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Comparison of Craniometric Features and Cranial Cavity Volume in Domestic Pig (*Sus scrofa forma domestica*) and Wild Boar (*Sus scrofa*) in View of Development

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The research involved 130 boar and 104 domestic pig skulls. The skulls were divided into sex and age groups and craniometric measurements were determined for each; the cranial cavity volume was determined. In boars, in both age groups, a greater cranial cavity volume was noted as compared with that of the domestic pig. The cranial cavity volume is correlated mostly with the length of the neurocranium base.

Key words: Craniometric features, domestic pig, wild boar.

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The morphological structure and craniometric features of skulls in different mammalian species is described in many papers in the literature. Most frequently these papers concern representatives of carnivores or rodent orders. Research into the development cycle of Micromammalia was initiated by DEHNEL (1949). WASILEWSKI (1956) investigated the volume of the cranial cavity in *Microtus agrestis*. The measurements and proportions of the skull depending on sex and origin in musk-rat were described by RUPRECHT (1974). EMPEL (1958) carried out observations of the cranial cavity volume in rabbit, while ANDERSON and WILG (1984), BUCHALCZYK and RUPRECHT (1977), HUSON and PAGE (1980), REIG and RUPRECHT (1989) – into craniometric features in different carnivore species.

In artiodactyla, craniometric features were described by MYSTKOWSKA (1966) in red deer, KOBRYŃCZUK and ROSKOSZ (1980) in European bison, KRASICKA (1988) in hybrids between European bison and domestic cattle, and WUSTINGER *et al*. (2005) in roe deer.

Data on craniometric features in representatives of Suidae can be found in the monograph of the boar, reported by KOZŁO (1975), while OBREZ (1996), analysed some craniometric features in miniature pigs.

Information on the cranial cavity in Suidae has only been reported by ADAMETZ (1925), who determined the anatomy of the cranial cavity and compared it in the boar and domestic pig, showing differences in the anatomy of both forms. According to this author, a change in the structure of the cranial cavity caused an increased pressure of bony elements on part of the pituitary gland, which resulted in an increased rate of metabolic transformations and, foremost, an increased growth and development rates of domesticated forms.

Taking the above into consideration, investigations were carried out involving extensive research material on the cranial cavity volume in domestic pig and wild boar in different age classes, followed by a comparison of the results obtained.

Material and Methods

The research covered 130 skulls in boar and 104 skulls in domestic pig, WBP breed, obtained from individuals of different sex and age. The animal skulls were macerated by cooking, and then muscles and the cerebrum were mechanically removed and immersed into 5% hydrogen peroxide for bleaching.

The boar and pig skulls were divided into two groups depending on sex and age. The age of boars was determined based on the Brandt method following HABER (1969), while the age of pigs was known from the breeding documentation.

Boars

Group I: piglets – the age ranged from 8 to 12 months; 75 individuals (40 females and 35 males);

Group II: boars in the second year of age (29 males and 26 females).

Domestic pigs

Group I: piglets 3-4 month-old (32 males and 32 females);

Group II (porkers): animals slaughtered at age 8-10 months (24 males, 16 females).

The following points were defined in the skulls: Basion (B), Bregma (Br), Euryon(eu), Nasion (N), Opisthocranion (Op), Prosthion (P), Sphenobasion (Sph), Staphylion (St).

The following measurements were taken for each skull:

1. Opisthocranion-Prosthion (Op-P) the greatest skull length
2. Basion-Prosthion (B-P) cranial base length
3. Basion-Staphylion (B-St) length of the base of the braincase
4. Euryon-Euryon (eu-eu) the greatest width of the braincase
5. Sphenobasion-Bregma (Sph-B) height of the braincase
6. Nasion-Bregma (N-B) angular height of the braincase

The measurements were taken with zootechnical dividers and calipers.

The cranial cavity volume was measured with gun-shots no 6, 2.5 mm in diameter. The openings running into the cranial cavity were filled with plasticine. The cranial cavity was filled with gun-shot through the occipital foramen magnum to the border of the occipital bone, using the DUERST (1926) method, which involved weighing the amount of gun-shot put into the cranial cavity, and then the result was compared against 100 cm^3 of the same kind of gun-shot. The measurements were made twice and the mean value constituted a basis for further research.

