A LATE UPPER PALAEOLITHIC SKULL FROM MOČA (THE SLOVAK REPUBLIC) IN THE CONTEXT OF CENTRAL EUROPE

ALENA ŠEFČÁKOVÁ
Department of Anthropology, Slovak National Museum, Vajanského nábr. 2, P.O. BOX 13, 810 06 Bratislava 16, Slovak Republic, e-mail: sefcakova@snm.sk

STANISLAV KATINA
Department of Applied Mathematics and Statistics, Faculty of Mathematics, Physics and Informatics, Comenius University, Mlynská dolina M, 842 48 Bratislava, Slovak Republic; School of Mathematics and Statistics, University of Glasgow, University Gardens, G12 8QQ Glasgow, Scottland, UK, e-mail: stanislav.katina@gmail.com

IVAN MIZERA
Department of Mathematical and Statistical Sciences, University of Alberta, Edmonton, Alberta, Canada T6G 2G1, e-mail: mizera@stat.ualberta.ca

† RUDOLF HALOUZKA
State Geological Institute of Dionýz Štúr, Mlynská dolina 1, 817 04 Bratislava, Slovak Republic

PETER BARTA
Dendrochronological laboratory Bratislava, Karloveská 34, P.O. Box 83, 840 00 Bratislava 4; Department of Archaeology, Faculty of Philosophy, Comenius University, Gondova 2, 818 01 Bratislava, Slovak Republic, e-mail: peterbarta@chello.sk

MILAN THURZO
Department of Anthropology, Faculty of Natural Sciences, Comenius University, Mlynská dolina B 2, 842 15 Bratislava, Slovak Republic, e-mail: thurzo@ fns.uniba.sk

Šefčáková, A., Katina, S., Mizera, I., Halouzka, R., Barta, P., Thurzo, M. (2011): A Late Upper Palaeolithic skull from Moča (the Slovak Republic) in the context of Central Europe. – Acta Mus. Nat. Pragae, Ser. B, Hist. Nat. 67 (1 – 2): 3 – 24. Praha ISSN 0036-5343.

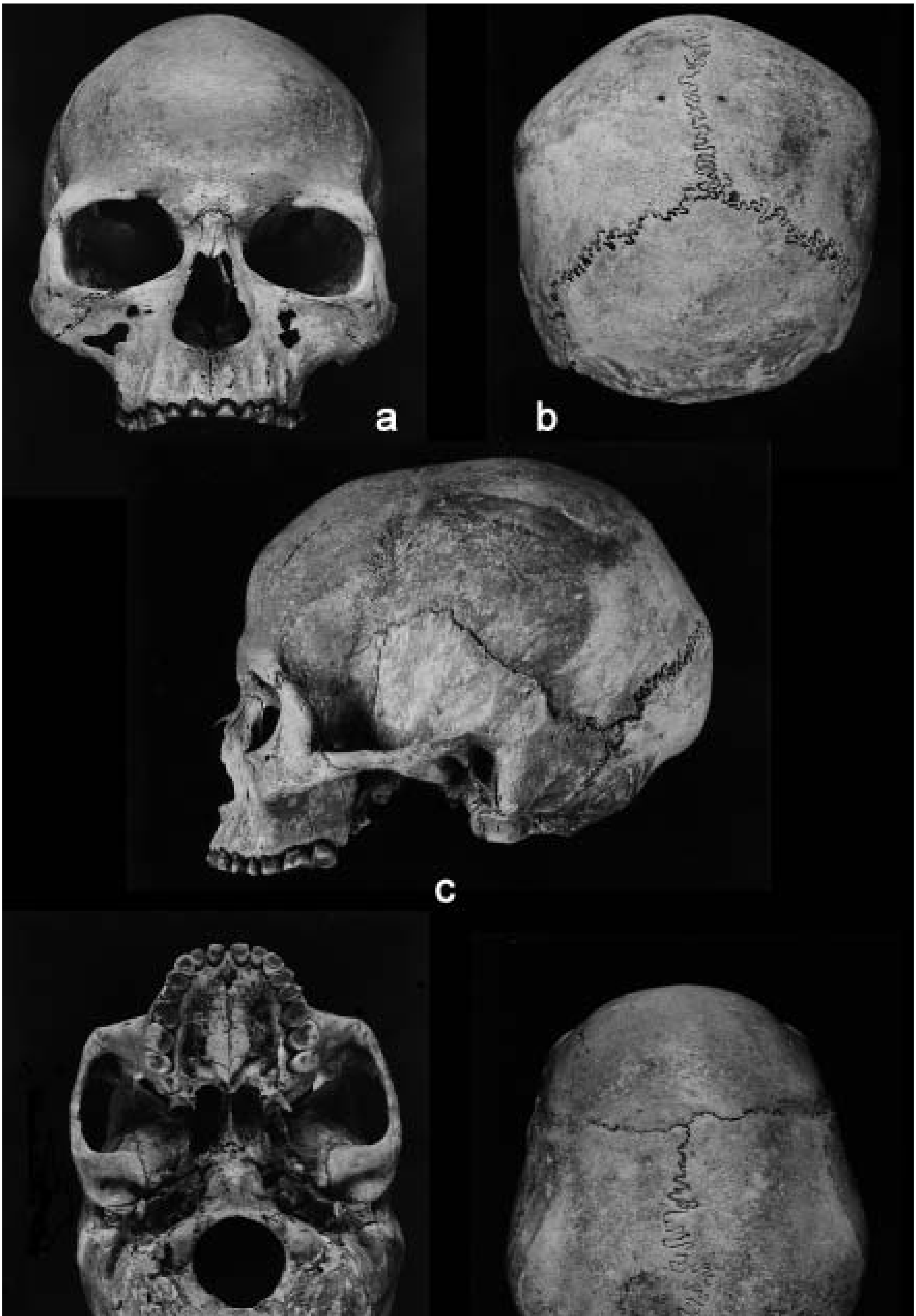
Abstract. In April 1990, an excellently preserved cranium was found during gravel extractions from the bottom of the river Danube at Moča, in the Komárno district of southern Slovakia. Neither animal, nor archaeological remains were associated with this find. According to the calibrated ^{14}C date, the individual had lived during the second half of the twelfth millennia cal BC, during the Late Upper Palaeolithic. The geologic-morphological background of this find, combined with absolute dating, made the reconstruction of its approximately primary position possible. The skull's primary fossilization site is presumed to have been somewhere on the periphery of the local Kravany Terrace of the Danube. Both the fossiliferous layer sediments and the skull were later eroded and transported to the flood plain. Regarding the skull, its sex, age, morphology and morphometrics were investigated. The partly fossilised cranium was of an adult female, most probably aged 40 ± 10 years. Her skull has a gracile to moderate construction, with moderately marked muscle relief. The Moča find adds to the small collection of directly dated Late Upper Palaeolithic humans in Central Europe. Measurements of the Moča skull and most of its morphology are mainly within the recent human remains variability; however, it does not basically differ from the Late Upper Palaeolithic sample. Conversely, some of its measurements, e.g. great basion-prosthion length, individualize it.

■ Human cranium; morphology; adult; southern Slovakia, Danube River, Central Europe

Received August 31, 2010
Issued August 2011

Introduction

In April 1990, an excellently preserved calvarium (Text-fig.1) was found during gravel extractions from the river bottom of the Danube at Moča, in the Komárno district of southern Slovakia. The partly fossilised skull was excavated by a dredger from the depth of ca 3 m. The site is localized in a small abandoned meander on the river km 1742.3, about 50 m from the riverbank – on the Slovak side of the Danube river. In 1994, the specimen was deposited in the Department of Anthropology, Slovak National Museum, Bratislava, Slovakia. Since the circumstances of the find did not provide any indication of its exact stratigraphy, the skull was dated by ^{14}C accelerator mass spectrometry in 1997 (Šefčáková 1997, Bronk Ramsey and al. 2002). The Moča skull represents the first known find of Late Upper Palaeolithic (LUP) human remains in the territory of Slovakia.



Text-fig. 1. Skull from Moča (Komárno district, southern Slovakia): a) anterior view, b) posterior view, c) left lateral view, d) inferior view, e) superior view

Among the middle-European fossils, the chronologically nearest to the Moča skull seem to be the specimens from the Czech Republic. Namely, a damaged skull, some vertebrae and fragments of ribs of a female from the Zlatý Kůň cave near Koněprusy in the Czech Karst dated to 12,870 ± ± 70 BP (GrA-13696) (Svoboda and al. 2002, 2003) and the human teeth, Kůlna 7 and 8, from Kůlna cave near Sloup in the Moravian Karst, coming from Epimagdalenian layer 3 (Jelínek 1988, Jelínek and Orvanová 1999). The late Magdalenian perinatal human skeleton from Wilczyce in Poland (12,870 ± 60 BP, OxA-16729) has the same uncalibrated ^{14}C age as the Zlatý Kůň skeleton (Irish and al. 2008).

As far as chronology is concerned, the skeleton of a young female from Staré Město (Uherské Hradiště district, the Czech Republic) (Jelínek 1956, 1986) is a somewhat older (second half of Würm3). In addition, there are remains of four individuals from caves near the village of Döbritz (Thuringia, Germany) dated to 10,235 ± 90 BP and the mandible of a child from Ilsenhöhle cave situated under Ranis castle near Weimar in Germany (Vlček 1994). To this group could also be assigned the somewhat older skeletal remains of a male and a female from Oberkassel near Bonn (Gieseler 1971, Henke 1984, 1989, Schmitz 2006).

In Europe, there are more than 150 similarly dated individuals, at least 108 of them coming from the territory of France (Gambier 1992). However, only a few of these skulls are as well preserved as the Moča skull. Its condition resembles an older Early Magdalenian skull from Rond-du-Barry, Auvergne, France (Heim 1992). Similar uncalibrated ^{14}C dates were yielded by some skulls coming approximately from the same period as the cranium from Moča, for example Bruniquel 24, Chancelade 1, Le Cheix, Le Bichon 1 (Ferembach and al. 1971, Henke 1989), Roc-de-Cave (Bresson 2000) from France, and San Teodoro (Gambier 1995), Ortucchio (Sergi and al. 1971, Henke 1989), Arene Candide 3 – 5 (Gambier 1995) from Italy.

Radiocarbon dating

The University of Oxford Research Laboratory for Archaeology and History of Art (the Oxford Radiocarbon Accelerator Unit, ORAU) processed the sample taken from the inner side of the right orbit and produced a conventional date OxA-7068: 11,255 ± 80 BP, with a $\delta^{13}C$ (PDB) = -21.7 per mil (Bronk Ramsey and al. 2002). This date is uncalibrated in the radiocarbon years BP using the half life of 5568 years. Isotopic fractionation was corrected for using the measured $\delta^{13}C$ values quoted (to ± 0.3 per mil relative to VPDB).

Taking into account the currently available calibration data set for the northern hemisphere (INTCAL09, Reimer et al. 2009), it is possible to discuss the calendar period in which the individual lived. Calibration of the measured 14C age against INTCAL09 gave a very similar result to one produced by INTCAL04. This is somewhat different from the date range produced by an earlier dataset INTCAL98 (Text-fig. 2).

At present, the skull from Moča may be viewed as belonging to 13,262 – 13,092 cal BP (68.2% confidence level) or 13,315 – 12,918 cal BP (95.4% confidence level). However, this result may change in the future with more data entering the debated portion of radiocarbon calibration dataset (cf. Reimer and al. 2004, 2009, Bronk Ramsey and al. 2006, Bondevik and al. 2006, Bronk Ramsey 2010).

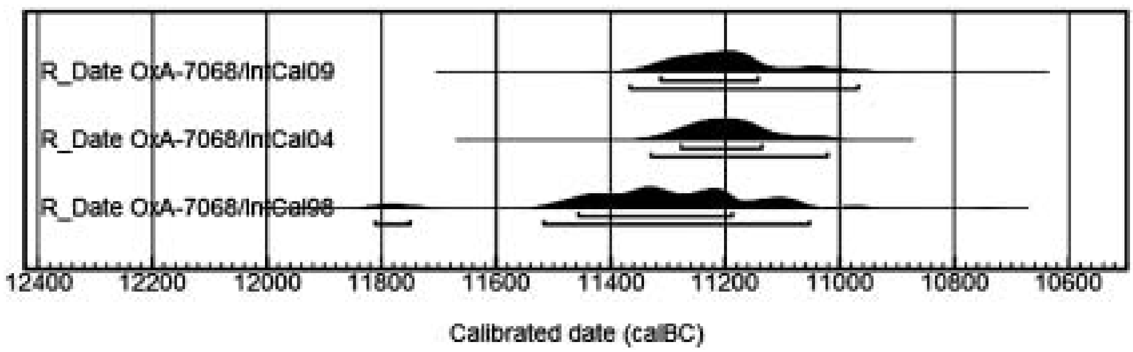
The Stratigraphy and Geological Context

The aim of geological analysis was to detect the primary deposition site and to reconstruct the transport of the fossil to its final location (Text-fig. 3).The analysis was based upon the complex stratigraphy and geologic-morphological setting of the south-eastern part of the Danube Lowlands (Halouzka in Vaškovský and Halouzka 1976, Vaškovský 1982).

The calvarium was found in flood-plain clayey-sandy loams and gravels of Holocene alluvia (Text-fig. 3, Nr.1) on the left bank of the Danube. The discovery site is located in the lower part of the river flood-plain zone, in the current floor of a narrow local arm of the river. As for geological context, the skull was evidently not found in its primary deposition site and the flood-plain sands and gravels could not have represented its original fossilization environment. The well-preserved skull with only limited abrasion is indicative of a very short displacement from its primary deposition site.

