FOLIA POMERANAE UNIVERSITATIS TECHNOLOGIAE STETINENSIS
Folia Pomer. Univ. Technol. Stetin., Agric., Aliment., Pisc., Zootech. 2014, 309 (29), 25–40

Lidia FELSKA-BŁASZCZYK, Piotr BARANOWSKI, Katarzyna PĘZIŃSKA-KIJAK, Piotr NOWAK, Olga STELTER

THE ASYMMETRY OF SELECTED SKELETON ELEMENTS IN RED FOX (*VULPES VULPES*) AND RACCOON DOG (*NYCTEREUTES PROCYONOIDES*), BOTH WILD AND FARMED

ASYMETRIA WYBRANYCH ELEMENTÓW SZKIELETU LISA POSPOLITEGO (*VULPES VULPES*) I JENOTA (*NYCTEREUTES PROCYONOIDES*) DZIKIEGO I HODOWLANEGO

Laboratory of Animal Anatomy, Faculty of Biotechnology and Animal Science, West Pomeranian University of Technology, Szczecin, Poland

Streszczenie. Celem badań było określenie wpływu pochodzenia i płci zwierząt na występowanie symetrii lub asymetrii wybranych elementów szkieletu kończyny piersiowej lisa pospolitego dzikiego i hodowlanego oraz jenota dzikiego i hodowlanego. Badania przeprowadzono na 20 osobnikach lisa pospolitego hodowlanego (10 samców i 10 samic) i 24 osobnikach lisa dzikiego (15 samców i 9 samic) oraz na 20 osobnikach jenota hodowlanego (10 samic i 10 samców) i 12 osobnikach jenota dzikiego (6 samic i 6 samców). Od wszystkich osobników wypreparowano elementy prawej i lewej kończyny obręczy piersiowej (*cingulum membri thoracici*) – łopatkę (*scapula*) oraz kościec części wolnej kończyny piersiowej reprezentowany przez kość ramienną (*humerus*), kość promieniową (*radius*) i kość łokciową (*ulna*). Kości zostały zmierzone za pomocą suwmiarki elektronicznej. W wyniku przeprowadzonych badań stwierdzono, że asymetria kości kończyny przedniej występuje sporadycznie i zasadniczo u zwierząt hodowlanych. Na wszystkie analizowane cechy metryczne wybranych kości miały wpływ badane źródła zmienności (pochodzenie zwierząt oraz płeć). W kości ramiennej lisów pospolitych stwierdzono asymetrię lewostronną, która występowała również w pozostałych elementach szkieletu. Przeprowadzone badania skłaniają do stwierdzenia, że utrzymanie zwierząt w warunkach hodowli stabulacyjnej może mieć wpływ na pojawianie się zjawiska asymetrii szkieletu w obręczy piersiowej.

Key words: domestication, fluctuating asymmetry, *humerus*, *radius*, relative asymmetry, *scapula*, ulna.
Słowa kluczowe: asymetria fluktuacyjna, asymetria względna, domestykacja, *humerus*, *radius*, *scapula*, *ulna*.

INTRODUCTION

The red fox is one of the world's most common carnivore (Vos 1995; Cavallini 1996; Cavallini and Santini 1996; Gortázar et al. 2003; Aubry et al. 2009). The first farm of red foxes were started in the nineteenth century, so the history of red fox breeding is more than

Corresponding autor – Adres do korespondencji: PhD Lidia Felska-Błaszczyk, Laboratory of Animal Anatomy, Faculty of Biotechnology and Animal Science, West Pomeranian University of Technology, Szczecin, Doktora Judyma 14, 71-466 Szczecin, Poland, e-mail: lidia.felska-blaszczyk@zut.edu.pl

120 years old. Raccoon dog breeding, on the other hand, does not have such a long tradition, and in Poland it has been carried out for about 50 years. The first attempts to farm this species took place in Russia (Gugołek 2013). Raccoon dog was brought to Europe between the years 1927–1957, and some animals were released into the wild for hunting purposes, and some allocated to farming farmed game (Kowalczyk et al. 2009; Święcicka et al. 2011; Mohammad Nafi Solaiman Al-Sabi et al 2013; Gugołek 2013). Currently, the raccoon dog occurs is a part of the ecosystem across the entire Northern and Central Europe.

Farming has induced a number of changes in the morphology and etiology of the red fox and, as a result, many differences exist between red foxes from the wild population and those bred on farms. For example, farmed foxes are characterized by a heavier body weight and shorter length compared to the wild-living red foxes (Felska-Błaszczyk et al. 2013). Forelimbs are significantly longer in farmed foxes. Wild foxes also show a considerable obliteration of sexual dimorphism within some skeletal characters (Felska-Błaszczyk et al. 2013). Besides morphology, farmed foxes differ in terms behavior from their wild kins. As a result of farming, the foxes have gradually lost the ability hunting, movement and orientation in the wild (O'Regan and Kitchener 2005). Wild foxes are also characterized by a stronger environmental and genetic variability (Cavallini 1997; Nowicki 2005).

