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MORPHOMETRIC ANALYSIS OF EARLY MEDIEVAL DOG SKULLS FROM POMERANIA ALLOWING FOR FOREHEAD POSITION INDEX AND DORSAL NOTCH OF THE *FORAMEN MAGNUM*

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ABSTRACT

The study aimed at analysis of the metric traits of historic dog skulls allowing for the value of forehead position index as well as the presence or the lack of dorsal notch in the *foramen magnum*. Examinations included 25 bone remnants of the head skeleton of dogs coming from archaeological sites, dated back to the time period between 9th and the 14th century, which were divided into two groups – short-snout skulls and medium-snout skulls. 48 metric traits of the neurocranium and the splanchnocranium and the nuchal surface of these skulls, as well as their cranial capacity, were estimated. 11 cranial indices were estimated and correlation coefficients were calculated between selected metric traits as well as correlations between some selected cranial indices and metric traits in relation to the area of the foramen magnum, its height and breadth and foramen magnum index. Analysis of the estimated values characterising the nuchal surface of skulls under examination allowed also determination of the degree of occipital dysplasis in the examined material. The carried out examination showed no influence of forehead position index on the value of examined traits.
Key words: archaeozoology, dog, skull index, dorsal notch of the *foramen magnum*

INTRODUCTION

Osteological evidence for dog polymorphism with respect to exterior traits being most strongly illustrated within the head traits has been already amassed in abundance (Alpak et al., 2004, Harcourt 1974, Kupczyńska et al., 2008). It confirms three basic morphotypes singled out within the species, i.e. dogs with brachycephalic skulls, dogs with mesaticephalic skulls and those with dolichocephalic skulls (Miller 1965). Apart from this division, a differentiation of dog skull specimens into short-, medium- and long-snout ones is being used based on forehead position index (Wyrost 1963). Comparative examination of the skull cap of three dog morphotypes showed large variation in structure and consequences of a weak development of the frontal sinus in brachycephalic dogs (Kupczyńska et al., 2005). A characteristic phenomenon for skulls of the brachycephalic type is the presence of dorsal notch of the *foramen magnum* being of various shape and size (Watson et al., 1989). Until recently, this notch appeared to be a result of breeding (Chrószcz et al., 2006) but examinations carried out on the skulls dated back to the Iron Age and coming from South-Eastern Europe also showed its presence in the *foramen magnum* of those dog forms (Janeczek et al., 2008). Its presence has been also found in other animal species (Baranowski et al., 2009) but the greatest variation within the nuchal plane has been revealed by examinations carried out on brachycephalic dog skulls (Simoens et al., 1994). In connection with the search for different objective criteria that aim at examination of dog skull morphology, and having in mind the above, it was decided to analyse craniometric traits allowing for forehead position index and the presence of dorsal notch in the foramen magnum of skulls dated back to Early Mediaeval period.

MATERIAL AND METHODS

Examination included 25 bone remnants of the head skeleton of dogs coming from archaeological sites, dated back to the time period from the mid-9th century to the 14th century and being part of a museum collection of the Department of Animal Anatomy, Western Pomeranian University of Technology in Szczecin (Table 1). Age of dogs from which the skulls under examination came was determined based on teeth and cranial sutures (Habermehl 1975). Among these skulls, 14 are slightly damaged, whereas other 10 specimens are damaged to an extent which makes taking skull measurements allowing the calculation of forehead position index impossible (the state of the *foramen magnum* in two specimens made determination of the dorsal notch impossible – see Table 8). Only selected measurements were taken on the latter, which characterise the neurocranium and its nuchal surface. Detailed measurements were made using the craniometric method. In Tables II to IV, apart from the measuring points determined for craniometric traits, number equivalents appropriate for the schematic diagrams found in von den Driesch (1976) are given in parentheses. The results collected by means of this method were supplemented with measurements not included in this guide but allowing collection of the following measuring data: *Frontal midpoint-Opisthion*, *Nasion-Akrokranion*, *Nasion-Basion*, cranium height (CH) measured from *Bregma* to the lower edge of *Bulla tympanica*, *Basion-Staphylion, Akrokranion-Opisthion*, and the length of the left and the right occipital condyle. Furthermore, using the method adopted in previous study (Baranowski et al., 2009), photographic documentation of the nuchal surface of skulls was prepared which was used for estimation of the area of the *foramen magnum*, its breadth and height as well as the size of dorsal notch of this foramen. The status of the foramen magnum in two specimens did not allow determination of the size of dorsal notch. Moreover, the area of occipital triangle was determined according to the following equation: P=a x h/2, where:

a – greatest breadth between paracondylar processes (measurement 26 according to von den Driesch, 1976)
h – *Basion-Akrokranion* (measurement 40 according to von den Driesch, 1976).

Using the measurement method, an ellipse curve was plotted on the photopgraphic image of the *foramen magnum* by means of MultiScan software from the edge of which a value of the dorsal notch of each skull was calculated to the most dorsal point of the *foramen magnum*. Applying the method of Parker & Park (1974) as well as the the method of Fedri et al. cited by Simoens et al. (1994), a degree of dysplasia of the *foramen magnum* was estimated. The results of craniometric measurements, along with data referring to the size of foramen magnum area and the value of its dorsal notch, were entered into a Statistica v.7 PL database. Mean value, standard deviation and minimum and maximum value for each trait were calculated. Statistical analysis showed normality of the distribution of traits examined. The obtained measurement results allowed calculation of 11 cranial indices and cranial capacity. Using the following measuring points on skulls: *Prosthion – Segactorbion* and *Segactorbion – Opisthion*, where *Prosthion* is an intersection of the skull midline (long line) with the line connecting lower (most oral) edges of alveoli of both central maxillar incisors, *Segactorbion* is an intersection of the sagittal suture with the line connecting most lateral points on zygomatic processes of frontal bones, and *Opisthion* is an intersection of the dorsal edge of the *foramen magnum* with the skull midplane, the available material was divided into two groups: short-snout skulls and medium-snout skulls. As short-snout specimens were assumed those for which forehead position index, being a *Prosthion-Segactorbion* to *Segactorbion-Opisthion* ratio, was smaller than 125, whereas as medium-snout ones those for which this index ranged 125.1 to 130.0. No skulls with forehead position index exceeding 130 were found in the material under examination. Differences between skull groups singled out this way were determined using the Student's t-test for independent samples from Statistica v.7 PL computer software package with the probability of the error of the first type of $P \leq 0.05$ and $P \leq 0.01$. Moreover, simple correlation coefficients calculated for selected metric traits and cranial indices were compared between each other, and the estimated differences were marked and presented together with the results in Tables 2 to 8.

RESULTS

The collected skulls of early mediaeval dogs from Pomerania represent mostly matured animals. They are characterised by narrow forehead, single sagittal crest, and rather large range of the zygomatic arch (eight specimens). The preservation of teeth differs but molars are medium worn, incisors show crown wear and canines are variously preserved in specimens with present teeth. One specimen shows the lack of P_2 with alveolar cavity being completely filled with bone tissue, pointing out to the loss long before animal death. One of the skulls presents an injury to the frontal bone, which resulted most probably from a heavy blow. Part of the collection does not have nasal bones. General preservation of the specimens under examination is good.