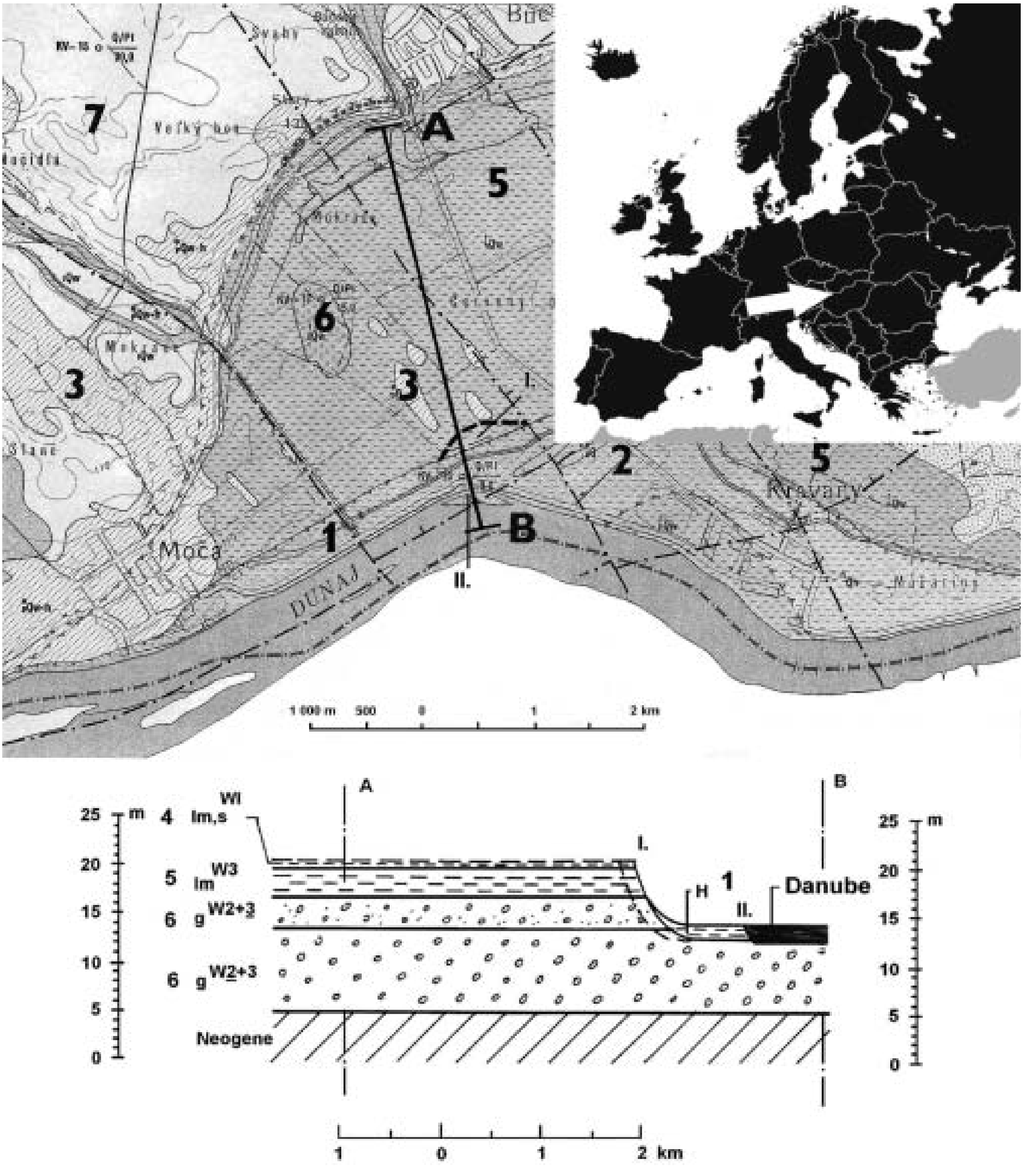
Accordingly, the primary deposition site was sought in a nearby geological formation suitable for fossilization of the skull and chronologically consistent with its ^{14}C date. Such an area is located about 100-150 m upstream from the discovery location, on the periphery of the current Danube bottom terrace (T I) adjacent to the flood plain. The terrace, i.e. the Kravany Terrace of the Danube, is formed by the Würm sandy-gravely alluvia (Text-fig. 3, W2 – W3, i.e. Nr. 6) including the so-called terminal Würm (Text-fig. 3, W3, Nr. 5) with a light-coloured surface area and cover of sandy loams.

Preserved remnants of the Kravany Terrace in the Moča-Štúrovo segment also comprise parts of the youngest sedi-



Text-fig. 2. Date calibration of skull from Moča (Komárno district, southern Slovakia).

ments, namely aeolian and fluvio-aeolian sands of a transient Würm/Holocene to Holocene age (Text-fig. 3, Nr. 3). An analogous terrace at Štúrovo also comprises extensive cover of the youngest (pre-Holocene) alluvia, i.e. fluvial darker-brown clayey loams, the so-called Nana loams, and light-coloured yellowish-brown fine-grained sands (Text-fig. 3, Nr. 4). These layers were subject a detailed lithofacial, geological and morphological study (Halouzka 1973, 1982),



Text-fig. 3. Geological map and schematic geological section of the discovery site of the Late Upper Palaeolithic skull from Moča (southern Slovakia). I. – Primary position (?), II. – The discovery site (secondary position), A – B – The schematic geological section of the discovery site

1. H – Fluvial clayey to sandy loams (subordinately humolites) – Holocene; secondary discovery site layer, 2. lm-p^{H} – Loam – peat – Holocene, 3. $^{e}_{s}$Wl – Eolian sands – Late Würm (Late glacial of Würm), 4. lm,s^{Wl} – Fluvial clayey (to humic) loams or fine sands – Late Würm (Late glacial of Würm); original discovery site layer, now eroded, 4a. $^{fe}_{s-lm}$Wl – Fluvial – aeolian silty sands (calcareous) – Late Würm (Late glacial of Würm), 5. lm^{W3} – Fluvial loams, sandy loams – final Würm (W3), 5a. $_{s}$W3 – Fluvial sands – final (?) Würm (?W3), 6. g^{W2+3} – Fluvial gravels, sandy gravels, sands with gravel – Pleniglacial of Würm (W2+3), 7. lW – Aeolian loess and loess loams – Würm (undivided)

which enabled their stratification range to be identified as the Late Würm (its terminal Alleröd and Late Dryas stages).

Considering fossilisation of the skull, the loamy layers of fluvial sands (analogous with intercalations in the so-called Štúrovo sands group) or darker clayey loams (analogous with the so-called Nana loams group) (Text-fig. 3, Nr. 4) seem to have been much more favourable than the fluvial and aeolian sandy sediments (Text-fig. 3, Nr. 3).

Ultimately, the skull's primary fossilization site is presumed to have been located at the periphery of the Kravany Terrace of the Danube. The fossiliferous sediments and the skull were later eroded and removed to the then just forming flood plain. The sediments were most probably fluvial, analogous in their lithology and stratigraphy to the so-called Nana loams at Štúrovo (Text-fig. 3, Nr. 4). The transport of the skull was brief in space and time. The fossil was displaced from the terrace to the flood-plain zone, a presumed 100-150 m distance downstream most probably due to gravity washover and less intense fluvial transport over the bed of the Danube River tributary.

One of the authors (R. H.) remembers the find of a similar skull in 1963 during channel construction at Štúrovo in the so-called Štúrovo sands group; however, this skull has not been offered for examination.

Paleobiological comparisons

Material and methods

Assessment of the Moča skull involved both detailed morphological descriptions of the bones and morphometric comparisons with relevant samples of Late Pleistocene and recent human remains using univariate and bivariate analyses.

The Late Upper Palaeolithic (LUP) group consists of associated human remains from European sites including the following specimens: Arene Candide 3, 4, 5; Bruniquel 24, Cap Blanc 1, Döbritz 1, Farincourt 1, Chancelade 1, Kostenki (Zamjatina), Le Bichon 1, Maritza 2, Montgaudier 4, Oberkassel 1, 2; Ortucchio 1, 2; Roc-de-Cave, San Teodoro 1, 2, 3, 5; Staré Město, Veyrier 1, 2, 3; Zlatý kůň. Concerning these fossils, some dating corrections were made (e.g. Jelínek 1986, Ullrich 1992, Ruff, Trinkaus and Holliday 1997, Gambier 1995, Gambier and al. 2000, Orschied 2000, Svoboda and al. 2002). The related metric data came from Henke (1989).

The recent sample consists of Early Medieval (9th c. AD) human skulls (18 males, 20 females) from the cemetery at Nitra-Lupka (district of Nitra, Slovakia); the relevant metric data were taken from Thurzo (1969). Some of the craniometrical comparisons were unfortunately limited due to the state of preservation of both the LUP and recent samples.

In addition to metric comparisons, non-metric or "epigenetic" traits are coded for on the Moča skull using a subset of the extensive series of such traits detailed in Hauser and De Stefano (1989). Also, given the importance of craniofacial morphology patterning in Later Pleistocene human evolution, Lahr's (1996) scoring grades for several morphological craniofacial traits were used here for comparison. These include cranial vault, supraorbital, infraglabellar, orbitozygomatic and occipital features.

The calvarium was studied and measured (in total 54 measurements and seven angles) according to the standard Martin and Saller's craniological techniques (Martin and Saller 1957, Bräuer 1988) using Martin's numbers; in addition a set of seven linear measurements according to Howells (1973) were utilised (Table 1, Table 2).

The Moča skull was compared metrically with samples of European Late Upper Palaeolithic and recent humans. The univariate comparisons are based on mean *z*-scores of skull measurements and indices from the LUP and the recent group (calculated from a pooled sample) and *z*-scores from the Moča individual (Table 3). Differences were evaluated using the 95% tolerance interval (TI) of the mean *z*-scores (LUP or recent group), the interval of group mean ± 1. 96 × group standard deviation. The individual Moča measurements could be assessed as not belonging into the particular population, if the Moča values exceeded 95% TI. When the means of the LUP and recent groups are out of the 95% confidence interval of the mean *z*-scores, their differences are significant. Only those having five or more specimens ($n \geq 5$) in each particular group were included. Given the contrasts or the relationship, some of the values have been plotted against each other. Accordingly, bivariate comparisons were made, where the convex hulls represent the limits of variability of the compared sets of measurements representing the LUP and recent group.

All computations were performed using the R software package (R Development Core Team 2008).

Preservation, morphology and morphometrics

The excavated, nearly undamaged calvarium (Text-fig. 1), with very well preserved symmetrical splanchnocranium and neurocranium, has a gracile to moderate construction, with moderate marked muscle relief. The small amount of splanchnocranium damage is limited mainly to both maxillary bones and it is localised below the infraorbital foramina, where some parts of bone are lost. In addition, the superior orbital roofs as well as portions of the orbital floor are damaged, especially on the right side.

In anterior view (Text-fig. 1a), there is a slight hint of frontal keeling in the midline which is apparent from an oblique (inferofrontal) view. Although weakly expressed, the keeling is especially evident in the area of the metopion. Approximately 27 mm laterally to the metopion, on both sides there are very weakly expressed frontal eminences.

On the left side of the frontal bone, there is a clearly defined (25 mm) frontal sulcus (groove) present, but on the right side, it is only indicated. There is generally a higher incidence of this trait in recent females with a significant preference for the left side. Positive intertrait association was found with respect to the presence of supraorbital and supratrochlear foramen (Hauser and De Stefano 1989).

An osteoma is visible on the left side of the frontal bone (Text-fig. 4a). The rest of the frontal suture is preserved in the form of a complicated supranasal suture (the extent of the zig-zag oscillation in the suture is uniform) located between the orbits (length 5 mm) (Text-fig. 4b). In 100 adult male middle Europeans the supranasal suture is expressed in 89 % (Hauser and De Stefano 1989).

Table 1. Measurements of the Late Upper Palaeolithic skull from Moča (Slovakia) in mm, angles in degrees, capacity in ccm.

Martin and Saller, 1957 Bräuer, 1988		Howells, 1973	Measurement definitions	Value
M 1	g-op	GOL	Maximum cranial length	179
M 1c	m-op		Metopion-opisthocranion length	183
M 1d	n-op	NOL	Nasio-occipital length	178
M 3	g-l		Glabello-lambda length	177
M 5	n-ba	BNL	Basion-nasion length	98
M 7	ba-o		Foramen magnum length	37
M 8	eu-eu	XCB	Maximum cranial breadth	131
M 9	ft-ft		Least frontal breadth	96
M 10	co-co	XFB	Maximum frontal breadth	110
M 11	au-au		Biauricular breadth	118
M 11b		AUB	Biauricular breadth	111
M 12	ast-ast	ASB	Biasterionic breadth	104
M 13	ms-ms		Bimastoideal breadth	95
M 16	fol-fol		Foramen magnum breadth	34
M 17	ba-b	BBH	Basion-bregma height	132
M 19a		MDH	Mastoideal length-left, right	23 25
		MDB	Mastoideal width-left, right	19 20
M 20	po-b		Auriculo-bregmatic height	100
M 23	g.op.g		Horizontal circumference	511
M 24	po.b.po		Transverzal arc	293
M 25	n.o		Total sagittal arc	377
M 26	n.b		Frontal sagittal arc	127
M 27	b.l		Parietal sagittal arc	132
M 28	l.o		Occipital sagittal arc	118
M 29	n-b	FRC	Nasion-bregma chord	108
M 29g		SOS	Supraorbital projection	6
M 29h		GLS	Glabella projection	2
M 30	b-l	PAC	Bregma-lambda chord	117
M 31	l-o	OCC	Lambda-opisthion chord	100
M 38	Welcker I		Cranial capacity	1313
M 38	Lee-Pearson		Cranial capacity	1140.3
M 38	Olivier et al. (1978)		Cranial capacity	1277.3
M 38	average		Cranial capacity	1243.5
M 40	ba-pr	BPL	Basion-prosthion length	102
M43	fmt-fmt		Outer biorbital breadth	104
M 43(1)	fmo-fmo		Inner biorbital breadth	97
M 44	ek-ek		Biorbital breadth	98
M 44b		EKB	Biorbital breadth	98
M 45	zy-zy	ZYB	Bizygomatic breadth	123
M 46	zm-zm		Bimalar breadth	98
M 48	n-pr		Upper facial height	63
M 49a	d-d	DKB	Naso-dacryal chord	20
M 49b		NDS	Naso-dacryal subtense	10
M 50	mf-mf		Anterior interorbital breadth	22
M 51	mf-ek		Orbital breadth	40
M 52		OBH	Orbital height	29
M 54	apt-apt	NLB	Nasal breadth	23
M 55	n-ns	NLH	Nasal height	48
M 57		WNB	Simotic chord	7
M 57a		SIS,SS	Simotic subtense	3
M 60	pr-alv		External palate length	49
M 61		MAB	External palate breadth	60

M 62	ol-sta		Internal palatal length	48
M 63	enm-enm		Internal palatal breadth	38
M 72	n-pr-OAE		Total facial angle	79
M 73	n-ns-OAE		Nasal angle	78
M 74	ns-pr-OAE			77
M 75	n-rhi-OAE			55
M 75(1)	72.-75.			24
M 76a		SSA	Zygomaxillary angle	133
M 77	fmo-n-fmo		Naso-malar angle	139
M 78			Orbital entrance angle	84
M 80			Maxilla dental arch length	49
M 80(1)			External dental arch width	62
M 80(2)				39
M 80(3)				26
		PAF	Bregma-subtense fraction	62
		FOL	Foramen magnum length	36
		ZMB	Bimaxillary breadth	97
		MLS	Malar subtense	18
		OBB	Orbital breadth, left	40
		NPH	Nasion-prosthion height	62

The supraorbital region shows a distinct separation of the medial and lateral components. The well-developed superciliary arches are prolonged medially to form a prominent glabella – ST 3 grade (Lahr 1996). The total lengths of this medial component (inclusive of the glabella) for both sides combined are ca. 62 mm. In the subglabellar area, a pair of tubercles occurs bilaterally, next to the supranasal suture (Text-fig. 4b). Pronounced development of the supraorbital torus (ST 5) is clearly an ancestral condition of all archaic hominids, present in most early modern humans (Lahr 1996).