Farmed animals are managed under relatively constant conditions, under the stability that is unknown in nature. Food availability, cage sizes, and selection are the factors that alter not only body size, but also may impose asymmetry in various morphological characters. Fluctuating asymmetry, which reflects the effects of environmental conditions on the bilateral traits f the skeleton (Siegel et al. 1977), can represent a measure of environmental impact in terms of the body symmetry (Hallgrimsson 1993; Graham et al. 1994; Tomkins and Kotiaho 2001). A certain degree of asymmetry in the body can be a result of various environmental factors that shape the final phenotypic image of the individual. It can be used for evaluating the adaptation and effects of living conditions on the organism. The degree of asymmetry can be used in studies on genotype-environment interactions and demonstrates whether the environment of the animals – natural or on-farm – is of an effect in terms of bilateral differences in morphology. Relative body asymmetry is another measure showing differences between the left and the right side of the body (Henneberg 1974; Baranowski and Wojtas 2011).

The aim of the study was to determine the effect of origin on the presence of asymmetry in selected bones of the forelimb of the red fox and raccoon dog living in different environments: natural and farm.

MATERIAL AND METHODS

The study involved 20 farmed red foxes (10 males and 10 females), 24 wild foxes (15 males and 9 females), 20 farmed raccoon dogs (10 males and 10 females), and 12 wild raccoon dogs (6 males and 6 females). The animals were collected in southern Poland; the wild foxes and raccoon dogs were captured in restraining traps, and the farmed animals were obtained from a fur farm. The following right- and left-side skeletal parts were dissected from all individuals: the shoulder blade (scapula) of the pectoral girdle (*cingulum membri thoracici*) and the thoracic limb bones, the humerus, the radius, and the ulna. Each bone underwent bilateral measurements using the methodology drawn from studies by Alpak et al. (2004) and Monchot and Gendron (2010).

The humerus was measured for the following morphometric characters: greatest length (GL), greatest length of the lateral part (GLI, from the cranial part of the lateral tuberosity to the most distal point of the lateral border of the trochlea), greatest length from caput (GLC), greatest breadth of the proximal end (BP), greatest breadth of the distal end (BD), greatest breadth of the trochlea (BT) smallest breadth of diaphysis (SD). The radius was measured for: greatest length (GL), greatest breadth of the proximal end (BP), greatest breadth of the distal end (BD), smallest breadth of diaphysis (SD). The ulna: greatest length (GL), smallest depth of the olecranon (SDO), depth across the anconeal process (DPA). The scapula: greatest dorsal length (LD), height along the spine (HS, external length of the scapula), diagonal height (DHA), smallest length of the collum scapulae (SCL), greatest length of the glenoid process (GLP).

The resulting data were processed statistically using Statistica v.10.0 PL package. Arithmetic mean, standard deviation (SD), and the coefficient of variability (V%) were calculated. To determine the effect of origin and sex between the averages in each measurement, nonparametric Mann-Whitney U-test was used. The effects of origin, sex, and the body was calculated using an F test of asymmetry relative values (AW) and fluctuating asymmetry (FA) was estimated by the following equations (Henneberg 1974), whose formulas are shown below:

$$RA = \frac{(\bar{r} - \bar{l}) \times 100}{\bar{l}}$$

Where:
RA – relative asymmetry,
$\bar{r}$ – right-side mean,
$\bar{l}$ – left-sie mean.

$$FA = \frac{varr - l}{\sqrt{varr \times varl}}$$

Where:
FA – fluctuating asymmetry,
r – right-side,
l – left-side.

Positive values of both relative and fluctuating asymmetry denote right-side asymmetry, while negative – left-side asymmetry. To determine the effect of differences between the characters depending on which side of the body they are located, we used the sign test and Wilcoxon matched pairs test.

RESULTS AND DISCUSSION

Table 1 presents the effect of selected sources of variability on some characters of pectoral girdle bones in the red fox. We found a significant effect of origin (wild vs. farmed foxes) on three characters in the scapula, four in the humerus and radius, and one in the ulna. Sex of the foxes was a significant source od variability in the case of all the traits in the studied bones. We did not, on the other hand, find a statistically significant effect of the side of the body on the studied traits. Interactions estimated for origin and sex of the studied bones were significant ($P \leq 0.05$ and $P \leq 0.01$) for 12 out of 19 studied characters of the bones of the pectoral girdle.

