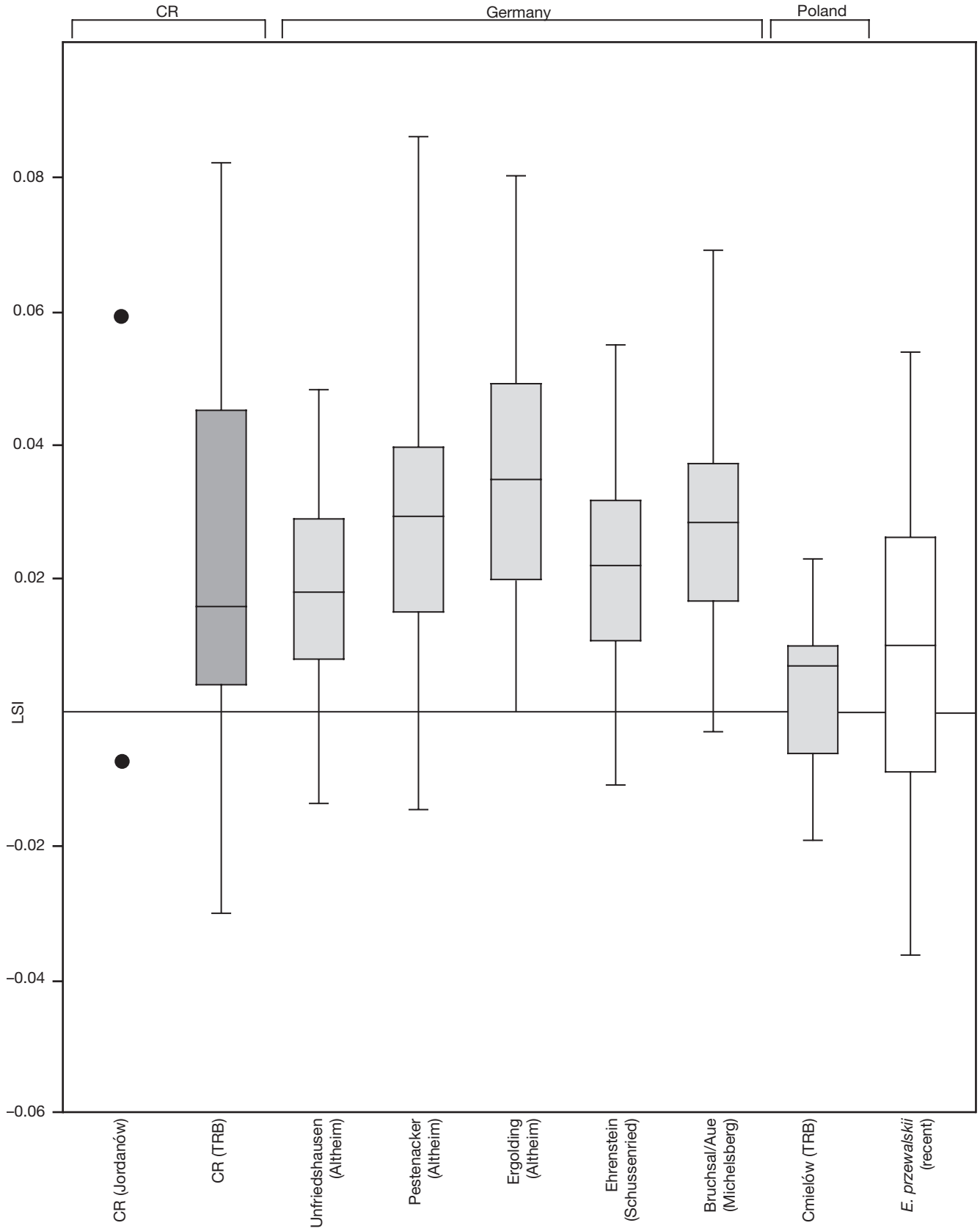

Fig. 7. — Size comparison within 4200-3400 BC. Statistics for TRB from the Czech Republic based on the same data as in Fig. 3. Statistics for Cmielów based on Krysiak (1950, 1952), for German sites taken from Benecke & Driesch (2003). Others as in Figs 3, 6. Abbreviations: **CR**, Czech Republic; **LBK**, Linear Pottery c; **TRB**, Funnel Beaker c.

time period (which can be measured in hundreds rather than thousands of years).

