Archaeological and Anthropological Sciences (2019) 11:5569–5590
https://doi.org/10.1007/s12520-019-00893-6

ORIGINAL PAPER

Crops along the trade routes? Archaeobotany of the Bronze Age in the region of South Bohemia (Czech Republic) in context with longer distance trade and exchange networks

Tereza Šálková[1,2,3] · Ondřej Chvojka[2,4] · Daniel Hlásek[2,3,4] · Jaroslav Jiřík[3,5] · Jan John[2] · Jan Novák[1,6] · Lenka Kovačiková[1,7] · Jaromír Beneš[1,2]

Received: 19 September 2018 / Accepted: 21 June 2019 / Published online: 13 July 2019

Abstract

The number of species of crop plants in Central Europe increased constantly during the Bronze Age. The structure of the composition of cultivated plants was probably connected to the cultural contacts of human populations. During the Bronze Age (2300/2000–800 BC), the region of South Bohemia (Czech Republic) increasingly became the focus of long-distance trade and exchange networks with regions to the east and many other regions (the Eastern Alps, the Alpine Foreland, the central lowlands of the Czech Republic, Hungary and Western Slovakia). The aim of the paper is to examine archaeobotanical assemblages of charred plant remains to see if these changes within Bronze Age societies, and their spheres of interaction, are also recorded within their agricultural practices. In particular, the importance of specific individual crop species can be reflected in the study region in comparison with other individual regions of Central Europe. Humans in the region of South Bohemia had more connections with the Eastern Alps and the Alpine Foreland region during the Early and Middle Bronze Ages. Regarding the structure of crop species, the composition of sub/dominant crops in South Bohemia and the Eastern Alps and the Alpine Foreland had many similarities. The cultural trajectory of the human populations of the South Bohemian region changed substantially in the Late and Final Bronze Ages: intensive contacts are documented, primarily with the region of Central Bohemia. This is reflected in the composition of the sub/dominant crops in South Bohemia, which shows many similarities to the other regions of the Czech Republic. Changes in migration and exchange networks—in particular those that involved more formalised trade—are associated with a large number of innovations and specific goods and led to much wider levels of cultural and social integration within Bronze Age Europe than had been previously seen.

Keywords Prehistoric agriculture · Bronze Age · Archaeobotany · Plant macroremains · Crop plant spectrum · South Bohemia · Trade routes

✉ Tereza Šálková
terezasalkova@seznam.cz

1 Faculty of Science, Laboratory of Archaeobotany and Palaeoecology, University of South Bohemia in České Budějovice, Branišovská 1760, 370 05 České Budějovice, Czech Republic

2 Faculty of Arts, Institute of Archaeology, University of South Bohemia in České Budějovice, Branišovská 31a, 370 05 České Budějovice, Czech Republic

3 Prácheň Museum in Písek, Velké náměstí 114, Písek, Czech Republic

4 South Bohemian Museum in České Budějovice, Dukelská 242/1, 370 51 České Budějovice, Czech Republic

5 Faculty of Arts, Institute for Archaeology, Charles University in Prague, Náměstí Jana Palacha 2, 116 38 Prague 1, Czech Republic

6 Faculty of Science, Department of Botany, Charles University in Prague, Benátská 2, 128 01 Prague 2, Czech Republic

7 Faculty of Science, Department of Zoology, University of South Bohemia in České Budějovice, Branišovská 1760, 370 05 České Budějovice, Czech Republic

Introduction

The Bronze Age society in Central Europe was influenced by trade involving many commodities (e.g. bronze goods, amber, salt, silex; Goldenberg 2004; Grabner et al. 2007; Ernée 2012; Tisucká and Ohlídalová 2013; Chvojka et al. 2017; Zápotocký 2013; Šebela and Přichystal 2014; Přichystal and Šebela 2015), that mediated contacts across cultural groups. Material impulses from higher social groups brought improvements on military, agricultural and technological levels. Innovations in the field of intangible culture influenced the cult and religion, identity-forming factors (Jockenhövel 2012). Our main question in this research is how the composition of the crop plant spectrum corresponds with the main phases of the Central European Bronze Age. Is it possible that the crop spectrum reflects changes in society?

Socially and economically, the Bronze Age was a dynamic period, with large-scale human population movement and replacement seen in Eurasia (Allentoft et al. 2015). Migration was also the main source of the spread of Indo-European languages across Europe (Anthony 2010; Haak et al. 2015) and in turn led to the rapid dispersal of specific cultural traits and other innovations. These migrations likely led to the spread of bronze-making technology throughout Eurasia and the formation of the Bronze Age World system across the continent at the end of the third millennium BC (Allentoft et al. 2015). Bronze technology was probably the prime mover.

Connections between migration and the products of agriculture have been proven on a macroeconomic scale (e.g. Evin et al. 2014; Arnold et al. 2016; Long et al. 2017). The transfer of animals, plants and plant and animal utilisation techniques may also have played an important role in trade networks and be connected to mobility throughout Eurasia. In Europe, hemp and millet were introduced (Long et al. 2017; Wang et al. 2017; Kučera et al. 2019). In a distant region of China, the utilisations of bronze, horses (*Equus caballus*) and new cereal crops (wheat) were introduced in the same time period (Allentoft et al. 2015). The transfer of products probably took place through a trail later called the Silk Road (Mair and Hickman 2014) and possibly used horse power (Hemphill and Mallory 2004). The horses of this period were of different origins and varied considerably in size (Kyselý and Peške 2016; Ludwig et al. 2009). During the second millennium BC, horses replaced cattle as a means of transport. They could be ridden, and they could also be harnessed to light wooden vehicles with spoked wheels, termed 'chariots' (Piggott 1983; Clutton-Brock 2012, p. 78). As far as the other domestic animals are connected, both sheep-wool production and woolen fabrics and artefact types, such as bone and antler needles, became more abundant throughout the Bronze Ages (Ryder 1992; Schibler 2006).

Trade and long-distance movement of population initiated changes in the European cultural milieu of the Bronze Age. The migration and movement of individuals across larger expanses of Europe, as a part of this increase in trade and exchange networks, became more commonplace (e.g. Frei et al. 2015; Harvig et al. 2014). The newcomers brought habits (along with items, tools, vessels and costume) from their original homes. Following the macroeconomic approach, the Bronze Age was characterised by changes in ritual practices and the organisation of exchange. Two transitional phases of the Bronze Age in Central Europe were defined by Primas (1997): (1) the beginning of the Early Bronze Age and (2) the formation of Late Bronze Age civilisation. Copper and bronze were generally used as a medium of exchange, symbols of rank and votive offerings. The situation changed in the Late Bronze Age, when cultural networks and attitudes towards bronze changed. The circulation of scrap metal and ingots are typical indicators.

Trade and cultural connections between the region of South Bohemia, Czech Republic (Fig. 1), and several other distant, geographically similar regions are known from all periods of the Bronze Age (2300/2000–800 BC; Table 1). The paths of prehistoric long-distance trade routes were reconstructed based on the locations of hoard finds, typical artefacts and uncommon trading posts (Chvojka 2015b; Gediga 2007; Unger and Pecinovská 2015).

Archaeological evidence includes prestige objects which document these connections. In addition to artefacts, various agricultural products could have been transported based on the archaeobotanical results presented from Bronze Age samples and later (Iron Age) finds of imported grape pips (*Vitis vinifera*) (Šálková et al. 2015). Written sources are not available for Central Europe in the period of the Bronze Age. But, changes in Central European Bronze Age society were caused by many factors, and the influence of contacts with other regions was crucial.

This study uses and interprets archaeobotanical data from the region of South Bohemia, which connects the densely occupied regions of the Danube and Central Bohemia. The main hypothesis tested is that the material culture (artefacts) and agriculture gradually changed, as was reflected in the spectrum of cultivated plants which Bronze Age society used.

Material and methods

South Bohemia is one of the best naturally defined regions in Central Europe, surrounded on almost all sides by a ring of mountains and highlands with little evidence of prehistoric settlement (Fig. 1). This geographic position generated a specific cultural identity in the region (Chvojka 2007). A stable

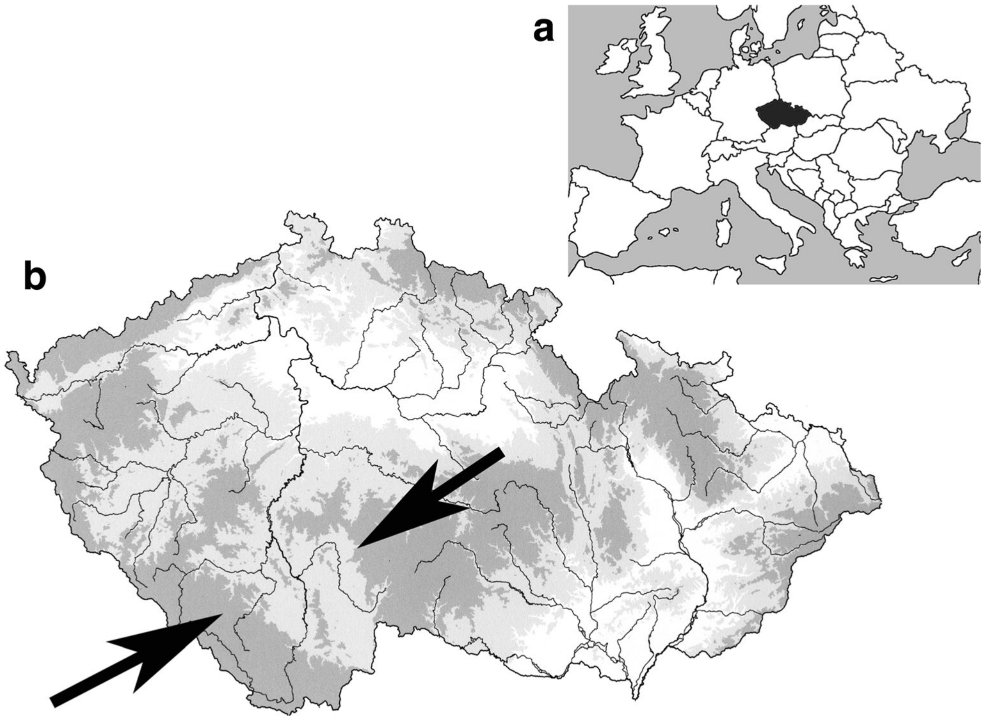


Fig. 1 **a**, **b** Relief of the Czech Republic, South Bohemia is marked by arrows

settlement structure existed there during all periods of the Bronze Age (Table 1, Fig. 2). A permanent settlement network also continued there during the Iron Age.

The subjects of the analyses are charred macroremains of cultivated plants (e.g. caryopsis, chaffs, seeds) from the area of South Bohemia, which were dated to periods from the Early Bronze Age to the Final Bronze Age (dated in South Bohemia 2000–800 BC; e.g. Hlásek and Chvojka in print; Table 1). The region was culturally uniform at particular periods of the Bronze Age. Sediment samples with charred remains came primarily from archaeological rescue excavations and partly from systematic excavations. Archaeological contexts (i.e. samples) were dated using the methods of artefactual archaeology (Jiráň et al. 2008) and/or AMS radiocarbon dating (Table 2). The chronology of the South Bohemian Bronze Age was also supported by

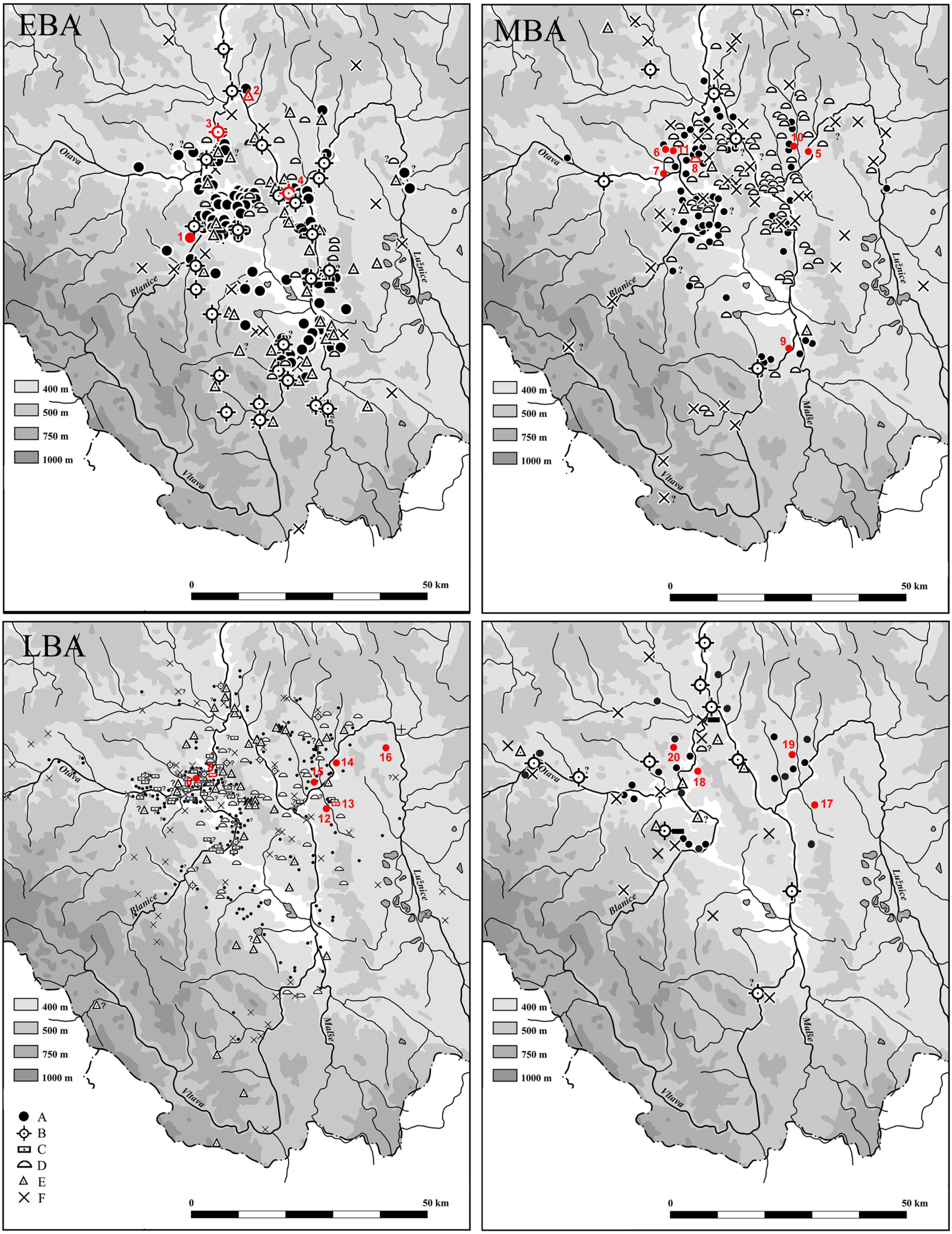
Table 1 Chronological table of archaeological time periods for Czech Republic. Settlements were not found for the earliest period of the Bronze Age in the region of the South Bohemia (see also Table 2). Intensive settlement was recorded by chronological stage EBA II