In order to compare between the respective groups, indices of relative volume of the cranial cavity were calculated.

$$\frac{\text{Cranial cavity volume}}{\text{Cranial base length}}$$

Similarly the relative cranial cavity volume was compared between a selected group of pigs and boars, namely between piglets of both forms, as well as between boars in the second year of age and porkers. Both groups represented a similar stage of development and growth. They also showed a similar length of the braincase. This measurement served as a basis for calculating the second index of relative volume of cranial cavity.

$$\frac{\text{Cranial cavity volume}}{\text{Length of the base of the braincase}}$$

The application of this index allowed for eliminating the differences caused by a greater length of splanchnocranium in boar.

Based on the results obtained, the relative and absolute volumes of the cranial cavity were calculated in both forms. The arithmetic mean, standard deviation and coefficient of variation values were calculated. Additionally, a correlation coefficient between the cranial cavity volume and respective skull measurements was calculated.

Results

The characteristics of the boar skull expressed as craniometric measurements are given in Table 1. The youngest age group in boar, piglets, had similar craniometric measurements in males and females and did not show significant differences. Also the absolute volume of the cranial base was similar (Table 3); in males – it was on average 155.71 cm^3, and in females – 147.88 cm^3. The difference was non-significant. The relative value of the cranial cavity volume against the cranial base (Table 3) in males was 6.31, while in females – 6.03. The difference between the individuals of both sexes was non-significant. The volume calculated against the length of the base of braincase in males amounted to 19.24, while in females – 18.07. The differences were not significant. As shown in Table 5, the youngest group of piglets demonstrated that the volume of cranial cavity was mostly correlated with the length of the base of braincase (B-St). The measurements which characterized the neurocranium metrically, i.e. the width of the braincase, the height of the braincase and the angular height of the braincase, also demonstrated a considerable degree of correlation. A slight correlation with the cranial cavity volume was, however, seen for the greatest length of the skull and the length of the braincase.

The second age group in boars included individuals in the second year of age. Over this period clear sexual dimorphism is observed in boars, e.g. in body size, which was reflected in the craniometric parameters. There is a clear increase in the average total length of the skull and the length of the cranial base (Table 1), which is a result of a consid-

Table 1

Craniometric features in boar

Measurement	Piglets								Boars in their second year of age							
	males				females				males				females			
	n	x (cm)	Sx	Vx	n	x (cm)	Sx	Vx	n	x (cm)	Sx	Vx	n	x (cm)	Sx	Vx
Op-P	40	26.40	1.23	4.65	35	26.01	0.83	3.19	29	33.71	2.20	6.52	26	31.20	0.40	1.26
B-P	40	24.64	1.13	4.58	35	24.51	1.81	7.38	29	31.76	1.90	5.98	26	29.73	1.03	3.46
B-St	40	8.08	0.38	4.69	35	8.18	0.39	4.76	29	9.96	0.38	3.56	26	8.97	0.21	2.34
Eu-eu	40	6.90	0.22	3.18	35	7.06	0.33	4.19	29	8.08	0.23	2.32	26	7.57	0.06	0.79
Sph-Br	40	7.86	0.58	7.36	35	7.63	0.30	3.93	29	9.62	0.96	4.97	26	8.87	0.50	5.63
N-B	40	18.74	0.47	3.69	35	12.81	0.63	4.41	29	16.50	0.66	4.25	26	14.70	0.79	5.57

Table 2

Craniometric features in domestic pig

Measurement	Piglets								Boars in their second year of age							
	males				females				males				females			
	n	x (cm)	Sx	Vx	n	x (cm)	Sx	Vx	n	x (cm)	Sx	Vx	n	x (cm)	Sx	Vx
Op-P	32	16.37	0.52	3.19	32	16.10	0.45	2.80	24	27.35	1.29	8.37	16	27.00	1.95	7.24
B-P	32	16.37	0.52	3.19	32	16.10	0.45	2.80	24	27.35	1.29	8.37	16	27.00	1.95	7.24
B-St	321	5.83	0.28	4.75	32	5.70	0.19	3.30	24	9.32	2.29	3.39	16	8.55	0.35	4.11
Eu-eu	32	6.03	0.07	1.20	32	6.10	0.07	1.12	24	7.35	0.16	1.74	16	7.53	0.14	1.82
Sph-Br	32	6.47	0.27	4.10	32	6.20	0.23	3.73	24	9.80	0.33	3.42	16	9.15	0.28	3.02
N-B	32	10.60	0.54	5.12	32	11.20	0.43	3.84	24	15.15	0.74	4.87	16	14.48	0.45	3.12