Table 1. Catalogue of the dog skulls examined with their contextual information

Item	Specimen's inventory number	Archaeological site					Specimen's age category	Forehead position index	References on site chronology and /or animal bone material characteristics, including skull measurements (year / author / page)	
		Location / County	Stratum chronology	Site No.	Trench	Stratum				
1	62/88 494	Gdańsk / *loco*	11th–12th c.	1	XVIII	–	*subadult*	–	1977	Kubasiewicz, p. 150
2	62/116 501	Gdańsk / *loco*	11th–12th c.	1	XVIII	–	*subadult*	–	1977	Kubasiewicz, p. 150
3	575	Gdańsk / *loco*	12th–13th c.	2	–	–	*adult*	111.00	1977	Kubasiewicz, p. 62 and p. 76
4	54/114 28	Gdańsk / *loco*	12th–13th c.	4	II–IV	–	*adult*	116.35	1977	Kubasiewicz, p. 90 and p. 92
5	59/53 279	Gdańsk / *loco*	13th c.	1	XVIII	–	*adult*	114.36	1977	Kubasiewicz, p. 150
6	1954 4	Gdańsk / *loco*	14th c.	4	II–IV	–	*adult*	120.54	1977	Kubasiewicz, p. 88 and p. 92
7	5172	Kołobrzeg / *loco*	Mid–9th c.	1	1	VII a	*subadult*	–	1965	Kubasiewicz & Gawlikowski, p. 72
8	5154	Kołobrzeg / *loco*	Second half of 11th c.	1	1	AIV	*subadult*	–	1965	Kubasiewicz & Gawlikowski, p. 72
9	801	Szczecin / *loco*	Not available	Castle	Mixed material		*adult*	125.94	1983	unpublished; Cnotliwy et al., p. 324
10	6247	Szczecin / *loco*	9th c.	Vegetable Marketplace		XXXIII	*adult*	–	1967 & 1971	unpublished; Kubasiewicz & Gawlikowski
11	1633	Szczecin / *loco*	13th c.	Vegetable Marketplace		VII	*adult*	–	1967 & 1971	unpublished; Kubasiewicz & Gawlikowski
12	17b	Szczecin / *loco*	Not available	Moat	Depth 150 cm	–	*adult*	118.54	1983	unpublished; Cnotliwy et al.
13	2572 A954	Wolin / *loco*	Second half of 10th c.	1	5	XVII	*adult*	120.75	1964 & 1965	unpublished; Kubasiewicz & Gawlikowski, Gawlikowski & Kubasiewicz
14	2947 A955	Wolin / *loco*	Second half of 10th c.	1	5	XVII	*adult*	129.92	1964 & 1965	unpublished; Kubasiewicz & Gawlikowski, Gawlikowski & Kubasiewicz
15	A954	Wolin / *loco*	Second half of 10th c.	1	5	XVII	*adult*	–	1964 & 1965	unpublished; Kubasiewicz & Gawlikowski, Gawlikowski & Kubasiewicz
16	2948 A955	Wolin / *loco*	Second half of 10th c.	1	5	Gd	*adult*	–	1965 & 1965	unpublished; Kubasiewicz & Gawlikowski, Gawlikowski & Kubasiewicz
17	2768 A955	Wolin / *loco*	Second half of 11th c.	1	5	E 10	*adult*	–	1964 & 1965	unpublished; Kubasiewicz & Gawlikowski, Gawlikowski & Kubasiewicz
18	437	Wolin / *loco*	Second half of 11th c.	1	4	IXC2/b	*adult*	118.62	1959	Kubasiewicz, p. 122
19	439	Wolin / *loco*	Second half of 11th c.	1	4	IX c	*subadult*		1959	Kubasiewicz, p. 122
20	831	Wolin / *loco*	Beginning of 12th c.	1	4	VIII	*adult*	112.27	1959	Kubasiewicz, p. 119
21	829/830	Wolin / *loco*	Beginning of 12th c.	1	4	VIII	*adult*	121.74	1959	Kubasiewicz, p. 122
22	2704 A995	Wolin / *loco*	Second half of 12th c.	1	5	C1	*adult*	104.25	1964 & 1965	unpublished; Kubasiewicz & Gawlikowski, Gawlikowski & Kubasiewicz
23	2595/96/97A954	Wolin / *loco*	Second half of 12th c.	1	5	A1	*adult*	129.56	1964 & 1965	unpublished; Kubasiewicz & Gawlikowski, Gawlikowski & Kubasiewicz
24	2493 AR 955	Wolin / *loco*	Second half of 13th c.	1	5	VII b	*adult*	126.70	1964 & 1965	unpublished; Kubasiewicz & Gawlikowski, Gawlikowski & Kubasiewicz
25	2490	Wolin / *loco*	12th–13th c.	1	5	VII–IX	*subadult*	–	1964 & 1965	unpublished; Kubasiewicz & Gawlikowski, Gawlikowski& Kubasiewicz