During the X-ray examination, a hypoplasia of the right frontal sinus was identified (Text-fig. 5). In both sexes the left sinus predominates over the right in recent populations (Hauser and De Stefano 1989). Among fossil finds, the frontal sinuses are absent e.g. in the skull of the Late Upper Palaeolithic skeleton (adolescent, female?) Roc-de-Cave (Bresson 2000). According to Lahr (1996), small sinuses generally characterise all modern groups, but there is a large variation in size.

The low, subrectangular orbits have rounded supraorbital margins with large bilateral medially positioned frontal notches; on the left side there is also a supratrochlear notch. The inferolateral margin of the orbits is relatively rounded, but raised in relation to the floor of the orbit – RO 2 grade (Lahr 1996). This is the most common condition, present in the majority of skulls (Lahr 1996).

On the left side, the infraorbital suture running medially to the zygomaxillary suture ends caudally in the form of a small tubercle located above the left infraorbital foramen (Text-fig. 4b); on the right side, there is no tubercle, and the infraorbital suture ends in the partially damaged right infraorbital foramen.

The shape of the zygomatico-frontal sutures is bilaterally complicated (Text-fig. 4d), it appears that they consist of sutural bones, but more detailed view reveals that there is a ragged frontal process on the zygomatic bone. The zygomaxillary (malar) tuberosity, zygomaxillary ridge according to Franciscus and Vlček (2006), is in the form of a small sized tubercle – ZT 2 grade (Lahr 1996). Most Upper Pleistocene fossils have no zygomaxillary tuberosity (ZT 1) or only a slight tubercle on their malar surface ZT 2 (Lahr 1996). On the facial surface of the corpus of the zygomatic bone, bilaterally there are two zygomatico-facial foramina. The postglenoidale tubercle is small.

Next to the zygomatico-maxillary suture, there are bilaterally visible moderately expressed zygomaxillary tubercles (Text-fig. 4b). In recent populations, absence of the tubercle is rare and tends to occur more often in females (Hauser and De Stefano 1989).

The nasal bones are divergent and the naso-frontal suture is of a step-wise form. The internasal suture meanders irregularly, it starts distinctly on the right side of the naso-frontal suture and in its first third continues with a concavity to the left side, then – approximately at half of its length – it returns to the centre (Text-fig. 4b). The profile of the nasal saddle and roof is in the form of the nasals forming a well-defined curve of moderate size – NS 3 grade (Lahr 1996). This type is the most common condition and is observed in approximately 48 % of the 235 modern crania examined (Lahr 1996). The area between the nasomaxillary suture and inferomedial orbital area is relatively smooth with only weakly expressed furrows. The roughened furrow or slight elevation are frequently found in both immature and mature archaic Homo (Franciscus and Vlček 2006). The lateral margins of the piriform aperture are complete and distinct along its entire length. The lower margin shows a single crest demarcating the internal nasal floor from the subnasoalveolar clivus. Canine fossae are shallow and the subnasal region is markedly undulated.

The anterior view reveals conspicuous wavy attrition of teeth (see below).

Table 2. Indices of the Late Upper Paleolithic skull from Moča (Slovakia) according to Martin and Saller (1957) and Bräuer (1988).

Index	Definition	Value
I 1	8 : 1	73.2
I 2	17 : 1	73.7
I 3	17 : 8	100.8
I 4	20 : 1	60.9
I 5	20 : 8	83.2
I 9	17 : 23	25.8
I 11	11 : 24	40.3
I 12	9 : 10	87.3
I 13	9 : 8	73.3
I 14	12 : 8	79.4
I 16	27 : 26	103.9
I 17	28 : 26	92.9
I 18	28 : 27	89.4
I 19	26 : 25	34.0
I 20	27 : 25	35.4
I 21	28 : 25	31.6
I 22	29 : 26	85.0
I 24	30 : 27	88.6
I 25	31 : 28	84.7
I 29	31 : 12	96.2
I 33	16 : 7	91.9
I 37	(1+8+17):3	147.3
I 39	48 : 45	51.2
I 41	46 : 45	79.1
I 42	52 : 51	72.5
I 42(1)	51 : 45	32.5
I 42(2)	52 : 48	46.0
I 46	50 : 44	22.4
I 48	54 : 55	47.9
I 51(1)	54 : 45	18.7
I 54	61 : 60	122.4
I 55	61 : 45	48.8
I 56	60 : 40	48.0
I 58	63 : 62	79.2
I 60	40 : 5	104.1
I 67	80(1) : 80	126.5
I 68	80(2) : 5	39.8
I 69	40 : 1	57.0
I 71	45 : 8	93.9
I 72	9 : 43	92.3
I 73a	9 : 45	78.0

The maximum cranial breadth of the Moča skull is across the parietal bones. Maximum cranial breadth across the temporal bones rather than across the parietals is by far the most common condition in Upper Pleistocene modern fossil crania, but a number of recent skulls have maximum cranial breadth across the temporals, and a few across the supramastoid crests (Lahr 1996).

The minimum frontal breadth corresponds to the mean of LUP, but it is greater than the recent group mean; on the other hand, maximum cranial breadth is markedly less than in LUP specimens and also in the recent group (Text-fig. 6a). The minimum frontal breadth, as well as the maximum cranial breadth of the Moča skull lies on the edge of the range for the LUP sample (Text-fig. 7c).

Despite the fact that both the orbital breadth and the orbital height of the Moča skull are markedly smaller than in LUP specimens suggests that (Text-fig. 6a), its orbital shape resembles the orbital shape of LUP skulls (Text-fig. 7g). Orbital breadth in the recent group is conspicuously smaller and orbital height is evidently greater than in LUP specimens. The data from the Moča skull lie in the LUP convex hull and close to the recent specimens' convex hull. Overall, the orbits of LUP specimens are wider and lower.

The measurements of the Moča piriform aperture do not differ from either the LUP or recent group variability. Its nasal height is a little shorter than the LUP mean, and in the case of the recent group, it is close to the mean. The Moča nasal breadth is less than the means of this measurement in both the LUP and the recent groups (Text-fig. 6a). On the scatter-plot, the Moča lies in the overlapped convex hulls of the LUP and recent groups (Text-fig. 7h).

In lateral view (Text-fig. 1c), the profile of the sagittal suture in the area of the bregma is nearly horizontal. In relation to the frontal chord, the frontal bone shows a near vertical frontal inclination with marked projection at the metopion. The glabellar region is markedly projecting, with both a slight supraglabellar inflection and relatively deep infraglabellar notch. The profile of the infraglabellar notch is formed by the prominent glabella and relatively deep, wide nasion angle – IN 3 grade (Lahr 1996). It is similar to the pattern found in all of the Dolní Věstonice and Pavlov individuals, and other Upper Palaeolithic samples (Franciscus and Vlček 2006).

The lateral margin of the orbit is posteriorly positioned relative to the nasion which indicates some degree of midfacial projection.

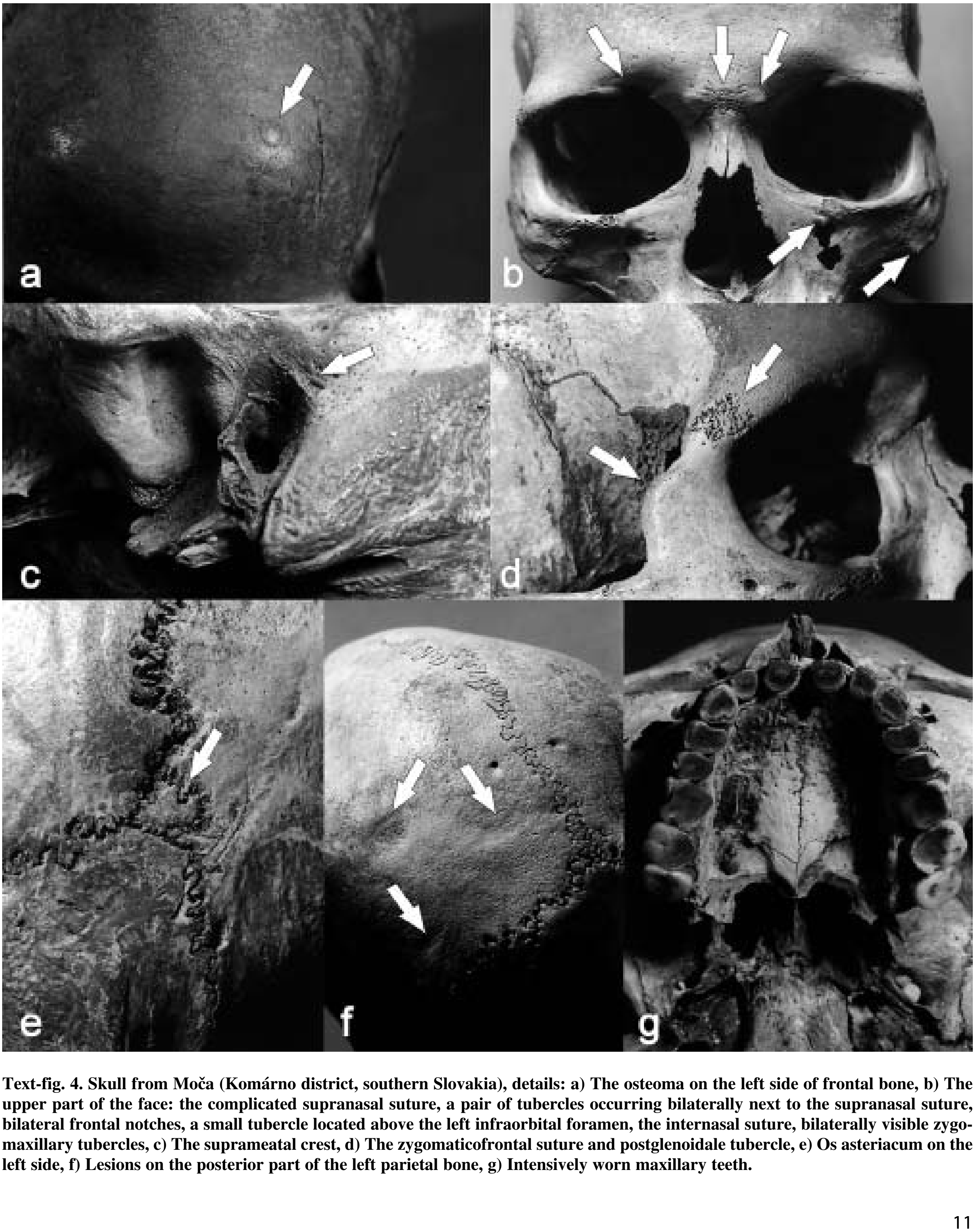
The nasal bones protrude and the profile of their lower part is convex. The anterior nasal spine is small. The nasal root is set deep below the markedly developed glabellar region. As to the dakryal index, its value (50.0) is less than the interval typical for Europoid individuals (61.0 – 63.3) and greater than the interval typical for Mongoloid individuals (39.0 – 46.2) (Schwidetzky 1965). On the other hand, the value of the simotic index (42.8) lies at the upper limit of the interval typical for Mongoloid individuals (30.8 – 42.8); an interval between 53.7 – 59.5 units is typical for Europoid individuals (Schwidetzky 1965). However, according to Strouhal's (1974) data, the simotic index of the Moča skull suggests a female individual of Europoid origin – the male values are greater than 43.1. In addition, values of simotic index lower than 34.0 are characteristic for some populations native to Africa (Strouhal 1974).

The sphenoparietal suture is wide, the parietals articulate with the large wings of the sphenoid ("H" form). Among human populations, this sphenoparietal type of articulation is the most common (Hauser and De Stefano 1989, Lahr 1996).

The zygomatic arches are thick, the marginal tubercles moderate in size (ca 4 mm) (Hauser and de Stefano 1989). Within the recent population, with respect to variation in the marginal tubercles, the most elaborate studies show preponderance in males and mainly a symmetric occurrence, with a preference for the right side in unilateral expression. There appears to be little correlation between the degree of expression of the marginal tubercle and that of the zygomaxillary tubercle (Hauser and de Stefano 1989).

The whole area of the zygomatic trigone is inflated and widened but retains a smooth surface – TR 3 grade (Lahr 1969).

The anterior portion of the temporal line on the frontal bone is well marked and rugose. On the temporal bone, the temporal line is moderately developed. The mastoid processes are very small – expression is of the 1st grade (Acsádi and Nemeskéri 1979, Buikstra and Ubelaker 1994), but they are clearly separated from the juxtamastoid eminence, above them there are mildly developed suprameatal crests (Text-fig. 4c) without suprameatal depressions. Within recent population variation, the presence of crest type is highly predominant (Hauser and De Stefano 1989). Small foramina mastoidea are expressed bilaterally in a sutural position. In recent populations, this is also the most frequent situation (Hauser and De Stefano 1989).



