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COMPARATIVE CRANIOMETRY AND SKULL MORPHOLOGY OF THE RED FOX (*VULPES VULPES*) AND THE ARCTIC FOX (*VULPES LAGOPUS*)

KRANIOMETRIA PORÓWNAWCZA I MORFOLOGIA CZASZKI LISA SREBRZYSTEGO (*VULPES VULPES*) I LISA POLARNEGO (*VULPES LAGOPUS*)

Summary. The aim of the present study was to test whether there are morphological and morphometrical differences between the red fox (*Vulpes vulpes*) (female – 9, male – 10) and the arctic fox (*Vulpes lagopus*) (female – 10, male – 10). Examinations were conducted on the skulls of captive-bred foxes aged about one year. Features describing the size of skull were generally strongly positively correlated with one another, so principal components analysis (PCA) was used. Red fox skulls were longer than those of arctic fox but had a more delicate construction. Arctic foxes had shortened facial part of the skull, and more compact mandible. PCA revealed differences in skull parameters of the two studied species of captive-bred foxes. Osteometric analysis of some cranial features revealed sexual differences in both studied species.

Key words: morphology, morphometry, skull, red fox, arctic fox

Introduction

The scientific literature revealed that the measurements of skull could be modified by parasites, however their influence is not easy to prove using material from predatory animals living in the wild, i.e. in uncontrolled conditions (DEMUTH et AL. 2009). This is why material from animals kept in controlled conditions, e.g. on farms where animals are subject to standard deworm can be very valuable. Comparative studied of the skulls of wild raccoon dogs and badgers were conducted by HIDAKA et AL. (1998). They found that the most distinct morphological differences were found in cranial bones, especially in the nasal, occipital, maxilla and temporal bones. Morphological differences were shown in mandible, too. Sexual dimorphism was detected in badgers for the temporal and occipital bone, but were not in raccoon dogs.

Despite of a relatively small sample, a morphometric and statistical analysis was undertaken because this material arises from controlled conditions and thus is a valuable source of information about the influence of animal husbandry on morphological and morphometrical changes in skulls of captive-bred foxes. It is important because no papers that find sexual dimorphism in canidae are mentioned in literature.

Materials and methods

Studies were conducted on two fox species: red fox (*Vulpes vulpes*) and arctic fox (*Vulpes lagopus*). *Vulpes vulpes* was represented by colour type called silver fox, whereas *Vulpes lagopus* was the Finnish type. Animal material came from a fur farm in western Poland. Examinations were conducted on 39 skulls from foxes aged about one year (19 red foxes: 9 females, 10 males and 20 arctic foxes: 10 females and 10 males). The material came from animals after copulation. Studies on animals were conducted with approval by the Local Ethics Committee, permission No. 7/2011.

Craniometry was made with a caliper to an accuracy of 0.1 mm, according to the standard method of VON DEN DRIESCH (1976). The mandible bones were also examined. The analysis was performed on 55 metric variables (Figs. 1-5). The abbreviations of measurements of the cranium and mandible are presented below. Statistical analyses were performed using the statistical package Minitab (MINITAB...). ANOVA on skull measurements was carried out and differences between species, sexes and their interaction were tested. The significance levels are reported (uncorrected for multiple testing) but the reader should be aware of the problems of testing such a large number of variables. Because of the number of measurements taken exceeds the number of animals the Bonferroni correction was performed. Tests between male and female foxes and between species were also performed by ANOVA of the first two principal component stores (PC1, PC2).

Measurements of the cranium

A-P: Total length
B-P: Basal length
CbL: Condylobasal length

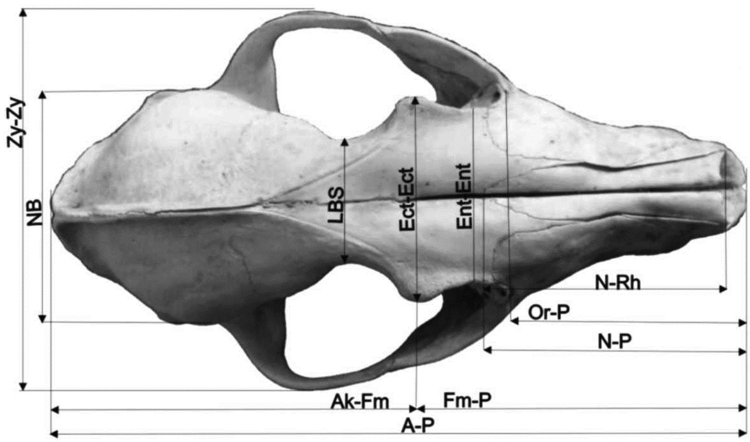

Fig. 1. Measurements of the cranium, dorsal view
Rys. 1. Pomiary czaszki, widok grzbietowy