Table 1. Sources of variability included in the linear model and estimation of their effect on the paramters of pectoral girdle and forelimb bones in the red fox
Tabela 1. Efekty uwzględnione w modelu liniowym i ocena ich wpływu na parametry kości obręczy przedniej lisa pospolitego

Trait – Cecha	Effect of origin Wpływ pochodzenia	Effect of sex Wpływ płci	Effect of the body side Wpływ strony ciała	Interactions Interakcje
		SCAPULA – ŁOPATKA		
LD	95.27**	60.66**	0.16	11.13** †
HS	8.85**	104.27**	0.18	0.02-0.60
DHA	3.45	113.31**	0.13	0.00–0.32
SCL	5.93*	36.80**	0.00	4.93* †
GLP	0.56	100.47**	3.39	7.58** †
		HUMERUS – KOŚĆ RAMIENNA		
GL	42.45**	142.31**	0.10	3.38* †
GLI	46.38**	131.24**	0.12	5.13* †
GLC	39.88**	120.31**	0.06	4.30* †
BP	1.07	52.37**	3.85	8.11** †
BD	1.00	57.81**	0.00	0.16–0.35
BT	0.49	15.36**	0.24	0.01–0.76
SD	13.24**	27.84**	0.28	17.29** †
		RADIUS – KOŚĆ PROMIENIOWA		
GL	28.57**	137.21**	0.04	7.75** †
BP	5.62*	55.84**	0.37	0.11–3.54
BD	7.98**	57.82**	0.04	8.55** †
SD	136.73**	6.49*	0.03	21.45** †
		ULNA – KOŚĆ ŁOKCIOWA		
GL	26.02**	103.61**	0.43	8.19** †
SDO	3.29	43.74**	0.04	0.03–2.75
DPA	0.08	36.82**	1.19	0.00–0.90

Explanations: column “Interactions” contain interaction value or its range;
† – interaction: origin × sex,
** – statistical significance at P ≤ 0.01,
* – statistical significance P ≤ 0.05.
Objaśnienia: w kolumnie „Interakcje” wpisano wartości interakcji lub zakres wartości interakcji;
† – interakcja: pochodzenie × płeć,
** – wpływ statystyczny czynnika na poziomie P ≤ 0,01,
* – wpływ statystyczny czynnika na poziomie P ≤ 0,05.

Tables 2–5 present the statistical characterization of the traits of the scapula, humerus, radius, and the ulna of females and males of the red fox. We found significant (P ≤ 0.05 and P ≤ 0.01) bilateral differences, confirmed by a significant (P ≤ 0.05) value of the sign test, for such traits as:

- the height along the spine (HS) of the scapulae in farmed fox females,
- the greatest breadth of the trochlea (BT) of wild fox females,
- the greatest breadth of the proximal end (BP) of the radius in farmed fox females, and
- the greatest breadth of the distal end (BD).

None of the three studied morphometric characters of the ulna, either in males or females of the red fox, showed a significant bilateral difference.

The skeletal elements of the pectoral girdle in raccoon dogs showed a significant effect of origin on most of the characters included in the analysis (Table 6). No statistically significant effect of origin (natural or farm conditions) was found in relation to the smallest length of the collum scapulae (SCL), greatest breadth of the proximal end (BP) or the smallest breadth of diaphysis (SD).

Table 2. Statistical characteristics of the scapula morphometrics in the red fox
Tabela 2. Charakterystyka statystyczna wymiarów łopatki lisa pospolitego

