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A Craniometrical Analysis of the Early Bronze Age Dogs from Vučedol Site (East Slavonia, Croatia)

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A B S T R A C T

During archaeological campaigne on Vučedol site 7 crania and cranial fragments together with 10 halfs of lower jawswere found. Due to existance of crania and lower jaws damages and therefore lack of preserved craniometrical points, it was not possible to measure the same craniometrical lengths on all the samples. Apart from craniometrical measurements, 6 craniometrical indices and ratios were calculated. Comparison of calculated values and values of craniometrical indices and ratios identify dog's crania from Vučedol site as dolichocephalic cranial type. Mutual comparison of all analyzed craniometricalvalues for crania and lower jaws of dog's crania don't show a significant difference in size and ratios of individual measures, nor significant deviation in value of the samples of other Vučedol culture sites. This point out on type of dogs with similar appearance which tallness and form respond to smaller dog's breed, in the first place a type of Croatian sheepdog or Hungarian Mudi.

***Key words**: dogs, Early Bronze Age, Vučedol, craniometric analysis, zooarchaeology, Vučedol culture, East Slavonia*

Introduction

Skeletal remains of early dogs from a different archaeological sites throughout the World demonstrate that its domestication starts in the late Pleistocene, probably 14.000 years ago, for example dog remains from a burial site Bonn-Oberkassel in Germany. However, it is possible to find even older samples of domesticated dogs, like a dog's skull from Siberian Altai Mountains (33.000 years old), or dog remains from Govet Cave in Belgum (31.700 years old). Further analysis didn't proof any connection of these old dogs from Siberian and Belgium sites with today's modern dog breeds[1]. Most likely, the reason was that during the Last Glacial Maximum, dogs, like many other species dissapeared.

Dog is the first domestic animal, but maybe its domestication happened more than once. It is presumed that an ancestor of an ancient dogs is wolf (*Canis lupus, L.*), because of similarities in morphology, physiology and behavior. This is also partly approved with modern molecular methods of analysis. It is partly presumed because it is not possible to determinate which subspecies of a dog was direct ancestor of today's dogs.

Three major differences between wolfs and ancient dogs were short skulls and snouts, wide palates and braincases[2,3].

A variation in a skull shape among dog's breeds (*Canis familliars, L.*) is significantly higher than skull shape variation among all mammal species.

A general simmilarity in cranial bones (*neurocranium*) of all dog's breeds exist, but marked difference are in the shape and appearance of facial bones (*splanhnocranium*), so called the nasomaxillary complex. Therefore a different dog's breeds represent a great sample of polimorphism within the same animal species and independent of sex differences. Based on the shape skull proportion of cranium and nasal cavity it is possible to distinguish three different shapes of skulls: dolichocephalic, mesocephalic and brachycephalic type. The cephalic index[4] was and still is widely used to categorize dog's skull. The brachycephalic skull with cranial index >80 is in the shape flattest of all three types. The mesocephalic skull type has the cranium index between 75 and 80. At last,

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the dolicocephalic type with cranium index <75 has the longest facial part of a skull with narrow and prolonged jaw.

Later, the authors[5] describe subtypes of a dog's skull shapes on the basis of three major shapes, mentioned above, with the measuring methods[6] that helps us to classify affiliation of a dog's skull to a specific morphological type. These methods involve determination of cranial indices and ratios for every skull shape andtype.

Complex craniometric research carried out after computerized tomography (CT) on modern breeds like German shepard dog[7,8] gave a broad picture of cranial variability, but also craniometrical research conducted on other modern breeds[9–11]. Moreover, the result of craniometrical and osteometrical long bones parameters shows predictive relationship. With longer stout (dolichocephalic cranial shape type), parameters of a long bones will be higher and vice versa.

Dogs studies are diverse, from analyzes the effects of cranial sizeand study shape in domestic dogs on predicted forces of biting[12], dog's diet in prehistoric times[13] to the newest DNA analysis which should show evidence of lineage replacement or genetic continuity of archaeological and recent sledge dogs through time[14].

Craniometry, in strict sense, is a measuring of the cranium, while general definition, besides craniometry, includes description of cranial anatomical elements and details which are not easy to measure, for example, presence of sutural form, bone or dental formula. Fixed craniometric points are determinated with anatomical elements, but some of them are necessary to project in space or determinate their position on a bone part. Craniometrical data gives a possibility of gain in new knowledge singular of classification inside the species, calculation of body mass, body heigh and others[15,16].