Table 2. Values of the metric traits for the dorsal surface of skull in short- and medium-snout historic dogs

Craniometric traits	Dog skull group									
	Short-snout					Medium-snout				
	n	x	sd	min	max	n	x	sd	min	max
Akrokranion-Prosthion (1)	10	198.20	14.02	182.00	223.00	4	192.50	9.56	182.00	207.00
Akrokranion-Frontal midpoint (7)	10	95.92	8.37	85.76	109.04	4	92.21	3.27	88.66	96.16
Prosthion-Nasion (8)	10	98.65	8.09	90.57	116.83	4	93.13	6.26	85.91	98.52
Prosthion-Frontal midpoint (9)	10	112.24	9.06	101.78	129.30	4	112.37	5.36	105.16	117.90
Frontal midpoint-Opisthion	10	97.00[A]	7.77	85.00	109.00	4	87.75[A]	3.40	83.00	91.00
Nasion-Rhinion (10)	9	77.90	7.79	70.74	93.26	4	74.13	2.15	71.63	76.80
Nasion-Akrokranion	10	99.54	6.34	91.43	107.20	4	99.37	8.69	92.12	110.09
Nasion-Basion	10	104.70	7.90	94.00	115.00	3	100.00	1.73	98.00	101.00
Prosthion-oral border of the orbits (12)	9	86.49	7.57	76.52	101.88	4	87.82	4.58	81.95	92.70
Euryon-Euryon (29)	11	57.08	2.96	52.90	62.00	4	58.29	1.62	56.28	60.00
Zygion-Zygion (30)	5	105.69	6.69	98.29	115.00	3	105.00	8.18	98.00	114.00
Least breadth of the neurocranium (31)	10	38.39	4.10	33.77	44.74	4	29.37	14.73	8.01	40.88
Ectorbitale-Ectorbitale (32)	10	54.72	8.29	43.54	68.01	4	53.73	10.23	46.67	68.65
Entorbitale-Entorbitale (33)	10	40.14	7.24	31.21	51.70	4	41.29	5.32	34.36	46.00
Eye-socket [Orbit] height (37)	10	30.89[A]	2.49	27.08	33.80	4	34.76[A]	2.03	32.38	36.96
Cranium height (38)	10	53.46	3.53	48.98	59.15	4	58.38	6.89	51.64	65.07
Cranium height (39)	10	49.02	4.23	44.25	59.39	4	47.50	4.27	43.13	52.49
Cranium heigh from *Bregma* to the lower edge of *bulla tympanica* (CH)	10	72.50	6.24	64.56	80.18	4	69.17	4.70	64.45	75.05

Explanations: mean values in rows marked with the same letters differ significantly at: a – $P \leq 0.05$; A – $P \leq 0.01$

Table 3. Values of the meatric traits for the skull base in short- and medium-snout historic dogs