Trait Cecha	Origin Pochodzenie	Sex Płeć	Body side Strona ciała	m (mm)	SD	V%	RA	FA	TpW	TZ
LD	Farmed fox Lis hodowlany	F	L	50.75	2.32	4.58	0.00	0.102	0.721	0.752
			R	50.75	2.44	4.82				
		M	L	52.82	1.73	3.26	0.57	0.247	0.445	0.752
			R	53.12	1.96	3.69				
	Wild fox Lis dziki	F	L	43.88	1.10	2.52	1.62	0.601	0.500	1.000
			R	44.59	1.48	3.33				
		M	L	49.87	2.16	4.34	–0.41	0.109	0.551	0.423
			R	49.67	2.29	4.60				
HS	Farmed fox Lis hodowlany	F	L	82.59	1.35	1.63	1.09	0.544	0.005**	0.004**
			R	83.49	1.76	2.11				
		M	L	88.17	1.16	1.31	0.46	0.221	0.047*	0.114
			R	88.57	1.29	1.46				
	Wild fox Lis dziki	F	L	81.31	2.14	2.63	–0.37	0.273	0.249	0.683
			R	81.01	2.39	2.95				
		M	L	87.04	3.38	3.89	–0.09	–0.118	0.754	0.789
			R	86.95	3.19	3.67				
DHA	Farmed fox Lis hodowlany	F	L	82.00	1.78	2.17	0.18	0.125	0.476	0.752
			R	82.15	1.89	2.30				
		M	L	87.32	1.77	2.03	0.68	–0.646	0.114	0.343
			R	87.91	1.29	1.47				
	Wild fox Lis dziki	F	L	80.80	1.61	1.99	–0.16	0.883	0.046*	0.221
			R	80.67	2.46	3.05				
		M	L	86.81	3.10	3.57	0.23	0.087	0.311	1.000
			R	87.01	3.24	3.72				
SCL	Farmed fox Lis hodowlany	F	L	15.27	0.42	2.76	0.58	–0.118	0.386	0.752
			R	15.36	0.39	2.57				
		M	L	16.11	0.67	4.15	1.47	–0.315	0.074	0.114
			R	13.35	0.57	3.51				
	Wild fox Lis dziki	F	L	15.40	0.98	6.35	–0.52	–0.147	0.600	0.683
			R	15.32	0.91	5.92				
		M	L	17.43	1.39	7.97	–1.06	3.00	0.132	0.181
			R	17.24	1.59	9.22				
GLP	Farmed fox Lis hodowlany	F	L	17.63	0.38	2.16	–1.24	0.660	0.169	0.343
			R	17.41	0.39	2.25				
		M	L	18.61	0.41	2.20	–0.44	–0.357	0.508	0.752
			R	18.53	0.34	1.87				
	Wild fox Lis dziki	F	L	17.46	0.72	4.16	–2.62	0.074	0.249	0.683
			R	17.00	0.75	4.42				
		M	L	19.24	0.85	4.41	–1.62	–0.134	0.026*	0.061
			R	18.93	0.79	4.20				

Explanations: – Objaśnienia:
F – female – samica; M – male – samiec; L – left body side – L strona ciała; R – right body side – prawa strona ciała; RA – Relative asymmetry value – wartości wskaźnika asymetrii względnej; FA – fluctuating asymmetry value – wartości wskaźnika asymetrii fluktuacyjnej; TpW – Wilcoxon test value – wartość testu Wilcoxona; TZ – sign test value – wartość testu znaków;
** Wilcoxon test or sign test value significant at P ≤ 0.01 – wartość testu Wilcoxona lub testu znaków istotna przy P ≤ 0,01;
* Wilcoxon test or sign test value significant at P ≤ 0.05 – wartość testu Wilcoxona lub testu znaków istotna przy P ≤ 0,05.

Table 3. Statistical characteristics of the humerus morphometrics in the red fox
Tabela 3. Charakterystyka statystyczna wymiarów kości ramiennej lisa pospolitego

Trait Cecha	Origin Pochodzenie	Sex Płeć	Body side Strona ciała	m (mm)	SD	V%	RA	FA	TpW	TZ
GL	Farmed fox Lis hodowlany	F	L	126.79	5.71	4.50	1.26	–1.416	0.285	0.752
			R	128.39	2.95	2.30				
		M	L	136.88	3.99	2.91	–0.25	–0.278	0.139	0.343
			R	136.54	3.47	2.54				
	Wild fox Lis dziki	F	L	119.72	3.97	3.32	–1.49	–0.265	0.686	1.000
			R	117.93	3.48	2.95				
		M	L	133.18	4.29	3.22	–0.51	–0.087	0.937	0.386
			R	132.50	4.11	3.10				
GLI	Farmed fox Lis hodowlany	F	L	125.52	5.65	4.50	1.04	–1.302	0.799	0.752
			R	126.83	3.06	2.42				
		M	L	135.16	3.77	2.79	–0.03	0.013	0.721	0.752
			R	135.11	3.80	2.81				
	Wild fox Lis dziki	F	L	118.27	4.26	3.60	–1.58	–0.437	0.500	0.371
			R	116.40	3.43	2.94				
		M	L	131.07	4.30	3.28	–0.55	–0.124	0.814	0.773
			R	130.34	4.04	3.10				
GLC	Farmed fox Lis hodowlany	F	L	123.83	6.98	5.63	1.60	–1.822	0.285	0.752
			R	125.80	3.08	2.45				
		M	L	134.08	4.28	3.20	–0.09	–0.255	0.799	0.752
			R	133.96	3.77	2.82				
	Wild fox Lis dziki	F	L	117.20	4.15	3.54	–1.82	–0.337	0.584	0.617
			R	115.06	3.51	3.05				
		M	L	129.98	4.16	3.20	–0.54	–0.141	0.790	1.000
			R	129.28	3.87	3.00				
BP	Farmed fox Lis hodowlany	F	L	18.11[a]	1.18	6.51	–4.04	–2.42	0.047*	0.114
			R	17.38[a]	0.42	2.43				
		M	L	18.70	0.49	2.63	–2.25	–0.181	0.037*	0.114
			R	18.28	0.45	2.49				
	Wild fox Lis dziki	F	L	17.46	0.79	4.56	–0.27	0.090	0.249	0.221
			R	17.42	0.83	4.79				
		M	L	19.22	0.73	3.79	–0.69	0.018	0.177	0.423
			R	19.08	0.73	3.84				
BD	Farmed fox Lis hodowlany	F	L	20.33	0.54	2.64	1.36	0.000	0.169	0.114
			R	20.61	0.53	2.59				
		M	L	21.77	0.41	1.87	–0.30	0.523	0.721	0.752
			R	21.70	0.53	2.43				
	Wild fox Lis dziki	F	L	20.24	0.77	3.82	–0.60	–0.052	0.917	0.683
			R	20.12	0.75	3.73				
		M	L	21.70	1.05	4.82	–0.34	0.053	0.507	1.000
			R	21.63	1.07	4.97				
BT	Farmed fox Lis hodowlany	F	L	12.69	0.43	3.43	3.12	–0.285	0.022*	0.114
			R	13.09	0.50	3.79				
		M	L	13.71	0.31	2.24	–0.08	0.50	0.959	0.752
			R	13.70	0.39	2.89				
	Wild fox Lis dziki	F	L	12.92	0.63	4.86	1.46	–0.054	0.028*	0.041*
			R	13.11	0.61	4.67				
		M	L	13.96	0.64	4.61	–1.12	2.655	0.397	0.789
			R	13.80	1.91	13.85				
SD	Farmed fox Lis hodowlany	F	L	7.70	0.47	6.06	–0.94	0.130	0.214	0.505
			R	7.63	0.50	6.52				
		M	L	7.80	0.36	4.63	–0.91	–0.400	0.093	0.114
			R	7.73	0.31	3.98				
	Wild fox Lis dziki	F	L	7.62	0.52	6.81	–0.09	–2.000	0.345	0.221
			R	7.61	0.22	2.96				
		M	L	8.53	0.42	4.93	–0.57	–0.125	0.363	0.423
			R	8.48	0.40	4.69				