Text-fig. 4. Skull from Moča (Komárno district, southern Slovakia), details: a) The osteoma on the left side of frontal bone, b) The upper part of the face: the complicated supranasal suture, a pair of tubercles occurring bilaterally next to the supranasal suture, bilateral frontal notches, a small tubercle located above the left infraorbital foramen, the internasal suture, bilaterally visible zygomaxillary tubercles, c) The suprameatal crest, d) The zygomaticofrontal suture and postglenoidale tubercle, e) Os asteriacum on the left side, f) Lesions on the posterior part of the left parietal bone, g) Intensively worn maxillary teeth.

Table 3. Mean *z*-scores of Moča, LUP and recent skull measurements and indices calculated from a pooled sample, Moča excluded (LUP + Recent), [N = n (LUP) + n (Recent)].

Measurements	Moča	Mean (LUP)	n (LUP)	Mean (Recent)	n (Recent)	N
M 1	-0.503	0.8	19	-0.434	35	54
M 5	-0.297	0.146	16	-0.087	27	43
M 7	0.022	0.467	11	-0.244	21	32
M 8	-0.792	0.284	17	-0.138	35	52
M 9	0.226	0.166	22	-0.105	35	57
M 10	-0.828	0.149	19	-0.079	36	55
M 12	-0.623	0.925	11	-0.299	34	45
M 17	-0.153	0.395	18	-0.264	27	45
M 20	-0.103	1.644	6	-0.267	37	43
M 23	-0.047	1.205	5	-0.177	34	39
M 38	-0.526	1.229	5	-0.236	26	31
M 40	1.088	-0.021	13	0.017	16	29
M 45	-0.921	0.62	14	-0.62	14	28
M 48	-0.613	0.133	17	-0.087	26	43
M 51	0.123	0.783	18	-0.504	28	46
M 52	-0.966	-0.373	18	0.231	29	47
M 54	-0.516	0.071	21	-0.071	21	42
M 55	-0.26	0.237	19	-0.166	27	46
I 1	-0.339	-0.508	16	0.226	36	52
I 2	0.118	0.048	17	-0.028	29	46
I 3	0.36	-0.187	16	0.1	30	46
I 13	0.891	-0.142	16	0.063	36	52
I 39	-0.144	-0.239	12	0.168	17	29
I 42	-0.716	-0.683	17	0.4	29	46
I 48	-0.354	-0.268	17	0.228	20	37

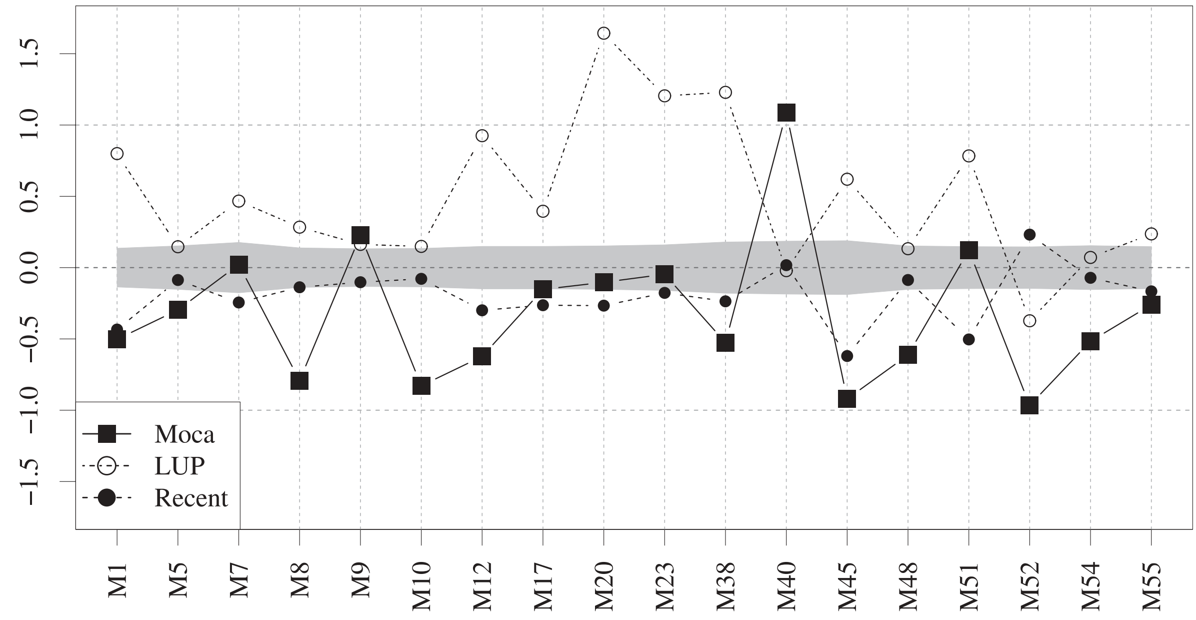
Text-fig. 5. Skull from Moča (Komárno district, southern Slovakia), frontal radiograph of skull showing hypoplasia of the right frontal sinus.

The asterion region shows bilateral suture ossicles (ossa asteriaca) (Text-fig. 4c). The majority of authors report higher frequencies of ossicles on the asterion in recent males and according to several authors, the formation of ossicles on the asterion shows some correlation with presence of other accessory ossicles in the skull, and especially with the paired forms (Hauser and De Stefano 1989) – but it is not so in our case, because accessory ossicles on other Moča sutures were not found. Given the results of studies of the non-metric traits in the Gravettian population, e.g. from Předmostí, it can be concluded that the Předmostí group shows a statistically greater occurrence of sutural bones in the rear parts of the cranial vault (the sagittal and lambdoid sutures), especially in the area of the lambda point (sagittal ossicles, the ossicle at lambda, lambdoid suture ossicles, ossicles on the asterion) (Velemínský et al. 2008).

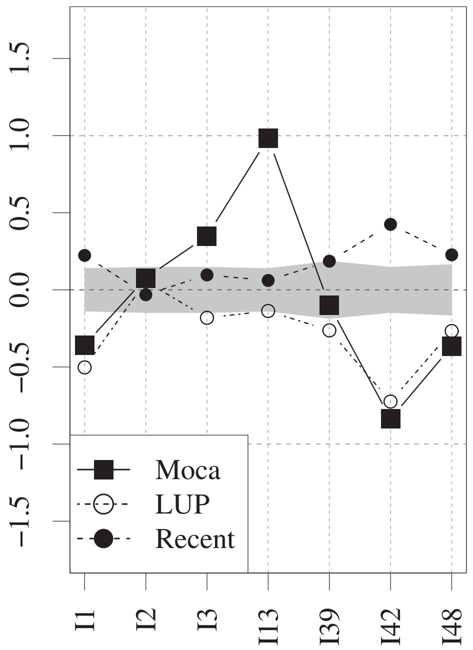
The occipital bun in the Moča skull is slightly elongated, with a relatively markedly developed external occipital protuberance – 4th grade (Acsádi and Nemeskéri 1979).

In the lateral view, both the height and length of the Moča neurocranium are smaller than in the LUP specimens and they are very similar to the recent means (Text-fig. 6a). The relationship between these two variables resembles that in the recent group. On the scatter-plot, the Moča skull lies in the middle of the recent convex hull and on the border of the LUP hull (Text-fig. 7b).

A comparison of the lower facial projection at the prosthion and the upper facial projection at the nasion



Text-fig. 6a. *Z*-score profile for Moča skull. Comparison of Moča skull measurements with LUP and recent sample, –1.96 and +1.96: 95% tolerance interval (95% of the LUP and recent variability), 0: LUP and recent sample mean, gray band: 95% confidence interval of mean *z*-scores. Only those samples having more than n = 5 in the particular group are included.



Text-fig. 6b. *Z*-score profile for Moča skull. Comparison of Moča skull indices with LUP and recent sample, –1.96 and +1.96: 95% tolerance interval (95% of the LUP and recent variability), 0: LUP and recent sample mean, grey band: 95% confidence interval of mean *z*-scores. Only those samples having more than n = 5 in the particular group are included.

(Text-fig. 8a) shows the Moča skull as having a high degree of facial projection, which is mainly caused by a very high value for the basion-prosthion length (Text-fig. 7e). Its value is much greater than the mean in both LUP and recent specimens. On the graph, the Moča sample lies outside the overlapping LUP and recent convex hulls.

The basion-prosthion length of the Moča skull is very long but the upper facial height (n-pr) is smaller than the LUP and recent means (Text-fig. 6a). On the scatter-plot showing the upper facial height versus the basion-prosthion length, the Moča cranium lies in the convex hull for the recent population but outside the LUP convex hull (Text-fig. 7f). The Moča skull upper facial height is small relative to the basion-prosthion length thus putting it into the low face range.

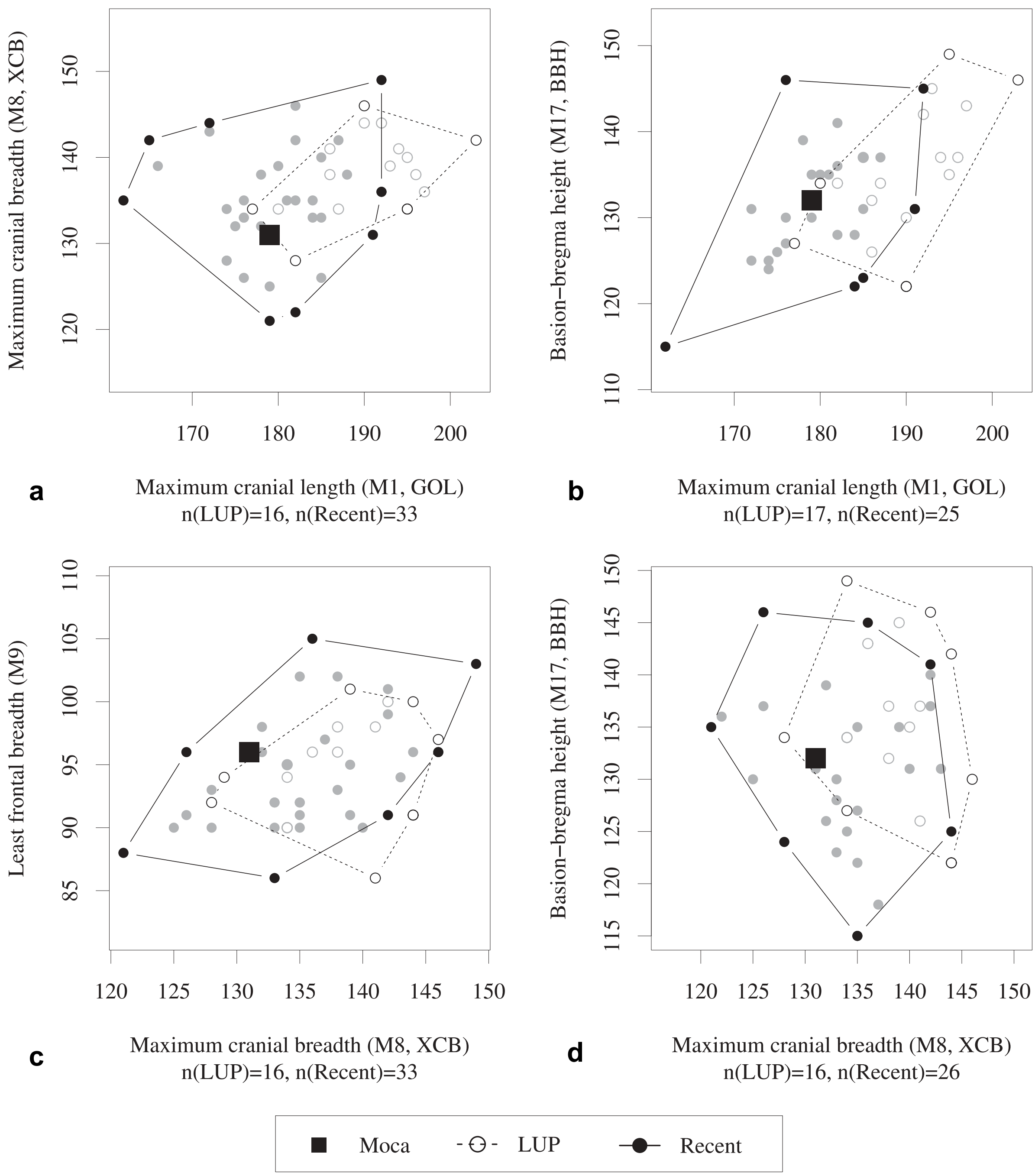
The waved abrasion of teeth is evident in both the lateral and anterior views.

In superior view (Text-fig. 1e), the conspicuously long skull exhibits a pentagonal contour, the zygomatic arches are visible (phenozygia), and parietal tubera are moderately developed. The sagittal keeling is present in superior view, with slight parasagittal depressions that are limited to the anterior sagittal area. According to Franciscus and Vlček (2006), Lahr’s sagittal keeling definition was operationalized for the extant Asian population and does not include parasagittal depressions; it therefore differs from Weidenreich´s definition, which was operationalized for *Homo erectus*.

One moderate large parietal foramen (a wire with the diameter of 1 mm enters according to Hauser and De Stefano 1989), is present bilaterally near the sagittal suture on the posterior part of parietal bone. Coronal, sagittal and lambdoidal sutures are very well preserved, detailed scoring results as epigenetic traits are presented in Table 4.

The posterior part of the left parietal bone reveals three distinct oval lesions (Text-fig. 4f; 9 x 11 mm, 18 x 14 mm, and 8 x 4 mm). Probably, they were caused by superficial injuries; X-ray examination shows only the damaged externa lamina. Analogous injuries could be found in some Palaeolithic, Mesolithic and/or Neolithic skulls (Newell and al. 1979, Vlček 1991, Teschler-Nicola and Berner 1994, Trinkaus and al. 2006); similarly as in the Moča skull, they could have originated during initiation ceremonies.