The remarkable increase in the variability in body size of horses between the Lengyel and TRB horizons and the statistically non-homogeneous nature of the metrical set from the Řivnáč culture (Fig. 5; Table 3) support the notion that both TRB and Baden-Řivnáč horses do not represent one closed wild population. The widening of size variability is a common side-effect of horse domestication (Bökönyi 1969; Meadow 1999). TRB horses could therefore represent either a mixed sample from more than one population or a domesticated breed (or a combination of both). The decrease in body size is another side-effect of the domestication of large mammals. The fact that horse size in TRB and, especially, the Baden-Řivnáč horizon is rising does not support the image of simple local domestication.

Although we are not excluding the possibility of the survival of wild horses in Eneolithic Central Europe (more probable, for example, in lowlands of North European Plain), we consider the combined observation of increasing variability in TRB (accompanied by possible secondary peaks in distribution; Fig. 4), the lack of homogeneity in Řivnáč culture, and the increasing size described above as evidence of an influx of new, foreign horses. Since large-scale importation of wild horses is improbable and spontaneous natural immigration over the unfavourable forested boundaries of the Bohemian basin to the areas occupied by farmers can hardly be expected in Eneolithic conditions, we believe that these new horses were under human control or domesticated. In this case, the importing of domesticated horses must have happened at least as early as the times of TRB culture (3800-3350 BC), which corresponds roughly with S. Bökönyi's (1978) second wave of domestic horse importation. The similarity between size distributions, especially variabilities, of TRB horses and Early Bronze horses (generally believed to have already been domesticated, see below) also supports domestic status in TRB culture (see box-plots in Fig. 3). Nevertheless, the picture could be more complicated, since central Europe in the fourth millennium BC could have seen, for example, a combination of imports and crossbreeding involving local horses. Furthermore, the role of the feralization of horses as early as the Eneolithic cannot be excluded. Introducing mares from various local populations to domestic herds mostly from the eastern steppes fits with the results of archaeo-genetic studies (Levine 2005; Cieslak *et al.* 2010; Achilli *et al.* 2012).

Since optimal conditions, enhanced by clinal variability, is likely to lead to larger horses in the steppes of eastern Europe and central Asia, we can assume that the larger horses that occupied the Czech lands in the Early and Middle Eneolithic may have their origin in the eastern steppes. The recent wild horses – Przewalski's horse and tarpan (comparable in size to one another) – are smaller than TRB and Řivnáč horses and also smaller than horses from Dereivka and Botai (Tables 4, 5; Fig. 6). Nevertheless, Przewalski's horse represents a different subspecies living in remote regions and the tarpan may well be influenced genetically by domesticated horses (Spasskaya & Pavlinov 2008). In the Magdalenien-Mesolithic, as well as in the Neolithic-Eneolithic, horses in the east (Mirnoe, Dereivka, Csepel-Háros, Botai) are usually larger than horses in the west (German sites); see Figs 6, 9, and below.

Despite the possibility that a domestication event also took place in the Iberian Peninsula (Warmuth *et al.* 2011; Achilli *et al.* 2012), importation from the east (or southeast) provides a more likely explanation. The Řivnáč c. (*c.* 3100-2800 BC) is a local Bohemian culture derived from Baden culture expanding around 3500-3300 BC to the Czech lands from its centre in Pannonia (Neustupný *et al.* 2013). The early phase of Baden c. (Boleráz phase, *c.* 3500-3400 BC, present also in Bohemia) is contemporaneous with the later phase of TRB. In the Kurgan hypothesis, Baden culture is seen to be a product of the second wave (*sensu* M. Gimbutas) of human migrations from the east (Gimbutas 1956; Mallory & Adams 1997). Despite the possibility that the kurgan theory might be wrong, there is a clear cultural influence from the North Pontic steppes, and massive migration from the east in the late Eneolithic/EBA is supported by new archaeo-genetic studies (cf. current opinions in Bouckaert *et al.* 2012; Klyosov & Tomezzoli 2013; Gibbons 2014; Haak *et al.* 2015). The influence is demonstrated by the emergence of the rite of burying the dead under kurgans and in ochre graves, which is a custom of eastern origin. These eastern cultural elements, already appearing in Tiszapolgár culture (5th millennium BC), become frequent during Baden culture, specifically from the pre-Yamnaya horizon, that is, from *c.* 3400-3300 BC (Dani 2011; Horváth *et al.* 2013). In the 4th millennium, the contact could be realised via Cernavoda culture (Anthony 2007; Furholt *et al.* 2008; Heyd 2012). Moreover, Baden culture is well known for repeated finds of clay chariot models, which suggests knowledge of how to harness animal power (Anthony 2007; Bondár 2012). Thus, the importation of horses could also be a part of this influence from the eastern steppes via Baden culture. This is possible as the horses from the Boleráz-Baden culture Hungarian site Balatonőszöd-Temetői are not statistically different from Czech horses in Baden-Řivnáč cultural complex and the size variability in the Boleráz horizon of Balatonőszöd-Temetői is remarkably high (Table 5; Figs 5, 8). The fact that size of the Czech horses dated presumably to Baden c. (Moravia, see footnote 1) and somewhat later (i.e. Řivnáč c. in Bohemia) do not differ from one another supports this notion. The Middle (or possibly Early) Eneolithic size increase, not documented in Germany, also supports the idea of the eastern influence. Further west, the extreme phenotypes could have been smoothed out by further domestication, inter-breeding or inbreeding depression.