Explanations: mean marked with lower-case letters differ in cilumns significantly at P ≤ 0.05; * – Wilcoxon test and sign test value significant at P ≤ 0.05.
Objaśnienia: średnie oznaczone w kolumnach małymi literami różnią się istotnie P ≤ 0,05; *– wartość testu par Wilcoxona i testu znaków istotna na poziomie P ≤ 0,05.

Table 4. Statistical characteristics of the radius morphometrics in the red fox
Tabela 4. Charakterystyka statystyczna wymiarów kości promieniowej lisa pospolitego

Trait Cecha	Origin Pochodzenie	Sex Płeć	Body side Strona ciała	m (mm)	SD	V%	RA	FA	TpW	TZ
GL	Farmed fox Lis hodowlany	F	L	120.14	2.22	1.85	0.22	–0.085	0.126	0.114
			R	120.41	2.13	1.77				
		M	L	127.97	3.30	2.58	–0.10	–0.049	0.878	0.752
			R	127.84	3.22	2.52				
	Wild fox Lis dziki	F	L	113.50	2.25	1.98	–0.29	1.298	0.068	0.134
			R	113.15	4.13	3.65				
		M	L	125.27	4.22	3.37	–0.70	10.73	0.638	0.773
			R	126.16	4.51	3.57				
BP	Farmed fox Lis hodowlany	F	L	11.05	0.37	3.39	2.89	–0.888	0.009**	0.027*
			R	11.37	0.25	2.22				
		M	L	11.74	0.24	2.09	0.42	0.333	0.541	0.752
			R	11.79	0.29	2.47				
	Wild fox Lis dziki	F	L	11.33	0.48	4.28	–1.23	–1.214	0.753	0.683
			R	11.19	0.59	5.30				
		M	L	12.18	0.47	3.84	5.00	0.346	0.917	1.000
			R	12.18	0.56	4.60				
BD	Farmed fox Lis hodowlany	F	L	14.64	0.43	2.93	1.09	0.333	0.059	0.114
			R	14.81	0.50	3.41				
		M	L	15.27	0.49	3.18	1.50	–0.238	0.051	0.182
			R	15.50	0.43	2.80				
	Wild fox Lis dziki	F	L	14.70	0.83	5.63	20.47	–0.193	0.043*	0.074
			R	14.71	0.75	5.13				
		M	L	16.34	0.77	4.69	–0.37	–0.590	0.006**	0.016*
			R	16.04	0.57	3.58				
SD	Farmed fox Lis hodowlany	F	L	7.12	0.57	8.07	–1.12	0.194	0.594	1.000
			R	7.04	0.63	9.01				
		M	L	6.86	0.50	7.26	–1.45	0.000	0.333	0.752
			R	6.76	0.50	7.45				
	Wild fox Lis dziki	F	L	7.91	0.76	9.57	–9.73	–1.058	0.116	0.683
			R	8.05	0.46	5.68				
		M	L	8.93	0.48	5.38	0.56	0.370	0.490	0.789
			R	8.88	0.57	6.47				

For explanations see Table 2.
Objaśnienia jak w tabeli 2.