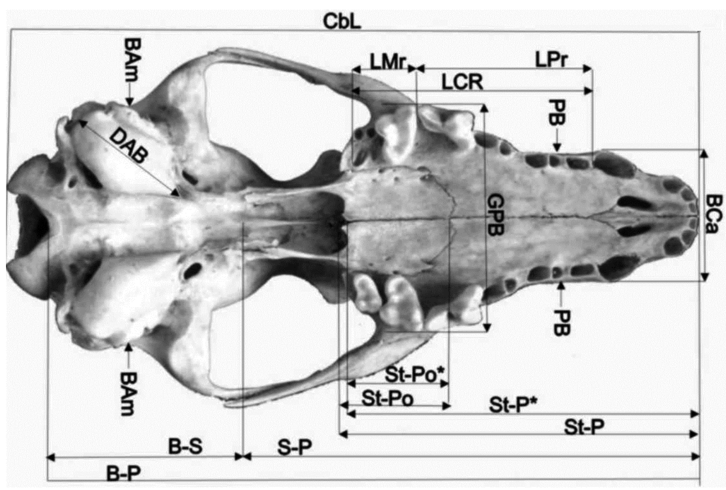

Fig. 2. Measurements of the cranium, basal view
Rys. 2. Pomiary czaszki, widok podstawny

B-S: Basicranial axis
S-P: Basifacial axis
Ak-Fm: Upper neurocranium length
N-P: Viscerocranium length
Fm-P: Facial length
N-Rh: Greatest length of nasals
Or-P: “Snout” length

Fig. 3. Measurements of the cranium, lateral view
Rys. 3. Pomiary czaszki, widok boczny

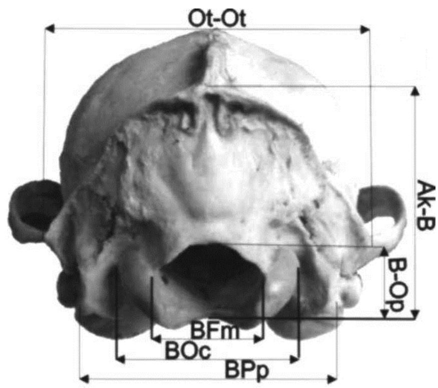

Fig. 4. Measurements of the cranium, nuchal view
Rys. 4. Pomiary czaszki, widok karkowy

St-P: Median palatal length
St-P*: Palatal length
St-Po: Length of the horizontal part of the palatine
St-Po*: Length of the horizontal part of the palatine
LCR: Length of cheektooth row
LMr: Length of the molar row
LPr: Length of the premolar row
DAB: Greatest diameter of the auditory bulla
Ot-Ot: Greatest mastoid breadth
BAm: Breadth dorsal to the external auditory meatus
BOc: Greatest breadth of the occipital condyles
BPp: Greatest breadth of the bases of the paraoccipital processes
BFm: Greatest breadth of the foramen magnum
B-Op: Height of the foramen magnum
NB: Greatest neurocranium breadth

Frąckowiak H., Nabzdyk M., Kulawik M., Przysiecki P., Nowicki S., 2013. Comparative craniometry and skull morphology of the red fox (*Vulpes vulpes*) and the arctic fox (*Vulpes lagopus*). Nauka Przyr. Technol. 7, 3, #42.

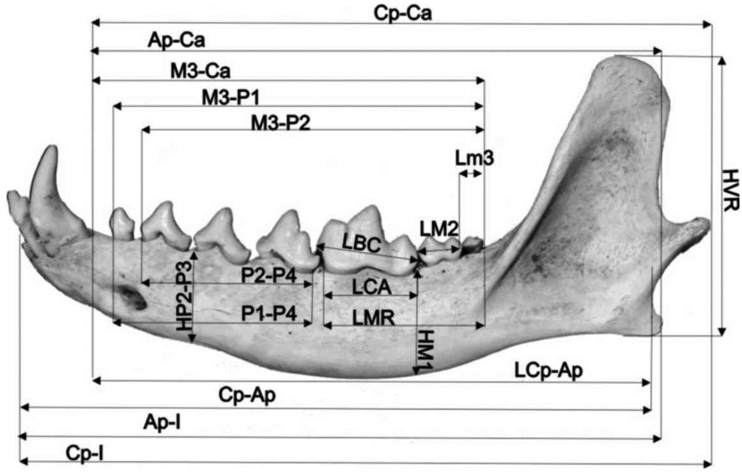

Fig. 5. Measurements of the mandible, lateral view
Rys. 5. Pomiary żuchwy, widok boczny