Late Eneolithic – Bronze Age (2800-1000 BC)

Late Eneolithic cultures (Corded Ware, Bell-Beaker), despite their presence in the Czech Republic, did not yet provide reliable postcranial osteometric data, so our comparisons are mainly based on published data from surrounding regions. Here, a higher mobility of cultures is expected, as demon-

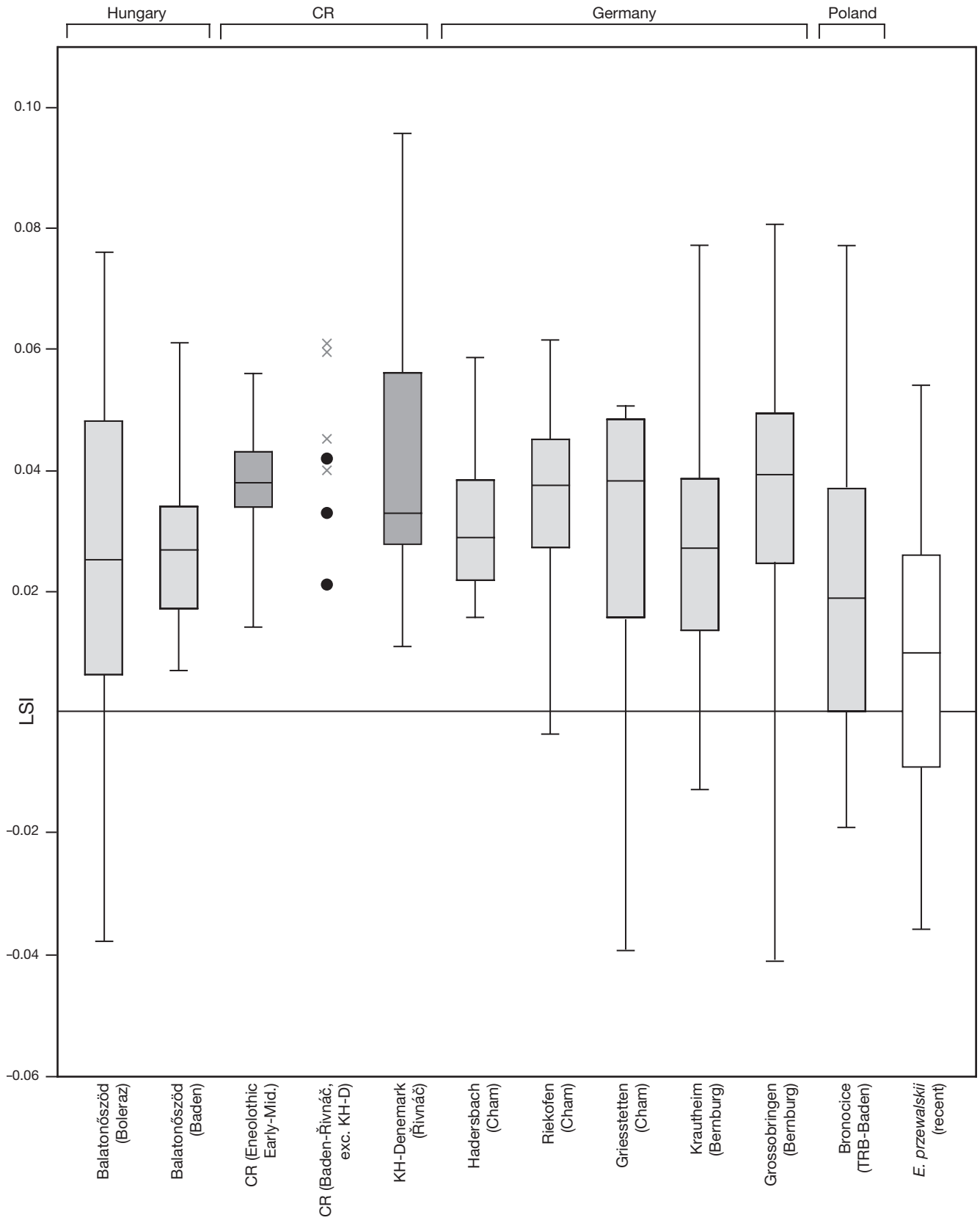

Fig. 8. — Size comparison within 3500-2700 BC. Statistics for the Czech early-mid Eneolithic based on the same data as in Fig. 3 (statistics are in Table 3). Statistics for Balatonőszöd (separately Boleráz and Baden phase) based on Vörös (2014); for Bronocice (incl. BR III-BR V, 3400-2700 BC, excl. 2 tibiae) based on Milisauskas *et al*. (2006); for German sites from Benecke & Driesch (2003) and Benecke (2006). Others as in Figs 3, 6. Abbreviations: **CR**, Czech Republic; **KH-Denemark**/**KH-D**, Kutná Hora-Denemark site; **TRB**, Funnel Beaker c.

strated by the well-known and rapid territorial expansion across a large area and suggested by Heyd (2011), based on isotope analyses. The Bell-Beaker culture represented by data from Hungary and Austria reveals relatively large horses (Fig. 9). A large variability in size of Bell-Beaker horses from Csepel-Háros (together with high abundance in the assemblage) is commonly believed to reflect domestic status (Bökönyi 1978; Uerpmann 1990; Anthony 2007). Alternatively, the large variability in this site, and the large variability in Czech horses from Vlíněves (Únětice c., with a secondary peak in distribution at this site), could reflect multiple origins of the populations. A statistically significant mutual difference in size between these chronologically proximate sites (Table 5) also supports the idea of multiple origin, which is consistent with the known mobility of Bell-Beaker c. (forming the basis for the genesis of Únětice c.; Jiráň & Venclová 2013). The existence of more than one horse type within the Carpathian arch in Bell-Beaker times also stems from new findings from Vienna (Austria; Czeika 2013) and from findings of two skulls of different sizes in one grave (grave 1 at Vyškov, Moravia), estimated to belong to individuals 120 cm and 140 cm high (after Ondráček 1961). A renewed size diminution in the Únětice