At the beginning, Vučedol culture was located only at the east border of Požega Valley till the mouth of a river Sava and encircled very narrow area around the center of the Vučedol culture. Then, 2900 BC on the right bank of Danube started to develop a great culture of the Late Cooper Age, Vučedol culture. This is a time when in Sumer a first letter was born, in Egypt one of the first state, it is a time of Troy foundation[17]. In its classic phase the culture spreads fast developing special types: the new teritory comprise Prague region, region around Vienna, Ljubljana and Romanian Banat and almost till Đerdap in Macedonia, including Alföld-Hungarian plain[18]. During that time inhabitants of Vučedol were farmers and cattle breeders, but that was also a population with a high developed knowledge of processing cooper and a specific alloy, such as arsenical bronze[17]. Complete animal skeletons were found as ritual burning near the cult area of the site (Gradac), or very fragmented animal remains in vaste pits near the houses or objects as discarded picking remains, or remains of craftswork – horns and bones (Vineyard Streim). Although Vučedol culture disappears around 2400 BC it has influenced other later cultures of a region and has left a significant trace in European heritage.

This article presents zooarchaeological analysis which results from archaeological campaigns between 1987 and 2009 on a Late Cooper Age site Vučedol in Croatia. The purpose of this research was to determinate characteristics of Vučedol dog's skulls and their specific cranial type by using craniometrical methods and calculation of craniometrical indices and ratios. With such research it would be possible to determinate an approximate cranial appearance of Vučedol's Early Cooper Age dogs together with a possible dog's native form during domestication.

Measured craniometrical values and calculated craniometrical indices and ratios could help in further craniometrical research of native dog breeds of Croatia. The application of such research is much wider and could give a new data and knowledgeinsights about dog's in archaeological context of a region, domestication and development of different dog's breeds.

Material and Methods

During the campaign between 1987 and 2009 on a site Vučedol, 15 skulls and skull fragments of a dogfrom Vučedol culture were excavated. All skull samples were found in a waste pits placed near the houses of Vučedol culture on location »Vineyard Streim«.

The material is stored at Department of Archaeology, Faculty of Humanities and Social Sciences, University of Zagreb. Zoological analysis was commited at Department of Anatomy, Histology and Embriology, Veterinary Faculty, University of Zagreb in collaboration with the Chair of Archaeometry and Methodology, Department of Archaeology, Faculty of Humanities and Social Sciences, University of Zagreb.

Of 15 revealed cranial bones, seven are more or less complete skulls and only four of them are completely preserved. A part of *os incisivum* was missing at one skull and in two cases only occipital part of a skull were preserved. Also, analysis determinated 10 fragments of lower jaw; in fact all were left or right half of lower jaw in a good condition. From them, six were preserved completely and one right half of a lower jaw was excluded from research because of severe fragmentation, and with it a lack of amajor craniometrical points. Three half lower jaws were partially damaged, but could be used and incorporated into craniometric analysis.On damaged skulls and lower jaws only few measures were taken. Therefore craniometrical measurements were taken on seven skulls and nine half lower jaws. Measurement of all craniometrical values on skulls and lower jaws were performed with a sliding calliper and spreading calliper with pointed ends (GPM-Sieber Hegner) with a precision of 0.1 mm and measuring tape with a precision of 0.1 mm. Craniometrical methods used in analysis were measures for genus *Canis* described in literature[15]. Detailed macromorphological examination was conducted prior to craniometrical analysis with determination of age at death due to the dental status and cranial suture closure.

In research 37 craniometrical measures were used, 19 on skull and 18 on lower jaws. Individual values were applied in calculation of 6 indexes and skull ratio.

Craniometric measurements of a skull comprise: 1 – total length, 2 – condylobasal length, 3 – basal length, 4 – neurocranial length, 5 – upper neurocranial length, 6 – viscerocranium length, 7 – facial length, 8 – greatest mastoid breadth, 9 – greatest breadth of the occipital condyles, 10 – greatest breadth of the bases of the paraoccipital processes, 11 – greatest breadth of the foramen magnum, 12 – heigh of the foramen magnum, 13 – greatest neurocranium breadth, 14 – zygomatic breadth, 15 – frontal breadth, 16 – least breadth between the orbits, 17 – breadth at the canine alveoli, 18 – greatest inner heigh of the orbit, 19 – heigh of the occipital triangle.