Period	Reinecke stage	BC
Late Eneolithic (EBA 0)	Br A0	2300–2000
Early Bronze Age (EBA I)	Br A1/A2 - Br A2	2000–1800
Early Bronze Age (EBA II)	Br A2/B1 - B1	1800–1500
Middle Bronze Age (MBA)	Br B2-D1	1500–1250
Late Bronze Age (LBA)	Br D1 - Ha A2/B1	1250–1000
Final Bronze Age (FBA)	Ha B	1000–800

AMS radiocarbon dating of a number of samples of plant origin (Table 2, Fig. 3). Archaeobotanical material from the Urnfield Period could be divided into groups of the Late Bronze Age (1250–1000 BC) and the Final Bronze Age (1000–800 BC), which was not a standard in most of the archaeobotanical works, based on precise artefact processing (and dating) in all contexts. The chronological components of the Late Bronze Age and the Final Bronze Age groups were in fact hidden within the Urnfield Period (Gyulai 1993; Kočár and Dreslerová 2010; Stika and Heiss 2013).

Bronze Age settlements in the region of South Bohemia occurred at altitudes of 375–462 m a.s.l. Most of the researched sites are located, today, on cambisols and planosols, which are less convenient for agriculture (Table 3). However, the current quality of these soils is the result not only of natural soil development but also of previous human activity (Dreslerová et al. 2016). Millennia of past agricultural practices and general land use has resulted in accumulation. It is therefore likely that these areas may have been more suited to agriculture during the Bronze Age than they are presently. Cambisols often form after clearance and during agriculture, whereas planosols are more associated with lowland areas and accumulation of clay and alluvium (Beneš 1998; Volungevičius et al. 2019).

Charred archaeobotanical macroremains were analysed from 23 sites (EBA 4, MBA 7, LBA 7, FBA 5). Samples were obtained from 19 settlements, three burial grounds, and one hoard find of bronze goods from the altitude 375–462 m a.s.l. (Table 3, Fig. 2). Soil quality and altitude were recorded for all


EBA
MBA
LBA
Otava
Blanice
Vltava
Lužnice
Malše
400 m
500 m
750 m
1000 m
A
B
C
D
E
F
0
50 km
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

◀ **Fig. 2** Settlement structure of the region of the South Bohemia. Archaeobotanically sampled sites are marked in red (A—flat settlement, B—hillfort, C—flat grave, D—tumulus grave, E—hoard find, F—isolated find). EBA (1. Dub/Javornice, 2. Kučeř, 3. Vrcovice, 4. Všemyslice), MBA (5. Dobronice u Bechyně, 6. Oldřichov, 7. Kestřany, 8. Písek, Bakaláře, 9. Planá u Českých Budějovic, 10. Rataje u Bechyně, 11. Písek, AISIN 2003), LBA (12. Březnice u Bechyně, Na Píckách, 13. Březnice u Bechyně, jatka, 14. Černýšovice, 15. Hvožďany u Bechyně, 6 Oldřichov, 8 Písek, Bakaláře, 16. Zhoř u Tábora), FBA (17. Březnice u Bechyně, U Františka, 18. Písek, hospital, 19. Rataje u Bechyně, III, 20. Čížová I)

sites (Table 3). Infills of archaeological features and cultural layers were sampled using the methods of total, systematic and probabilistic sampling (Marston et al. 2014; Jones 1991). The number of samples from different periods of the Bronze Age varied (Table 3). In total, 481 samples were analysed in this dataset, with a volume of more than 6144 l of sediment (EBA 89 soil samples, 1414 l; MBA 32 soil samples, 617 l; LBA 332 soil samples, 3675 l; FBA 38 soil samples, 438 l; Table 3). All of the samples were taken in open archaeological terrain situations (Jacomet et al. 1989) and reflected structured human activities.

Archaeobotanical samples from archaeological sediments were extracted by water flotation, using a flotation tank (modified ANAKARA type; Pearsall 1989). Samples from four archaeological sites (Čulíková 2004, Čížová I, Písek—Bakaláře, Kučeř) were floated using the washing over method (bucket flotation; Pearsall 1989). The light fraction was collected on sieves with mesh sizes of 0.25 and 0.4 mm. Both flot

Table 2 Radiocarbon data from the Bronze Age of South Bohemia. Data were calibrated by OxCal v4.2.4 (Bronk Ramsey 2013) and IntCal13 (Reimer et al. 2013)

	Lab. code	Sample	Context	Material	14C age, years BP	±	Calibrated BC			
							From	To	%	Reference
Borek	UGAMS-23267	75	S	Caryopsis	3430	25	1873	1661	95.4	Unpublished
Purkarec	KIA-35089		H	Rope	3417	28	1869	1632	95.4	Chvojka and Havlice (2009)
Zahrádka	UGAMS-13077	2	B	Caryopsis	3380	30	1746	814	95.4	Šálková et al. (2015)
Dobešice	Poz-26985		B	Charcoal	3360	35	1744	1534	95.4	Krištuf and Rytíř (2009)
Všemyslice	UGAMS-19561	12	S	Charcoal, branch	3360	20	1731	1614	95.4	Hlásek et al. (2015)
Kroclov	UGAMS-25534	2	H	Rope	3350	25	1735	1545	95.4	Unpublished
Dobešice	Poz-26984		B	Charcoal	3340	35	1736	1528	95.4	Krištuf and Rytíř (2009)
Křenovice	UGAMS-25535	4	H	Rope	3340	25	1691	1532	95.4	Unpublished
Vrcovice	UGAMS-15485	36	S	Caryopsis	3300	25	1631	1509	95.4	Hlásek et al. (2014)
Planá u ČB	UGAMS-10030		S	Caryopsis	3300	25	1631	1509	95.4	Unpublished
Dobešice	Poz-26987		B	Charcoal	3265	35	1625	1451	95.4	Krištuf and Rytíř (2009)
Vrcovice	UGAMS-15486	3	S	Fruit	3250	25	1611	1453	95.4	Hlásek et al. (2014)
Všemyslice	UGAMS-19562	20	S	Caryopsis	3240	20	1607	1446	95.4	Hlásek et al. (2015)
Písek AISIN	UGAMS-19554	46	S	Caryopsis	3240	25	1609	1443	95.4	Hlásek et al. (2017)
Temešvár	UGAMS-23272		H	Stalks	3220	25	1595	1431	95.4	Fröhlich et al. (2016)
Dobešice	UGAMS-26133		B	Charcoal	3135	35	1497	1301	95.4	Krištuf and Rytíř (2009)
Haškovcova Lhota	UGAMS-10029	1	B?	Wood	3110	25	1435	1297	95.4	Chvojka et al. (2011)
Planá u ČB	UGAMS-8026	34	S	Acorn	3080	25	1415	1274	95.4	Unpublished
Písek AISIN	UGAMS-19556	63	S	Caryopsis	2990	25	1367	1124	95.4	Hlásek et al. (2017)
Borek	UGAMS-23268	82	S	Caryopsis	2990	25	1367	1124	95.4	Unpublished
Hvožďany	UGAMS-8027	1	S	Caryopsis	2950	25	1231	1055	95.4	Chvojka et al. (2011)
Březnice	UGAMS-8024	19	S	Seed	2870	25	1121	940	95.4	Chvojka and Šálková (2011)
Hvožďany	UGAMS-9885	2	S	Caryopsis	2870	25	1121	940	95.3	Chvojka et al. (2011)
Voltýřov	Bln-4208		S	Charcoal	2795	50	1084	828	95.4	Smejtek (2011)
Brloh	UGAMS-16798		S	Charcoal	2790	20	1006	859	95.4	Fröhlich et al. (2014)
Voltýřov	Bln-4207		S	Charcoal	2785	60	1107	814	95.4	Smejtek (2011)
Zahrádka	UGAMS-13078	3	B	Stalks	2700	30	905	806	95.4	Šálková et al. (2015)
Albrechtice	UGAMS-19563		B	Caryopsis	2640	20	827	795	95.5	Unpublished

S—settlement, *H*—hoard find of bronze artefacts, *B*—burial ground

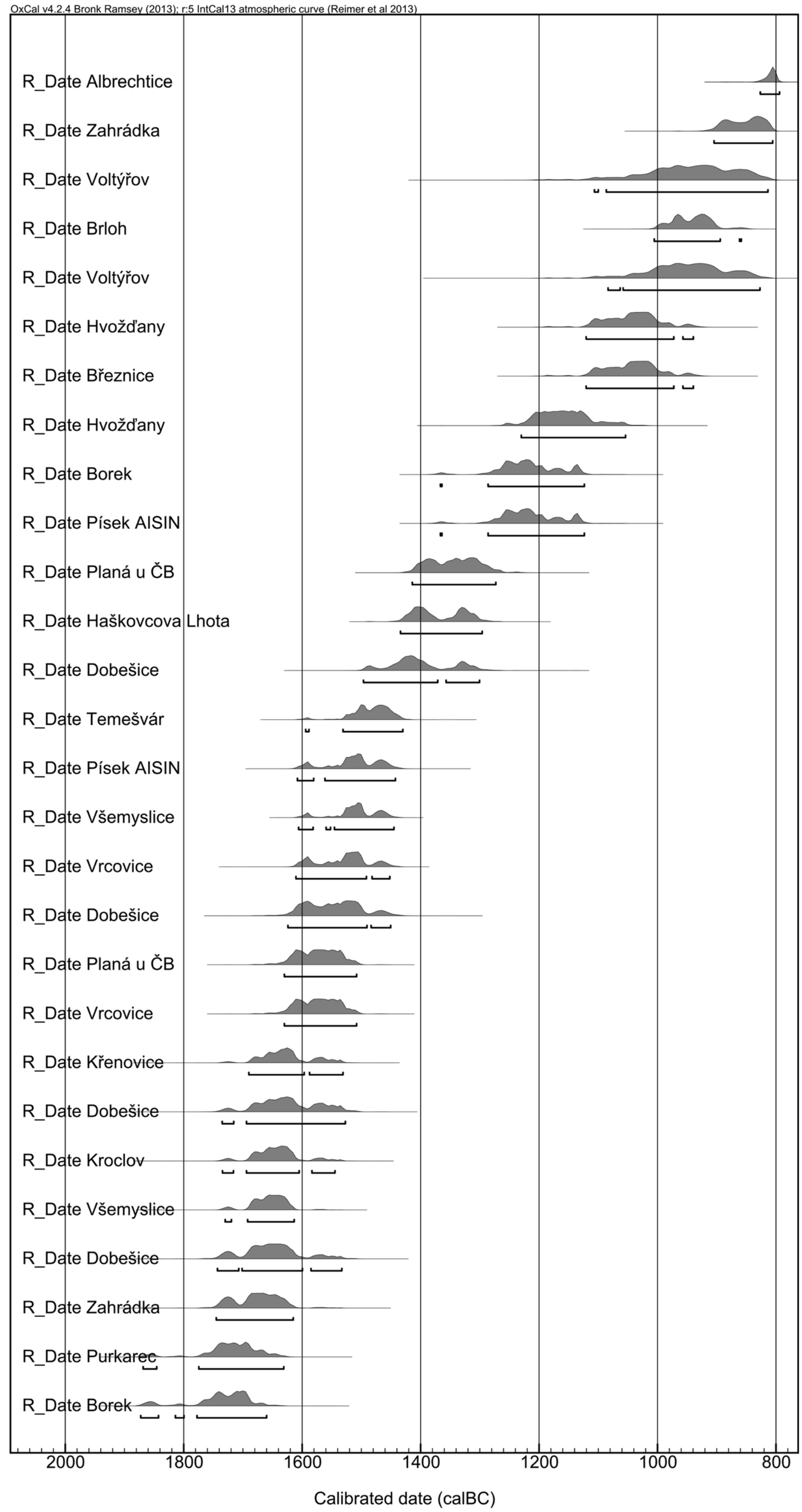


Fig. 3 Radiocarbon data from the Bronze Age of South Bohemia. Data were calibrated by OxCal v4.2.4 (Bronk Ramsey 2013) and IntCal13 (Reimer et al. 2013)

and heavy fractions were sorted in full and analysed under a stereomicroscope. All macroremains (charred and uncharred remains of crops and all other plants) were collected. All plant macroremains were determined, but only charred remains of crops were used for the purpose of this work (determined by Jacomet 2006; Hajnalová 1993; Hajnalová 2012, and