c., and their relatively large abundance (Roblíčková 2003a; Kyselý pers. obs.) in comparison with previous local Eneolithic cultures, provides further evidence of domestication in that period. The persistence of wild horses in these cultures cannot be proved by osteometry, but osteometric evidence supports the presence of domesticated horses. The domestic status in EBA horses is generally accepted based on the obvious presence of domesticated horses in EBA in Great Britain (Bendrey 2010; Bendrey *et al.* 2013) and in EBA in the Balkans, where wild horses became extinct prior to these horizons (Benecke 1994), and on Early Bronze Age finds of components of harnessing and textual and artistic evidence (Hüttel 1982; Levine 1999b; Dietz 2003; Brownrigg 2006; Olsen 2006; Szédeli 2006; Bendrey 2012).

The diminution of horses which began in EBA (Bohemian and Austrian sites) is followed by rapid and significant diminution in LBA (Knovíz c.). This reduction, which can be clearly observed in the Czech material (Figs 2-4), reflects unambiguously a well-known and common domestication trend. The decrease in size may later result in especially small Iron Age horses, or the so-called Celtic or Germanic pony (Peške 1994). Horses in Knovíz culture (1300-1100 BC) are significantly smaller than Przewalski's horses (Fig. 3; Table 4). Their homogeneity and relatively small variability can be expected in well established, autochthonous breeding, already without the genetic influence of wild individuals or domestic horses imported from other regions.

GENERAL DISCUSSION

Our inter-regional comparisons reveal larger horse size in the eastern parts of Europe than in the west in most periods. This corresponds with the earlier findings on horse size within Mesolithic-Iron Age of Uerpmann (1990), Bökönyi (1993), Benecke (1998b, 2006), Benecke & Driesch (2003) and Czeika (2010). To the north (Poland), smaller horses were detected in two different periods. The Czech territories seem to span the borders of two worlds: the eastern plains and the western, geomorphologically diverse regions. While in the Magdalenien, the south Moravian horses seem to belong to the larger steppe populations of the east, in the Lengyel period they more resemble the smaller western horses.