Table 5. Statistical characteristics of the ulna morphometrics in the red fox
Tabela 5. Charakterystyka statystyczna wymiarów kości łokciowej lisa pospolitego

Trait Cecha	Origin Pochodzenie	Sex Płeć	Body side Strona ciała	m (mm)	SD	V%	RA	FA	TpW	TZ
GL	Farmed fox Lis hodowlany	F	L	140.35	2.53	1.80	0.33	0.057	0.047*	0.114
			R	140.82	2.60	1.85				
		M	L	148.82	3.80	2.55	–0.12	0.013	0.508	0.343
			R	148.64	3.82	2.57				
	Wild fox Lis dziki	F	L	132.74[a]	2.93	2.21	–1.53	9.965	0.068	0.134
			R	130.71[a]	7.99	6.11				
		M	L	146.83[b]	5.52	3.76	0.12	–0.232	0.552	1.000
			R	145.65[b]	4.91	3.37				
SDO	Farmed fox Lis hodowlany	F	L	12.44	0.53	4.25	0.64	0.000	0.203	0.114
			R	12.52	0.53	4.26				
		M	L	13.36	0.72	5.39	–1.42	–0.524	0.037*	0.343
			R	13.18	0.73	5.51				
	Wild fox Lis dziki	F	L	12.48	0.83	6.66	0.48	0.338	0.345	0.683
			R	12.53	0.88	7.01				
		M	L	13.86	0.69	4.99	0.50	0.364	0.315	0.789
			R	13.79	0.67	4.86				
DPA	Farmed fox Lis hodowlany	F	L	14.90	0.58	3.87	2.21	–0.56	0.032*	0.114
			R	15.23	0.44	2.86				
		M	L	15.74	0.43	2.71	1.33	3.052	0.203	0.752
			R	15.95	0.47	2.93				
	Wild fox Lis dziki	F	L	14.97	0.74	4.93	–0.06	–3.960	0.345	0.221
			R	14.96	0.70	4.67				
		M	L	15.96	0.80	4.99	0.87	0.20	0.029*	0.096
			R	16.10	0.85	5.27				

Explanations: mean marked with same upper-case letters differ in columns significantly at P ≤ 0.01; lower-case letters: at P ≤ 0.05; ** – Wilcoxon test and sign test value significant at P ≤ 0.01; * – Wilcoxon test and sign test value significant at P ≤ 0.05.
Objaśnienia: średnie oznaczone w kolumnach: tymi samymi wielkimi literami różnią się istotnie P ≤ 0,01; małymi literami – P ≤ 0,05; ** – wartość testu Wilcoxona lub testu znaków istotna przy P ≤ 0,01; * – wartość testu Wilcoxona lub testu znaków istotna przy P ≤ 0,05.

Table 6. Sources of variability included in the linear model and estimation of their effect significance on the parameters of pectoral girdle and forelimb bones in the raccoon dog
Tabela 6. Efekty uwzględnione w modelu liniowym i ocena ich istotności wpływu na parametry kości obręczy przedniej jenota

Trait Cecha	Effect of origin Wpływ pochodzenia	Effect of sex Wpływ płci	Effect of body side Wpływ strony ciała	Interactions Interakcje
		SCAPULA – ŁOPATKA		
LD	5.82*	0.36	0.04	7.49** †
HS	19.22**	1.26	0.00	0.04-0.86
DHA	16.07**	0.65	0.16	7.00* †
SCL	2.01	0.07	0.31	7.20** †
GLP	14.57**	4.10*	1.83	0.38–1.83
		HUMERUS – KOŚĆ RAMIENNA		
GL	13.35**	1.01	0.05	0.22–2.91
GLI	14.70**	1.52	0.02	0.22–2.92
GLC	9.38**	3.97	0.27	0.06–3.76
BP	0.36	0.06	0.72	0.73–2.01
BD	43.67**	1.51	0.00	0.00–0.93
BT	67.44**	0.33	0.08	0.00–0.41
SD	2.40	2.24	0.01	0.02–3.82
		RADIUS – KOŚĆ PROMIENIOWA		
GL	37.92**	1.09	0.78	0.26–2.85
BP	74.40**	2.68	0.04	0.03–1.02
BD	5.87*	9.34**	0.68	0.00–0.02
SD	37.36**	2.89	0.23	0.09–0.74
		ULNA – KOŚĆ ŁOKCIOWA		
GL	37.75**	9.54**	0.04	0.00–0.07
SDO	65.78**	1.86	3.55	0.02–1.07
DPA	276.59**	0.88	0.04	0.02–1.31

For explanations see Table 1.
Objaśnienia jak w tabeli 1.