Table 3 Properties of the archaeobotanicaly analysed sites

	Dating	Component	Average altitude	Soil	Number of samples	Volume of soil (l)
Dub/Javornice	EBA	S	462.00	Cambisols	2	134
Kučeř	EBA	H	458.00	Planosols	7	4.5
Vrcovice	EBA	S	408.00	Cambisols, rankers, lithosol	37	675
Všemyslice	EBA	S	395.00	Cambisols	43	600.5
Sum			430.75		89	1414
Dobronice u Bechyně	MBA	S	420.00	Cambisols	2	45
Oldřichov	MBA	S	410.00	Albic luvisols	3	30
Kestřany	MBA	S	383.00	Planosols	1	20
Písek, Bakaláře	MBA	B	375.00	Cambisols	7	170
Planá u Českých Budějovic	MBA	S	400.00	Planosols	16	292
Rataje u Bechyně	MBA	S	395.00	Planosols	3	60
Písek, AISIN 2003	MBA	S	393.00	cambisols, Rankers, lithosols		
Sum			396.57		32	617
Březnice u Bechyně, Na Píckách	LBA	S	439.00	Cambisols	166	1991
Březnice u Bechyně, jatka	LBA	B	449.00	Cambisols	14	125
Černýšovice	LBA	S	420.00	Planosols	4	7
Hvožďany u Bechyně	LBA	S	451.00	Planosols	112	1251
Oldřichov	LBA	S	410.00	Cambisols	7	75
Písek, Bakaláře	LBA	B	375.00	Cambisols	14	165
Zhoř u Tábora	LBA	S	428.00	Cambisols	5	61
Sum			424.57		322	3675
Březnice u Bechyně, U Františka	FBA	S	445.00	Orthic luvisols	6	23
Písek, hospital	FBA	S	399.00	Cambisols	9	75
Rataje u Bechyně, III	FBA	S	402.00	Planosols	1	10
Čížová I	FBA	S	440.00	Planosols	2	?
Čížová	FBA	S	440.00	Planosols	20	330
Sum			425.20		38	438

S—settlement, *H*—hoard find of bronze artefacts, *B*—burial ground

comparative collection). Crops were divided into three groups: (1) cereals (caryopsis, glume bases and chaff), (2) legumes (seeds) and (3) oil plants (seeds). Plant remains were primarily counted in NISP (Table 4). Bronze Age plant macroremains from the South Bohemian region were frequently degraded because the soils were acidic, the features were often shallow and disturbed and the macroremains were burned at a high temperature.

Due to the character of the dataset, the archaeobotanical records were standardised by conversion to percentages. Primary results were obtained in two ways: (A) plant remains counted in NISP as a sum of all sites for individual periods of the Bronze Age were shown as percentages (Figs. 4a, 5a and 6a); (B) remains were counted as percentages for all single sites and shown as an average percentage for single periods (Figs. 4b, 5b and 6b). The comparative results of various sites were thus averaged within the specific time period. This projection (B) was considered to be more representative than using NISP and more reflective of the reality of the past (Figs. 4b, 5b and 6b).

The multivariate statistical analysis implemented in Canoco v. 5 (Šmilauer and Lepš 2014) was used to compare

Table 4 Results of archaeobotanical analyses from the region of South Bohemia (Czech Republic) during the Bronze Age, which were largely obtained between 2005 and 2015. Crop spectra from Bronze Age sites in South Bohemia, spectra in NISP

	Dub/ Javornice	Kučeř	Vrcovice	Všemyslice	Dobronice u Bechyně	Oldřichov	Kestřany	Písek, Bakaláře	Planá u Českých Budějovic	Rataje u Bechyně	Písek, AISIN 2003	Březnice u Bechyně, Na Píckách
References	EBA Unpublished	EBA Chvojka et al. (2018)	EBA Hlásek et al. (2014)	EBA Hlásek et al. (2015)	MBA Chvojka et al. (2011)	MBA Unpublished	MBA Unpublished	MBA Unpublished	MBA Unpublished	MBA Chvojka et al. (2011)	MBA Čulíková (2004) in Fröhlich et al. (2004)	LBA Unpublished
Avena sp.												
Cerealia	6	4	208	3	6	2	3		462	2	154	1310
Hordeum vulgare	24		11	4	1				1428	5	1	537
Hordeum vulgare var. *vulgare*									232			3
Hordeum vulgare var. *nudum*												16
Lens culinaris												315
Lens/*Pisum*												3
Panicum miliaceum									99		2	6549
Panicum/*Setaria*												17
Papaver somniferum								1				2
Pisum sativum				2								247
Pisum/*Vicia*			4						9			1037
Secale cereale												3
cf. *Secale cereale*					2						1	
Triticum aestivum/*durum*/*turgidum*/*compactum*												47
Triticum cf. *durum*/*turgidum* R												
Triticum aestivum/*durum*/*turgidum*/*spelta*												7
Triticum compactum												
Triticum cf. *spelta*	2											9
Triticum spelta GB									333			7
Triticum spelta									4381			42
Triticum dicoccum GB	5	2	11									6
Triticum cf. *dicoccum*												2
Triticum dicoccum	10		6	1					6			36
Triticum dicoccum/*spelta*	1											3
Triticum dicoccum/*spelta* GB	2		1									87
Triticium dicoccum/*monococcum*											10	1
Triticium dicoccum/*monococcum* GB											58	
Triticum monococcum	1											6
Triticum monococcum GB		5								1	43	18
Triticum sp.			4									112
Triticum sp. GB		2	15									103
Vicia faba												54
Sum	51	13	260	10	9	2	3	1	6950	8	269	10,579

Table 4 (continued)

References	Březnice u Bechyně, jatka LBA Chvojka et al. (2009)	Černýšovice LBA Unpublished	Hvožďany u Bechyně LBA Chvojka et al. (2011)	Oldřichov LBA Unpublished	Písek, Bakaláře LBA Unpublished	Zhoř u Tábora LBA Chvojka et al. (2014)	Březnice u Bechyně, U Františka FBA Unpublished	Písek - hospital FBA Pokorná et al. (2016)	Rataje u Bechyně, III FBA Unpublished	Čížová I FBA Čulíková (2005)	Čížová FBA Unpublished
Avena sp.			1	2				4			
Cerealia	11	29	76	57	8	25	52	72	28	15	50
Hordeum vulgare	3	2	50	3	4		39	12	6	1	15
Hordeum vulgare var. *vulgare*				2	1		2			1	
Hordeum vulgare var. *nudum*								1			
Lens culinaris	1	7	24	1		272	18	2			5
Lens/Pisum											
Panicum miliaceum	1	23	283	3		1	7	2	1	5	11
Panicum/Setaria		1		1		3					
Papaver somniferum			1						1		
Pisum sativum		1	7			1	1	1		2	1
Pisum/Vicia		18		5	1	9	7				6
Secale cereale											
cf. *Secale cereale*											
Triticum aestivum/durum/turgidum/-compactum			3					3			4
Triticum cf. *durum/turgidum* R								2			
Triticum aestivum/durum/turgidum/spelta											
Triticum compactum								7			
Triticum cf. *spelta*			3				1				
Triticum spelta GB		2	2				1	2			
Triticum spelta								4			
Triticum dicoccum GB		1	3				2	2			1
Triticum cf. *dicoccum*											2
Triticum dicoccum		1	14	1		2	4	3	2		
Triticum dicoccum/spelta			2	2			12	5			
Triticum dicoccum/spelta GB		1	2	5				1			
Triticium dicoccum/monococcum							1				
Triticium dicoccum/monococcum GB				5							
Triticum monococcum			1								
Triticum monococcum GB		1	1	3				3			
Triticum sp.		1	15					1			3
Triticum sp. GB			2								2
Vicia faba							2				1
Sum	16	88	490	90	14	313	149	127	38	24	101

R—rachis fragment, *GB*—glume base

spectra of crop species in individual periods of the Bronze Age in South Bohemia. Logarithmic transformation of the percentage data and centring by species was used for all ordinations. A detrended correspondence analysis (DCA) was carried out to check the length of the gradient. The maximum length of the gradient was 1.4, so a principal component analysis (PCA) was performed.

The composition of crop plant spectra from the South Bohemian region was compared with the results from these neighbouring regions: (1) Bohemia and Moravia lowlands, (2) the Eastern Alps and Alpine Foreland, (3) western Slovakia and (4) Hungary. The data from the South Bohemian region were mostly collected by the authors; data from neighbouring regions were compiled from existing published works (Stika and Heiss 2013; Kočár and Dreslerová 2010; Hajnalová 2012; Gyulai 1993).

Archaeobotanical datasets in these reference regions usually have more conclusive results and are supported by a greater quantity of finds. On the other hand, they were obtained within larger regions, with variable culture backgrounds and environmental conditions (e.g. the Alps and Upper Danube, Central Bohemia and South Moravia). Despite this fact, a framing comparison within the regions thus defined seems to be possible (Figs. 7 and 8). Since the published data had different formats (NISP, MNI, percent, etc.), it was necessary to standardise them. For this purpose, a summarising comparison was elaborated, in which the dominant species (the most numerous) has the numerical value ‘3’, the subdominants (frequently occurring, but not the most numerous) ‘2’ and the proven lower density species ‘1’ (Table 5). PCA was used to compare spectra of dominant and subdominant species of South Bohemia and reference regions using Canoco 5 software (Šmilauer and Lepš 2014; Fig. 9a–c). In the next step, accordance between the dominants and subdominants in the comparative regions was searched for. If the same crop was observed to represent a dominant in both regions, the numerical value ‘2’ was ascribed; in case the specific crop represented a dominant in one region, but a subdominant in another, the numerical value ‘1’ was attributed (Fig. 7). Thus, the resulting diagram always expresses the similarity of important crops in two focused regions (Fig. 7).

Results

The composition of crop plant spectra during study periods

A total of 19,613 plant macroremains were obtained from the various Bronze Age sites of South Bohemia. The dataset was

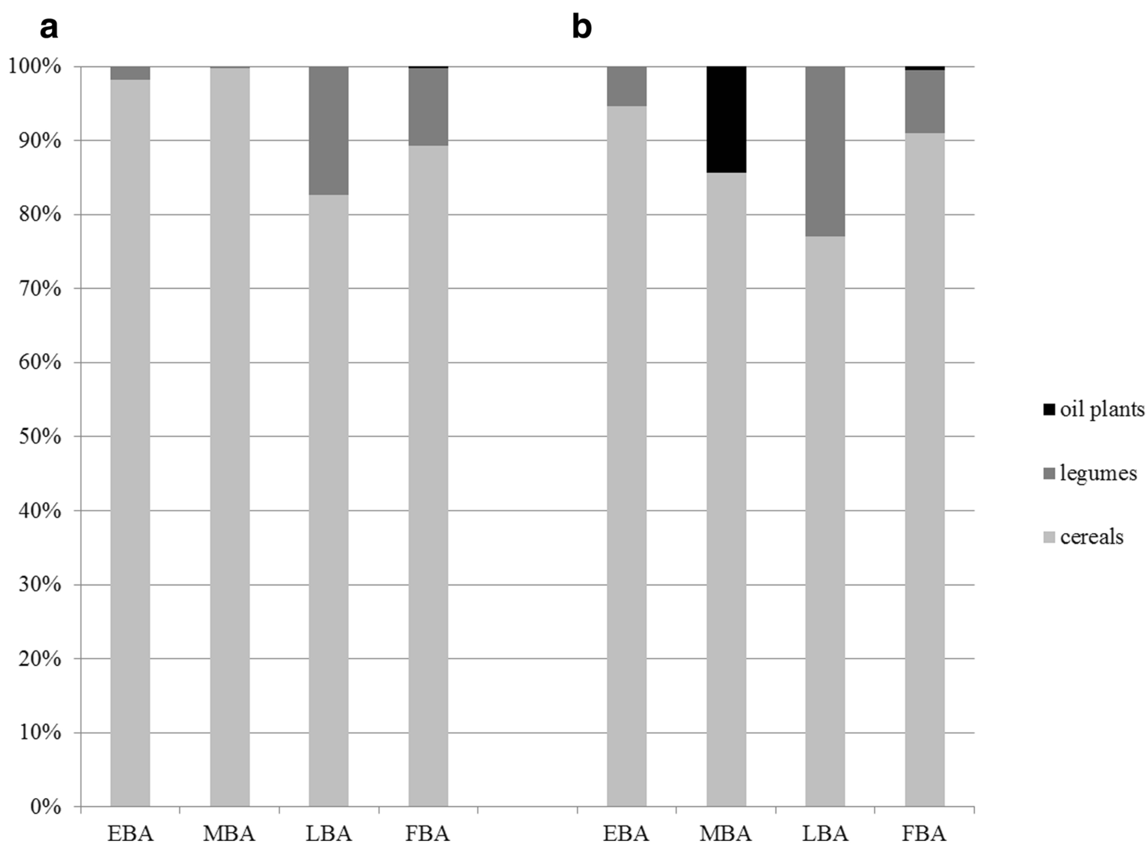


Fig. 4 Composition of macroremains of crops (the sum of all remains: **a**—counted in NISP as a sum of all sites for individual periods of the Bronze Age, showed in percentage; **b**—counted in percentage for all single site, showed in average percentage for single periods