The maximum cranial length of the Moča skull is less than in LUP specimens but near the mean of the recent group, its maximum cranial width is much less than in LUP specimens and the recent sample also (Text-fig. 6a). On the



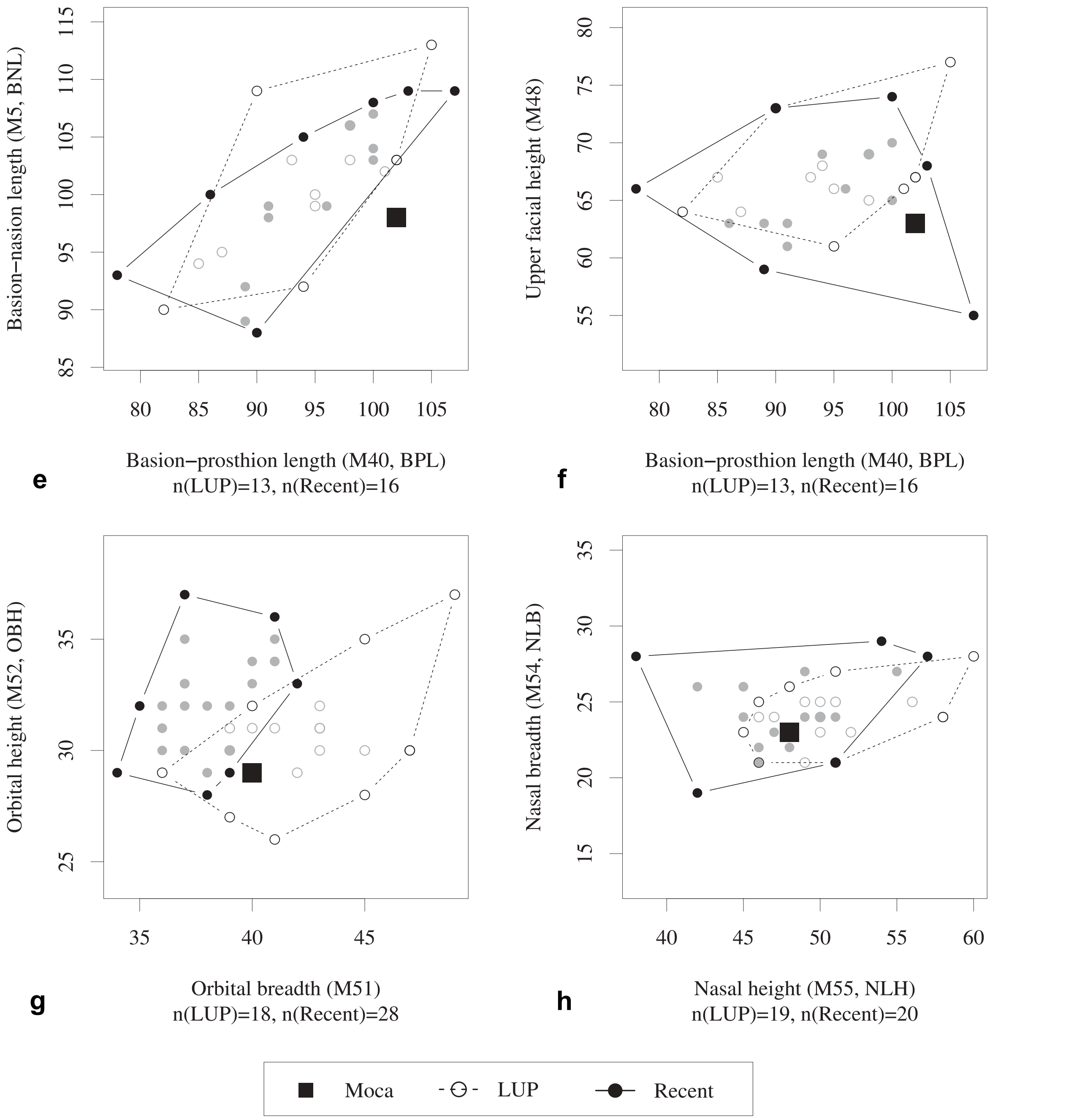
Text-fig. 7a,b,c,d. Bivariate scatter-plots of chosen skull measurements of Moča skull, LUP and recent group bounded by convex hulls: a) M1 vs. M8, b) M1 vs. M17, c) M8 vs. M9, d) M8 vs. M17.

graph, the Moča sample lies inside the recent group convex hull, but at the limit of the LUP convex hull (Text-fig. 7a). The Moča cranial breadth is small relative to its length, putting it into the dolichocranial range. The relationship between the maximum cranial length and maximum cranial breadth of the Moča skull is similar to that in recent specimens.

In inferior view (Text-fig. 1d), there is a deep palatum osseum with strong palatine torus, it covers most of the palate and the elevations are strongly posteriorly developed. With few exceptions, markedly or significantly higher incidences of palatine tori are reported in females rather than in males (Hauser and De Stefano 1989). The transverse palatine suture is straight, symmetric with posteriorly protruding asymmetric convexity (on the right side moderate-sized, on the left side shorter and narrow). Within recent population variation, there is a tendency for females to show a higher incidence of anteriorly deflected variants, and a more frequent occurrence of a straight suture in males (Hauser and De Stefano 1989).

The foramen magnum is circular; the dental arch of the maxilla is formed in the shape of a “U”. The occipital condyles, without condylar canals, are very small. On the right side, there is a small damaged area in the posterior section of the occipital condyle. The hypoglossal canal is completely bilaterally undivided, precondylar tubercles are absent.

All the maxillary permanent teeth are preserved and fully erupted up to the third molars, the teeth are without caries but they are intensively worn down (Text-fig. 4g) which may have been caused by paramastical activities. The



Text-fig. 7e,f,g,h. Bivariate scatter-plots of chosen skull measurements of Moča skull, LUP and recent group bounded by convex hulls: e) M40 vs. M5, f) M40 vs. M48, g) M51 vs. M52, d) M55 vs. M54.

incisors are worn up to the neck (complete loss of crown, no enamel remaining; crown surface take on the shape of the roots, 8th stage). On the occlusal surface, the canines have a large dentine area with only a very thin enamel rim (6th stage). The dentine of the premolars is fully exposed, with the enamel rim absent on one side (7th stage). In the first molars, there is only a very thin strip of enamel preserved on one side (score 9). In the second molars, enamel is found on two sides of the quadrant surface (score 7). The occlusal surface of the third molars is flat, with weak dentine exposure (score 5) (Buikstra and Ubelaker 1994). The attrition of the incisors is orientated horizontally, in the case of the canines, the premolars and first molars it slopes lingually, whereas in the second and third molars buccally.

Regarding the Gravettians from Dolní Věstonice and Pavlov, they were also affected by intensive dental attrition; their attrition was found to be four to five times higher than that of individuals of the same age in recent population. This indicates much more intensive stress on the dentition during food consumption. In the Dolní Věstonice 16 and Brno 2 crania, there was massive attrition presented in all teeth, and especially in the incisors, where the attrition of crowns and roots is labially oriented. It also suggests some specific activity, probably during skin processing (Vlček 1997).

In posterior view (Text-fig. 1b), the contour of the skull forms sagittal keeling with pronounced angling of the parietal bones towards the sagittal suture. It is with the formation of a distinct ridge along the entire sagittal suture – SK 3 grade (Lahr 1996). Only 20.5 % of recent Australian skulls had no sagittal keeling compared to approximately 60 – 85 % in other populations. In the Fueguian-Patagonian crania, as in Australians, the most common condition is keeling of the

Table 4. Cranial suture scoring as epigenetic traits for the Moča skull. Maximum sutural shape extension: 1 – absent, 2 – trace (< 1 mm), 3 – small (1 – 3 mm), 4 – moderate (3 – 6 mm), 5 – large (6 – 10 mm), 6 – excessive (> 10 mm); Basic configurations: 1 – simple, 2^d – widely dentate, 2^l – widely looped, 3^d – narrow dentate, 3^l – narrow looped; Secondary protrusions: 1 – absent, 2 – weakly expressed, 3 – well expressed, 4 – strongly expressed. According to Hauser and De Stefano (1989), inspirated by Franciscus and Vlček (2006).

Suture and Location	Criteria	Moča
Coronal (bregmatic)	Maximum sutural shape extension	1, 3
	Basic configurations	2^d
	Secondary protrusions	1, 2
Coronal (complicated)	Maximum sutural shape extension	5, 5
	Basic configurations	3^l
	Secondary protrusions	4
Coronal (temporal)	Maximum sutural shape extension	3
	Basic configurations	2^d
	Secondary protrusions	2
Sagittal (bregmatic)	Maximum sutural shape extension	3
	Basic configurations	2^d
	Secondary protrusions	2
Sagittal (vertex)	Maximum sutural shape extension	6
	Basic configurations	2^l
	Secondary protrusions	2
Sagittal (obelic)	Maximum sutural shape extension	5
	Basic configurations	2^l
	Secondary protrusions	2
Sagittal (lambdic)	Maximum sutural shape extension	4
	Basic configurations	2^l
	Secondary protrusions	2
Lambdoid (lambdic)	Maximum sutural shape extension	4, 5
	Basic configurations	2^d
	Secondary protrusions	2
Lambdoid (intermediate)	Maximum sutural shape extension	4, 5
	Basic configurations	2^d, 3^l
	Secondary protrusions	2, 4
Lambdoid (asteric)	Maximum sutural shape extension	5, 4
	Basic configurations	2^d
	Secondary protrusions	3

vault but this is rarely pronounced. The Mediterranean Epi-Palaeolithic (Afalou, Taforalt and Natufian) populations vary in the proportion of cases with some keeling of the parietal bones; however, they lack pronounced sagittal keeling. No cases of pronounced sagittal keeling were observed in the contemporary European samples. The distribution of the three grades of sagittal keeling in the Late Pleistocene hominids shows that sagittal keeling is not an ancestral trait of late African archaic hominids or early modern fossils (Lahr 1996). A weak form of sagittal keeling could be seen, for instance, in the Late Upper Palaeolithic specimen from Staré Město by Uherské Hradiště (the Czech Republic) (Jelínek 1956) and the Gravettian skulls Dolní Věstonice 13 and 15 (Franciscus and Vlček 2006). Pronounced sagittal keeling seems to be a late specialization of modern human populations (Lahr 1996).

The greatest width of the Moča skull is at the level of the temporal squama, the base of the skull is flat. The parietal and temporal squamas are superolaterally inclined. Together with the parietal tubera and the posterior vertex, these form the typical pentagonal configuration that is associated with modern humans (Franciscus and Vlček 2006).

The occipital crest is formed as the superior occipital crest (sagittal ridge) – OCR 2 grade (Lahr 1996). The highest nuchal line is strong – markedly protruding. Among a hundred adult male Central Europeans, the highest nuchal line was expressed as "strong" in only four. There is no consistency in a sex differences (Hauser and De Stefano 1989). The occipital torus is formed by the visible supreme and superior nuchal lines and joined medially by the external occipital protuberance – OT 4 (Lahr 1996). The retromastoid processes are expressed only as a trace (protruding from the occipital surface up to 0.5 mm) (Hauser and de Stefano 1989). The mastoid foramina are visible bilaterally.

The maximum cranial breadth of the Moča skull is much smaller than in the LUP and recent sample (Text-fig. 6a). The basion-bregma height is smaller than in LUP but similar to that in the recent group. The relationship between these two dimensions in the Moča skull places it inside the LUP and recent populations convex hulls but in the LUP it lies almost at the limit of this hull (Text-fig. 7d).

Discussion

The morphometric comparison (Table 5, Text-fig. 6a, b) of the LUP and recent groups allows us to state that among the 18 craniological measurements available for comparison, in the case of the LUP group, 16 of them are greater than in the recent group.

In the LUP group, the measurement means are significantly greater than in the recent group for M1 (maximum cranial length), M12 (biasterionic breadth), M17 (basion-bregma height), M20 (auriculo-bregmatic height), M23 (horizontal circumference), M38 (cranial capacity), M45 (bizygomatic breadth) and M51 (orbital breadth). Non-significantly different are M5 (basion-nasion length), M7 (foramen magnum length), M8 (maximum cranial breadth), M10 (maximum frontal breadth), M40 (basion-prosthion length), M54 (nasal breadth), M55 (nasal height), while M9 (least frontal breadth) is on the limit of significance (Table 5, Text-fig. 6a).

In the recent group, the only measurements mean which is significantly greater (Table 5, Text-fig. 6a) than in LUP group is that of M52 (orbital height). From this point of view, the LUP specimens are overall more robust than the specimens in the recent group.

The means of the LUP skull indices which are available for comparison with the recent group, have – with the exception of the vertical index (I 2) – lower values (Table 5, Text-fig. 6b); significantly lower is I 42, but not significantly lower are I 1, I 3, I 39 and I 48.

Basically, differences between the Moča skull and specimens of the LUP and recent groups are not significant; the Moča measurement variability is similar to the variability in both groups.

As to the individual measurements, the Moča skull, in comparison with both the LUP and recent groups,

Table 5. Selected craniometrics of the Moča skull, Late Upper Palaeolithic (LUP) and recent skulls [mean ± standard deviation (N)]. The comparative samples include the following LUP specimens: Arene Candide 3, 4, 5; Bruniquel 24, Cap Blanc 1, Doebritz 1, Farincourt 1, Chancelade 1, Kostenki (Zamjatina), Le Bichon 1, Maritza 2, Montgaudier 4, Oberkassel 1, 2; Ortucchio 1, 2; Roc-de-Cave, San Teodoro 1, 2, 3, 5; Staré Město, Veyrier 1, 2, 3; Zlatý Kůň (data from Henke, 1989). The recent sample consists of Early Medieval (9th c. A.D.) human skulls (18 males, 20 females) from the cemetery at Nitra-Lupka site, district of Nitra, Slovakia (data from Thurzo, 1969). The P-value is from a t-test between LUP and recent samples; * = P < 0.05.