Zy-Zy: Zygomatic breadth
LBS: Least breadth of skull
Ect-Ect: Frontal breadth
Ent-Ent: Least breadth between the orbits
GPB: Greatest palatal breadth
PB: Least palatal breadth
BCa: Breadth at the canine alveoli
Sh: Skull height
Sh*: Skull height without the sagittal crest
Ak-B: Hight of the occipital triangle
IHO: Greatest inner height of the orbit

Measurements of the mandible

Cp-I: Total length from condyle process
Ap-I: Length from angular process
Cp-Ap: Length from the indentation between the condyle process and the angular process
Cp-Ca: Length from the condyle process to the aboral border of the canine alveolus
LCp-Ap: Length from the indentation between the condyle process and the angular process to the aboral border of the canine alveolus
Ap-Ca: Length from the angular process to the aboral border of the canine alveolus
M3-Ca: Length from the aboral border of the alveolus of M3 to the aboral border of the canie alveolus
M3-P1: Length of the cheektooth row
M3-P2: Length of the cheektooth row
LMR: Length of the molar row

P1-P4: Length of the premolar row
P2-P4: Length of the premolar row
LBC: Length of the carnassials
LCA: Length of the carnassial alveolus
LM2: Length of M2
LM3: Length of M3
HVR: Height of the vertical ramus
HM1: Height of mandible behind M1
HP2-P3: Height of the mandible between P2 and P3

Results

The study shoved that the external sagittal crest in the red fox arises at the junction of the temporal lines near the interparietal bone. Temporal lines in the arctic fox stand a part near the zygomatic process of the frontal bone and joining the frontal bone create the external sagittal crest. Morphological investigations revealed, that the external sagittal crest in the arctic fox, in comparison with the red fox, is clearly marked and higher. The interfrontal and interparietal sutures in the red fox running between temporal lines are typically serrated. However, in the arctic fox this sutures are plane. The anterior end of the nasal bone in the red fox is divided into two sharp processes. In the arctic fox these processes are poorly developed. The wider squamous part of the frontal bone and more massive zygomatic process of this bone characterise the skull of the arctic fox (Figs. 6a, 6b).

The squamous part of the occipital bone in the arctic fox is smaller and becomes narrow towards the top of the skull, but in the red fox it is wider, with a gently oval course. Examinations showed that the nuchal crest of the arctic fox is like a V-letter, but in the red fox it is semicircular. The occipital condyles and paracondylar processes in the arctic fox are better developed than in the red fox. However, the tympanic bullae of the arctic fox are smaller. The foramen magnum of the arctic fox is wider than in the red fox (Figs. 7a, 7b).

The body of mandible in the arctic fox is high and its ventral margin is significance arcuate. On the mandible of the arctic fox is one mental foramen. Two mental foramina of the mandible in the red fox are distant from one another. The masseteric fossa is deeper and clearly marked in the arctic fox. However, in the red fox, the mandibular notch and angular process are better developed (Figs. 8a, 8b).

The following morphological differences in the studied species were confirmed from skull measurements. All measurements of the skull length (A-P, Cbl, B-P) revealed significant differences between sexes in both studied species. Measurements related to the viscerocranium (N-P, Fm-P, N-Rh) showed significant differences between sexes except measurements of snout length (Or-P). Among the measurements of the palatine, three concerning the length of the palatine (S-P, St-P, St-P*) and one of the breadth of the palatine (GPB) revealed significant differences between sexes. All measurements of palatal breadth showed significant species differences. Both measurements of the length of palatal bone (St-Po, St-Po*) were not significantly different between either species or sexes (Table 1).