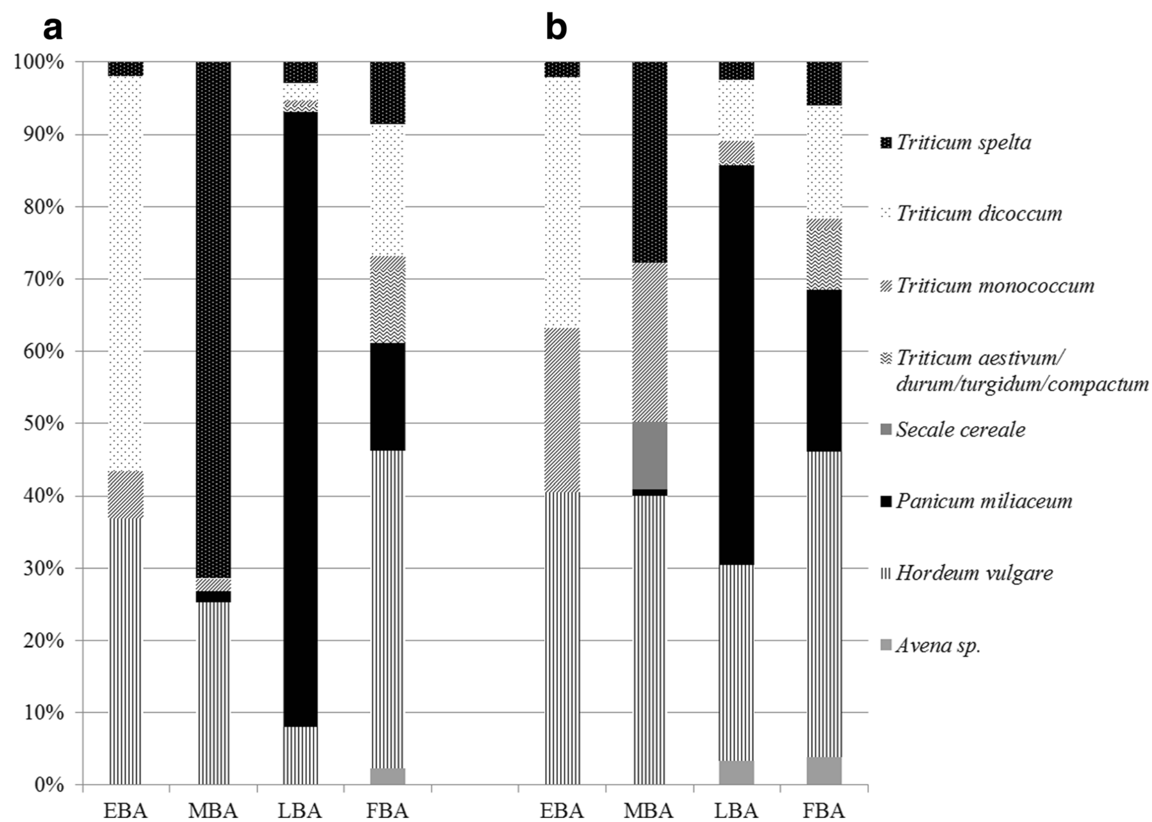


Fig. 5 Composition of macroremains of cereals (the sum of all remains); **a**—counted in NISP as a sum of all sites for individual periods of the Bronze Age, showed in percentage; **b**—counted in percentage for all single sites, showed in average percentage for single periods

weighted more heavily towards samples from the Middle, and especially, the Late Bronze Age (EBA 334, MBA 7250, LBA 11,590, FBA 439 of plant macroremains; Table 4, Fig. 4).

Cereals

Early Bronze Age Remains of barley (*Hordeum vulgare*) and emmer wheat (*Triticum dicoccum*) were dominant in samples from the Early Bronze Age. Remains of einkorn wheat (*Triticum monococcum*) were less frequent in this period, with only a few records of spelt wheat (*Triticum spelta*).

Middle Bronze Age Barley could still be considered the dominant cereal during the Middle Bronze Age, while spelt wheat and, to a certain extent, einkorn wheat can be considered important crops during this period. However, emmer wheat is notably almost entirely absent during this period. Additionally, there are remains of rye (*Secale cereale*), but these are few in number. This period also provides the earliest findings for caryopses of common millet (*Panicum miliaceum*) in this region, although these were rarely present.

Late Bronze Age The Late Bronze Age was characterised by large quantities of remains of common millet, which was dominant in most of the researched sites. With the exclusion of millet (with small caryopses), remains of barley indicated it was still the dominant crop. Remains of spelt and emmer wheat were common components of the crop package during this period. Remains of einkorn and naked wheat (*Triticum aestivum*/*durum*/*turgidum*) were commonly found within samples but rarely constituted more than a few grains within each. Remains of oat (*Avena* sp.) and rye were infrequent.

Final Bronze Age The species of crops in the Final Bronze Age remained the same as in the Late Bronze Age, but the composition of the crop plant spectrum changed. Barley stayed dominant, and remains of emmer wheat were subdominant, along with remains of common millet. In comparison with the Late Bronze Age, the quantity of remains of spelt wheat and naked wheat increased. Einkorn wheat and oat were few in number (Table 4, Fig. 5).

It could be concluded that barley was a stable cereal in South Bohemia throughout the Bronze Age. The state of preservation of barley remains did not allow for conclusive determination of its forms throughout the Bronze Age. Rachis fragments were rarely present, and caryopses were often degraded. Caryopses of hulled barley (*Hordeum vulgare* var. *vulgare*) were identified in the Middle Bronze Age (inside feature infill in Planá u Českých Budějovic). During the Late and Final Bronze Age periods, both forms of barley—hulled and naked

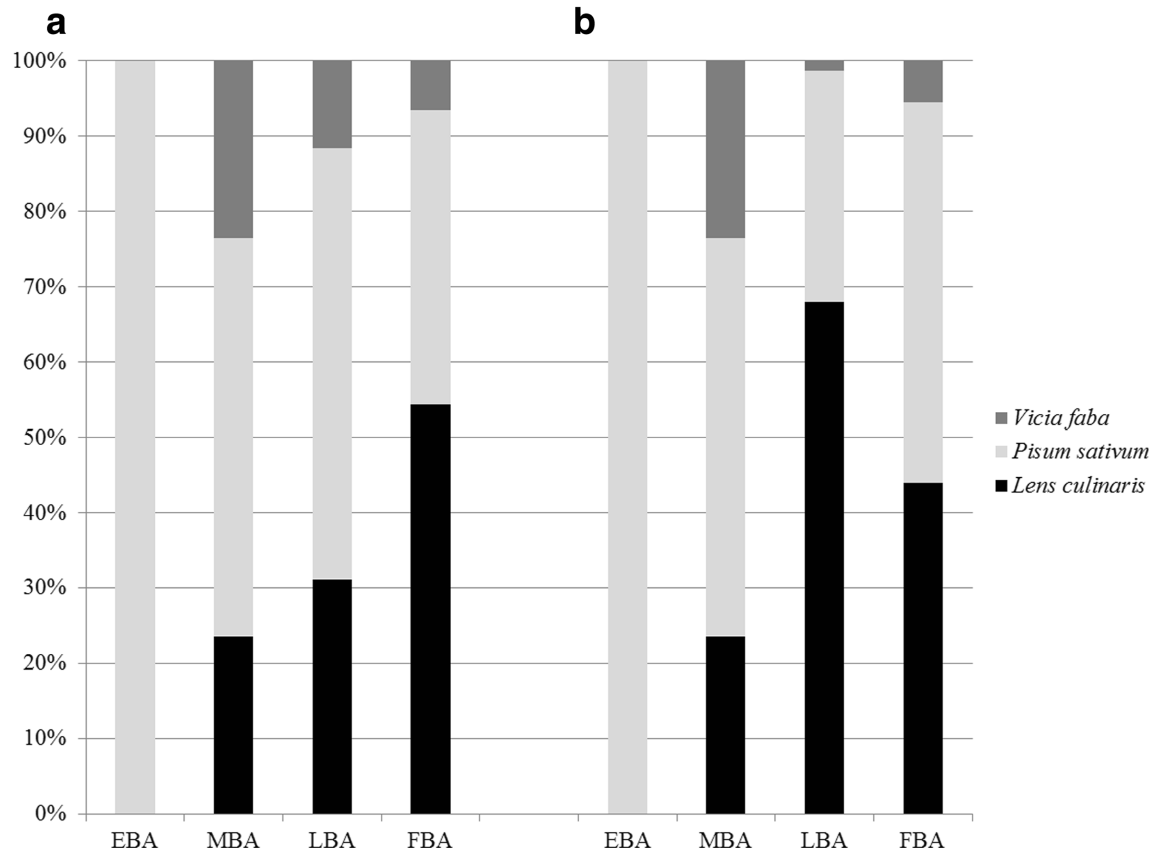


Fig. 6 Composition of macroremains of pulses (the sum of all remains); **a**—counted in NISP as a sum of all sites for individual periods of the Bronze Age, showed in percentage; **b**—counted in percentage for all single sites, showed in average percentage for single periods

(*Hordeum vulgare* var. *vulgare* and *Hordeum vulgare* var. *nudum*)—occurred repeatedly. Distinction of the species of naked (free-threshing) wheat (*Triticum aestivum*/*durum*/*turgidum*/*compactum*) was also impossible, because of a near total absence of rachis fragments. Only two degraded fragments of rachis of wheat were found (FBA, Písek-hospital). They were determined rather as tetraploid species (cf. *T. durum*/*turgidum*).

Pulses

Remains of pulses (Table 4, Figs. 4 and 6) were less numerous in the Early and Middle Bronze Ages (less than 2%). In samples from the Early Bronze Age, only seeds of pea (*Pisum sativum*) were found, but in the Middle Bronze Age, seeds of pea, lentil (*Lens culinaris*) and faba bean (*Vicia faba*) were present. The proportion of pulse seeds in the remains of crops in the Late Bronze Age was ca. 17% in NISP. The spectrum of species remained the same as in the Middle Bronze Age. Seeds of lentil were the most frequently recorded. The proportion of pulse seeds in the remains of crops was in NISP ca. 10% in the Final Bronze Age, and the numbers of seeds of lentil and garden pea were balanced. Seeds of faba bean (*Vicia faba* var. *minor*) were less frequent from the Middle Bronze Age to the Final Bronze Age. Pulses have important implications for the general nature of agriculture. So, remains of pulses were commoner in the Late and Final Bronze Ages than the Early and Middle Bronze Ages.

Oil plants

Oil plants were represented by seeds of the opium poppy (*Papaver somniferum*), which was less frequent (less than 1% of crops in NISP) from the Middle Bronze Age.

On average, more than a third of the detected crop macroremains had to be classified as "Cerealia indet." (EBA 38.13%; MBA 50.79%; LBA 36.86%; FBA 55.46%). It was possible to divide the similarity of the spectra and the quantity of the remains of crops found in the following way: (1) Early Bronze Age and Middle Bronze Age sites and (2) Late Bronze Age and Final Bronze Age sites. The Middle Bronze Age archaeological sites, however, had some peculiar features, which were suggestive of evidence found either in the earlier or in the later period, e.g. MBA samples from settlements in

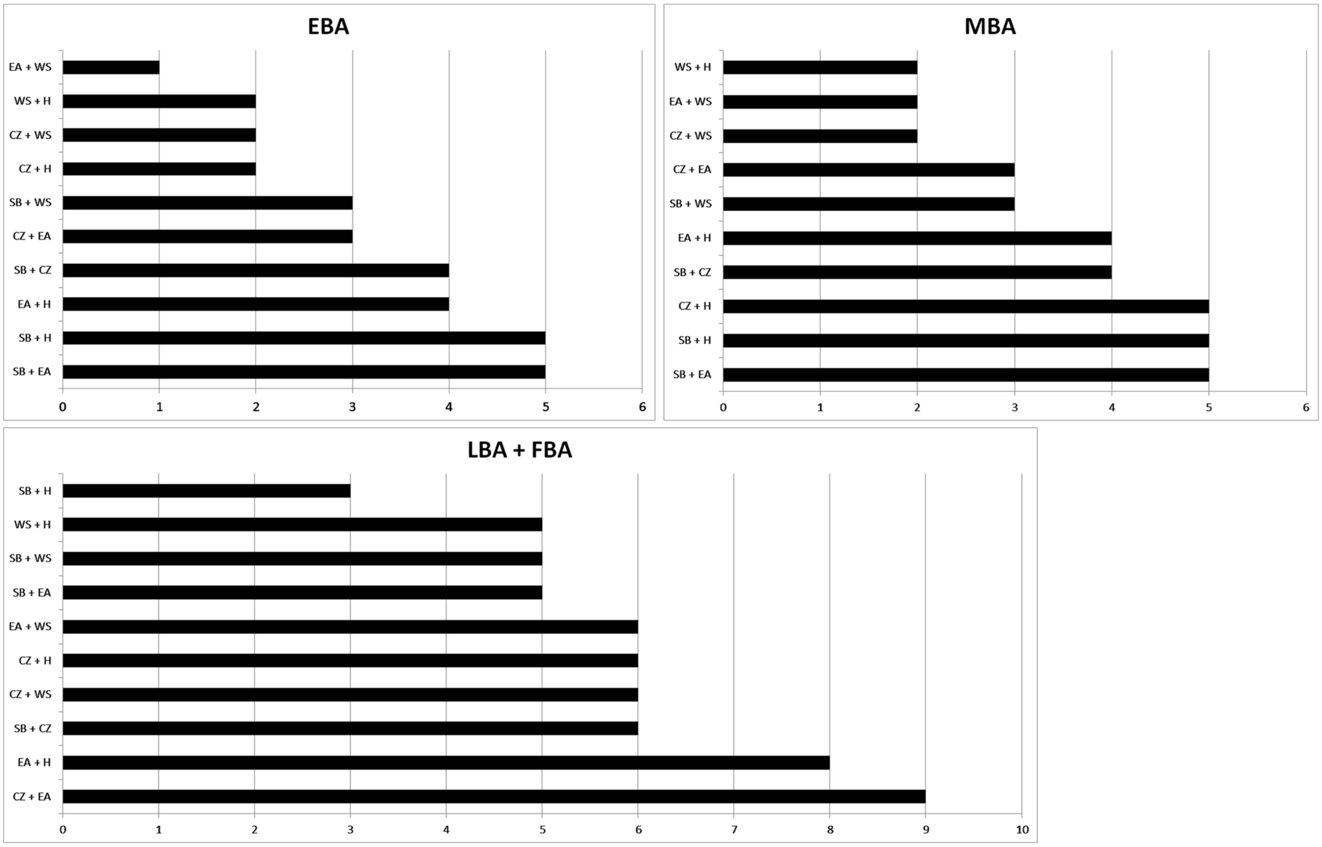


Fig. 7 Comparison of dominant and subdominant crops in observed regions. Individual peaks are the sum of the similarity values of dominant and subdominant crops (values 1 or 2) of two of the monitored regions. The length of the peaks shows the similarity of the structure of important crops. Also noticeable is the increase of important species in the Late and Final Bronze Ages in all regions. SB—South Bohemia, CZ—Czech Republic (excluding South Bohemia), EA—Eastern Alps and the Alpine Foreland, WS—Western Slovakia, H—Hungary

Planá and Písek AISIN contained common millet which was typical for the LBA. Other MBA settlements had crop spectra rather more typical for EBA (Table 4, Fig. 5).