Measurement (mm)	Moča	LUP specimens	Recent specimens	LUP-Recent P-value
Maximum cranial length (M 1)	179	190.2 ± 6.7 (19)	179.6 ± 7.3 (35)	* 0.0001
Basion-nasion length (M 5)	98	100.8 ± 6.2 (16)	99.3 ± 6.5 (27)	0.467
Foramen magnum length (M 7)	37	38.3 ± 2.8 (11)	36.2 ± 2.7 (21)	0.055
Maximum cranial breadth (M 8)	131	137.8 ± 5.1 (17)	135.1 ± 6.7 (35)	0.156
Least frontal breadth (M 9)	96	95.7 ± 4.7 (22)	94.5 ± 4.5 (35)	0.334
Maximum frontal breadth (M 10)	110	116.3 ± 5.0 (19)	114.8 ± 7.0 (36)	0.428
Biasterionic breadth (M 12)	104	113.0 ± 6.1 (11)	105.9 ± 4.6 (34)	*0.0001
Basion-bregma height (M 17)	132	136.4 ± 7.5 (18)	131.1 ± 7.8 (27)	*0.029
Auriculo-bregmatic height (M 20)	100	122.8 ± 9.6 (6)	107.7 ± 5.3 (37)	*0.0001
Horizontal circumference (M 23)	511	533.0 ± 18.0(5)	508.7 ± 15.4 (34)	*0.003
Cranial capacity (M 38)	1277.3	1486.4 ± 122.7 (5)	1274.8 ± 122.9 (26)	*0.001
Basion-prosthion length (M 40)	102	94.2 ± 6.8 (13)	94.5 ± 7.4 (16)	0.920
Bizygomatic breadth (M 45)	123	138.4 ± 8.5 (14)	126.0 ± 7.2 (14)	*0.0001
Upper facial height (M 48)	63	66.7 ± 4.2 (17)	65.6 ± 5.4 (26)	0.488
Orbital breadth (M 51)	40	42.2 ± 3.2 (18)	37.9 ± 2.2 (28)	*0.0001
Orbital height (M 52)	29	30.6 ± 2.6 (18)	32.1 ± 2.5 (29)	*0.042
Nasal breadth (M54)	23	24.8 ± 3.4 (21)	24.3 ± 2.7 (21)	0.649
Nasal height (M 55)	48	50.2 ± 4.1 (19)	48.4 ± 4.5 (27)	0.181
I 1 (M 8 : M 1)	73.2	75.3 ± 10.7 (16)	76.1 ± 6.2 (36)	0.717
I 2 (M 17 : M 1)	73.7	73.6 ± 8.7 (17)	73.1 ± 3.7 (29)	0.780
I 3 (M 17 : M 8)	100.8	94.2 ±18.6 (16)	97.6 ± 7.7 (30)	0.375
I 13 (M 9 : M 8)	73.3	69.2 ± 3.5 (16)	69.9 ± 3.8 (36)	0.516
I 39 (M 48 : M 45)	51.2	50.4 ± 7.2 (12)	52.7 ± 3.1 (17)	0.241
I 42 (M 52 : M 51)	72.5	71.5 ± 9.6 (17)	85.4 ± 7.0 (29)	*0.0001
I 48 (M 54 : M 55)	47.9	48.5 ± 4.2 (17)	51.6 ± 7.3 (20)	0.136

approaches the LUP mean only in the case of M9 (least frontal breadth); its other measurements are lower than in the LUP group. The measurement M40 (basion-prosthion length) seems to be evidently greater than the means of both compared groups but is not significantly so.

The Moča skull measurements M1 (maximum cranial length), M5 (basion-nasion length), M17 (basion-bregma height), M20 (auriculo-bregmatic height), M23 (horizontal circumference) and M55 (nasal height) are closer to the recent group mean than the mean of the LUP group. On the other hand, there are some Moča measurements which are lower than in the recent group: M8 (maximum cranial length), M10 (maximum frontal breadth), M12 (biasterionic breadth), M38 (cranial capacity), M45 (bizygomatic breadth), M48 (upper facial height), M52 (orbital height) and M54 (nasal breadth). As to the indices, the Moča skull is characterized by greater means than the means of both the compared groups in the case of I 3 (basion-bregma height: maximum cranial breadth) and I 13 (least frontal breadth: maximum cranial breadth). The value of I 13 suggests a relatively wide forehead in relation to maximum cranial breadth (Text-fig. 6a, b, Text-fig. 7c).

Overall, and also according to bivariate comparisons, the Moča skull is typified by a markedly prognathic maxillary part of the face. Its low, wide orbits are analogous to the shape of the LUP orbits and are outside the variability of the recent population. However, all other morphological characteristics are comparable to the recent group variability, only some of them (e.g. relationships between maximum cranial length-maximum cranial breadth, maximum cranial length-basion bregma height, maximum cranial breadth-basion bregma height) are at the limit of the LUP variability.

In cranial morphology, the rather gracile Moča skull possesses evident development of cranial superstructures, particularly in the supraorbital region. In addition, it exhibits an expressive determination of neurocranial features and strong development of the facial skeleton. The Moča skull is relatively small in its absolute cranial dimensions and some of their proportions. With its gracility, the Moča skull is probably similar to the group of remains from Staré Město in the Czech Republic, Muge in Portugal, or Vasiľevka in the Ukraine. All the remains are characteristically gracile. It is possible that along the Mediterranean and associated river basins, gene flow from the Middle East accelerated a process of gracilisation (already observed to a large extent in the Natufian people of Israel), creating a morphological cline towards northern Europe (Lahr 1996).

In general, although most early modern fossils are comparatively large and robust (Lahr and Wright 1996), there seems to be a chronologically decrease in size and robustness whilst maintaining the original levels of variability from early to late Upper Palaeolithic to modern times (Lahr 1996, Larsen 1997). This gracilisation is visible in the overall fossil assemblage (Schwidetzky and al. 1982), while individual Mesolithic sites show more differentiated morphologies (Lahr 1996). The cultural development in the Upper Palaeolithic/Mesolithic transition, accompanied by a remarkable population increase plus climatic and ecological change in the Late Pleistocene/Early Holocene period, obviously led to a continuous gradual change in morphological appearance (Henke 1991).

The Moča simotic index lies at the upper limit of interval typical for Mongoloid individuals, so its value is not typical for individuals of Europoid origin. According to Gochman (1982), the gracilisation trend is closely connected with another trend – flattening of the face and nose during the Upper Palaeolithic and Neolithic in some European populations, especially in northern and eastern regions of the European territory.

From the morphological gestalt, it is evident that the Moča skull principally belongs to recent (Holocene) human populations, and there are few of its characteristics which are not readily observed in the cranial remains of this recent human population. From a morphological point of view, it refers to the sagittal keeling, a pair of tubercles bilaterally next to the supranasal suture in the subglabellar area – the marked, inflated and widened zygomatic trigone. All the permanent maxillar teeth in the Moča skull are preserved but are intensively worn down. The Moča is prognathic but the protruding of its nasal bones is reduced as in the recent European population.

Other interesting features of the Moča skull are the series of minor superficial injures to the neurocranial vault. These kinds of injury are known in Gravettian Dolní Věstonice 13, 16 and Pavlov 1. A predominance of skull injuries is unusual among Holocene human populations, but it is common among other Palaeolithic populations. Yet, when associated skeletons are available and not just the isolated craniofacial elements, the head injuries are normally associated with upper limb injuries – taken across the samples as a whole, if not necessarily within individual skeletons (Trinkaus and Svoboda 2006).

Our results partially match those in the studies of Lieberman and al. (2002, 2008) and Bruner and al. (2004). As these studies suggest, "anatomically modern" *Homo sapiens* crania are uniquely characterized by two general structural autapomorphies: facial retraction and neurocranial globularity. According to these authors, morphometric analysis of the ontogeny of these autapomorphies indicates that the changes in development leading to modern human cranial form, originated from the combination of shifts in the cranial base angle, cranial fossae length and breadth, and facial length.

However, the cranium from Moča lacks an archaeological context; it provides only a glimpse into the biology and behaviour of this individual living more than ten thousand years ago. From a rather gracile-built human, the Moča skull provides an evolutionary link between the earlier (Magdalenian?) and later (Holocene) populations in Europe. It documents a still incompletely understood mosaic of the lifetime of a late Upper Palaeolithic individual.

The assessment of sex

Material and Methods

Given that the calvarium, like other fossil specimens, differs in certain morphological details from more recent skulls, we decided to use linear discriminant analysis (LDA) for sex determination (Giles and Elliot 1963, Henke 1977, 1989, Uytterschaut 1986, Cunha and Van Vark 1991, Van Vark and Pasveer 1994), considering this statistical method more objective than visual diagnosis.

In addition to measurements of the Moča skull (Table 1), LDA used two reference data samples: 1) the 129 fossil specimens (European part of the database aged from adult to senility, dated to Late Pleistocene and Early Holocene) from Henke's dissertation (Henke 1989), 2) Howells's (1996) database of a heterogeneous sample collected from recent individuals of known sex (n = 2524). In Henke's data, certain dating corrections were made based on e.g., Straus (1991), Ruff, Trinkaus and Holliday (1997), Schulting (1999), Churchill and Smith (2000), Henry-Gambier (2002), Svoboda and al. (2002) and Wild and al. (2005).

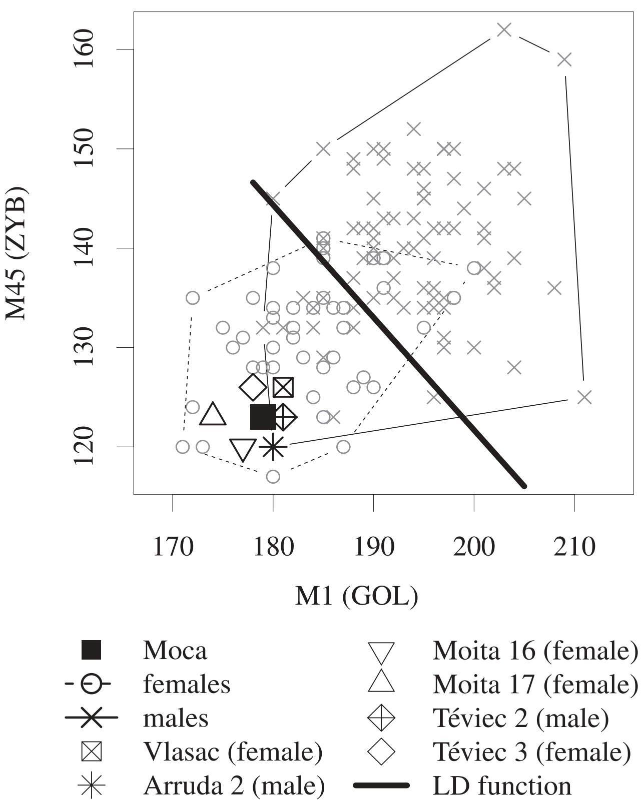
All computations were performed using the R software package (R Development Core Team 2008); the use of the library MASS by Venables and Ripley (2002) is also acknowledged.

Results and Discussion

Probably the most decisive aspect in sex estimation of the Moča calvarium was the choice of database. While Howells' (1996) recent database offers a sample collection of objects and attributes, Henke's (1989) database of fossil skulls is probably more relevant. However, in Henke's collection (not surprisingly) many measurements are not available. This fact had seriously affected the model selection and the selection of discriminators. To achieve a reasonable number of the complete training specimens, we had to resort to fewer variables, the choice of which was mostly influenced by their availability.

Using independent variables-discriminators M1/GOL and M45/ZYB from Henke´s database (n = 129, f = 46, m = 83), we obtained a posterior probability of 0.94 that the Moča skull is female (correct classification = 0.831 for females). Text-figure 8 shows the discriminating line; in fact, the high posterior probability can be verified also visually – the relevant measurements of the Moča skull lie outside the convex hull of Henke's male data. Nearest to the Moča skull are fossil samples from the Mesolithic: females Vlasac (Serbia), Moita 16, Moita 17 (Portugal), Téviec 3 (France), and males Arruda 2 (Portugal) and Téviec 2.

Our model is quite consistent with the original recommendations of Henke (1989): M1, M17and M45, which is equivalent to Howells' GOL, BBH, ZYB; and M1, M8, M45 and M52 (Howells' GOL, XCB, ZYB and OBH). The



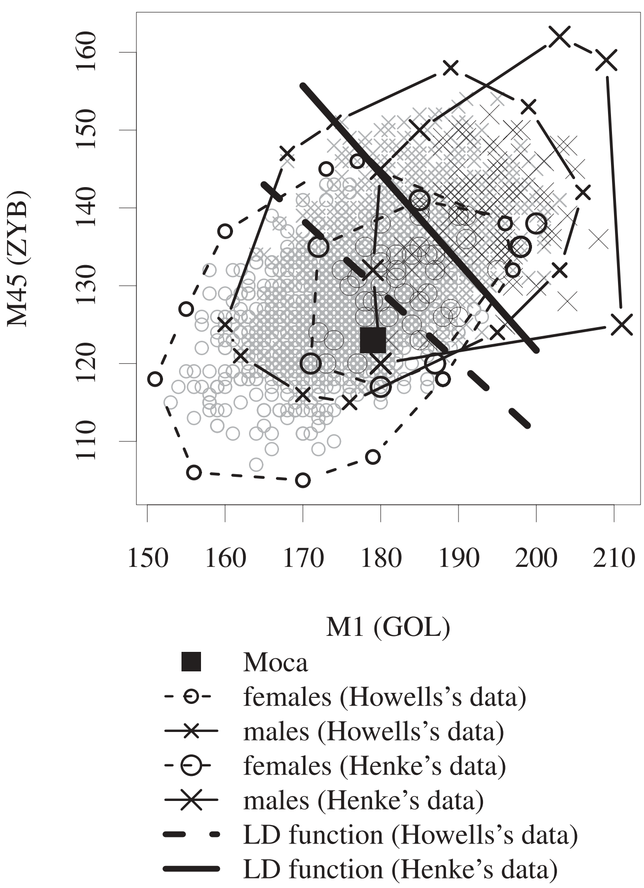
Text-fig. 8. Sex estimation of Moča skull (Komárno district, southern Slovakia), linear discriminant analysis using Henke's Late Upper Palaeolithic and Mesolithic database (n = 129, f = 46, m = 83) with variables M1 (GOL) and M45 (ZYB). As the closest to the Moča skull, the following fossil samples from Mesolithic could be identified: Vlasac, Arruda 2, Moita 16, Moita 17, Téviec 2, Téviec 3.

discriminatory value of M8 turned out to be poor and the inclusion of M17 and/or M52 would undesirably downsize the sample. The models considered so far could be compared with the results of Giles and Elliot (1963), Uytterschaut (1986), Cunha and Van Vark (1991), Van Vark and Pasveer (1994), and others.

Howells' complete data (1996) indeed offers much more powerful discriminators (Cunha and Van Vark, 1991): ZYB (M45), MDH (M19a), SOS (M29g), PAF, GLS (M29h), FOL, AUB (M11b); however, many of these are rarely preserved in the fossil specimens. The incompatibility of Henke's (1989) and Howells's (1996) measurement systems further complicate the situation; thus some recommendations are simply not applicable to the existing source of fossil data. Nevertheless, our critical assessment of the models recommended in the literature revealed that our simple model performs tolerably well also on Howells'data (Text-fig. 9). Particularly, many authors recommend the ZYB – M45 variable (Giles and Elliot 1963, Henke 1977, 1989, Uytterschaut 1986, Cunha and Van Vark 1991, Van Vark and Pasveer 1994).