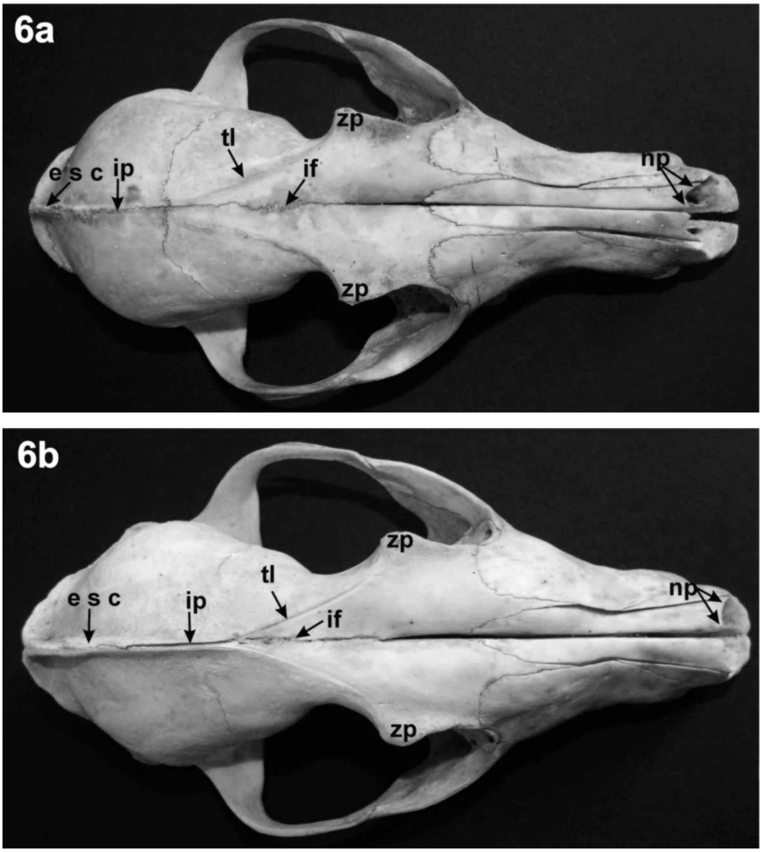

Fig. 6a-6b. Dorsal view of the skull of the red fox (6a) and the arctic fox (6b): esc – external sagittal crest, ip – interparietal suture, tl – temporal line, if – interfrontal suture, zp – zygomatic process, np – nasal processes
Rys. 6a-6b. Widok grzbietowy czaszki lisa srebrzystego (6a) i lisa polarnego (6b): esc – grzebień strzałkowy zewnętrzny, ip – szew międzyciemieniowy, tl – kresa skroniowa, if – szew międzyczołowy, zp – wyrostek jarzmowy, np – wyrostki nosowe

Among the measurements related to the base of the skull, the most significant differences were between sexes in the length of the basicranial axis (B-S) and between species in the mastoid breadth of the base of the skull (Ot-Ot). In the neurocranium, the most significant species differences were related to measurements of the breadth (LBS) and the height of the neurocranium (Sh). Most measurements of the length of the mandible (Cp-I, Cp-Ap, Ap-Ca) revealed significant differences between species, among which the Cp-Ca and Ap-Ca measurements also showed significant sex differences. Measurements of the posterior part of the body of mandible (HM1) revealed very significant differences between species, while the measurements of the anterior part of the body of mandible (HP2-P3) revealed significant differences between species and sexes.

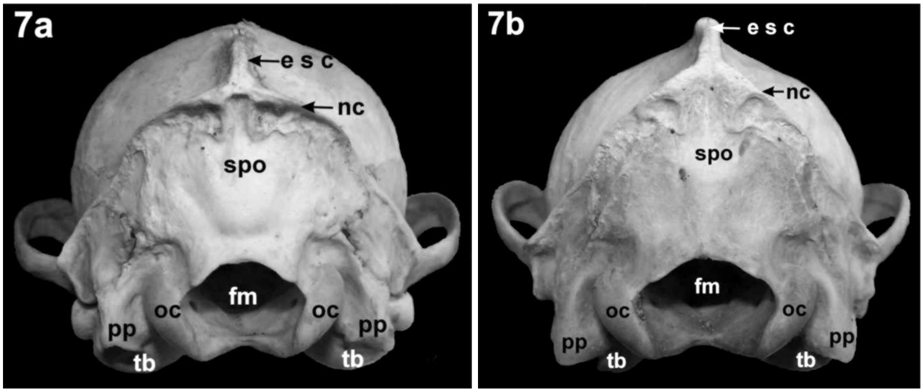

Fig. 7a-7b. Nuchal view of the skull of the red fox (7a) and the arctic fox (7b): esc – external sagittal crest, nc – nuchal crest, spo – squamous part of the occipital bone, oc – occipital condyle, pp – paracondylar process, tb – tympanic bulla, fm – foramen magnum
Rys. 7a-7b. Widok karkowy czaszki lisa srebrzystego (7a) i lisa polarnego (7b): esc – grzebień strzałkowy zewnętrzny, nc – grzebień karkowy, spo – część łuskowa kości potylicznej, oc – kłykieć potyliczny, pp – wyrostek przykłykciowy, tb – puszka bębenkowa, fm – otwór wielki

Most of the dental measurements of the skull and mandible revealed very significant differences between species (Table 1). In total 25, 22 and 8 significant differences were detected for species, sexes and interaction terms respectively out of the 55 variables analysed. The measurements describing the size of the skull were, in general, strongly positively correlated, so a principal components analysis (PCA) was done on skull measurements.

The first two principal components explained 50.4% of the total variance (34.9% and 18.5% for PCA1 and PCA2, respectively). The loadings of the first two principal components are shown in Table 2. The first principal component has positive loadings for most variables suggesting this is a "skull size" variable. The second principal component has large negative loadings (< –0.2) for greatest palatal breadth (GBP), least palatal breadth (PB), breadth of the canine alveoli (BCa) and height of mandible behind M1 (HM1). However, PCA2 has large positive loadings (> 0.2) for length of cheektooth row (LCR), length of premolar row (LPr), length from the aboral border of the alveolus of M3 to the aboral border of the canie alveolus (M3-Ca), length of the cheektooth row M3-P1 (M3-P1), length of the cheektooth row M3-P2 (M3-P2), length and breadth of the carnassials (LBC) and length of the carnassial alveolus (LCA).