Reference regions

Comparative region 1: Eastern Alps and the Alpine Foreland

Barley (mostly hulled, but naked was also present) was dominant in the region of the Eastern Alps and the Alpine Foreland during the Early and Middle Bronze Ages (Table 5). Emmer wheat and spelt wheat were subdominants, followed by einkorn wheat and naked wheat. Common millet, rye and oat were recorded in low numbers. Barley, emmer wheat and common millet were recorded as the main cereals, with subdominant spelt and einkorn in the Late Bronze Age. Pulses were recorded with low numbers in the Early and Middle Bronze Ages (garden pea with a few counts of field bean and lentil), and they were probably more important in the Late Bronze Age (garden pea with a less abundant field bean and lentil, and a few counts of bitter vetch). The oil plants poppy, gold-of-pleasure and linseed were present with single counts (Stika and Heiss 2013).

Comparative region 2: Czech Republic (excluding South Bohemia)

Average data from the region of the Czech Republic showed emmer wheat as a dominant in the Early Bronze Age (Table 5). Barley was the subdominant and einkorn wheat, spelt, naked wheat, common millet, oat and rye were present in a small number of determinations. In the Middle Bronze Age, einkorn was the dominant and emmer was the subdominant. Spelt and naked wheat increased in comparison with the Early Bronze Age, and they were counted in similar numbers as barley. Rye and oat were present in few numbers. In the Late and Final Bronze Ages, a trio of cereals was found in the same frequency: millet, barley and emmer. Spelt, einkorn and naked wheat were present in few

Fig. 8 Ordination diagram showing results of a PCA analysis of the comparison of crop plant spectra during individual periods of the Bronze Age in the region of the South Bohemia. The first axis explained 50.08% of the variability, and the first two axes together explained 87.78% of the variability

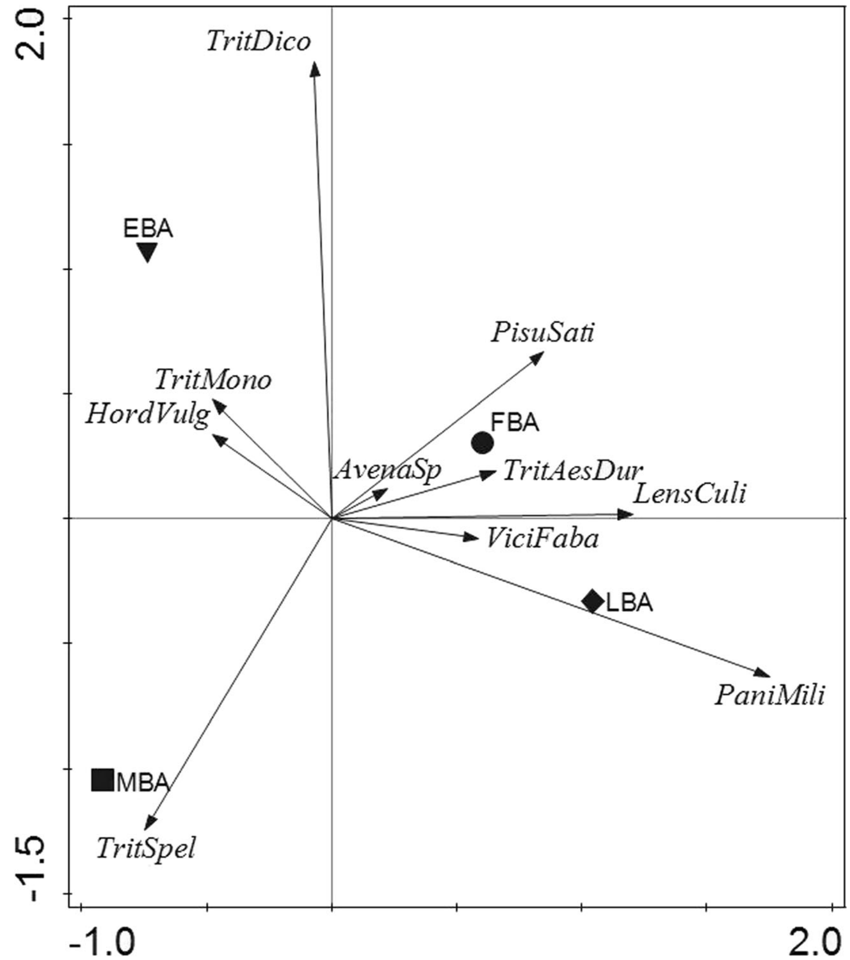


Table 5 The comparison of crop plant spectra with reference regions. The dominant species have the numerical value '3', the subdominants '2', and the species proven in a lower density '1'

	South Bohemia			Czech Republic			Eastern Alps + Alps Foreland			West Slovakia			Hungary		
	EBA	MBA	LBA FBA	EBA	MBA	LBA FBA	EBA	MBA	LBA FBA	EBA	MBA	LBA FBA	EBA	MBA	LBA FBA
Avena sp.	0		1	1	1	1	1	1	1	1		1			1
Hordeum vulgare	3	3	2	1	1	3	3	3	3	1	1	1	3	3	2
Panicum miliaceum		1	3	1	1	3	1	1	3	1	3	3	1	1	2
Secale cereale		1	1	1	1		1	1	1	1	1	1		1	1
Triticum aestivum/durum/turgidum/-compactum		1	1	1	1	1	1	1		1	1	2	1	1	1
Triticum monococcum	2	2	1	1	3	1	1	1	2	2	2	1	2	3	2
Triticum dicoccum	3	1	1	3	2	3	2	2	3	3	1	2	2	3	3
Triticum spelta	1	2	1	1	1	1	2	2	2	1	3	3	1	1	2
Lens culinaris		2	3	1	2	3		1	2	1		3	1	3	2
Pisum sativum	3	3	2	3	3	2	3	3	3	1	2	2	2	2	2
Vicia faba		2	1		1	2	1	1	2			1	1	1	1
Papaver somniferum		1	1			1	1	1	1						1

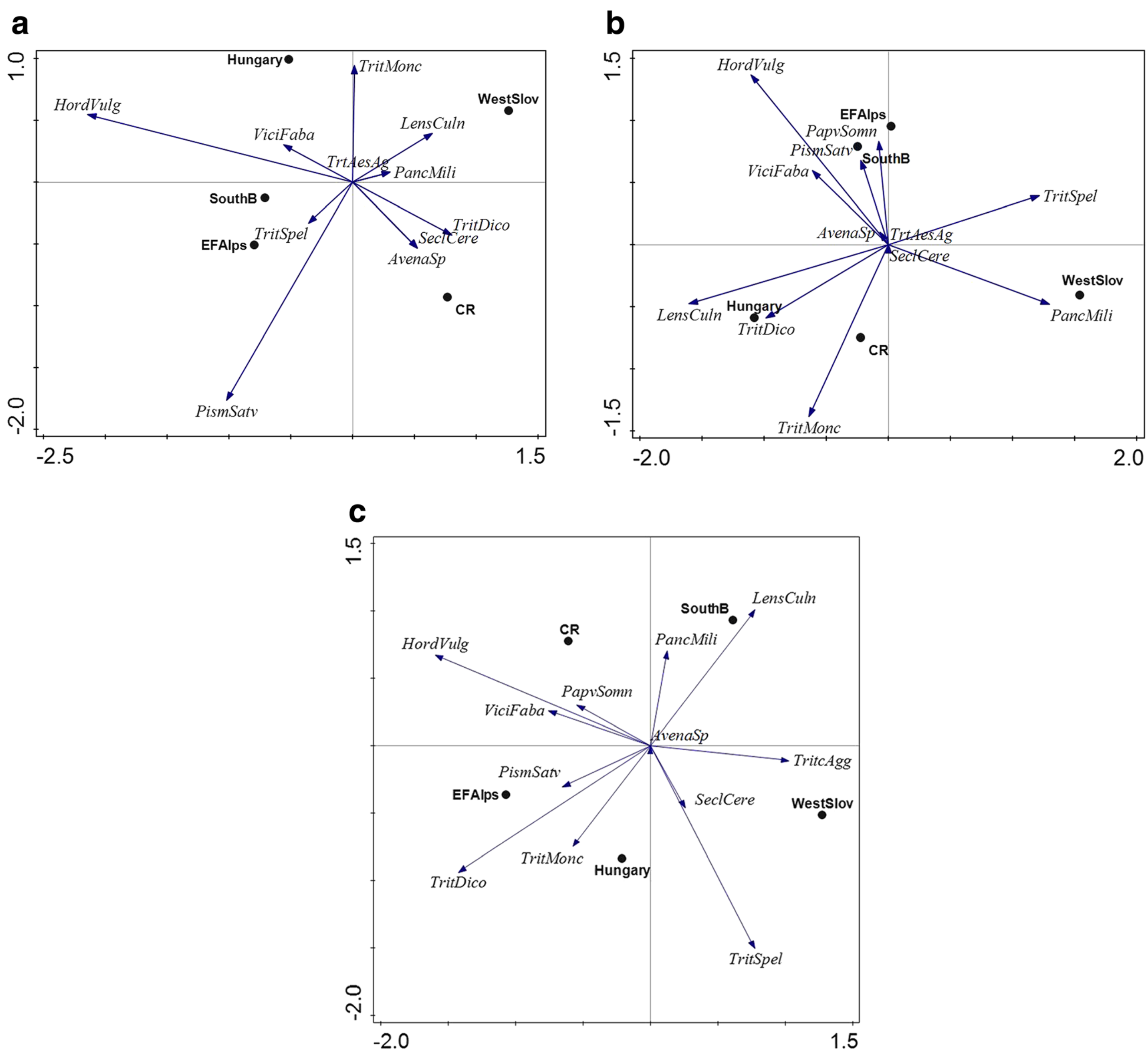


Fig. 9 PCA ordination diagram for the comparison of crop plant spectra with reference regions. **a** Early Bronze Age (the first axis explained 47.318% of the variability, and the first two axes together explained 74.04% of the variability). **b** Middle Bronze Age (the first axis explained 57.39% of the variability, and the first two axes together explained 76.95% of the variability). **c** Late and Final Bronze Ages (the first axis explained 49.72% of the variability, and the first two axes together explained 75.25% of the variability)

numbers, and less numerous were oat and foxtail millet (*Setaria italica*). Our knowledge of the composition of pulses in the Early and Middle Bronze Ages in the Czech Republic is fragmentary (garden pea was more numerous than lentil). In the Middle Bronze Age, faba bean was sporadically present. During the Late and Final Bronze Ages, a wide spectrum of pulses was documented: lentil was dominant, followed by garden pea and faba bean. Common vetch (*Vicia sativa*) and grass pea (*Lathyrus sativus*) were present in low numbers (Kočár and Dreslerová 2010).

Comparative region 3: Western Slovakia

Emmer and einkorn wheat were frequently present in Early Bronze Age assemblages in the region of Western Slovakia (Table 5). Common millet was present in high numbers (but in low numbers of features). Spelt was also frequently found, with einkorn wheat being the important subdominant. Common millet and spelt were dominant in numbers in the Late and Final Bronze Ages, as well as in the Middle Bronze Age. Emmer and naked wheat were important subdominants (Hajnalová 2012). The number of pulses (especially lens) in the Late and Final Bronze Ages was higher in comparison to the Early and Middle Bronze Ages.

Comparative region 4: Hungary

Barley was dominantly present in the Early Bronze Age of Hungary (Table 5). Emmer and einkorn wheat were subdominantly present. The numbers of barley, einkorn and emmer wheat were similar and dominant in the Middle Bronze Age. Emmer wheat was dominantly present in the Late and Final Bronze Ages, while the spectrum of subdominants was wide (barley, einkorn, spelt and common millet; Gyulai 1993).