We would like to emphasize once more that while Howells' data can be used for the selection of discriminators, the particular coefficients would differ substantially between recent and fossil data, and hence should be estimated from the appropriate (Henke's) data set. The difference is caused by an increased gracility of the recent populations documented as smaller skull dimensions (Text-fig. 8, Text-fig. 9). In spite of the fact that the convex hulls of both males and females in Henke's database are overlapping with the convex hulls of males and females in Howells' database, a number of the females from Howells' data are located outside the overlapping areas of other convex hulls (Text-fig. 9). This finding confirms the emphasized gracility of the female skulls from Howells' data.

Finally, we could try to ignore the differences between recent and fossil populations, and assess how the Moča skull could be classified according to the recent criteria (capitalising on the larger training set). The skull is well preserved, so all variables needed in the Howells-based system can be reliably measured. When the LDA was based on the same variable-discriminators M1/GOL and M45/ZYB (n = 2524, f = 1156, m = 1368), but on Howells' database instead, the female posterior probability came up as 0.80 (correct classification = 0.806 for females). Other subsets of variables at times gave slightly worse results, but the posterior probability was in no instance less than 0.60. We noted that the coefficients differ substantially when estimated from recent (i.e., Howells') and fossil (Henke's) data. The difference is caused by an increased gracility of the recent populations, indicated by smaller skull dimensions (Text-fig. 9).



Text-fig. 9. Sex estimation of Moča skull (Komárno district, southern Slovakia), linear discriminant analysis using Henke's Late Upper Palaeolithic and Mesolithic database (n = 129, f = 46, m = 83), as well as according to recent Howells's database (n = 2524, f = 1156, m = 1368) with variables M1 (GOL) and M45 (ZYB).

The age at death

The age estimation for the studied individual was based on both the endocranial and exocranial suture closure (Acsádi and Nemeskéri 1970, Masset 1982, Meindl and Lovejoy 1985), as well as the dental attrition (Lovejoy 1985).

Based on the above mentioned criteria (Tables 6, 7), the age of the female at the time of death has been estimated to be between 30 and 60 years. The individual age estimation lies, with high probability, in the interval 40 ± 10 years.

Regional affinity

Material and methods

Despite the fact that the Moča skull was found on the territory of Central Europe, a Central-European origin cannot be taken for granted. For the purpose of resolving the Moča skull's autochthonic or allochthonic origin, we studied its regional affinity. This was again done using LDA (Van Vark 1984, Van Vark and Schaafsma 1992), using the Moča skull's cranial measurements and those of other anthropological finds from the European portion (n = 76) of Henke's (1989) Mesolithic-Upper Palaeolithic database including in the first instance individuals whose dating corresponded to that of the Moča skull.

Inspired by Henke (1989), we separated all individuals according to the geographical position of their sites – i.e., longitude and latitude – into three regions: broadly West (n = 9), Central-East (n = 23) and South (n = 44).

The selection of the variables for the LDA model, on the basis of published recommendations and discriminatory power (Howells 1973, Sokal and al. 1987, Sokal and Uytterschaut 1987, Henke 1989, 1991), was a heuristic compromise between experiments with the error rate and the capability of the model to produce a representative training sample (not all measurements were equally available from all the specimens).

As most suitable discriminatory measurements, we choose M1 (GOL), M5 (BNL), M8 (XCB) and M40 (BPL) (marked according to Martin and Saller 1957, Bräuer 1988, Howells 1973), from which M40 (BPL) turned out to be the most powerful.

All computations were performed using the R software package (R Development Core Team 2008); the use of the library MASS by Venables and Ripley (2002) is also acknowledged.

Results and Discussion

While comparing the Moča skull with similarly dated individuals, the posterior probabilities were quite inconclusive: 0.53 for "Central-East", 0.38 for "South" and 0.09 for "West" (Text-fig. 10). The Moča skull was located outside the West data group convex hull.

Generally, it could be supposed that the Moča skull (Komárno district, southern Slovakia), according to its craniometrical features, comes from an unspecified Central European area with certain Eastern European indications. It appears that the Late Upper Palaeolithic female lived in the territory where her remains were found.

Conclusions

The gracile Moča calvarium from the river Danube (southern Slovakia), with a high degree of facial projection and strong dental attrition, is dated as 11,255 ± 80 years BP (OxA-7068). According to the calibrated ^{14}C date, the individual lived during the second half of the twelfth millennia cal BC. The skull belonged to a middle-aged female who died at around 40 ± 10 years of age. According to the regional affinity analyses of craniometrical measurements, the Moča skull probably belongs to the autochthonic population.

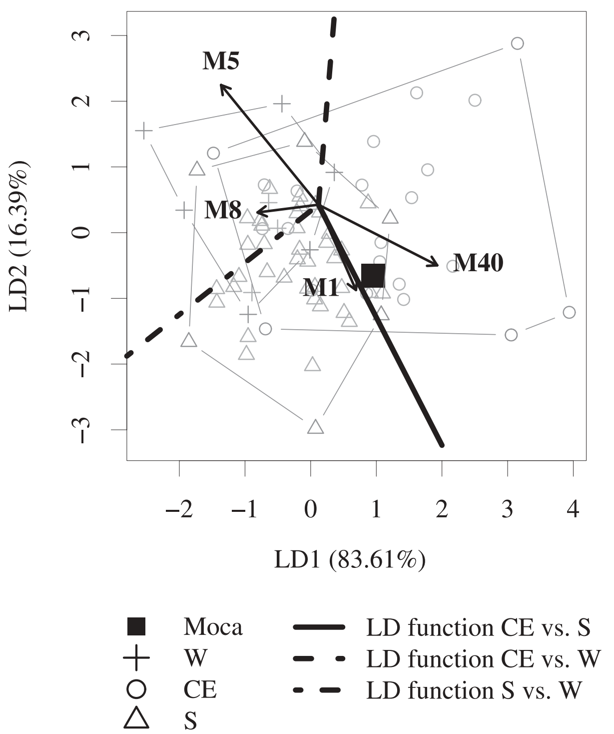
The Moča skull adds some information to the limited series of directly dated Late Upper Palaeolithic humans from Central Europe. Its measurements and most of its morphology are mainly within the recent human remains sample variability. The differences between the Moča skull and the LUP group are also not significant, too. It corresponds

Table 6. Estimation of the suture obliteration stages of the Late Upper Palaeolithic Moča skull (Slovakia).

Stages (0 – 4) (Martin and Saller, 1957)	Sutures obliteration															
	coronal						sagittal				lambdoidal					
	left			right							left			right		
parts	C3	C2	C1	C1	C2	C3	S1	S2	S3	S4	L3	L2	L1	L1	L2	L3
exocranial	3	0	0	0	0	2	0	1	1	1	0	0	0	0	0	0
endocranial	4	4	3	1	4	4	4	2	0	0	0	1	0	0	0	1

Table 7. Estimation of the age at death according to the suture obliteration of the Late Upper Palaeolithic Moča skull (Slovakia).

Authors	Criterion	Results
Acsádi and Nemeskéri (1970)	endocranial sutures	43.7 ± 14.48
Masset (1982)	endocranial sutures	46.3 ± 15.00
Lovejoy and Meindl (1985)	exocranial sutures - vault	34.7 ± 7.80
Lovejoy and Meindl (1985)	exocranial sutures -later.-anter.	41.1 ± 10.00
Lovejoy (1985)	dental attrition	45 – 55
Conclusion		30 – 60



Text-fig. 10. Regional affinity of the Moča skull (Komárno district, southern Slovakia), linear discriminant analysis using the Henke's Late Upper Palaeolithic and Mesolithic database (Europe, n = 76) with variables M1 (GOL), M5 (BNL), M8 (XCB), M40 (BPL), W – West Europe, CE – Central-East Europe, S – South Europe.

well despite the fact that the LUP and recent groups are significantly different. In addition, as could be expected, some of the Moča measurements (e.g. high basion-prosthion length) individualize it.

The primary deposition site of the skull has been estimated to have been in an area, at most, 100 – 150 m upstream from the finding place (1,100 m downstream from the border of the village of Moča). The original site is located on the surface of the recent "low" Danube terrace T I. This terrace (Kravany Danube step) is composed of fluvial sandy Würm (W2 and W3) gravels and a surface planar cover of bright loams and sandy loams (W3). The skull could be stratified to late Würm (Alleröd and Younger Dryas phases), i.e. the period 11,800 – 10,200 years BP, which is in line with the acquired ^{14}C date.

Acknowledgements

The research was supported by The Maison des Sciences de l´Homme in Paris, the Council of American Oversearch Centers in Washington D.C., the Grant Agency of the Slovak Republic (the VEGA 1/0077/09 project), and by EU FP6 Marie Curie Actions grant MRTN-CT-2005-019564 (EVAN).We also wish to thank Jaroslav Brůžek for productive discussion on methodological questions, as well as Mária Krčmářová, Irena Keprtová and Peter Klepsatel for their technical assistance.

References

Acsádi, GY., Nemeskéri, J. (1970): History of Human Life Span and Mortality. – Akadémiai Kiadó, Budapest, 346 pp.

Bondevik, S., Mangerud, J., Birks, H. H., Gulliksen, S., Reimer, P. (2006): Changes in North Atlantic Radiocarbon Reservoir Ages During the Alleröd and Younger Dryas. – Science, 312: 1514-1517.

Bräuer, G. (1988): Osteometrie. – In: Knussmann, R. (ed.): Anthropologie: Handbuch der vergleichenden Biologie des Menschen. Band I., Gustav Fischer Verlag, Stuttgart-New York, pp. 160-232.

Bresson, F. (2000): Le squelette du Roc-de-Cave (Saint-Cirq-Madelon, Lot). – Paleo, 12: 29-60.

Bronk Ramsey, C. (2010): OxCal v 4.1.6. http://c14.arch.ox.ac.uk/embed.php?File=oxcal.html.

Bronk Ramsey, C., Higham, T. F. G., Owen, D. C., Pike, A. W. G., Hedges, R. E. M. (2002): Radiocarbon dates from Oxford AMS System: Archaeometry datelist 31. – Archaeometry, 44(3), Supplement 1: 17-18.

Bronk Ramsey, C., Buck, C. E., Manning, S. W., Reimer, P., van der Plicht, H. (2006): Developments in radiocarbon calibration for archaeology. – Antiquity, 80(310): 783-798.

Bruner, E., Saracino, B., Ricci, F., Tafuri, M., Passarelo, P., Manzi, G. (2004): Midsagittal Cranial Shape Variation in the Genus Homo by Geometric Morphometrics. – Coll. Antropol., 28(1): 99-112.

Buikstra, J. E., Ubelaker, D. H. (eds.) (1994): Standards for data collection from human skeletal remains. – Arkansas Archaeological Survey Research Series No. 44, Fayetteville, Arkansas.

Cunha, E., Van Vark, G. N. (1991): The construction of sex discriminant function from a large collection of skulls of known sex. – Intern. J. Anthropol., 6(1): 53-66.

Ferembach, D., Bouvier, J-M., Vandermersch, B., Petit-Maire, N. (1971): France. – In: Oakley, K. P., Campbell, B. G., Molleson, T. I. (eds.): Catalogue of Fossil Hominids, Trustees of the British Museum (Natural History), London, pp. 88-89, 97-98, 100-101.

Franciscus, R. G., Vlček, E. (2006): The Cranial Remains. – In: Trinkaus, E., Svoboda, J. (eds.): Early Modern Human Evolution in Central Europe. The People of Dolní Věstonice and Pavlov, Oxford University Press, Oxford-New York, pp. 63-152.

Gambier, D. (1992): Les populations Magdaléniennes en France. – In: C.T.H.S. (ed.): Le peuplement Magdalénien. Paris, pp. 41-51.

Gambier, D. (1995): Les sepultures du paleolithique superieur en Europe occidentale. La dame de Brassempouy. – Actes du Colloque de Brassempouy (juillet 1994), Ličge, E.R.A.U.L., 74: 89-111.

Gambier, D., Valladas, H., Tisnérat-Laborde, N., Arnold, M., Bresson, F. (2000): Datation de vestiges humains présunés du Paléolithique supérieur par la méthode du carbone 14 en spectrométrie de masse par accélérateur. – Paleo, 12: 201-212.

Gieseler, W. (1971): Germany. – In: Oakley, K. P., Campbell, B. G., Molleson, T. I. (eds.): Catalogue of Fossil Hominids, Trustees of the British Museum (Natural History), London, pp. 200-201.

Giles, E., Elliot, O. (1963): Sex Determination by Discriminant Function Analysis of Crania. –Am. J. Phys. Anthropol., 21: 53-68.

Gochman, I. I. (1982): Several problems of forming ancient anthropological types in Eastern Europe in the light of palaeoanthropological and craniological materials of the Czechoslovak territory. – In: Novotný, V. V. (ed.): IInd Anthropological Congress of Aleš Hrdlička, Universitas Carolina Pragensis, Praha, pp. 413-415.

Halouzka, R. (1973): Riečne terasy a sedimenty južnej časti dolného Pohronia; RNDr. Dissertation. – MS, Comenius University: 1-145, 1 inset. Bratislava.

Halouzka, R. (1982): Dolné Pohronie – kvartér a morfológia; Ph.D. Dissertation. – MS, Geological Institute of D. Štúr: 1-148, 24 insets. Bratislava.

Hauser, G., De Stefano, G. F. (1989): Epigenetic Variants of the Human Skull. – E. Schweitzerbart´sche Verlagsbuchhandlung, Stuttgart, 301 pp.

Heim, J-L. (1992): Le crâne Magdalénien du Rond-du-Barry (Haute-Loire). – In: C.T.H.S. (ed.): Le peuplement Magdalénien, Paris, pp. 53-61.

Henke, W. (1977): On the Method of Discriminant Function Analysis for Sex Determination of the Skull. – J. Hum. Evol., 6: 95-100.