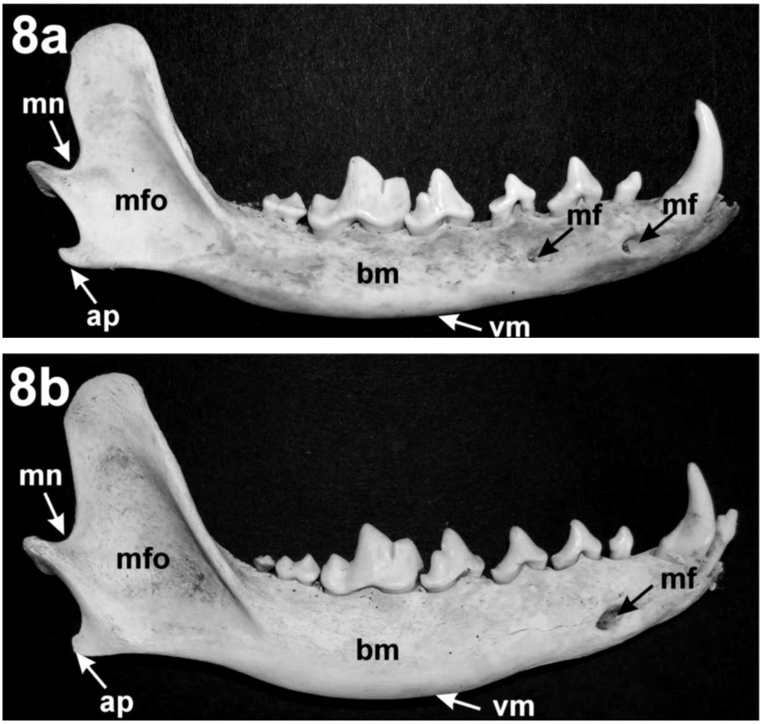

Fig. 8a-8b. Lateral view of the mandible of the red fox (8a) and the arctic fox (8b): vm – ventral margin of the body of the mandible – bm, mf – mental foramen, mfo – masseteric fossa, mn – mandibular notch, ap – angular process
Rys. 8a-8b. Widok boczny żuchwy lisa srebrzystego (8a) i lisa polarnego (8b): vm – brzeg dobrzuszny trzonu żuchwy – bm, mf – otwór bródkowy, mfo – dół żwaczowy, mn – wcięcie żuchwy, ap – wyrostek kątowy

Table 1. Mean, minimum and maximum values for skull and mandible measurements and an indication of the significance of differences between species, sexes and their interactions
Tabela 1. Wartości: średnia, minimalna i maksymalna pomiarów czaszki i żuchwy oraz wskazanie istotności różnic między gatunkami, płciami i ich interakcje

Cecha Feature	Arctic fox – Lis polarny						Red fox – Lis srebrzysty						Significances, P Istotności, P		
	♀			♂			♀			♂					
	x̄	Min	Max	x̄	Min	Max	x̄	Min	Max	x̄	Min	Max	species gatunek	sex płeć	inter-actions inter-akcje
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A-P	141.00	138.7	148.4	149.60	140.5	169.2	142.30	135.0	146.2	143.00	131.7	148.4	0.014	0.007	0.009
B-P	129.50	127.6	136.8	136.10	128.6	145.8	130.90	121.7	136.4	133.50	123.7	139.5	0.111	< 0.001	0.445
CbL	135.40	133.5	142.4	142.90	135.3	152.6	138.30	128.2	143.5	139.40	130.9	145.2	0.136	0.002	0.128