The comparison of crop plant spectra in South Bohemia with other reference regions

An overview of identical dominant and subdominant crops in particular monitored regions clearly shows that during the Bronze Age—in all regions—species of crops which had significant economic importance increased (particularly, but not in all cases: spelt, naked wheat and common millet). The crop structure in the South Bohemian region was similar to the Eastern Alps and their Foreland in the Early and Middle Bronze Ages (Figs. 7 and 9a, b), while in the Late and Final Bronze Ages, there was a greater similarity to the rest of the Czech Republic (Figs. 7 and 9c). The presence of spelt and barley in the region of the Alps and the Alpine Foreland (as subdominant) and South Bohemia is typical for the periods of the Early and Middle Bronze Ages (Fig. 9a, b). During the Late and Final Bronze Ages, there was a correlation between the rest of the Czech Republic and the Eastern Alps and their Foreland in the average data on composition of crop dominants and subdominants; South Bohemia, on the contrary, represents a specific region in terms of important economic plants (Figs. 7 and 9c). In contrast with other regions, there was a much smaller quantity of remains of emmer.

Analogy in the composition of dominants and subdominants of crops in regions of South Bohemia and Hungary was strong for the Early and Middle Bronze Ages (Fig. 9a, b), but very poor for the Late and Final Bronze Ages (Fig. 9c). Connections in the composition of sub/dominants between regions of the Czech Republic and Hungary were very poor in the Early Bronze Age (Figs. 7 and 9a), strong for the period of the Middle Bronze Age (Figs. 7 and 9b) and relatively strong in the period of the Late and Final Bronze Ages. Composition of sub/dominant crops for regions of the Eastern Alps and the Alpine Foreland and Hungary had some analogy, but a strong similarity between these regions existed in the Late and Final Bronze Ages (Fig. 9c).

Discussion

Crop production was a very dynamic sector of the economy, well-documented in many connected regions across Central Europe. The aim of this contribution was to compare the composition of crops in the South Bohemian region—in all periods of the Bronze Age—with other regions which shared cultural, trade and social contact (e.g. Gyulai 1993; Hajnalová 2012; Stika and Heiss 2013). It can be assumed that, in the region of South Bohemia, the composition of the crop plant spectrum in the Bronze Age was defined by many factors—two of which were fundamental: (a) the condition of the natural environment (flexible adaptation to local climate and cambisols) and (b) traditions of cultural practices and social environmental conditions, including socioeconomic contacts with neighbouring regions.

Connections between crop plant composition and soil quality and altitude have been demonstrated (Dreslerová et al. 2013, 2016) for the region of the Czech Republic. Most of the sites used to create a diagram of the average data of crops in the Czech Republic were found in regions with lower altitudes and more fertile soils (Kočár and Dreslerová 2010, p. 223, figs 5.3 and 5.4; Dreslerová et al. 2013, 2016) than the sites analysed in South Bohemia (Table 3). The dependence of crop spectrum on the quality of soils, and on the altitude, has been demonstrated for the Late Bronze Age (average altitude 286 m) and Final Bronze Age (average altitude 296 m) in the area of the Czech Republic (Dreslerová et al. 2013, 2016). It could be predicted that South Bohemia, with higher altitudes and cambisols and planosols (average altitudes of both LBA and FBA 425 m), should be a typical region for barley cultivation. This would be more probable in higher altitude areas, especially if the upper parts of the soil horizon are subject to drying out. In general, barley is favoured in higher altitudes with a shorter growing season.

This prediction seems to be confirmed. The influence of climate on yields of different plant species was certainly crucial. On the other hand, we can assume that the recorded change in climate (Poschold 2015) was somehow reflected in the wider area of Central Europe. If changes in the composition of crop remains in reflected regions were conditioned only by the influences of climate, those changes should also be recorded in other regions—but they are not evidenced.

Growing seasons of crops, as well as their suitability to various aspects, might also be important to understanding the spectra of crops found in the reflected regions during the Bronze Age. Barley may be a spring-sown crop or a winter crop but often will be more favoured in areas with shorter growing seasons, i.e. as a spring crop. This will also be true of common millet that is sown in spring. Pulses are sown in spring. Emmer and einkorn wheat are either a spring-sown crop or a winter crop. Spelt is often a winter cereal. Based on results from Slovakia, it may be assumed that wheats are grown as a winter crop (Kočár and Dreslerová 2010; Hajnalová 2012, pp. 140–141). Under this assumption, the importance of spring-sown crops would increase in the Late Bronze Age in Central Europe. Especially in South Bohemia, spring crops would be dominant. This observation suggests that the influence of the social factor was high. The reference regions similarly include results from sites with different conditions (variable altitudes, different soil qualities, climate and cultural environments). For example, the region of the Eastern Alps and the Alpine Foreland similarly includes the results from sites in the Danube region, together with the Alps (Stika and Heiss 2013).

The climatic conditions of the Early and Middle Bronze Ages were associated with favourable temperatures and alternation of shorter, drier and wetter fluctuations. The Late and Final Bronze Ages were characterised by a decrease in precipitation and by favourable temperatures. Local climate conditions were also specific for sites with different geographic characteristics (Ložek 1973; Hajnalová 2012; Kuna et al. 2007; Fohlmeister et al. 2012; Breitenbach et al. 2019). The regions of Western Slovakia and Hungary were probably more climactically continental than other referenced regions.

South Bohemia: character of crop plant assemblages and differences among the Bronze Age phases

The settlement structure in the region of South Bohemia changed during the Bronze Age. A stable settlement structure was documented in both southern and northern parts of the region during the Early and Middle Bronze Ages. Many more archaeological sites were documented in the northern part of the region than in the southern part for the periods of the Late and the Final Bronze Ages. Fewer archaeological sites were known for the Final Bronze Age than for the Late Bronze Age. Hillforts were typical for the Early and Final Bronze Ages. The burial rite was also changing: inhumation rites and burial mounds were typical for the Early and Middle Bronze Ages; cremation rites and flat graves were typical for the Late and Final Bronze Ages. The characteristic form of copper–bronze ingots also changed during the Bronze Age. These ingots reflect trade and are evidence of human mobility at the time of the Bronze Age (Chvojka 2007).

The structure of economically important crops (Fig. 8), the intensity of trade contacts with single neighbouring regions and settlement structures (Fig. 2) were all changing at the end of the Middle Bronze Age. Alterations in society are reflected in many different sources, and the development of society is also obvious in the archaeobotanical record. The average density of crop remains per liter of soil was low in almost all sites (Fig. 2), except for some archaeological features in Planá (storage pit, MBA) and Černýšovice (pit, LBA) which could be interpreted as partial crop stores (Chvojka et al. 2014). All the other samples, obtained in features and cultural layers, probably reflected different sorts of waste stored in open situations—which could be considered as ideal for the reconstruction of crop production (Willerding 1971; Hillman 1984; Jones 1984).

Archaeobotanical evidence from Early Bronze Age hillforts (Všemyslice and Vrcovice; Hlásek et al. 2014, 2015) is the basic source of archaeobotanical knowledge of this period. Barley, emmer and einkorn wheats were the characteristic crops for South Bohemia in the Early Bronze Age (Fig. 8). Information about agriculture during the Middle Bronze Age is confirmed by archaeobotanical knowledge from three microregions: Písek (Oldřichov, Kestřany, Písek—Bakaláře, Písek—AISIN), Bechyně (Dobronice u Bechyně, Rataje u Bechyně) and Planá. Samples that contained the broadest range of crops were recorded only in Písek—at the AISIN site (Čulíková in Fröhlich et al. 2004), and at the Planá. The composition of the crop plant spectrum at single sites was considerably different, but spelt was the characteristic crop in this period (Fig. 8). The probability of preservation of the remains of pulses and oil plants in dry archaeological assemblages was lower in comparison with cereals. Because of the high number of seeds from pulses (Table 4), the importance of pulses in the food economy of people in the Early and Middle Bronze Ages in South Bohemia cannot be significantly reconstructed.

For the Late Bronze Age, many sites with representative results were available [Bechyně microregion: Březnice – Na Píckách, Černýšovice, Hvožďany u Bechyně, Zhoř u Tábora (Chvojka et al. 2011, 2014); the Písek microregion: Oldřichov; see Fig. 2]. Archaeobotanical data for the Late Bronze Age could be considered consistent in the composition of the crop spectrum at all sites, with common millet as the dominant (Fig. 8). Common millet was important in Final Bronze Age assemblages as well, but its dominance was not absolute. The data for the Final Bronze Age was representative, as the composition of the crop plant spectrum was identical to the Late Bronze Age (barley was the dominant species). Naked wheat was frequently found in the Final Bronze Age assemblages (Fig. 8). An economy, such as that documented in the Late and Final Bronze Ages in South Bohemia, based on a combination of barley and common millet could be considered as unusual. Barley grows well in a cold, wet climate, while millets, on the other hand, are not suited for regions with frequent late frosts—although they grow well on sandy soils (Kočár and Dreslerová 2010). This composition of dominant crops probably had no analogy in Central Europe.

The difference in importance of common millet in the macroremain records for the Late Bronze Age (i.e. 1250–1000 BC) and the Final Bronze Age (i.e. 1000–800 BC) could be caused by the fact that, in previous studies, archaeobotanical samples were summarily evaluated for most regions of the Urn Field cultures (i.e. 1250–800 BC). Based on the South Bohemian data, it is possible to observe changes in human behaviour which are reflected in the huge quantity of common millet caryopsis in the Late Bronze Age and their reduction in the Final Bronze Age (Table 4, Fig. 5).

Seeds of pulses and oil plants had a lower chance of preservation in dry-soil excavation sites in comparison with cereals, so the significance of oil plants during individual periods of the Bronze Age in South Bohemia was not reconstructed. Seeds of pulses were present in high numbers only in assemblages from the Late Bronze Age.

The Bronze Age of South Bohemia in comparison with the reference regions

Contacts with many regions have also been documented by typical imported artefacts or raw materials for all periods of the Bronze Age, including the South–Danube Region (modern Bavaria and Austria), the Alps (trade in copper and salt: Goldenberg 2004; Grabner et al. 2007; Powell et al. 2018) and with North–Central Bohemia and northern-located regions [trade in amber (Ernée 2012; Tisucká and Ohlídalová 2013; Chvojka et al. 2017) and silicite goods (Zápotocký 2013; Šebela and Přichystal 2014)]. The frequency of these interactions obviously varied in different individual periods (Jiráň et al. 2008, p. 15). Contacts with the region of the South–Danube and the Alps were stronger in the Early and the Middle Bronze Age periods, while contacts with the region of Central Bohemia were stronger in the Late and Final Bronze Age periods (e.g. Chvojka 2015a). Cultural contacts between the South Bohemian region and the regions of Western Slovakia and Hungary were less frequent than contacts between South Bohemia and the rest of the Czech Republic and the region of the Eastern Alps and the Alpine Foreland, during all periods of the Bronze Age (Bouzek 1988–1989; Havlice 2000). Both the material and non-material segments of the culture, and the makeup of the human population in South Bohemia, were probably changing, inter alia, as a result of these contacts (Jiráň et al. 2008; Chvojka 2015a). This geographic position thus allowed for the diffusion of different cultural impulses and for their local adaptation (Chvojka 2007). The interpretation of the results of archaeobotanical research corresponded with the intensity of contacts reflected in material culture in individual periods of the Bronze Age.

The archaeobotanical reference data requires a critical approach because the settled areas of the reference regions were much larger than South Bohemia. It is evident that within the reference regions, more different human populations coexisted (as is reflected in more variable archaeological assemblages), with many related specifics in their systems of agriculture during each period of the Bronze Age. Finally, the life of the people was affected by different natural conditions in the various parts of the reference regions. Differences in conditions (cultural, social and natural) should be reflected in the composition of the crop plant spectrum. Last—but not least—the dating of individual periods of the Bronze Age in Central European countries was not completely uniform. This inconsistency in dating was transferred to comprehensive archaeobotanical works, which were used as reference material for presented research. Based on the results currently available, it could be concluded that there were many common properties throughout the Bronze Age in all reflected regions of Central Europe, despite the fact that we were aware of the complexity of reference data and the small number of identified plant remains of crops in South Bohemia—especially for the Early and Middle Bronze Age periods (Fig. 7). The presence of most cultivated plants was recorded in all of the monitored regions throughout the Bronze Age, although the dominance of certain crop plants was crucial. For economically important species, South Bohemia shared many common characteristics with all the reference regions during the Bronze Age (Fig. 7). It was also evident that, in the category of cultivated plants, the South Bohemian region was similar to the Eastern Alps and their Foreland during the Early and Middle Bronze Ages (Figs. 7 and 9a, b), while in the Late and Final Bronze Ages, South Bohemia demonstrated a greater similarity to the rest of the Czech Republic (Figs. 7 and 9c). Recent knowledge about imports of artefacts and innovation in material culture could correspond with archaeobotanical interpretations. Cultural contacts between these regions were very significantly documented for all periods of the Bronze Age (Chvojka 2004). Based on evidence from the material culture (particularly bronze artefacts and, less frequently, ceramic ones; Chvojka 2015b), connections with south-eastern regions were very intensive in the Early Bronze Age, although their intensity decreased in the Middle Bronze Age and in the Late and Final Bronze Ages, and contacts were less intensive. On the other hand, the connection of the South Bohemian region to the rest of the Czech Republic increased, with very strong contacts with human groups of Central Bohemia in the Late Bronze Age, as reflected in the character of the ceramic vessels (Chvojka 2009, p. 162).