Table 3

Statistical characteristics of the cranial cavity volume in boar

Item measured	Statistical measures	Piglets		Boars in the second year of age	
		males	females	males	females
Absolute volume in cm^3	n	40	35	29	26
	x	155.71	147.88	198.50	178.70
	Sx	6.3	14.0	13.48	14.0
	Vx	4.04	9.46	6.79	7.83
Relative volume $\frac{\text{Absolute volume}}{\text{B -P}}$	n	40	35	29	26
	x	6.31	6.03	6.25	6.01
	Sx	0.28	0.40	0.57	0.49
	Vx	4.40	6.66	9.62	7.16
Relative volume $\frac{\text{Absolute volume}}{\text{B - St}}$	n	40	35	29	26
	x	19.24	18.07	20.54	19.92
	Sx	0.97	0.74	0.96	0.83
	Vx	5.05	4.11	4.47	4.36

Significant differences between means at P=0.95, α=0.05

erable elongation of the splanchnocranium in the animals. The neurocranium is subject to proportionally lesser growth. Importantly, in this age group all the parameters examined showed considerable variation. The absolute volume of the cranial cavity in males is 198.50 cm^3, in females – 178.70 cm^3. As compared with piglets, the difference between the animals of both sexes is already clearer, although still non-significant. Generally, the skull measurements in females of this age group are smaller. The indicators of the relative volume against the cranial base in males amounted to 6.25, and in females – 6.01. The difference was non-significant. The cranial cavity volume measured against the length of the braincase also showed similar values in both sexes. In piglets,

similarly to the previous age group, the cranial cavity volume was mostly correlated with the length of the braincase.

Piglets

This group included the skulls of animals 3-4 months of age. The craniometric characteristics are given in Table 2. The length of the cranial base, and at the same time the greatest length of the skull in males is 16.37 cm, while in females – 16.10 cm. The length of the base of the braincase accounts for less than one third of the length of the cranial base and in males it reaches 5.83 cm, while in females – 5.70. The other measurements in this age group also show similar values for both sexes. The cranial base volume in domestic piglets was 91.0 cm^3 in males, and in females – 91.8 cm^3. The relative volume calculated against the length of the cranial base was also similar in individuals of both sexes and was 5.56 in males, while in females 5.70. The second index, namely the cranial cavity volume converted into the length of the base of the brain-

Table 4

Statistical characteristics of the cranial cavity volume in domestic pig

Item measured	Statistical measures	Piglets		Porkers	
		males	females	males	females
Absolute volume in cm^3	n	32	29	24	16
	x	91.00	91.80	135.75	133.50
	Sx	6.60	6.30	9.85	8.16
	Vx	6.25	6.84	7.27	6.11
Relative volume $\frac{\text{Absolute volume}}{\text{B-P}}$	n	32	29	24	16
	x	5.56	5.70	4.96	4.94
	Sx	0.32	0.29	0.22	0.24
	Vx	5.08	5.08	4.43	4.85
Relative volume $\frac{\text{Absolute volume}}{\text{B-St}}$	n	32	29	24	16
	x	15.60	16.15	14.96	15.61
	Sx	0.93	0.90	0.21	0.23
	Vx	6.00	5.06	1.40	1.47

Significant differences between means at P=0.95, α=0.05.

Table 5

Correlations between cranial cavity volume and skull measurements in boar

Group	Sex	Measurements					
		Op-P	B-P	B-St	eu-eu	Sph-Br	N-B
Piglets	Males	0.36	0.47	0.88	0.66	0.74	0.69
	Females	0.42	0.45	0.80	0.69	0.74	0.72
Boars in their second year of age	Males	0.25	0.32	0.84	0.68	0.59	0.56
	Females	0.28	0.33	0.85	0.71	0.60	0.62

Correlation coefficient at P=0.95, α=0.05.