Craniometric traits	Dog skull group									
	Short-snout					Medium-snout				
	n	x	sd	min	max	n	x	sd	min	max
Condylobasal length (2)	10	187.45	13.60	173.50	209.00	4	185.25	13.67	171.00	197.00
Basion-Prosthion (3)	10	175.55	11.07	163.00	192.00	4	173.63	9.81	162.00	184.50
Basion-Synsphenion (4)	10	49.40	3.85	44.52	54.74	4	46.26	3.21	42.71	49.71
Basion-Staphylion	10	78.70	5.06	71.11	85.16	4	76.90	7.95	69.41	85.10
Prosthion-Synsphenion (5)	10	127.33	8.94	118.15	144.16	4	124.65	6.42	115.75	136.92
Prosthion-Staphylion (13)	10	96.61	6.99	89.64	107.51	4	96.73	3.86	91.22	99.59
Palatal length (13a)	10	94.20	6.29	88.33	103.45	4	95.54	4.18	90.01	97.33
Staphylion-Palatinoorale (14)	10	33.83	4.09	29.04	41.24	4	34.61	1.68	32.67	36.63
Length of the horizontal part of the palatine corresponding to measurement 13a (14a)	10	31.24	3.60	26.74	37.89	4	32.82	1.85	31.02	35.52
Length of cheektooth row (15)	10	67,17	5,10	61,24	75,63	4	68,42	1,42	66,83	69,82
Length of the molar row (16)	10	20,79	1,56	17,65	23,36	4	21,11	1,85	18,95	22,90
Preamorale-Postdentale (17)	10	49,85	5,21	40,83	60,37	4	51,92	2,67	48,49	54,77
Greatest diameter of the auditory bulla (22)	10	22.17	2.95	18.39	26.60	4	32.51	19.23	20.02	61.00
Breadth dorsal to the external auditory meatus (24)	10	65.88	4.64	59.67	72.72	4	64.06	2.63	60.84	66.90
Greatest palatal breadth (34)	10	62.56	4.68	56.66	69.95	4	60.84	1.27	59.07	61.82
Least palatal breadth (35)	10	36.27	3.77	32.03	44.14	4	33.26	2.91	30.37	37.17
Breadth of the canine alveoli (36)	8	37.75	3.27	34.08	42.33	4	33.99	2.34	31.85	37.24

Table 4. Values of the metric traits for the nuchal surface of skull in short- and medium-snout historic dogs

Craniometric traits	Dog skull group									
	Short-snout					Medium-snout				
	n	x	sd	min	max	n	x	sd	min	max
Ot-Ot (23)	10	66.43	4.95	60.00	74.00	4	65.89	2.16	64.00	68.88
Greatest breadth of the occipital condyles (25)	10	36.78	2.84	33.56	43.04	4	39.91	7.77	34.43	54.24
Greatest breadth of the bases of the paraoccipital processes (26)	10	49.16	9.64	23.62	67.83	4	59.94	8.01	49.41	68.51
Greatest breadth of the foramen magnum (27)	10	18.44	1.15	16.74	20.44	4	18.76	1.03	17.49	20.00
Akrokranion-Opisthion	10	24.00	4.38	17.30	30.26	4	20.71	2.09	18.99	28.05
Height of the dorsal notch of the *foramen magnum*	10	1.23	0.97	0.00	3.64	4	1.05	0.58	0.34	1.52
Basion-Opisthion (28) (without dorsal notch)	10	16.28	1.32	14.46	18.82	4	14.02	1.10	12.49	15.09
Basion-Opisthion (28) (with dorsal notch)	10	15.15	1.06	13.95	16.86	4	16.32	2.59	12.94	15.85
Akrokranion-Basion (40)	10	41.22	3.66	35.30	47.03	4	38.00	1.54	36.52	46.05
Area of the foramen magnum [mm^2]	10	195.16	25.78	166.33	238.10	4	180.26	23.55	150.21	206.67
Length of the left occipital condyle	10	19.00	2.29	13.64	22.17	4	18.73	1.09	17.84	20.20
Length of the right occipital condyle	10	19.56	1.55	17.93	22.58	4	18.91	0.66	18.30	19.83
Area of the occipitale triangle [mm^2]	10	1001.04	251.79	445.47	1527.53	4	1138.60	156.12	925.20	1297.24

Table 5. Values of selected cranial indices for short- and medium-snout historic dogs