Judging from other examples of material culture (bronze artefacts), connections between the South Bohemian region and Hungary existed in the Early and Middle Bronze Ages, but were probably less intensive than contacts with the region of the Eastern Alps and the Alpine Foreland and other parts of the Czech Republic (Beneš 1989; Chvojka 2015b). Due to the presence of the Danube, contacts between the Eastern Alps and the Alpine Foreland and Hungary were intensive for all periods of the Bronze Age (Havlice 2000; Chvojka and Jiráň 2004). Interpretation of the results of the analysis of macroremains seems to have corresponded with our recent knowledge of the cultural context of the Bronze Age in

Central Europe. It could be connoted, from South Bohemian archaeobotanical data, that the finds of cultivation crops probably followed social factors and the plant-related part of the diet. The human diet was a reflection of contemporary behaviour and thinking. In this reflection, the cultural relationship between South Bohemia and the Danube region was evident, especially during the Early Bronze Age. According to many opinions, the region of South Bohemia represented the periphery of the Danubian cultural millieu (Bartelheim 1998; Chvojka 2015b). A similar situation was still obvious in the Middle Bronze Age, but to a considerably lesser extent. During the Urn Field Period (the Late and the Final Bronze Ages), the South Bohemian region formed an autonomous agricultural area (e.g. visible in the structure of dominant crops: barley and millet), related to the Central Bohemian area and populations. Despite the fact that the tie to Central Bohemia seemed to play a dominant role, contacts with the Danube civilisation had never been broken (Chvojka and Jiráň 2004; Chvojka 2009).

Conclusion

Based on the currently available archaeobotanical data obtained in South Bohemia, it was possible to observe general trends of crop composition during the Bronze Age in terms of quantitative (number of species) as well as qualitative (change of dominant species; diversity) development. The observed data showed the South Bohemian Bronze Age (in the context of Central Europe) as a very dynamic period in terms of perception of the evolution of agricultural production. The composition of economically important crops changed during the Bronze Age. The connections between the trade contacts of the South Bohemian region and the reference regions and the structure of sub/dominant crops were demonstrated. The South Bohemian Region had more connections with the region of the Eastern Alps and the Alpine Foreland during the Early and the Middle Bronze Ages. This was probably primarily related to the copper trade. Likewise, the composition of sub/dominant crops in South Bohemia and the Eastern Alps and the Alpine Foreland had many similarities. The cultural orientation of the South Bohemian region was changed in the Late and the Final Bronze Ages: intensive contacts were documented primarily with the region of Central Bohemia. Likewise, the composition of sub/dominant crops in South Bohemia and (the rest of the) Czech Republic had many similarities. An important finding was the fact that barley represented a stable cereal cultivated during the whole of the Bronze Age. This result is consistent with the prediction of a preference for barely in soils of inferior quality in the Czech Republic. Hulled forms of barely were evident from the Middle Bronze Age, naked forms from the Early Bronze Age. The Middle Bronze Age, however, represents an abandonment of the usage of emmer wheat in favour of spelt wheat. In the Late Bronze Age, the spectrum of cultivated crops was wide (millet and barley, with additional crops: emmer, naked wheat, spelt, einkorn). The settlement structure of this period was much denser and more structured in comparison to the Early and Middle Bronze Ages (Fig. 2). In accordance with the increasing number of sites, it was clearly possible to presuppose an increase in the population. During the Final Bronze Age, according to current knowledge, the settlement structure was distinctly reduced in comparison to the period of the Late Bronze Age described above. The composition of the crop plant spectrum was similar to the Late Bronze Age, although the role of common millet was decreasing. South Bohemia in the Bronze Age should be seen as a region developing in the context of the neighbouring regions. Crop production features in South Bohemia shared much more in common with the region of the Eastern Alps during the Early and Middle Bronze Ages, while, on the contrary, the study region is much more related to the rest of the Czech Republic during the phase of the Late/Final Bronze Age.

Acknowledgements We would like to thank Pavla Figurová and Michael Hensen for English proofreading. We are grateful to anonymous reviewers for suggestive comments on the text.

Funding information This research was supported by the projects GAČR P405/18-10747S and GAJU 145/2016H, and some of the assemblages were analysed with the support of the project “PAPAVER - Centre for human and plant studies in Europe and Northern Africa in the postglacial period” reg. No. CZ.1.07/2.3.00/20.0289.

References

Allentoft ME, Sikora M, Sjögren KG, Rasmussen S, Rasmussen M, Stenderup J, Damgaard PB, Schroeder H, Ahlström T, Vinner L, Malaspinas AS, Margaryan A, Higham T, Chivall D, Lynnerup N, Harvig L, Baron J, Casa PD, Dąbrowski P, Duffy PR, Ebel AV, Epimakhov A, Frei K, Furmanek M, Gralak T, Gromov A, Gronkiewicz S, Grupe G, Hajdu T, Jarysz R, Khartanovich V, Khokhlov A, Kiss V, Kolář J, Kriiska A, Lasak I, Longhi C, McGlynn G, Merkevicius A, Merkyte I, Metspalu M, Mkrtchyan R, Moiseyev V, Paja L, Pálfi G, Pokutta D, Pospieszny Ł, Price TD, Saag L, Sablin M, Shishlina N, Smrčka V, Soenov VI, Szeverényi V, Tóth G, Trifanova SV, Varul L, Vicze M, Yepiskoposyan L, Zhitenev V, Orlando L, Sicheritz-Pontén T, Brunak S, Nielsen R, Kristiansen K, Willerslev E (2015) Population genomics of Bronze Age Eurasia. Nature 522:167–172. https://doi.org/10.1038/nature14507

Anthony DW (2010) The horse, the wheel, and language: how Bronze-Age riders from the Eurasian steppes shaped the modern world. Princeton University Press

Arnold ER, Hartman G, Greenfield HJ, Shai I, Babcock LE, Maeir AM (2016) Isotopic evidence for early trade in animals between old kingdom Egypt and Canaan. PLoS One 11(6):5555. https://doi.org/10.1371/journal.pone.0157650

Bartelheim M (1998) Studien zur böhmischen Aunjetitzer Kultur – Chronologische und chorologische Untersuchungen.

Universitätsforschungen zur prähistorischen Archäologie 46. (Bonn 1998)
Beneš A (1989) Hosty: Die südböhmische frühbronzezeitliche Siedlung unter Teilnahme der karpatenländlichen Kulturen. Praehistorica 15: 227–232
Beneš J (1998) Keramika, ornice a reliéf. Výzkum polykulturního osídlení v Kozlech, okr. Louny (SZ Čechy). Archeologicke Rozhledy 50:170–191 (In Czech with Englisch summary)
Bouzek J (1988-1989) Böhmen, Mähren und Österreich in der Urnenfelderzeit, Mitteilungen der Anthropologischen Gesellschaft in Wien 118-119, 219–227
Breitenbach SFM, Plessen B, Waltgenbach S, Tjallingii R, Leonhardt J, Jochum KP, Scholz D (2019) Holocene interaction of maritime and continental climate in Central Europe: new speleothem evidence from central Germany. Glob Planet Chang 176:144–161. https://doi.org/10.1016/j.gloplacha.2019.03.007
Bronk Ramsey C (2013) OxCal 4.2.1. http://c14.arch.ox.ac.uk/oxcal/OxCal.html
Chvojka O (2004) Jihovýchodní vlivy v jižních Čechách ve střední a mladší době bronzové. In: Měřínský Z, Šabatová K (eds) Kazdová, E. K poctě Vladimíru Podborskému, Brno, pp 327–340
Chvojka O (2007) Současný stav poznání doby bronzové v jižních Čechách. In: Chvojka O, Krajíc R (eds). Archeologie na pomezí. Sborník příspěvků ze semináře, České Budějovice 8. 11. 2007. Archeologické výzkumy v jižních Čechách (Supplementum 4), Jihočeské muzeum v Českých Budějovicích, České Budějovice, 29–55. (In Czech)
Chvojka O (2009) Jižní Čechy v mladší a pozdní době bronzové. Dissertationes Archaeologicae Brunenses/ Pragensesque 6. Filozofická fakulta Masarykovy univerzity, Brno
Chvojka O (2015a) Možnosti rekonstrukce dálkových i lokálních stezek v době bronzové v jižních Čechách - Rekonstruktionsmöglichkeiten der bronzezeitlichen Fern- sowie lokalen Wege in Südböhmen. In: Kubů, F., Parkman, M. (eds). Zlatá stezka - Supplementum 1, Staré stezky. Sborník příspěvků z konference o výzkumu starých komunikací. Prachatice 9.-11. 6. 2010. Prachatické muzeum, Prachatice, 115–127
Chvojka O (2015b) Chronologie und Kulturen der südböhmischen Bronzezeit und Ihre Parallelisierung zu den Donaugebieten und Karpatenbecken. In: Németh R E and Rezi B, Bronze Age chronology in the Carpathian Basin. Proceedings of the Internation colloquium from Targu Mures 2-4 October 2014. Targu Mures, 9-22
Chvojka O, Havlice J (2009) Měděná žebra starší doby bronzové v jižních Čechách. Nové depoty z Přídolí, Purkarce a Chvalšin. Památky archeologické 100:49–90 (In Czech with German summary)
Chvojka O, Jiráň L (2004) Kontakty jižních Čech a rakouského Podunají v době popelnicových polí. Archeologické výzkumy v jižních Čechách 17:163–173 (In Czech with German summary)
Chvojka O, Šálková T (2011) Březnice u Bechyně. K interpretaci sídelního areálu z mladší doby bronzové se žlabovitými objekty Podbrdsko – Miscelania 2:103–127 (In Czech with German summary)
Chvojka O, Šálková T, Beneš J, Kovačiková L, Novák J (2009) Březnice - první ploché pohřebiště mladší doby bronzové na Bechyňsku - Březnice - das erste Flachgräberfeld der Urnenfelderzeit im Gebiet von Bechyně. Archeologické výzkumy v jižních Čechách 22:61–98
Chvojka O, Beneš, J., Fröhlich, J., John, J., Michálek, J., Šálková, T., Bernardová, A., Houfková, P., Křivánek R, Majer A, Novák J, Nováková K, Talarovičová E (2011) Osídlení doby bronzové v povodí říčky Smutné v jižních Čechách - Bronzezeitliche Besiedlung im Flussgebiet von Smutná in Südböhmen. Archeologické výzkumy v jižních Čechách (Supplementum 8) Jihočeské muzeum v Českých Budějovicích, České Budějovice
Chvojka O, Menšík P, Prokop V, Novák ŠT, Fröhlich J, Michálek J (2014) Sídliště z mladší doby bronzové na Zhoři na Táborsku - Eine jungbronzezeitliche Siedlung in Zhoř bei Tábor. Archeologické výzkumy v jižních Čechách 27:69–85
Chvojka O, Chytráček M, Metlička M, Michálek J (2017) Jantar střední až pozdní doby bronzové v Čechách. Památky archeologické 108: 89–120
Chvojka O, Menšík P, Houfková P, Šálková T (2018) K depotům měděných žeber ze starší doby bronzové v sídlištním kontextu: Depot z Kučeře (okr. Písek) pohledem archeologie a archeobotaniky/ Ein Beitrag zur Problematik der Spangenbarrenhortfunde vom Ende der frühen Bronzezeit im Siedlungskontext. Archeologické rozhledy 70:195–238
Clutton-Brock J (2012) Animals as domesticates: a world view through history. East Lansing (MI): Michigan State University Press
Čulíková V (2004) in Fröhlich J, Chvojka O, Jiřík J. Mladomohylové sídliště v průmyslovézóně Písek-Sever. Archeologické výzkumy v jižních Čechách 17:83–101 (In Czech with German summary)
Čulíková V (2005) Rostlinné makrozbytky ze záchranného archeologického výzkumu - lokalita Čížová. Unpublished research report, logged in Prácheň Museum in Písek. (In Czech)
Dreslerová D, Kočár P, Chuman T, Šefrna L, Ponistiak Š (2013) Variety in cereal cultivation in the Late Bronze and Early Iron ages in relation to environmental conditions. J Archaeol Sci 40:1988–2000. https://doi.org/10.1016/j.jas.2012.12.010
Dreslerová D, Kočár P, Chuman T (2016) Pravěké osídlení, půdy a zemědělské strategie - Prehistoric societies, soils and agricultural strategies. Archeologické rozhledy LXVIII:19–46
Ernée M (2012) Jantar v České únětické kultuře - k počátkům jantarové stezky. Bernstein in der böhmischen Aunjetitz-Kultur - Zu den Anfängen der Bernsteinstrasse Památky archeologické 103:71–172
Evin. A, L. Flink. G, A. B l escu, D. Popovici, R. Andreescu, D. Bailey, P. Mirea, C. Laz r, A. Boronean , C. Bonsall, U. S. Vidarsdottir, S. Brehard, A. Tresset, T.Cucchi, G. Larson, K. Dobney, (2014) Unravelling the complexity of domestication: a case study using morphometrics and ancient DNA analyses of archaeologicalpigs from Romania. Philosophical Transactions of the Royal Society B: Biological Sciences 370 (1660):20130616-20130616
Fohlmeister J, Schröder-Ritzrau A, Scholz D, Spötl C, Riechelmann DFC, Mudelsee M, Wackerbarth A, Gerdes A, Riechelmann S, Immenhauser A, Richter DK, Mangini A (2012) Bunker cave stalagmites: an archive for Central European Holocene climate variability. Clim Past 8(5):1751–1764. https://doi.org/10.5194/cp-8-1751-2012
Frei KM et al (2015) Tracing the dynamic life story of a Bronze Age female. Sci Rep 5:10431. https://doi.org/10.1038/srep10431
Fröhlich J, Chvojka O, Jiřík J (2004) Mladomohylové sídliště v průmyslové zóně Písek-Sever. Archeologické výzkumy v jižních Čechách 17:83–101
Fröhlich J, Chvojka O, John J, Michálek J, Pokorná K, Šálková T, Beneš J (2014) Dvě fortifikace u Brloha na Písecku. Archeologické výzkumy v jižních Čechách 27:87–112 (In Czech with German summary)
Fröhlich J, Chvojka O, John J, Šálková T (2016) Kovové depoty z doby bronzové v zázemí hradiště u Chřešťovic na Písecku. Archeologické výzkumy v jižních Čechách 29:117–141
Gediga B (2007) Remarks on long-distance trade exchange in the Bronze Age and early Iron Age. In: Baron, J. and Lasak, I. (eds.), Long distance trade in the Bronze Age and Early Iron Age. Conference materials, Wroclaw 19.–20. 5. 2005. Studia Archeologiczne 40. Wroclaw, 7–13
Goldenberg G (2004) Ein Verhüttungsplatz der mittleren Bronzezeit bei Jochberg (Nordtirol). In: Weisgerber G., Goldenberg G (eds) Alpenkupfer - Rame delle Alpi. Der Anschnitt, Beiheft 17, Bochum, 165-176
Grabner M, Klein A, Geihofer D, Reschreiter H, Barth FE, Sormaz T, Wimmer R (2007) Bronze Age dating of timber from the salt-mine