Table 1 – cont. / Tabela 1 – cd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
B-S	36.14	35.4	37.9	38.14	35.4	45.0	36.32	33.7	38.5	37.50	34.1	40.4	0.658	0.003	0.069
S-P	93.53	92.3	97.9	98.51	92.5	105.5	95.14	87.9	99.6	96.33	88.4	105.0	0.791	0.019	0.002
Ak-Fm	62.68	59.5	65.2	65.05	61.7	70.4	66.34	60.7	68.4	66.92	61.9	73.7	< 0.001	0.05	0.031
N-P	67.29	63.7	70.6	72.63	67.4	78.0	70.68	61.7	74.5	74.02	67.6	82.0	0.082	< 0.001	0.617
Fm-P	82.82	64.5	87.7	89.23	84.3	95.0	83.20	78.6	86.4	85.98	76.6	94.5	0.044	0.003	0.589
N-Rh	53.97	47.2	69.5	58.71	54.4	62.5	54.64	43.5	59.0	58.85	52.9	65.2	0.381	0.001	0.629
Or-P	59.25	44.6	64.1	62.89	48.5	82.0	60.97	55.8	63.5	60.80	53.2	65.5	0.854	0.311	0.564
St-P	72.26	69.4	76.7	75.30	70.9	81.9	72.02	67.5	75.1	73.65	64.9	83.3	0.456	0.061	0.456
St-P*	70.44	68.4	73.3	72.94	68.8	78.1	69.73	59.2	73.5	72.55	64.1	80.8	0.057	0.023	0.366
St-Po	22.39	20.2	23.7	22.70	20.9	24.9	21.58	19.7	23.4	22.53	19.4	25.8	0.854	0.011	0.747
St-Po*	21.27	19.3	21.2	20.54	18.9	21.6	20.43	18.7	31.7	20.99	18.1	23.3	0.369	0.787	0.293
LCR	51.61	50.3	54.7	54.28	50.9	59.7	47.66	45.0	51.4	46.99	41.4	52.3	< 0.001	0.431	0.001
LMr	13.27	12.5	14.2	14.54	12.6	19.0	11.84	10.8	13.5	11.72	11.1	13.1	< 0.001	0.272	0.021
LPr	38.30	36.6	41.6	41.26	36.7	45.9	34.43	26.6	39.8	35.76	30.6	40.1	< 0.001	0.043	0.257
DAB	20.36	17.2	22.1	21.14	20.0	23.1	20.64	19.3	22.3	20.71	18.9	21.5	0.892	0.142	0.047
Ot-Ot	45.73	42.9	49.1	46.85	43.2	49.6	47.79	44.9	50.4	48.43	45.6	52.5	0.067	0.069	0.886
BAm	42.66	37.2	48.0	42.20	37.0	47.8	43.17	27.1	47.6	45.12	38.0	51.4	0.095	0.599	0.584
BOc	25.11	24.5	26.2	25.68	23.9	27.4	25.77	23.5	27.2	26.14	23.9	28.9	0.552	0.142	0.683
BPp	38.44	35.4	41.2	37.31	24.9	45.5	37.02	33.7	41.6	38.34	33.5	43.9	0.707	0.923	0.307
BFm	14.64	14.1	15.4	14.76	13.3	15.8	14.56	13.4	15.3	14.57	12.9	15.6	0.608	0.771	0.677
B-Op	11.68	10.0	13.3	11.27	9.7	12.8	11.80	10.3	12.8	11.97	10.4	13.6	0.372	0.656	0.349
NB	45.69	43.5	47.4	45.77	43.5	47.9	45.50	44.1	48.3	46.04	44.5	47.5	0.276	0.413	0.398
Zy-Zy	72.64	69.6	76.3	74.59	71.2	77.5	72.27	69.2	78.9	73.08	67.9	78.8	0.292	0.073	0.249
LBS	24.56	20.9	27.6	22.95	21.5	26.1	21.49	19.2	24.7	21.84	20.4	23.5	< 0.001	0.031	0.021
Ect-Ect	35.38	33.3	40.2	35.72	33.9	39.3	34.51	31.4	39.2	35.78	31.5	39.6	0.652	0.321	0.125
Ent-Ent	26.98	24.3	29.1	28.57	25.2	38.2	29.29	26.7	32.4	29.65	27.5	32.1	0.002	0.006	0.411
GPB	39.56	37.8	40.6	41.62	39.1	43.9	42.83	38.6	45.5	43.05	39.6	45.7	0.365	0.098	0.058
PB	21.42	19.9	23.4	22.89	21.1	24.8	25.84	19.1	30.3	26.01	20.5	28.9	< 0.001	0.002	0.003
BCa	23.76	22.6	26.1	25.15	24.2	26.7	27.83	21.5	31.4	28.18	23.6	29.9	< 0.001	0.021	0.211
Sh	40.67	36.4	44.2	40.84	38.2	42.9	42.80	37.8	47.3	43.05	40.3	49.0	0.004	0.475	0.996
Sh*	39.30	33.2	42.8	39.04	35.6	41.0	39.41	36.2	41.7	39.05	35.1	43.3	0.654	0.425	0.874
Ak-B	31.54	30.0	33.5	33.68	30.1	39.8	33.42	30.2	35.0	33.87	30.6	37.9	0.065	0.031	0.199
IHO	25.28	24.0	29.2	26.65	24.3	28.9	24.34	22.2	25.5	24.69	22.6	26.5	< 0.001	0.089	0.729
Cp-I	105.10	101.3	116.8	110.20	104.1	118.7	106.10	99.3	110.9	107.70	98.7	113.2	0.541	0.011	0.211
Ap-I	102.10	96.7	106.0	106.90	100.7	114.4	101.10	96.3	106.1	97.00	47.3	107.4	0.03	0.654	0.124