The following specific observations from the Czech Republic have no plausible explanation in a natural context: the occasional occurrence of extremely large individuals in Lengyel and TRB cultures; a rapid change to relatively large horses between Lengyel and Baden-Řivnáč horizons. While the existence of imported tamed or even domestic horses in central Europe in the Lengyel period (4700-4200 BC) is highly disputable and so far not directly proven, several authors currently believe that around one and half millennia later (around 3300-2800 BC), horses found in central Europe were already domesticated. This suggestion, mostly based on size changes, the widening of variability, and increase in horse abundance, follows from analyses of equid material from the Bernburg culture (Germany, *c.* 3200-2800 BC; Benecke 1999), from the Corded Ware c. (Switzerland, *c.* 2900-2400 BC; Schibler *et al.* 2004) and from the Ossarn group of the Baden c. (Austria, *c.* 3350-2900 BC; Pucher 2006). From a similar or slightly earlier time (*c.* 3500 BC), well proven domestic horses are reported in the central Asian steppes (Botai, Kazakhstan; Outram *et al.* 2009).

The increase in horse size until, or in, Baden-Řivnáč coincides with small (*c.* 1° C) decrease of temperature (*c.* 3500 BC, see Introduction), but a notable shift in size as a result of such a small temperature change is hardly likely within such a short period as hundreds of years.

Interestingly, the increase in body size of horses proven in the Czech territories in this crucial period corresponds with the increasing size of domestic cattle and sheep, both observed in Řivnáč culture, and similar body enlargement of pigs during the Proto- and Early Eneolithic (Kyselý 2016). While in the case of cattle this increase is probably a result of inter-breeding between domestic and wild forms, in the case of sheep it can be explained by the importation of new larger breeds, and in the case of pigs it may be a result of the replacement of domestic pigs by newly domesticated wild boar (Kyselý 2016).

Current knowledge about changes in precipitation and temperature in the region do not support the expansion of steppe-like ecosystems. During the Holocene, a constant succession process towards a forested environment (except certain sites such as rocky terrain, braided rivers, swamps/moors or south-facing hillsides) took place. Human agricultural activities started to influence the environment from the Neolithic, but in the Czech territory this influence is significant only from the Late Bronze Age and Hallstatt, as detected, for example, in pollen and mollusc spectra (Ložek