at Hallstatt, Austria.Dendrochronologia 24:61–68. https://doi.org/10.1016/j.dendro.2006.10.008
Gyulai F (1993) Environment and agriculture in Bronze Age Hungary. Archaeolingua (Series Minor), Budapest
Haak W, Lazaridis I, Patterson N, Rohland N, Mallick S, Llamas B, Brandt G, Nordenfelt S, Harney E, Stewardson K, Fu Q, Mittnik A, Bánffy E, Economou C,Francken M, Friederich S, Pena RG, Hallgren F, Khartanovich V, Khokhlov A, Kunst M, Kuznetsov P, Meller H, Mochalov O, Moiseyev V, Nicklisch N, PichlerSL, Risch R, Rojo Guerra MA, Roth C, Szécsényi-Nagy A, Wahl J, Meyer M, Krause J, Brown D, Anthony D, Cooper A, Alt KW, Reich D (2015) Massive migration from the steppe was a source for Indo-European languages in Europe. Nature 522:207–211. https://doi.org/10.1038/nature14317
Hajnalová E (1993) Obilie v archeobotanických nálezoch na Slovensku. Archeologický ústav Slovenskej akadémie vied, Nitra (In Slovak)
Hajnalová M (2012) Archeobotanika doby bronzovej na Slovensku. Štúdie ku klíme, prírodnému prostrediu, poľnohospodárstvu a paleoekonómii. Univerzita Konštantína Filozofa v Nitre press, Nitra. (In Slovak with English summary)
Harvig L, Frei KM, Price TD, Lynnerup N (2014) Strontium isotope signals in cremated petrous portions as indicator for childhood origin. PLoS One 9(7):e101603. https://doi.org/10.1371/journal.pone.0101603
Havlice J (2000) Kontakty mezi jižními Čechami a středním Podunajím ve starší době bronzové. Unpublished diploma thesis, Faculty of Philosophy, Charles University in Prague. (In Czech)
Hemphill BE, Mallory JP (2004) Horse-mounted invaders from the Russo-Kazakh steppe or agricultural colonists from western Central Asia? A craniometric investigation of the Bronze Age settlement of Xinjiang. Am J Phys Anthropol 124:199–222. https://doi.org/10.1002/ajpa.10354
Hillman G (1984) Interpretation of archaeological plant remains: the application of ethnographic models from Turkey. In: van Zeist W, Casparie WA (eds) Plants and ancient man: studies in palaeoethnobotany. Balkema, Rotterdam, pp 1–41
Hlásek D, Chvojka O in print: The beginning of the Bronze Age in South Bohemia. In: Reinecke's heritage. Conference book Křtiny 2017
Hlásek D, Houfková P, Kovačiková L, Majer A, Novák J, Pavelka J, Bešta T, Šálková T (2014) The use of environmental methods for studying the fortifcation, economic system and natural environment of a hillfort from the beginning of the middle Bronze Age at Vrcovice, Czech Republic. Interdisciplinaria Archaeologica, Natural Sciences in Archaeology 5:31–47. https://doi.org/10.24916/iansa.2014.1.3
Hlásek D, Houfková P, John J, Novák J, Šálková T (2015) Všemyslice - Kozí vrch. Nové poznatky o hradišti z počátku střední doby bronzové, výsledky multidisciplinárního výzkumu. Archeologie západních Čech 9:96–121 (In Czech with German summary)
Hlásek D, Hiltscher T, Šálková T, Pták M (2017) Záchranný archeologický výzkum polykulturní lokality Písek-AISIN II (okr. Písek) z roku 2014 - Archäologische Rettungsgrabung an der mehrperiodigen Fundstelle Písek-AISIN II (Kr. Písek) im Jahr 2014. Archeologické výzkumy v jižních Čechách 30: 159–197
Jacomet S (2006) Identification of cereal remains from archaeological sites, second edn. IPNA Universität Basel, Basel
Jacomet S, Brombacher C, Dick M (1989) Archaobotanik am Zurichsee. Ackerbau, Sammelwirtschaft und Umwelt von neolithischen und bronzezeitlichenSeeufersiedlungen im Raum Zurich. Ergebnisse von Untersuchungen pflanzlicher Makroreste der Jahre 1979-1988. Zurcher Denkmalpflege, Monographien 7. Zurich
Jiráň L (ed) et al (2008) Doba bronzová. Archeologie pravěkých Čech, vol 5. Archeologický ústav AV ČR v Praze, Praha (In Czech with English summary)
Jockenhövel, A., 2012. Alteuropäische Bronzezeit: Interaktionen und regionale Identitäten. In: Bérenger, D et al. (Hrsg.), Gräberlandschaften der Bronzezeit – Paysages funéraires de l'age du Bronze. Intern. Koll. Bronzezeit, Herne 15.-18. Oktober 2008. Bodenaltertümer Westfalens 51, 667–690
Jones G (1984) Interpretation of archaeological plant remains: ethnographic models from Greece. In: van Zeist W, Casparie WA (eds) Plants and ancient man: studies in palaeoethnobotany. Balkema, Rotterdam, pp 43–61
Jones MK (1991) Sampling in palaeoethnobotany. In: Van Zeist W et al (eds) Progress in Old World palaeoethnobotany. Balkema, Rotterdam, pp 53–63
Kočár P, Dreslerová D (2010) Archeobotanické nálezy pěstovaných rostlin v pravěku České republiky - Archeobotanical finds of cultivated plants in the prehistory of Czech Republic. Památky archeologické 101:203–242
Krištuf P, Rytíř L (2009) Radiokarbonová data z mohylového pohřebiště "Na hrůbatech", k. ú. Dobešice (okr. Písek). Archeologické výzkumy v jižních Čechách 22:49–60 (In Czech with English summary)
Kučera L, Peška J, Fojtík P, Barták P, Kučerová P, Pavelka J, Komárková V, Beneš J, Polcerová L, Králík M, Bednář P (2019) First direct evidence of common millet (*Panicum miliaceum*) in Central Europe. Archaeol Anthropol Sci. https://doi.org/10.1007/s12520-019-00798-4
Kuna M, Brůžek J, Černý V, Dreslerová D, Hájek M, Horáček I, Kráčmarová A, Likovský J, Neustupný E, Pokorný P, Stránská P, Šmahel Z, Urbanová M, Vařeka P, Velemínský P, Nývlt D, Pleinerová I, Světlík I (2007) Archeologie pravěkých Čech 1, Pravěký svět a jeho poznáni. Praha : Archeologický ústav AV ČR
Kyselý R, Peške L (2016) Horse size and domestication: Early equid bones from the Czech Republic in the European context. Anthropozoologica 51(1):15–39
Long T, Wagner M, Demske D, Leipe C, Tarasov PE (2017) Cannabis in Eurasia: origin of human use and Bronze Age trans-continental connections. Veget Hist Archaeobot 26(2):245–258. https://doi.org/10.1007/s00334-016-0579-6
Ložek V (1973) Příroda ve čtvrtohorách. Academia, Praha
Ludwig A, Pruvost M, Reissmann M, Benecke N, Brockmann GA, Castaños P, Cieslak M, Lippold S, Llorente L, Malaspinas A-S, Slatkin M, Hofreiter M (2009) Coat color variation at the beginning of horse domestication. Science 324(5926):485–485. https://doi.org/10.1126/science.1172750
Mair V H, Hickman J eds. (2014) Reconfiguring the silk road: new research on east-west exchange in antiquity. Philadelphia
Marston JM, d'Alpoim Guedes J, Warinner C (eds) (2014) Method and theory in paleoethnobotany. University Press of Colorado
Pearsall SDM (1989) Palaeoethnobotany: a handbook of procedures. Academic, San Diego
Piggott S (1983) The Earliest Wheeled Transport: From the Atlantic Coast to the Caspian Sea. Ithaca: Cornell University Press
Pokorná K, Šálková T, Jiřík J, Fröhlich J, Michálek J (2016) Sídliště z pozdní doby bronzové z areálu písecké nemocnice. Archeologické výzkumy v jižních Čechách 29:167–199 (In Czech with English summary)
Poschold P (2015) The origin and development of the Central European man-made landscape, habitat and species diversity as affected by climate and its changes—a review. Interdisciplinaria Archaeologica, Natural Sciences in Archaeology VI/2:197–221
Powell W, Mathur R, Bankoff AH, John J, Chvojka O, Tisucká M, Bulatović A, Filipović V (2018) Copper isotopes as a means of determining regional metallurgical practices in European prehistory: a reply to Jansen (2018, J. Arch. Sci. 89). J Archaeol Sci. https://doi.org/10.1016/j.jas.2018.02.015
Přichystal A, Šebela L (2015) Silicite daggers from the territories of the Czech Republic and Slovakia (a preliminary study). In: Frieman, J., Eriksen, B., V. (eds.), Flint gaggers in prehistoric Europe (Oxford/Philadelphia), 133-148

Primas M (1997) Bronze Age economy and ideology: Central Europe in focus. J Eur Archaeol 5:115–130. https://doi.org/10.1179/096576697800703593

Reimer PJ, Bard E, Bayliss A, Beck JW, Blackwell G, Bronk Ramsey C, Buck CE, Cheng H, Edwards RL, Friedrich M, Grootes PM, Guilderson TP, Hajdas I, Hatte C, Heaton TJ, Hoffmannm DI, Hogg AG, Hughen KA, Kaiser KF, Kromer B, Manning SW, Niu M, Reimer RW, Richards DA, Scott EM, Southon JR, Staff RA, Turney CSM, van der Plicht J (2013) INTCAL13 and MARINE13 radiocarbon age calibration curves,0–50,000 years cal. BP Radiocarbon 55:1869–1887. https://doi.org/10.2458/azu_js_rc.55.16947

Ryder ML (1992) Wool fibres in cloth remains throw light on fleece evolution. Circaea 9:7–9

Šálková T, Bezděk A, Březinová H, Farkašová K, Houfková P, Chvojka O, John J, Kmošek J, Koník P, Kovačiková L, Michálek J, Msallamová Š, Novák J, Pavelka J, Šuláková H, Bešta T, Myšková E, Weiter L, Zronek P (2015) Bioarchaeological reconstruction of the funeral rite—case study based on organic material from the Hallstatt period tumulus at the site Zahrádka (South Bohemia, Czech Republic). Památky archeologické 106:95–135

Schibler J (2006) The economy and environment of the 4th and 3rd millennia BC in the northern Alpine Foreland based on studies of animal bones. Environ Archaeol 11:49–64. https://doi.org/10.1179/174963106x97052

Šebela L, Přichystal AB (2014) Silicitové dýky na území České a Slovenské republiky: předběžná studie - Silicite daggers on the territory of the Czech Republic and Slovakia: preliminary study. Studia Archaeologica Brunensia 19:67–94

Smejtek L (2011) Osídlení z doby bronzové v Kněževsi u Prahy. Ústav archeologické památkové péče středních Čech, Praha (In Czech with English summary)

Šmilauer P, Lepš J (2014) Multivariate analysis of ecological data using Canoco 5. Cambridge University Press, Cambridge

Stika HP, Heiss AG (2013) Plant cultivation in the Bronze Age. Chapter 19. In: Fokkens H, Harding A (eds) The Oxford handbook of the European Bronze Age. Oxford University Press, Oxford, pp 348–369

Tisucká M, Ohlídalová M (2013) Luxus ze vzdálených zemí. Jantar doby bronzové ze sbírky Národního muzea. Editio Monographica Musei Nationalis Pragae 18, Národní muzeum, Praha (In Czech with English summary)

Unger J, Pecinovská M (2015) Obříství, a late Bronze Age port of trade in Central Bohemia. Studia Hercynia 2015/1–2:71–95

Volungevičius J, Feiza V, Amalevičiute-Volunge K, Liaudanskiené I, Šlepetiené A, Kuncevičius A, Vengalis R, Velius G, Prapiestiene R, Poškiene J (2019) Transformations of different soils under natural and anthropogenized land management. Zemdirbyste-Agriculture 106:3–14. https://doi.org/10.13080/z-a.2019.106.001

Wang T, Wei D, Chang X, Yu Z, Zhang X, Wang Ch, Hu Y, Fuller B T (2017) Tianshanbeilu and the Isotopic Millet Road: reviewing the late Neolithic/Bronze Age radiation of human millet consumption from north China to Europe, *National Science Review*, nwx015. https://doi.org/10.1093/nsr/nwx015

Willerding U (1971) Methodische Probleme bei der Untersuchung und Auswertung von Pflanzenfunden in vor- und frühgeschichtlichen Siedlungen. Nachrichten Niedersachsen Urgesch 40:180–198

Zápotocký M (2013) Silicitové dýky z mladšího eneolitu a starší doby bronzové v Čechách - Silexdolche aus dem jüngerem Äneolothikum und dem älterem Bronzezeit in Böhmen. Archeologicke rozhledy 65:3–55