Table 6

Correlations between the cranial cavity volume and skull measurements in domestic pig

Group	Sex	Measurements					
		Op-P	B-P	B-St	eu-eu	Sph-Br	N-B
Piglets	Males	0.54	0.54	0.73	0.81	0.93	0.74
	Females	0.56	0.56	0.70	0.78	0.95	0.72
Porkers	Males	0.43	0.43	0.73	0.69	0.46	0.51
	Females	0.41	0.41	0.75	0.71	0.48	0.47

Correlation coefficient at P=0.95, α=0.05.

case, in males amounted to 15.60, while in females – to 16.15 (Table 4). The correlations between the volume of the cranial cavity and the skull measurements are given in Table 4. A high correlation between the cranial cavity volume and the greatest width of the braincase was noted, as well as a very highly correlated volume with the height of the braincase.

Porkers

The craniometric characteristics of this group of animals are given in Table 2. The length of the cranial base, as in the previous group, coincided with the greatest length of the skull and in males it reached 27.35 cm, while in females – 27.0 cm.

The cranial cavity volume in this group of animals was as follows: in males – on average 135.75 cm^3, in females – 133.50 cm^3. The volume in both sexes was similar; the difference was non-significant. The volume of the cranial cavity against the length of the cranial base was 4.96 in males, while in females – 4.94

The cranial cavity volume was mostly correlated with the base of the braincase. The correlation coefficient of the cranial cavity volume with the angular height of the skull and the height of the braincase attained lower values.

A comparison of the cranial cavity volume is given in Table 3; the absolute volume of the cranial cavity in boar piglets was 155.71 cm^3 in males, and 147.88 cm^3 in females. In the youngest age group in domestic pig, of corresponding body weight and of similar age, the absolute volume of the cranial cavity was 91.0 cm^3 in males, while in females 91.8 cm^3. For both sexes the difference was highly significant. The relative volume measured against the length of the cranial base demonstrated lower differences and was significant only in males. The other indicator of relative volume calculated against the length of the braincase was also higher in boar and the difference in both cases was highly significant. A comparison of the group of boars in the second year of age with an age-correspondent group of porkers was as follows: the absolute volume in males reached on average 198.50 cm^3, while in females it was clearly lower and amounted to 178.70 cm^3. In pigs the absolute volume was clearly lower. In males it was 135.75 cm^3, while in females 133.50 cm^3. The difference in the volume observed in individuals of both sexes was low, while the cranial cavity volume demonstrated significant differences between both forms of the species investigated, wild and domesticated. The cranial cavity volume in boar was clearly greater.

Discussion

The examinations of the cranial cavity carried out in boar and domestic pig defined its absolute volume for respective age and sex groups in both forms.

In both age groups in boar the absolute volume of the cranial cavity is slightly greater in males than in females, which is due to differences in the skull size itself, especially the braincase (Table 5). As reported by KOZŁO (1975), the size and shape of the boar skull differ and depend on the sex and age. In boar piglets the absolute volume was 155.71 cm^3 in males and 147.88 cm^3 in females. In the individuals in their second year of age, as compared with the first group, the cranial cavity volume increased very clearly; in males it attained a value of 198 cm^3, while in females 178.70 cm^3, which must have been due to growth of the skull. As reported by HABER (1969), in the second year of age in boar clear sexual dimorphism can be observed, e.g. in body size and the shape of the skull. The correlations of the cranial cavity volume with the measurements taken for the neurocranium are similar as in the previous group. However, there is a decrease in the value of the correlation coefficient between the cranial cavity volume and the total length of the skull and the length of the cranial base. This demonstrates the harmonious growth of the braincase accompanied by the elongation of the viscerocranium. Similar information is presented by KOZŁO (1975). In the second age group in boar it was interesting to see the index of relative volume, calculated against the length of the braincase (the measurement most correlated with the cranial cavity volume). An increase in its value, as compared with the piglets group, indicates that an increase in the cranial cavity volume is in that age group more intensive than the increase in the length of the base of the braincase. A similar phenomenon was reported in European bison by KOBRYŃCZUK and ROSKOSZ (1980).

Craniometric analysis of the skull in pigs was carried out for two age groups: piglets and porkers. The absolute volume of the cranial cavity in the piglets was clearly lower, as compared with that of the corresponding group in boar. The relative volume indices also reached higher values in the boar group. The group of porkers was comparable, as far as the body weight was concerned, to the boar group in the second year of age, which allowed for comparisons between these groups. Similarly, in this case both the absolute volume and the volume measured against the length of the braincase attained higher values in boar. The differences in both sexes were significant. Also the cranial cavity volume index in boar, measured against the length of the cranial base, was greater.