Measurements of a lower jaw comprise: 1 – total length, 2 – length: the angular process–Infradentale, 3 – length from the indentation between the condyle process and the angular process–Infradentale, 4 – length: the condyle process-aboral border of the canine alveolus, 5 – length from the indentation between the condyle process and the angular process, 6 – length: the angular process-aboral border of the canine alveolus, 7 – length: the aboral border of the alveolus of M3-aboral border of the canine alveolus, 8 – length of the cheektooth row, M_3–P_1, measured along the alveoli, 9 – length of the cheektooth row, M_3–P_2, measured along the alveoli, 10 – length of the molar row, measured along the alveoli, 11 – length of the premolar row, P_1–P_4, measured along the alveoli, 12 – length of the premolar row, P_2–P_4, measured along the alveoli, 13 – length of M_1, 14 – length of M_1 alveolus, 15 – greatest thickness of the body of a jaw (below M_1), 16 – height of the vertical ramus: basal point of the angular process-Coronion, 17 – height of the mandible behind M_1, measured on the lingual side and at right angles to the basal border, 18 – height of the mandible between P_2 and P_3, measured on the lingual side and at right angles to the basal border.

Results

Craniometric measurements involved seven skulls and nine lower jaws, while one was excluded due to missing measuring points. Complete measurements were not possible to conduct on three fragmented crania and three lower jaws samples. Alltogether, 37 craniometric measurements were taken and 6 indices and ratios connected with a cranial type were calculated. It was possible to take complete cranial measures on four skulls, on one skull two measures were missing because of fragmentation and lack of *os incisivum*. On two remaining skulls only measurements of neurocranium were taken while bigger part of splanchocranium were missing. For a two skulls, calculated arithmetic mean values demonstrate lesser craniometric length values from average for slightly more than 10%, but both skulls were of a young individuals (Table 1). Complete craniometric values of lower jaw were possible to determinate for six samples. Due to the damage and mandibular fragmentation on two samples values for caudal part and only one measure on cranial part of lower jaw was taken.Values for total mandibular lenght varied for less than 10% from calculated means for dogs from Vučedol culture (Table 2). During cranial index and ratio calculating (a part of which detects a cranial type), craniometric values of seven skulls were used. Afilliation of a skull type was not possible to determinate for two samples due to severe fragmentation. On the base of obtained values of skull indices (and all of indices were lower than 75 in all the specimens), a dolichocephalic cranial type was determinated for Vučedol skull samples.

Our results are in accordance with results of other researchers which described and analyzed dog skeletal remains from Early Bronze Age, medieval and 19th century archaeological sites[3,6,19,20,21]. Cranial sutures closure is used to determine age at death of individuals. Remains of one skull signed as L6 had entirely open cranial sutures which is indicator of a young age, maximum one

TABLE 1
CRANIOMETRICAL VALUES OF CRANIAL SAMPLES, DOGS FROM A SITE VUČEDOL

(mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Lx	151	148	139	80	73	75	83	56	34	45	18	16	54	94	49	35	32	26	37
L Mi	191	186	174	101	91	99	110	69	37	53	19	14	52	104	55	38	38	30	40
L 187											18	14	52						37
L 6								57	33	45	17	12							37
L	172	183	166	92	88	85	97	63	35	49	19	15	53	99	52	36	35	29	39
L 67	188	185	171	98	87	95	107	67	36	52	19	14	54	102	53	37	37	29	38
Lv		153	139	88	74	75		59	35	47	18	15	52	96	51	35		27	37
$\overline{X}$	175.5	171	157.8	91.8	82.6	84	99.3	61.8	35	48.5	18.2	14.2	52.8	99	52	36.2	35.5	28.2	37.8

1 – total length, 2 – condylobasal length, 3 – basal length, 4 – neurocranial length, 5 – upper neurocranial length, 6 – viscerocranium length, 7 – facial length, 8 – greatest mastoid breadth, 9 – greatest breadth of the occipital condyles, 10 – greatest breadth of the bases of the paraoccipital processes, 11 – greatest breadth of the foramen magnum, 12 – heigh of the foramen magnum, 13 – greatest neurocranium breadth, 14 – zygomatic breadth, 15 – frontal breadth, 16 – least breadth between the orbits, 17 – breadth at the canine alveoli, 18 – greatest inner heigh of the orbit, 19 – heigh of the occipital triangle

TABLE 2
CRANIOMETRICAL VALUES OF MANDIBLE SAMPLES, DOGS FROM A SITE VUČEDOL

(mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
M 2	115	113	110	98	94	97	65	61	55	30	32	27	20	19	10	45	19	16
M 3	117	116	111	101	96	100	66	61	57	31	32	28	20	19	10	45	20	16
M 4	125	126	120	107	103	109	68	66	63	32	34	30	20	18	11	50	21	17
M 5	129	127	123	110	106	111	70	67	65	33	35	32	21	19	12	51	22	18
M 6	123	125	119	106	104	107	67	65	63	32	33	30	20	18	11	49	21	17
M 8	107	104	97	93	88	94	55	51	48	26	27	23	17	16	8	37	17	14
M 7										31			19	17	11	47	18	
M 1										31			20	19	11	51	17	
M 9							67	64	62	31	34	31	20	19	11		21	17
$\overline{X}$	119.3	118.5	113.3	102.5	98.5	103	65.4	62.1	59	30.7	32.4	28.7	19.6	18.2	10.5	46.8	19.5	16.4