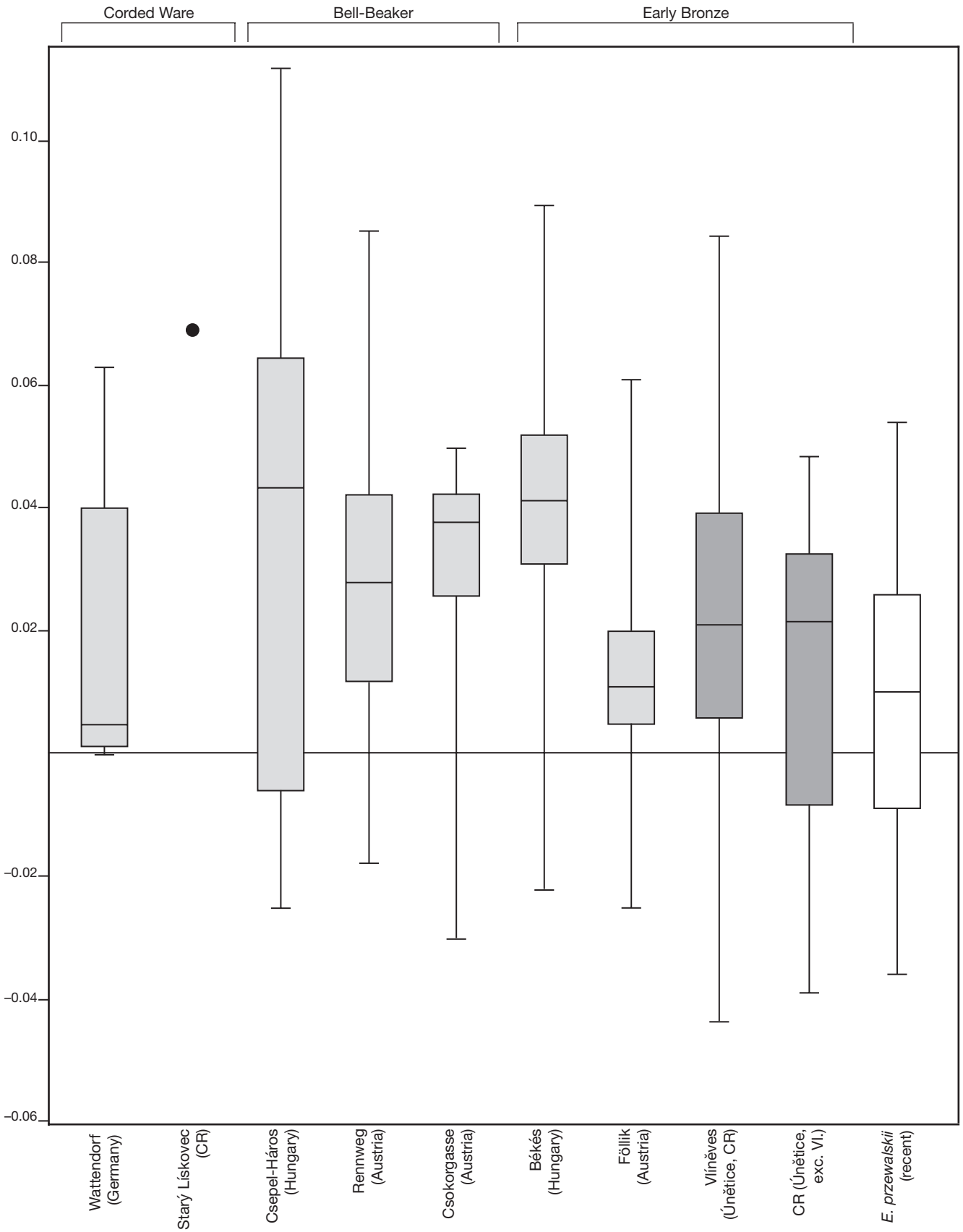

FIG. 9. — Size comparison within 2800-1700 BC. Statistics for Vlíněves and other Únětice c. Czech sites are in Table 3. Statistics for Wattendorf-Motzenstein based on Becker (2008); for Rennweg and Csokor-gasse on Czeika (2010); for Csepel-Háros on Benecke & Driesch (2003); for Békés-Városerdö on Bökönyi (1974); for Föllik on Amschler (1949); re-dated to Litzenkeramik in Benkovsky-Pivovarová *et al*. (1987). Others as in Figs 3, 6. Abbreviations: **CR**, Czech Republic; **Vl**,, Vlíněves site.

1981, 1998, 2007; Dreslerová *et al.* 2007; Pokorný 2004; Kozáková *et al.* 2015). Considering the environment, double-track development (Ložek 1981) should be emphasised, which means the areas uninhabited by man continued in succession, i.e. afforestation, and areas inhabited by man were adapted to human activities (see also our views above, in Discussion: LBK-Lengyel). Even if the impact on the natural environment, considered low in the Neolithic and Eneolithic in the region, was greater than expected, it does not seem likely that it would open the terrain to an extent corresponding to wide steppe-like areas in the relatively variable terrain of the Czech lands. Despite the fact that some authors accept a forest environment for horses, they clearly prefer open habitats, which are more suited to their feeding strategy (Klich & Grudzień 2013). The ability to survive in difficult-pervious forests is seriously hindered by the reduced ability to escape or to use cooperative defence tactics against predators such as wolves (for the high intensity of wolf predation see Lagos 2013), which undoubtedly were an important component of the natural conditions in the Neolithic-Bronze Age period. Areas opened up by man, presumably relatively small, do not seem to provide sufficient space for easy escape from predators. This assumption corresponds with the re-examination and revision of the spatio-temporal dynamics of horse populations across Europe and the western end of the steppe zone for the early and middle Holocene carried out by Sommer *et al.* (2011), who correlated wild horse populations with open rather than closed (wooded) environments.