Data that metrically compare the cranial cavity volume in both forms, wild and domesticated, are lacking. ADAMETZ (1925), however, provides photographs of the sagittal section of both forms and an applicable description, which suggested that in boar the cranial cavity volume is greater. This was confirmed by research on the body weight and the cerebrum size, which was usually greater in boar.

A comparison of the cranial cavity volume in both forms is confounded by the non- uniform rate of growth as well as the skull shape itself, which is elongated in boar with a more developed visceral part. Comparisons can be made only based on the indices of relative volume, assuming the length of the braincase, which at a specific age in both forms is similar, as the basis. Additionally, it should be mentioned that in both forms the length of the base of the braincase was most highly correlated with the cranial cavity volume.

Based on the present comparative study, the cranial cavity volume in boar, both in piglets and in the individuals in the second year of age, is greater than the corresponding values for the appropriate age and body weight groups of domestic pig.

The present research confirms other observations of wild animals having both the cranial cavity volume and the cerebrum greater in size as compared with closely related domestic animals.

For that reason the research into the cranial cavity volume should be carried out as closely connected with the skull size, mainly the neurocranium. This size is usually expressed by adequate craniometric measurements. In order to illustrate the relationship between the cranial cavity volume and the skull size, correlation matrixes were calculated, showing the cranial cavity volume both in boar and domestic pig groups is mostly correlated with the length of the braincase, and then with its height and the angular height. Especially in boar, the cranial cavity volume is slightly correlated with the length of the cranial base and the total skull length. This concerns especially older boars, with a clearly developed splanchnocranium.

In the porker group special attention should be paid to two measurements, namely the length of the base of the braincase and the height of the braincase. The latter in the corresponding age group in domestic pig always attained a higher value, unlike in boar where, usually, the length of the braincase was greater.

The correlation coefficient attained considerably lower values for the height of the braincase and the angular height of the braincase, justifiable as over this period of life in pigs extensive frontal sinuses develop in the region of frontal bones, therefore braincase growth is not directly related to an increase in the height of the cranial cavity (Tables 5 & 6).

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The research involved 130 boar and 104 domestic pig skulls. The skulls were divided into sex and age groups and craniometric measurements were determined for each; the cranial cavity volume was determined. In boars, in both age groups, a greater cranial cavity volume was noted as compared with that of the domestic pig. The cranial cavity volume is correlated mostly with the length of the neurocranium base. 11 References. No Supplementary Data. No Article Media. No Metrics. Keywords: CRANIOMETRIC FEATURES; DOMESTIC PIG; WILD BOAR. Learn how our modern domestic pig (Sus scrofa) was developed from the ferocious wild boar in two very distant places in the world: Turkey and China.Â All of the modern swine breeds today â€" there are hundreds of breeds around the globe â€" are considered forms of Sus scrofa domestica, and there is evidence that the genetic diversity is decreasing as cross-breeding of commercial lines threatens indigenous breeds. Some countries have recognized the issue and are beginning to support the continued maintenance of the non-commercial breeds as a genetic resource for the future. Domestic pigs Sus scrofa domestica of the Large White breed included animals of the Achinsk (LWA) and Novosibirsk (LWN) types bred at the Inya stud Farm. Landrace pigs were obtained from the Kudryashovskoe farm (LNK) and the Experimental Farm of the Siberian Branch of the Russian Academy of Sciences, hereafter referred to as the Experimental Farm (LNE).Â by selection for a less intense fat deposition. The ele-vated fat deposition in domestic pigs in comparison with wild or early domesticated forms is an obvious abnor-mality, which may have been caused by the breakdown of some genes owing to PERV insertion. Therefore, the natural selection against these breaks favoured alleles characteristic of the original wild boar or similar. Wild boar are now present on all continents except Antarctica and can greatly affect community structure and ecosystem function. Their destructive feeding.Â Antolova D, ReiterovÃ¡ K, Dubinsky P (2007) Seroprevalence of Toxoplasma gondii in wild boars (Sus scrofa) in the Slovak Republic. Ann Agric Environ Med 14:71. PubMed Google Scholar. Aplet GH, Anderson SJ, Stone CP (1991) Association between feral pig disturbance and the composition of some alien plant assemblages in Hawaii Volcanos National Park. Vegetatio 95:55â€“62. Article Google Scholar.