1 – total length, 2 – length: the angular process – Infradentale, 3 – length from the indentation between the condyle process and the angular process – Infradentale, 4 – length: the condyle process-aboral border of the canine alveolus, 5 – length from the indentation between the condyle process and the angular process, 6 – length: the angular process–aboral border of the canine alveolus, 7 – length: the aboral border of the alveolus of M3-aboral border of the canine alveolus, 8 – length of the cheektooth row, M_3–P_1, measured along the alveoli, 9 – length of the cheektooth row, M_3–P_2, measured along the alveoli, 10 – length of the molar row, measured along the alveoli, 11 – length of the premolar row, P_1–P_4, measured along the alveoli, 12 – length of the premolar row, P_2–P_4, measured along the alveoli, 13 – length of M_1, 14 – length of M_1 alveolus, 15 – greatest thickness of the body of a jaw (below M_1), 16 – height of the vertical ramus: basal point of the angular process–Coronion, 17 – height of the mandible behind M_1, measured on the lingual side and at right angles to the basal border, 18 – height of the mandible between P_2 and P_3, measured on the lingual side and at right angles to the basal border

TABLE 3
VALUES OF CALCULATED CRANIOMETRICAL INDICES AND RATIOS, DOGS FROM A SITE VUČEDOL

Signature	Skull Index (30/1*100)	Cranial Index (29/NA*100)	Facial Index (30/8*100)	Index foramen magnum (28/27*100)	Length-length index 2 (NA/8)	Ratio of cranium to facial bones (NA/8*100)
Lx	62.25	67.50	125.33	88.89	1.07	106.67
L 187				77.78		
L 6				70.59		
L Mi	54.45	51.49	105.05	73.68	1.02	102.02
L	57.55	57.60	116.47	78.94	1.08	108.23
L 67	54.25	55.10	107.36	73.68	1.03	103.15
Lv	–	59.09	128.00	83.33	1.17	117.33

year (Figure 1). For two samples (Lx and Lv) were determinate age range from 1–2 years, while other samples were from older dogs, older even than four years (Figures 2 and 3).

Discussion and Conclusion

Metric values for length in two samples (Lx and Lv) were from younger individuals (1–2 years of age); they were smaller than other three samples – adult individuals.

It is possible to presume how this individuals have not yet finished their development and growth, but also could indicate on presence of dogs of a smaller constitution. Because of a young age of individuals it is more probable that analyzed individuals were not finished their development and growth which, this conclusion supports results of other authors[10,11,22].

Fig. 1. L_6 – cranium of a young dog with open neurocranial suturae, view from behind.

Fig. 2. LMi – cranium of adult dog with closed suturae, view from above.

Fig. 3. LMi – cranium of adult dog with closed suturae, view from below.

Morphological characteristics of examined skull samples demonstrate a great similarity in cranial type. Two cranial samples had preserved only parietal and occipital part of a neurocranium, so they were not usefull in analysis of cranial type. However, few morphometrical data obtained with a measurements of individual points (witheven such damaged skulls) were in a percentual range obtained for well preserved skulls. It is possible to assume how their cranial indices values would not significantly deviate from a limiting value for dolichocephalic skulls.

Results comparison for craniometrical values of analyzed dogs from a site Vučedol and results of other authors[5,6,20–23] demonstrate that, with a high certanity, analyzed skulls belong to dolicocehalic cranial type. Dolicocephalic cranial type has a longfacial part of crania with narrow and long jaw. Limiting index value of cranial dolichocephalic type is 75. Comparing obtained results for Vučedol samples with results of cranial values of dogs samples from Early Iron Age Van-Yoncatepe in Turkey [9] it is clear how skulls Lx i Lv show deviation in skull index, cranial index and facial index from all others analyzed cranial samples and samples included in this research[13]. However, our research are very similar to our results[24] from archaeological site of Vučedol culture, Ig in Slovenia.