Table 1 – cont. / Tabela 1 – cd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Cp-Ap	98.74	93.7	103.3	103.42	98.3	108.7	98.90	93.4	103.7	99.48	91.7	104.9	0.006	0.011	0.192
Cp-Ca	93.31	89.6	101.4	97.90	91.3	102.8	92.03	86.3	95.7	93.37	85.6	98.8	< 0.001	0.012	0.35
LCp-Ap	87.33	83.5	90.2	86.25	82.8	96.4	84.58	79.1	88.9	86.69	78.8	98.4	0.698	0.959	0.541
Ap-Ca	89.71	86.3	93.1	94.83	88.4	99.4	88.36	79.0	95.4	90.04	80.7	97.9	0.007	0.023	0.437
M3-Ca	61.86	57.3	66.0	65.79	57.0	69.7	58.26	55.3	62.4	58.34	54.2	73.8	< 0.001	0.013	0.323
M3-P1	58.90	56.9	63.2	62.20	59.8	65.6	56.00	53.1	58.4	56.13	52.3	60.4	< 0.001	0.044	0.037
M3-P2	54.57	52.8	58.6	57.29	53.3	61.7	50.19	43.7	54.1	51.20	48.4	55.8	< 0.001	0.079	0.242
LMR	25.24	21.3	29.3	25.54	18.3	28.6	25.69	22.9	32.3	23.80	21.7	25.3	0.535	0.415	0.251
P1-P4	33.09	31.0	35.0	35.43	33.5	38.2	32.47	30.2	34.7	32.27	31.0	34.3	< 0.001	0.021	0.025
P2-P4	29.74	27.2	44.9	28.31	27.8	33.0	27.44	24.1	29.1	27.48	26.3	29.6	0.005	0.501	0.352
LBC	14.78	13.4	16.0	15.59	14.6	16.6	14.09	13.4	15.5	13.90	12.9	15.6	< 0.001	0.201	0.041
LCA	13.76	12.2	15.0	14.46	13.2	15.9	12.76	11.7	14.5	12.31	11.5	13.9	< 0.001	0.937	0.005
LM2	7.21	6.5	7.7	7.38	6.7	8.2	6.47	5.6	7.9	6.54	5.0	7.2	< 0.001	0.821	0.492
LM3	3.29	2.9	4.2	3.41	2.9	4.6	3.32	2.7	3.7	3.54	2.5	4.2	0.556	0.291	0.257
HVR	37.46	36.3	41.6	39.42	34.0	42.5	37.77	28.4	40.9	39.38	36.7	43.0	0.187	0.03	0.552
HM1	13.85	13.0	15.0	14.65	13.2	16.6	16.59	12.9	17.9	16.87	13.7	19.9	< 0.001	0.076	0.705
HP2-P3	11.79	11.0	13.4	12.81	12.0	14.4	13.36	8.2	15.1	14.02	10.3	15.3	0.003	0.002	0.757
PCA1	–2.45			3.29			–1.45			0.47			0.488	0.006	0.152
PCA2	2.96			2.99			–2.74			–3.49			< 0.001	0.312	0.271

Table 2. Loadings of the first two principal components for respective variables
Tabela 2. Wartości dwóch pierwszych składowych głównych dla poszczególnych zmiennych

Variable Zmienna	PCA1	PCA2	Variable Zmienna	PCA1	PCA2
1	2	3	4	5	6
A-P	0.193	0.045	Ent-Ent	0.084	–0.146
B-P	0.213	–0.014	GPB	0.100	–0.208
CbL	0.196	–0.013	PB	0.087	–0.242
B-S	0.179	–0.015	BCa	0.082	–0.257
S-P	0.211	–0.027	Sh	0.075	–0.157
Ak-Fm	0.149	–0.170	Sh*	0.112	–0.027
N-P	0.179	–0.110	Ak-B	0.167	–0.093

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Table 2 – cont. / Tabela 2 – cd.