The effect of sex was significant (P ≤ 0.05) only in relation to the greatest length of the glenoid process (GLP) in the scapula, the greatest breadth of the distal end (BD) of the radius (P ≤ 0.01), and the greatest length of the ulna (GL). If we look into the bilateral characters of the skeletal elements of the pectoral girdle in raccoon dogs, no statistically significant effect of the side of the body can be found. The estimated values of origin × sex interactions included in the statistical analysis were significant (P ≤ 0.05 and P ≤ 0.01) only for three scapular characters: the greatest dorsal length (LD), diagonal height (DHA), and the smallest length of the collum scapulae (SCL).

Statistical characterization of scapulae measurements in farmed raccoon dogs demonstrates its bilateral relationship for the greatest length of the glenoid process (GLP). The matched pairs values estimated using the Wilcoxon test reveal a significant (P ≤ 0.01) left-sided asymmetry, which was confirmed by the sign test. Also in the females of farmed raccoon dogs, the estimated right-sided asymmetry in the smallest depth of the olecranon (SDO) was significant (P ≤ 0.01) and confirmed by the sign test (P ≤ 0.05). The remaining characters of the skeleton of the pectoral girdle in both farmed and wild raccoon dogs did not show any differences in the morphometric values which could have been confirmed by the applied tests.

Table 7. Statistical characteristics of the scapula morphometrics in the raccoon dog
Tabela 7. Charakterystyka statystyczna wymiarów łopatki jenota

Trait Cecha	Origin Pochodzenie	Sex Płeć	Body side Strona ciała	m (mm)	SD	V%	RA	FA	TpW	TZ
LD	Farmed raccoon dog Jenot hodowlany	F	L	42.59	1.94	4.54	0.68	–0.279	0.575	0.752
			R	42.88	1.69	3.93				
		M	L	44.00	1.82	4.14	0.43	–0.369	0.386	0.752
			R	44.19	1.52	3.44				
	Wild raccoon dog Jenot dziki	F	L	46.14	3.57	7.75	–0.57	–0.174	0.593	1.000
			R	45.87	3.21	6.99				
		M	L	43.74	2.61	5.96	0.65	0.095	0.361	0.617
			R	44.03	2.73	6.21				
HS	Farmed raccoon dog Jenot hodowlany	F	L	83.96	2.06	2.45	0.07	0.126	0.799	0.752
			R	84.01	2.19	2.61				
		M	L	86.07	7.11	8.26	0.79	–3.770	0.919	0.752
			R	86.75	1.77	2.04				
	Wild raccoon dog Jenot dziki	F	L	80.48	5.92	7.36	–1.44	–0.978	0.593	1.000
			R	79.32	3.70	4.66				
		M	L	79.93	3.27	4.09	0.49	–0.006	0.068	0.134
			R	80.32	3.26	4.06				
DHA	Farmed raccoon dog Jenot hodowlany	F	L	81.71	2.46	3.01	0.64	0.292	0.074	0.114
			R	82.23	2.13	2.59				
		M	L	84.58	1.57	1.86	–0.08	0.073	0.919	0.752
			R	84.51	1.63	1.93				
	Wild raccoon dog Jenot dziki	F	L	81.39	2.86	3.51	–1.07	0.334	0.593	1.000
			R	80.52	3.38	4.20				
		M	L	79.98	3.49	4.36	–0.97	0.445	0.465	0.617
			R	79.20	4.35	5.49				
SCL	Farmed raccoon dog Jenot hodowlany	F	L	16.15	0.63	3.90	0.34	–0.052	0.838	0.752
			R	16.21	0.62	3.82				
		M	L	16.60	0.51	3.08	–0.02	0.000	0959	0.752
			R	16.60	0.51	3.08				
	Wild raccoon dog Jenot dziki	F	L	16.33	0.48	2.92	0.89	–0.687	1.000	1.000
			R	16.47	0.34	2.09				
		M	L	15.79	0.65	4.12	1.23	0.537	0.715	0.617
			R	15.98	0.85	5.30				
GLP	Farmed raccoon dog Jenot hodowlany	F	L	18.51	0.57	3.08	–2.40	0.333	0.005**	0.004**
			R	18.07	0.65	3.60				
		M	L	18.68	0.43	2.32	–1.73	–0.400	0.047*	0.114
			R	18.35	0.35	1.93				
	Wild raccoon dog Jenot dziki	F	L	17.47	0.76	4.35	1.35	–8.142	0.593	1.000
			R	17.70	0.09	0.54				
		M	L	18.17	0.60	3.30	–1.81	0.25	0.068	0.134
			R	17.84	0.68	3.79				

Explanations: ** – Wilcoxon test or sign test value significant at P ≤ 0.01; * – Wilcoxon test or sign test value significant at P ≤ 0.05.
Objaśnienia: ** – wartość testu par Wilcoxona lub testu znaków istotna przy P ≤ 0,01; * – wartość testu par Wilcoxona lub testu znaków istotna przy P ≤ 0,05.