Although both skulls Lx i Lvare still in a group of dolichocephalic type, measured values are very close to mesocephalic cranial type with intermediate length and width[22]. Both of this skulls have greater width and shorter facial bones than other analyzed skulls from a site Vučedol, but also from a skulls that we use for comparison[24]. Such result could be influenced by the age of individuals, because a skulls were of a younger animals. The only index that was possible to measure on all analyzed skull specimens and also presented for a comparison samples in a work of other authors[3–7,10,11,20,21,24–26] was index of *foramen magnum*. Comparison of this index detect smaller indices for dog skulls from a site Vučedol. With smaller index it is obviously that dogs from Vučedol had bigger *foramen magnum* than the ones from a Turkish site Van-Yoncatepe and other dog skulls from other sites involved in research. Therefore, it is possible to presume that dogs from a site Vučedol were closer to a native form of dogs then todays dog breeds. This values significantly differ, from cranial dog samples from archaeological site near Cambridge, but the results has a similarity with osteological remains of relatively small dogs described by Bartosziewicz[27] on arhaeological site of Vučedol culture Ig.

By analyzing a skull, morphological characteristic and level of suture closing it is possible to aproximatly determinate age at death of individual. On skull L_6 sagital suture is not closed yet, and a sample along this sutura demonstrate a span of 2 mm. This confirmes that an individual was a young, in age range 1–2 years. Crania of other two samples, (L Mi i L 187) demonstrate completely closure of *suturae*, a certain sign of adult age (Figures 2 and 3).

Comparison of cranial values for mandible classifies dogs in dolichocephalic type. Measured cranial and mandibular values pointed on the medium sized dogs, similar to native breed Croatian sheepdog. It is possible that a head size doesn't always correspond with other body values, so it is not correct to determinate size and body mass just on the base of cranial values. Far more correct is to bring final conclusions from dental measurements, first of all from heigh of premolars[19], but goal of this article was to determinate a cranial type of the skull rather than a mass of each individual dog.

Together with craniometrical analysis[27] dog's mass could be calculated based on values for M_1. The author, at the same time, defines a presence of relatively small dogs, which have the resemblance of herding dog breed from Hungary (Mudi) or Croatian sheepdog type. Both breeds subsist in the Panonian plain since long and have a high percentage of resemblance. Croatian sheepdog is one of the oldest native breeds in Central and Southeast Europe and is very similar to a dog from pile-dwellings. Therefore, it is possible to assume that dogs of Vučedol culture in the area of today's Slovenija and Croatia were relatively small dogs which patrimony could be detected in dog breeds of Croatian sheepdog and Mudi. We could just assume that dogs of Vučedol culture from a site Vučedol were more like a native breeds (such as Croatian sheepdog and Hungarian Mudi) and not like modern breeds. That is because similarity can not be based: a) exclusively on morphometric dana of analyzed skulls, and b) because craniometricl analysis of a native dog breeds of Croatia is not finished yet. Nevertheless, it is possible to determinated with a very high precision that dogs of Vučedol culture were, in general, smaller dogs and a good basical form for developing both breeds, only if more skeletal remains from Vučedol site will be examined.

In further research it would be necessery to compare the results of craniometrical analysis for dogs from Vučedol with values obtained for modern native dog breeds of Croatia (Croatian sheepdog, Posavac hound, Medji-a small dog of Međimurje), but also with modern native dog breeds of neighbouring countries.

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KRANIOMETRIJSKA ANALIZA RANOBRONČANODOBNIH PASA S LOKALITETA VUČEDOL (ISTOČNA SLAVONIJA, HRVATSKA)

SAŽETAK

Tijekom arheoloških iskopavanja na lokalitetu Vučedol pronađeno je ukupno 7 lubanja i dijelova lubanje te 10 polovica donjih čeljusti. Zbog oštećenja na lubanjama i donjim čeljustima, kao i posljedičnog nedostatka kraniometrijskih točaka, nije bilo moguće izmjeriti iste kraniometrijske dužine na svim uzorcima. Uz kraniometrijska mjerenja izračunato je i 6 kraniometrijskih indeksa i omjera. Usporedba izračunatih vrijednosti s vrijednostima kraniometrijskih indeksa i omjera ukazuje kako lubanje pasa lokaliteta Vučedol pripadaju dolihocefaličnom tipu. Uspoređujući međusobno izmjerene kraniometrijske mjere pasa s lokaliteta Vučedol, zaključujemo da analizirane lubanje i donje čeljusti ne pokazuju znatne razlike u veličini i odnosima pojedinih mjera. Utvrđeno je da ne postoje znatnija odstupanja u mjerama kada se uspoređuju sa uzorcima vučedolske kulture s lokaliteta Ig u Sloveniji. To nam ukazuje na podatak da se radi o psima sličnog izgleda čija veličina i oblik lubanje odgovara manjim pasminama ovčara, prvenstveno u tipu hrvatskog ovčara, ali i mađarskog mudija.