The osteometric analysis presented here can only partially be complemented by other sources of archaeozoological information, as to date, relevant in-depth analyses are absent within the studied region. To the present discussion we can add only fragments of information from the existing literature and from unpublished sources. A preliminary report by Peške (1986), representing an attempt to combine arguments (ecological, morphometric, demographic, taphonomic) concerning the status of Neolithic-Eneolithic horses in the Czech lands based on existing rare material, revealed features of domestic or tamed horses as early as the Lengyel period (5th millennium BC), but our osteometric analysis cannot give unambiguous resolution to this period. Further information is contained in a dissertation by Kyselý (2010) and in Roblíčková (2003a, b). Mortality age based on dental finds including Proto- and Middle Eneolithic records (n = 10) reveals that only adult individuals (over four years) are present, mostly aged 5-10 years, but also older individuals were detected (Kyselý 2010). In the same study, and later determination (Kyselý pers. obs.) including material from Lengyel to Early Bronze Age, no unfused epiphysis was found among postcranial bones (incl. zonopodium, stylopodium, zeugopodium, metapodium and acropodium, n = 46). Other analyses from the Czech Neolithic, Eneolithic and Bronze Age also show that young individuals are absent or rare (Roblíčková 2003a; Peške pers. obs.). Age profiles obtained from hunted horses found at Magdalenien and Mousterien sites, including settlements, hunting grounds and sites for processing horse bodies, contain notable portions of juveniles (specifically Solutré, Bau de l'Aubesier and others; data from Turner 2002; Fernandez & Legendre 2003). They differ widely from the age structure of the Czech Eneolithic horses (Kyselý 2010). Furthermore, the age structure of the Czech Eneolithic horses does not correspond with the age structure in viable wild equid herds, including the high percentage of juveniles (cf. Boyd & Houpt 1994; Moehlman 2002; Fernandez & Legendre 2003). These observations suggest that the horses were not bred for meat alone. Despite existing difficulties in the interpretation of age profiles (Olsen 2006), the absence of juveniles in Eneolithic archaeozoological records and consequently the use of horses for purposes other than for meat accords with their domestic status, since meat consumption, as a primary aim, is typical for those regions where horses are naturally well adapted to the ecological conditions (cf. Levine 1998; Bendrey 2011). In addition, there is only marginal evidence of butchery marks (chopping) on Eneolithic horse bones (Kyselý 2012a, 2013), although frequent anthropogenic traces found on horse bones in the Middle Bronze Age site at Velim-Skalka (Bohemia) seem to provide exceptional evidence of horse consumption in the region (Roblíčková 2003a).

We can speculate about the symbolic significance (prestige, religion, cult, sexual symbolism or symbols of power) and about the combined use of horses for riding or as draught animals, but emotional reasons could also play a role. Stallions especially, potentially detected in our study as outliers in the Lengyel and TRB horizons, could be kept for such reasons. The symbolic status of the horse is demonstrated by two horse craniums found in a grave with human cremation in Vyškov (Moravia, CR; Ondráček 1961) dated to Bell-Beaker culture (the period when Central Europe was very probably already indo-europanised: Mallory 2013; Klyosov & Tomezzoli 2013; Haak *et al.* 2015). It is the only evidence so far of the ritual use of horses in the Czech territory from the Neolithic and Eneolithic; further possibly ritual horse depositions are known within the Czech territory from EBA (Berkovec & Peška 2006) and from LBA (Peške 1988; Jiráň *et al.* 2013) and frequent horse burials are known within the cemeteries of later invaders from the eastern steppes (such as Avars in Pannonia; Ambros & Müller 1980). There is rich evidence of the sacrificing of domestic horses in various Indo-European traditions, probably derived from Proto-Indo-European ritual, and of the importance of myths involving horses in Indo-Europeans (Mallory & Adams 1997, 2006; Anthony & Brown 2003; Kuzmina 2006; Anthony 2007). Evidence of horse sacrifice (or rituals in general), frequently including separated skulls, was found in Botai (Olsen 2003), a site of early horse domestication. Ritually deposited skulls were also found in other sites in the eastern steppes; they therefore seem to be a typical feature there (Mallory 1981; Kuzmina 2003; Anthony & Brown 2003; Olsen 2006; Anthony 2007). Despite the fact that we do not know the meaning or significance of the deposition of the skulls at Vyškov, they

could be explained as relating to an imported custom of horse sacrifice originating in the east. Apart of the find at Vyškov (and an uncertain find of metapodium from a Bell Beaker grave near Kolín; Kyselý pers.obs.), all equine finds from the Czech territory originate from settlement waste represented by fragmentary material, in which anatomical representation does not differ from other large mammals such as cattle or deer (Kyselý 2012b).