Henke, W. (1984): Vergleichend-morfologische Kennzeichnung der Jungpaläolithiker von Oberkassel bei Bonn. – Z. Morph. Anthrop., 75(1): 27-44.

Henke, W. (1989): Jungpaläolithiker und mesolithiker Beiträge zur Anthropologie; Habilitationschrift. – MS, Institut für Anthropologie, Johannes Gutenberg-Universität Mainz: 1-1684.

Henke, W. (1991): Biological distances in Late Pleistocene and Early Holocene human populations in Europe. Variability and Evolution 1. – Adam Mickiewicz University Press, Poznaň, pp. 39-64.

Henry-Gambier, D. (2002): Les fossils de Cro-Magnon (Les Eyzies-de-Tayac, Dordogne): Nouvelles données sur leur position chronologique et leur attribution culturelle. – Bull. et Mém. De la Société d´Anthropologie de Paris. n.s., t. 14(1-2): 89-112.

Howells, W. W. (1973): Cranial Variation in Man. – Papers of the Peabody Museum of Archaeology and Ethnology, Harvard University, Vol. 1967, 259 pp.

Howells, W. W. (1996): Howells's Craniometric Data on the internet. – Am. J. Phys. Anthrop., 101: 441-442.

Churchil, S. E., Smith, F. H. (2000): Makers of the Early Aurignacian of Europe. – Yearbook of Phys. Anthrop., 43: 61-115.

Irish, J. D., Bratlund, B., Schild, R., Kolstrup, E., Królik, H., Mańka, D., Boroń, T. (2008): A late Magdalenian perinatal human skeleton from Wilczyce, Poland. – J. Hum. Evol., 55: 736-740.

Jelínek, J. (1956): Homo sapiens fossilis ze Starého města u Uherského Hradiště [Homo sapiens fossilis from the Staré Město by Uherské Hradiště]. – Časopis Moravského musea v Brně - vědy přírodní (Acta Musei Moraviae – Scientiae Naturales, Brno), 51: 139-165 [in Czech].

Jelínek, J. (1986): Staré Město Epipalaeolithic skull and the Palaeolithic-Neolithic Evolutionary Transition. – Human Evolution, 1(4): 353-360.

Jelínek, J. (1988): Anthropologische Funde aus der Kůlna-Höhle. – In: Valoch K. (ed.): Die Erforschung der Kůlna-Höhle 1961 – 1976, Moravské muzeum – Anthropos Institut, Brno, pp. 261-283.

Jelínek, J., Orvanová, E. (1999): Czech and Slovak Republics. – In: Orban, R., Semal, P. (eds.): Hominid Remains – an Up-Date, 9: 95-118.

Lahr Mirazón, M. (1996): The evolution of modern human diversity. A study of cranial variation. – Cambridge University Press, Cambridge, 416 pp.

Lahr, M. M., Wright, R. S. V. (1996): The question of robusticity and the relationship between cranial size and shape in Homo sapiens. – J. Hum.Evol., 31: 157-191.

Larsen, C. S. (1997): Bioarchaeology: Interpreting behaviour from the human skeleton. – Cambridge University Press, Cambridge, 461 pp.

Lieberman, D. E., McBratney, B. M., Krovitz, G. (2002): The evolution and development of cranial form in Homo sapiens. – PNAS, 99(3): 1134-1139.

Lieberman, D. E. (2008): Speculations About the Selective Basis for Modern Human Craniofacial Form. – Evolutionary Anthropology, 17: 55-68.

Lovejoy, C. O. (1985): Dental wear in the Libben population: Its functional pattern and role in determination of adult skeletal age at death. – Am. J. Phys. Anthrop., 68: 47-56.

Martin, R., Saller, K. (1957): Lehrbuch der Anthropologie in systematischer Darstellung. Band I. – Gustav Fischer Verlag, Stuttgart, 661 pp.

Masset, C. (1982): Estimation de l´age au décés par les sutures craniennes; Thése présentée devant l´Université Paris VII pour l´ obtention du grade de Docteur és Sciences Naturelles. – MS, l´Université Paris VII.: 186-194. Paris.

Meindl, R. S., Lovejoy, C. O. (1985): Ectocranial Suture Closure: A Revised Method for the Determination of Skeletal Age at Death Based on the Lateral-Anterior Sutures. – Am. J. Phys. Anthrop., 68: 57-66.

Newell, R. R., Constandse-Westermann, T. S., Meiklejohn, Ch. (1979): The Skeletal Remains of Mesolithic Man in Western Europe: an Evaluative Catalogue. – J. Hum. Evol., 8: 1-225.

Olivier, G., Aaron, C., Fully, G., Tissier, G. (1978): New Estimations of Stature and Cranial Capacity in Modern Man. – J. Hum. Evol., 7: 513-518.

Orschiedt, J. (2000): Germany. – In: Orban, R., Semal, P. (eds.): Hominid Remains. An Up-date 10, Supplement to Anthropologie et Prehistoire, Laboratory of Anthropology, Royal Belgian Institute of Natural Sciences, Brussells, pp. 1-112.

R Development Core Team (2008): R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org.

Reimer, P. J., Baillie, M. G. L., Bard, E., Bayliss, A., Beck, J. W., Bertrand, C. J. H., Blackwell, P. G., Buck, C. E., Burr, G. S., Cutler, K. B., Damon, P. E., Edwards, R. L., Fairbanks, R. G., Friedrich, M., Guilderson, T. P., Hogg, A. G., Hughen, K. A., Kromer, B., McCormac, G., Manning, S., Bronk Ramsey, C., Reimer, R. W., Remmele, S., Southon, J. R., Stuiver, M., Talamo, S., Taylor, F. W., van der Plicht, J., Weyhenmeyer, C. E. (2004): IntCal04 terrestrial radiocarbon age calibration, 0-26 cal kyr BP. – Radiocarbon, 46(3): 1029-1058.

Reimer, P. J., Baillie, M.G. L., Bard, E., Bayliss, A., Beck, J. W., Blackwell, P. G., Bronk Ramsey, C., Buck, C. E., Burr, G. S.; Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Hajdas, I., Heaton, T. J., Hogg, A. G., Hughen, K. A., Kaiser, K. F., Kromer, B., McCormac, F. G., Manning, S. W., Reimer, R.W., Richards, D. A., Southon, J. R., Talamo, S., Turney, C. S. M., van der Plicht, J., Weyhenmeyer, C. E. (2009): IntCal09 and Marine09 radiocarbon age calibration curves, 0–50,000 years cal BP. – Radiocarbon, 51(4): 1111-1150.

Ruff, C. B., Trinkaus, E., Holliday, T. F. (1997): Body mass and encephalisation in Pleistocene Homo (Supplement of the equally named database). – Nature, 387:173-175.

Sergi, S., Cardini, L., Leonardi (1971): Italy. – In: Oakley, K. P., Campbell, B. G., Molleson, T. I. (eds.): Catalogue of Fossil Hominids, Trustees of the British Museum (Natural History), London, pp. 248-249.

Schmitz, R. W. (2006): Homo sapiens aus Bonn-Oberkassel (Deutschland). – In: Lötters, S. (ed.): Roots Wurzeln der Menschheit. Landschaftsverband Rheinland/ Rheinisches LandesMuseum, Bonn, pp. 350.

Schulting, R. J. (1999): Nouvelles dates AMS à Téviec et Hoëdic (Quiberon, Morbihan). Rapport préliminaire. – Bulletin de la Société préhistorique française, 96(2): 203-207.

Schwidetzky, I. (1965): Zur Frage mongolider Beimischung bei den Altslawen. – Anthrop. Anz., 29: 228-233.

Schwidetzky, I., Wierciński, A., Wiercińska, A. (1982): Long-term trends in European populations. – Anthropos (Brno), 22: 301-310.

Sokal, R. R., Uytterschaut, H., Rösing, F. W., Schwidetzky, I. (1987): A Classification of European Skulls From Three Time Periods. – Am. J. Physic. Anthrop., 74: 1-20.

Sokal, R. R., Uytterschaut, H. (1987): Cranial Variation in European Populations: A Spatial Autocorrelation Study at Three Time Periods. – Am. J. Physic. Anthrop., 74: 21-38.

Straus, L. G. (1991): Southwestern Europe at Last Glacial Maximum. – Current Anthropology, 32(2): 189-199.

Strouhal, E. (1974): Využití metod horizontální profilace obličejového skeletu u nubijských souborů [The methods of face skeleton horizontal profil used in Nubian groups]. – Antropol. Archiv, 4: 165-178 [in Czech].

Svoboda, J. A., van der Plicht, J., Kuželka, V. (2002): Upper Palaeolithic and Mesolithic human fossils from Moravia and Bohemia (Czech Republic): some new ^{14}C dates. – Antiquity, 76: 957-962.

Svoboda, J. A., Kuželka, V., Vlček, E. (2003): Koněpruské jeskyně: nálezová situace lidského skeletu a první radiokarbonové datování [Koněpruské jeskyně caves: the archaeological context of a human skeleton find and its first radiocarbon dating]. – In: Hašek, V., Nekuda, R., Unger, J. (eds.): Ve službách archeologie, IV: 278-284 [in Czech].

Šefčáková, A. (1997): A New Find of Upper Palaeolithic Skull in Slovakia. – Anthropologie (Brno), 35(2): 233.

Teschler-Nicola, M., Berner, M. E. (1994): Zur Anthropologie der endneolitischen Funde aus Vučedol. – In: Amt der Bgld. Landesregierung (eds.): Die Neandertaler und die Anfänge Europas. Katalog zur Sonderausstelung im Burgenländischen Landesmuseum Eisenstadt, Neue Folge, 36: 61-78.

Thurzo, M. (1969): Antropologický rozbor kostrového pohrebiska „Lupka“ v Nitre [Anthropological analysis of a skeletal cemetery „Lupka“ in Nitra]. – Acta Rer. Natur. Mus. Nat. Slov., 15(1): 77-153 (in Slovak).

Trinkaus, E., Hillson, S. W., Franciscus, R. G., Holliday, T. W. (2006): Skeletal and Dental Paleopathology. – In: Trinkaus, E., Svoboda, J. (eds.): Early Modern Human Evolution in Central Europe. The People of Dolní Věstonice and Pavlov, Oxford University Press, Oxford-New York, pp. 419-465.

Trinkaus, E., Svoboda, J. A. (2006): The Paleobiology of the Pavlovian People. – In: Trinkaus, E., Svoboda, J. A. (eds.): Early Modern Human Evolution in Central Europe. The People of Dolní Věstonice and Pavlov, Oxford University Press, Oxford-New York, pp. 459-465.

Ullrich, H. (1992): Armenia, Azerbaijan, Georgia, Russia, Ukraine and Uzbekistan. Hominid Remains. – In: Orban, R., Slachmuylder, J. L., Semal, P. (eds.): Hominid Remains. An Up-date 5, Department of Anthropology and Human Genetics, Université Libre de Bruxelles, Bruxelles, 91 pp.

Uytterschaut, H. T. (1986): Sexual Dimorphism in Human Skulls. A Comparison of Sexual Dimorphism in Different Populations. – Hum. Evol., 1(3): 243-250.

Van Vark, G. N. (1984): On the Determination of Hominid Affinities. – In: Van Vark G. N., Howells W. W. (eds.): Multivariate Statistical Methods in Physical Anthropology, D. Reidel Publishing Company, Dordrecht (Holland), pp. 323-349.

Van Vark, G. N., Schaafsma, W. (1992): Advances in the Quantitative Analysis of Skeletal Morphology. – In: Saunders, S. R., Katzenberg, M. A. (eds.): Skeletal Biology of Past Peoples: Research Methods, Wiley-Liss, New York, pp. 225-257.

Van Vark, G. N., Pasveer, J. M. (1994): Mathematical Multivariate Analysis in Physical Anthropology, Exemplified by the Sex-Diagnosis of Archaeological Skeletal Series of Homo Sapiens Sapiens. – In: Bacco M., Pacciani, E., Borgognini Tarli, S. (eds.): Statistical Tools in Human Biology, World Scientific Publishing Co., Singapore, pp. 231-254.

Vaškovský, I., Halouzka, R. (1976): Geologická mapa Podunajskej nížiny – juhovýchodná časť (1 : 50 000) [The geological map of Podunajská nížina lowland – the south-eastern part]. Geologický ústav Dionýza Štúra, Bratislava (in Slovak).

Vaškovský, I. (ed.) (1982): Vysvetlivky ku geologickej mape juhovýchodnej časti Podunajskej nížiny (1 : 50 000) [The legend to the geological map of the south-eastern part of Podunajská nížina lowland]. Geologický ústav Dionýza Štúra, Vydavateľstvo SAV, Bratislava (in Slovak).

Velemínský, P., Brůžek, J., Velemínská, J., Katina, S. (2008): Non-metric Traits in the Gravettian Human Population Sample from Předmostí. Chapter 11. – In: Velemínská, J., Brůžek, J. (eds.): Early Modern Humans from Předmostí near Přerov: A new reading of old documentation, Academia, Praha, pp. 113-124.

Venables, W. N, Ripley, B. D. (2002): Modern Applied Statistics with S-Plus. 4nd ed. Springer-Verlag, New York, xi + 495 pp.

Vlček, E. (1991): Nové nálezy lovců mamutů v Dolních Věstonicích [New mammoth finds at Dolní Věstonice]. – Sborník čs. Společnosti antropologické při Čs. akademii věd za rok 1989: 1-9 [in Czech].

Vlček, E. (1994): Vývoj fosilního člověka na našem území [Evolution of fossil man in our territory]. – In: Svoboda, J. (ed.): Paleolit Moravy a Slezska [The Palaeolithic of Moravia and Silesia]. Dolnověstonické studie, svazek 1, Archeologický ústav AV ČR, Brno, pp. 50-69 [in Czech].

Vlček, E. (1997): Human remains from Pavlov and the biological anthropology of the Gravettian human population of South Moravia. – In: Svoboda, J. (ed.): Pavlov I – Northwest. The Upper Palaeolithic burial and its settlement context. The Dolní Věstonice Studies, Vol. 4, Archeologický ústav AV ČR, Brno, pp. 53-153.

Wild, E. M., Teschler-Nicola, M., Kutschera, W., Steier, P., Trinkaus, E., Wanek, W. (2005): Direct dating of Early Upper Palaeolithic human remains from Mladeč. – Nature, 435: 332-335.