Cranial indices	Dog skull group									
	Short-snout					Medium-snout				
	n	x	sd	min	max	n	x	sd	min	max
Zyg-Zyg /A-P x 100	5	53.26	2.20	51.36	56.10	3	54.50	5.04	48.76	58.16
Eu-Eu/A-N x 100	10	57.44	2.46	53.52	61.25	4	59.07	6.37	52.48	64.88
Zyg-Zyg/N-P x 100	5	108.04	6.69	102.20	116.06	3	115.70	16.48	99.80	132.70
Index 1 (Eu-Eu/A-P X 100)	10	28.85	1.08	26.93	30.77	4	30.34	2.00	28.00	32.48
Index 2 (Eu-Eu/B-P x 100)	10	32.57	1.18	30.12	34.15	4	33.69	2.72	31.01	36.49
Index 3 (Eu-Eu/condylobasal length x 100)	10	30.51	1.30	28.29	32.18	4	31.99	3.17	29.16	34.88
Foramen magnum index 1 (H (with dorsal notch)/W x 100)	10	89.14	10.49	77.25	110.79	4	80.31	4.27	76.08	84.06
Foramen magnum index 2 (H (without dorsal notch)/W x 100)	10	82.30[a]	6.61	73.54	92.09	4	74.66[a]	2.18	71.40	75.91
Cranial volume (A-N x Eu-Eu x CH)	10	41.58	7.71	32.72	51.63	4	40.13	5.38	35.10	47.74
N-B/B-P x 100	10	59.62	1.45	57.32	62.50	3	58.61	3.47	55.49	62.34
Pm-Pd/St-P x 100	10	53.24[A]	3.09	47.82	57.76	4	44.36[A]	9.34	36.07	53.88

Explanations: see Table II.

Table 6. Values of the correlation coefficients for craniometric traits in short- and medium-snout historic dogs

	Zyg-Zyg		Ent-Ent		Ect-Ect		Least breadth of the neurocranium		Eu-Eu		Ot-Ot	
	short-snout	medium-snout	short-snout	medium-snout	short-snout	medium-snout	short-snout	medium-snout	short-snout	medium-snout	short-snout	medium-snout
A-P	0.76	-	0.74	0.68	0.80	0.25	0.32	0.80	0.40	-0.70	0.85	0.77
A-N	0.89*	-	0.86	0.44	0.83	0.96*	0.78	0.71	0.52[a]	-0.78[a]	0.98**	0.90
N-P	0.32	-	0.31	0.35	0.52	-0.57	0.16	0.25	0.09	-0.08	0.40	0.05
B-P	0.66	-	0.67	0.68	0.74	0.59	0.50	0.88	0.50[a]	-0.83[a]	0.82	0.93
B-N	0.63	-	0.60	-0.07	0.58	0.09	0.49	0.18	0.45[a]	-0.84[a]	0.82	0.32
Condylobasal length	0.86	-	0.93*	0.50	0.98**	0.77	0.79	0.77	0.71[A]	-0.92[A]	0.88*	0.92
So-O	0.79	-	0.84	0.74	0.84	0.19	0.69	0.82	0.71[a]	-0.61[a]	0.91*	0.75
F. m. breadth	0.71[a]	-0.64[a]	0.83	0.18	0.89*[a]	-0.17[a]	0.63	0.52	0.83[A]	-0.94[A]	0.83[a]	-0.25[a]

Explanations: values of simple correlation coefficients marked with * are significant at P≤0.05, while those marked with ** are significant at P≤0.01; correlation coefficients marked in rows with the same letters differ significantly at: a – P≤0.05; A – P≤0.01.

Table 7. Values of the correlation coefficients for selected traits of the foramen magnum of skull in short- and medium-snout historic dogs

Index	Fm area		Fm breadth		Fm heigh		Fm index	
	short-snout	medium-snout	short-snout	medium-snout	short-snout	medium-snout	short-snout	medium-snout
Eu-Eu/A-P x 100	-0.15	-0.76	-0.74	-0.74	0.44	-0.29	0.58	0.30
Eu-Eu/P-B x 100	-0.17	-0.78	-0.51	-0.73	0.44	-0.40	0.62	0.12
Eu-Eu/condylobasal length x 100	-0.22	-0.85	-0.69*	-0.79	0.48	-0.58	0.74*	-0.08
Area of the occipital triangle	0.45	0.80	0.22	0.73	0.17	0.94	0.04	0.67
Cranial capacity	0.35	0.15	0.38	0.02	-0.38	0.19	-0.49	0.26
Greatest breadth of the occipital condyles	0.70*	0.36	0.77*	0.24	-0.20	0.46	-0.55	0.44
Greatest breadth of the paraoccipitalis processes	0.32	0.61	0.20	0.54	0.18	0.93	0.05	0.86