There is no artefactual evidence, such as bridles or other components of horse harnessing, before the Middle Bronze Age. The earliest bronze components are known in the Czech territory from early Urnfield culture, Late Bronze Age (Kytlicová 2007), but not yet stated for Early Bronze Age (Moucha 2005). A probable horse-bridle piece made from antlers dated as early as the Tumulus c., Middle Bronze Age, 1600-1300 BC, is known from Moravia (Olbramovice, Kos & Parma 2003). However, although some putative Eneolithic finds of bridle cheek-pieces found in Europe have since been questioned (Dietz 2003; Brownrigg 2006), in other European regions, Bronze Age finds of horse harnessing components that are slightly earlier than those found in the Czech territory have been recorded (Dietz 2003; Brownrigg 2006; Olsen 2006; Szédeli 2006; Bendrey 2012; Maran & Moortel 2014). From the adjacent region, a Middle Bronze Age domestic or tamed horse has been documented based on mandibular pathology originating from the bridle (Polgár-Kenderföld, Hungary; Bartosiewicz 2013). These finds taken together show that equestrian knowledge was already well developed in central Europe in the 2nd millennium BC.

"Baden culture is frequently discussed in association with the spread of Indo-Europeans because it possesses a number of cultural traits that have been regarded as diagnostic markers of Indo-European society: the use of small fortified settlements, houses with apsidal ends (suggesting a pastoral ancestry), wheeled vehicles,…., sexual dimorphism in burial rite with males interred on their right sides and females on their left, (etc.)…" (Mallory & Adams 1997). See also Gimbutas (1956). This dating of occurring of Indo-Europeans (considered to be in close relation to horses) in central Europe could correspond to the occurrence of domestic horses in the middle part of the 4th millennium BC, as suggested in this paper.

CONCLUSIONS

The very small size of some equids in Linear Pottery culture undoubtedly confirms the presence of *Equus hydruntinus* in the Czech territories, including the globally northernmost evidence so far in Chotěbudice (north Bohemia).

Generally, horses from the Magdalenien to the Early Bronze Age are statistically larger in the Czech Republic than Przewalski's horse, except for Lengyel horses, which are similar in size. Late Bronze Age (Knovíz culture) horses are significantly smaller than Przewalski's horse.

Quite dynamic changes in horse size detected in the Czech territories from the Magdalenien to the Late Bronze Age are not consistent with the natural evolution of a single wild population. Relatively large wild horses inhabiting Moravia in the Magdalenien and Mesolithic periods were replaced by smaller horses in the Early Neolithic-Lengyel period. After that period, horses became larger, especially in the Baden-Řivnáč horizon. Later, during the Bronze Age, the horses became smaller again.

Generally, larger horses are more often reported in the eastern part of Europe than in the western part. The Czech Republic seems to span two worlds, eastern and western. While south Moravian horses from the Magdalenien are as large as in contemporaneous eastern steppe populations, in the Lengyel period they resemble smaller western horses.

Although we are not excluding the possibility of the survival of wild horses in Eneolithic Europe, we argue that the presence of high size variation in TRB, the similarity between TRB and Early Bronze Age size variation, the non-homogeneous size distribution in Řivnáč culture, the significant increase in size between Lengyel and Baden-Řivnáč horizons (possibly already in TRB), together with the occasional occurrence of unexpectedly large individuals, probably reflects the importation of domestic horses to Central Europe at least as early as the times of TRB culture (3800-3350 BC), which is earlier than claimed in other recent studies. Imports from the east in this period are highly likely, and multiple origins of horse populations are possible.

Significant size reduction during the Bronze Age clearly reflects a common domestication trend. The relatively narrow variability of horses in the Late Bronze Age could be a result of close autochthonous breeding without genetic influence from external sources.

Despite the fact that we see the osteometric argument for our conclusions being fairly solid, we accept the need to evaluate evidence other than the measurement of postcranial bones. The intentional deposition of two horse skulls in a grave (Moravia) together with the large size difference between the skulls supports the notion of the domestic status of the horse in Bell-Beaker culture. Furthermore, the mortality profile of Middle Eneolithic horses and the find of an extremely large skull in TRB (Moravia) also seem to support domestic status. However, the status of relatively small and numerous horses from Moravia in the Lengyel period remains disputable; the exceedingly large horse recorded there is difficult to explain (occasional import of tamed individual?). Accordingly, a detailed study including age profiles, pathologies, cranial and dental morphology and osteometry in the region as well as non-osteological archaeological indications of horse history and domestication is planned for the coming years.

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