1	2	3	4	5	6
Fm-P	0.200	0.034	IHO	0.146	0.101
N-Rh	0.158	–0.060	Cp-I	0.196	–0.035
Or-P	0.103	0.006	Ap-I	0.117	0.077
St-P	0.206	0.012	Cp-Ap	0.197	0.032
St-P*	0.186	–0.005	Cp-Ca	0.197	0.062
St-Po	0.126	0.054	LCp-Ap	0.095	0.005
St-Po*	0.026	0.016	Ap-Ca	0.194	0.047
LCR	0.115	0.241	M3-Ca	0.085	0.221
LMr	0.007	0.067	M3-P1	0.146	0.200
LPr	0.097	0.205	M3-P2	0.101	0.218
DAB	0.099	–0.011	LMR	0.094	0.193
Ot-Ot	0.152	–0.168	P1-P4	0.152	0.160
BAm	0.018	–0.112	P2-P4	0.078	0.141
BOc	0.145	–0.094	LBC	0.081	0.215
BPp	0.116	–0.058	LCA	0.062	0.222
BFm	0.036	0.089	LM2	0.091	0.183
B-Op	0.063	–0.115	LM3	0.096	–0.068
NB	0.059	–0.019	HVR	0.112	–0.043
Zy-Zy	0.162	–0.012	HM1	0.107	–0.241
LBS	0.020	0.117	HP2-P3	0.113	–0.174
Ect-Ect	0.094	–0.034			

Discussion

Comparative studies of the skulls of wild raccoon dog and badger were conducted by HIDAKA et AL. (1998). They found that the most distinct morphological differences were found in cranium bones, especially in the nasal, the occipital, the temporal bones, and the maxilla and the mandible areas. Sexual dimorphism was also detected in the badgers for the temporal and the occipital bone but was not in the raccoon dogs. Our study revealed that meaningful morphological differences were observed in nasal, temporal, parietal and occipital bones of both species.

SJŘVOLD (1977) compared morphological differences in the skulls of captive arctic foxes and wild red foxes. The accessory mental foramina in red fox were reported by this author, and they were confirmed by our data. Growth in size of skulls of Danish populations of badger and red fox during the 20th century, under the influence of changing diet and changes in climate, were show by YOM-TOV et AL. (2003). They confirmed that the measured traits of the molars in females of the studied species (badger and red fox) were larger than in males. However, this was not a consequence of changing climate, but reflects their role in raising offspring (more food, richer diet). In our study showed that length of the molar row of maxilla was larger in females than in males of both species. The length of the molar row of mandible of females red fox was larger than in males. However, this trait in arctic fox was greater in males.

Our comparative study of the red and arctic fox skulls revealed better fully-developed external sagittal crest in the arctic fox. However, JURGELENAS et AL. (2007), comparing skulls of the raccoon dog and wild red fox, more clearly affirmed the sketched external sagittal crest in raccoon dog. Differences were also observed in a shape of the foramen magnum between wild red fox and raccoon dog. The foramen magnum of the red fox was V-shaped but in the raccoon dog – U-shape. Our study revealed, that in the red and arctic fox the foramen magnum was similar to U-letter. However, the foramen magnum of the arctic fox is more elongated than in the red fox. JURGELENAS et AL. (2007) observed double mental foramen in the wild red fox and single one in the raccoon dog. In our study two mental foramina were revealed in the red fox. The arctic fox always had one mental foramen.

One can hypothesis that changes in the morphology of skulls of the studied species may be under intensive selection to enlarge the body sizes of fur animals. MCPHEE (2004) described changes in the skull morphology of a mouse species (*Peromyscus polionotus subgriseus*) under the influence of the domestication process. In studies over 35 generations she found that the skulls of "founders" of the generation were larger than the first descendent generation, but were smaller than the skulls of captive mice from the same population.

Conclusions

1. The red fox skull is longer and narrower, while the skull of the arctic fox is shorter and more massive.
2. The measurements describing the size of the skull and mandible are, in general, strongly positively correlated.
3. Osteometric analysis of some cranial features reveal sexual differences in both species.

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KRANIOMETRIA PORÓWNAWCZA I MORFOLOGIA CZASZKI LISA SREBRZYSTEGO (*VULPES VULPES*) I LISA POLARNEGO (*VULPES LAGOPUS*)

Streszczenie. Celem badania było sprawdzenie, czy istnieją morfologiczne i morfometryczne różnice pomiędzy lisem srebrzystym (*Vulpes vulpes*) i lisem polarnym (*Vulpes lagopus*). Badania zostały przeprowadzone na 39 czaszkach lisów trzymanych w hodowli, mających około jednego roku. Cechy opisujące wielkość czaszki były ogólnie silnie dodatnio skorelowane, dlatego zastosowano analizę składowych głównych (PCA). Czaszki lisa srebrzystego były dłuższe niż u lisa polarnego, ale miały bardziej delikatną konstrukcję. Lisy polarne miały skróconą część twarzową czaszki i bardziej zwartą żuchwę. PCA wykazała różnice parametrów czaszki dwóch badanych gatunków lisów utrzymywanych w hodowli. Analiza osteometryczna niektórych cech czaszkowych wykazała różnice ze względu na płeć u obu badanych gatunków.

Słowa kluczowe: morfologia, morfometria, czaszka, lis srebrzysty, lis polarny

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