Table 8. Degree of the occipital dysplasia being expressed by the maximum height of the *foramen magnum* to its greatest breadth ratio

Dorsal notch index according to the method of PARKER & PARK (1974)	Grade 1	Grade 2	Grade 3
Skull group:	Dorsal notch/H < 0.5	Dorsal notch/H ≈ 1	Dorsal notch/H > 1
Short-snout (n=10)	0.07 (min. 0.00 – max. 0.18)	–	–
Medium-snout (n=4)	0.06 (min. 0.02 – max. 0.09)	–	–
Occipital index according the method of Fedrigo et al. (SIMOENS et al. 1994)	H/W < 95	H/W > 105	95 < H/W <105
Short-snout (n=10)	7	1	2
Medium-snout (n=4)	4	–	–
Undetermined forehead position (n=9) *)	6	2	1

*) the state of the *foramen magnum* in two specimens made determination of the dorsal notch impossible

From among 14 skull specimens, 10 were characterised by forehead position index smaller than 125 (from 104.25 to 121.74). They were assumed to be short-snout skulls. The value of this index for other 4 skulls ranged from 125.94 to 129.92, thus they were considered to represent medium-snout dogs. Twelve metric traits out of 18 ones characterising the dorsal surface of short-snout skulls demonstrated higher values than in medium-snout specimens, but the Student's t-test showed a significant difference ($P \le 0.01$) between groups only with respect to the *Frontal midpoint-Opisthion* length and the orbit height (Table 2). No statistically significant differences were found between groups with respect to the traits characterising the cranial base (Table 3) and the nuchal surface of dog skulls of both groups (Table 4). Statistical analysis of the value of calculated cranial indices (Table 5) showed only differences between groups in relation to the *foramen magnum* index calculated without the dorsal notch ($P \le 0.05$) and for the Pm-Pd/St-P x 100 index ($P \le 0.01$). The values of correlation coefficients for selected craniometric traits of both examined groups are presented in Table 6. It was demonstrated that the strength of association between examined traits was within the range of weak to almost full but confirmation with statistical analysis was basically obtained for short-snout specimens with respect to such traits as *Akrokranion-Nasion* x *Zygion-Zygion* ($P \le 0.05$), *condylobasal length* x *Entorbitale-Entorbitale* ($P \le 0.05$), *condylobasal length* x *Ectorbitale-Ectorbitale* ($P \le 0.01$), *foramen magnum breadth* x *Ectorbitale-Ectorbitale* ($P \le 0.05$), *Akrokranion-Nasion* x *Otion-Otion* ($P \le 0.01$) as well as for medium-snout skulls for *Akrokranion-Nasion* x *Ectorbitale-Ectorbitale* ($P \le 0.05$). Comparison of the values of estimated correlation coefficients revealed significant and highly significant differences occurring between some of them. Differences between coefficients describing mainly correlations between the greatest breadth of neurocranium and the traits characterising its length and foramen magnum breadth are calling attention. The carried out analysis of correlations between the values of selected cranial indices characterising skull proportions and its nuchal surface and cranial capacity and the traits of the foramen magnum showed statistically significant strong correlations only in relation to the skulls being assumed to be short-snout ones due to forehead position index (Table 7). Analysis of the estimated values characterising the nuchal surface of skulls under examination allowed also establishment of the degree of occipital dysplasia being expressed by the maximum height of the *foramen magnum* to its greatest breadth ratio (Table 8). It turned out that all skulls out of 14 ones could be classified (according to the method of Parker and Park, 1979) to specimens with the first degree of occipital dysplasia. On the other hand, the use of the method of Fedrigo et al. (Simoens et al., 1994) revealed specimens with the first, the second and the third degree of dysplasia among 10 short-snout skulls. Four medium-snout skulls is characterised by the first degree of occipital dysplasia, whereas 10 skulls for which forehead position index could not be determined also show three degrees of *foramen magnum* dysplasia.

DISCUSSION

Based on the skull length measurements taken (*A-P* and condylobasal length), it is possible to state that the short-snout specimens examined are being included into a group of large and medium size dogs. Among the short-snout specimens, as many as 4 ones have the *A-P* length within the range from 205.00 to 223.00 mm, while other 6 ones from 182.00 to 198.00 mm. It is also confirmed by the condylobasal length which in 8 specimens is from 173.50 to 198.00 mm, whereas in other two from 205.00 to 209.00 mm. These values exceed the length of skull in modern brachycephalic dogs (Kupczyńska et al., 2008). According to the division proposed by Wyrost (1963) who examined archaeological skulls, the material examined at present could have come from animals of the *C. inostrancewi* and *C. intermedis* type although in the papers reporting the status of animal bone remains excavated in Pomerania (Kubasiewicz 1959; Kubasiewicz & Gawlikowski 1964, 1965; Kubasiewicz 1977) they were classified to three basic types, i.e. i) a form approximating the so called peat bog dogs of the spitz type of the Stone Age (*Canis palustris*), ii) medium-size dogs of the *Canis intermedius* and *Canis matris optimae* type, and iii) large dogs of the C*anis inostrancevi* type. These animals did not existed in the pure form but as most diverse mixed-breed dogs, although it could not be excluded that breeds belonging to medium size dogs (*Canis intermedius*) and smaller forms, with predominance of traits of the peat bog spitz (*Canis palustris*), were the most abundant. The measurements taken at present as well as the cranial indices calculated on their basis did not admittedly show a direct influence of forehead position index, determining the length of snout in dogs, on absolute values of the basic metric traits characterising the splanchnocranium and the neurocranium and its nuchal surface but the carried out statistical analysis consisting in examination of correlations between the traits determining skull proportions points to high positive correlations between the traits of short-snout skulls, as opposed to medium-snout specimens. The existence of such an influence is also showed by statistically significant differences ($P \le 0.05$ and $P \le 0.01$) between the estimated correlation coefficients. Based on the values of estimated correlation coefficients for the traits characterising the skull length and the skull breadth in the point located most externally on the wall of the braincase, a rather clear picture of a long and narrow skull is being drawn. Such skulls have probably the structure of the skull cap similar to the long-head morphotype as well as show the presence of fully developed frontal sinuses (Kupczyńska et al., 2005). The sparse material collected does not reason acknowledgment of the influence of forehead position index on the degree of dysplasia of the foramen magnum but it is significant when using the method of Parker & Park (1974) that short-snout specimens with the first degree of dysplasia found have a larger length of the dorsal notch than medium-snout ones (Table 8). A confirmation of the influence of forehead position index on the nuchal surface of dog skulls can be the value of estimated occipital index, based on which 100% of the medium-snout skulls examined can be considered to be normal, while only 64% of the short-snout skulls; other 36% can be considered as being burdened with dysplasia or doubtful (Simoens et al., 1994).

Morphological data on the history of dog origin (Clutton-Brock 1999; Davis & Villà 1978) have been confirmed by genetic examinations (Savolainen et al., 2002; Vilà et al., 1997), while the recent isotopic examination of wolf and dog fossil remains (Germonpré et al., 2009) supplement earlier reports that base on osteometry. These data point to the fact that separation of the first dog form from wolf population took place as early as in the Upper Paleolithic. Domestication process of the form preceding a dog associated with the man for over 31 thousand years and lasting for several thousand years has brought about numerous morphological changes, far deeper than those which allowed separation of a new taxonomic unit, i.e. a domestic dog (Benecke 1987).

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