Table 8. Statistical characteristics of the humerus morphometrics in the raccoon dog
Tabela 8. Charakterystyka statystyczna wymiarów kości ramiennej jenota

Trait Cecha	Origin Pochodzenie	Sex Płeć	Body side Strona ciała	m (mm)	SD	V%	RA	FA	TpW	TZ
GL	Farmed raccoon dog Jenot hodowlany	F	L	99.49	1.72	1.73	–0.48	0.389	0.114	0.752
			R	99.01	2.09	2.11				
		M	L	100.91	2.66	2.64	0.29	–0.035	0.139	0.114
			R	101.21	2.62	2.59				
	Wild raccoon dog Jenot dziki	F	L	97.42	3.58	3.67	–0.23	–0.179	0.465	0.617
			R	97.18	3.28	3.37				
		M	L	97.26	3.84	3.95	1.07	0.308	0.500	1.000
			R	96.96	4.48	4.62				
GLl	Farmed raccoon dog Jenot hodowlany	F	L	97.91	1.56	1.59	–0.33	–0.504	0.093	0.343
			R	97.58	2.00	2.05				
		M	L	99.35	2.73	2.75	0.28	–0.025	0.445	0.752
			R	99.63	2.70	2.71				
	Wild raccoon dog Jenot dziki	F	L	95.54	3.71	3.88	0.01	–0.200	0.715	0.617
			R	95.56	3.34	3.50				
		M	L	95.91	3.73	3.89	–0.38	–0.119	0.080	0.371
			R	95.54	3.51	3.67				
GLC	Farmed raccoon dog Jenot hodowlany	F	L	97.53	1.81	1.86	–0.22	0.607	0.683	0.752
			R	97.30	2.45	2.51				
		M	L	99.08	2.88	2.90	0.47	0.184	0.241	0.752
			R	99.55	3.15	3.17				
	Wild raccoon dog Jenot dziki	F	L	95.15	3.59	3.78	–0.05	–0.166	0.715	0.617
			R	95.10	3.31	3.48				
		M	L	97.49	2.43	2.49	–1.96	1.308	0.686	1.000
			R	95.57	4.49	4.70				
BP	Farmed raccoon dog Jenot hodowlany	F	L	17.94	0.79	4.40	–1.50	–0.387	0.139	0.343
			R	17.67	0.65	3.69				
		M	L	18.30	0.48	2.61	–2.51	0.428	0.037*	0.343
			R	17.84	0.59	3.30				
	Wild raccoon dog Jenot dziki	F	L	17.70	0.36	2.03	2.59	0.153	0.068	0.134
			R	18.16	0.39	2.13				
		M	L	17.89	0.54	3.03	–1.67	–0.500	0.345	0.074
			R	17.59	0.42	2.38				
BD	Farmed raccoon dog Jenot hodowlany	F	L	22.45	0.90	4.01	–0.35	–0.373	0.610	0.343
			R	22.36	0.74	3.33				
		M	L	22.80	0.24	1.05	0.35	1.846	0.953	1.000
			R	22.88	0.55	2.41				
	Wild raccoon dog Jenot dziki	F	L	21.30	0.55	2.58	0.04	–0.107	0.715	0.617
			R	21.31	0.52	2.44				
		M	L	21.34	0.86	4.05	0.14	0.113	0.686	1.000
			R	21.37	0.92	4.30				
BT	Farmed raccoon dog Jenot hodowlany	F	L	15.16	0.90	5.96	–0.19	–0.461	0.878	0.752
			R	15.13	0.72	4.75				
		M	L	14.77	1.00	6.81	3.11	–0.742	0.028*	0.114
			R	15.23	0.70	4.59				
	Wild raccoon dog Jenot dziki	F	L	13.27	0.73	5.51	–0.37	0.135	0.465	0.617
			R	13.22	0.79	5.95				
		M	L	13.18	0.61	4.61	–0.83	0.325	0.893	1.000
			R	13.07	0.72	5.49				
SD	Farmed raccoon dog Jenot hodowlany	F	L	7.89	0.43	5.54	0.38	–0.250	0.799	0.752
			R	7.81	0.38	4.89				
		M	L	8.22	0.37	4.47	–0.65	–0.076	0.139	0.343
			R	8.14	0.37	4.50				
	Wild raccoon dog Jenot dziki	F	L	8.18	0.17	2.10	0.24	2.375	1.000	0.617
			R	8.20	0.46	5.68				
		M	L	8.15	0.37	4.51	–0.24	0.529	0.715	0.617
			R	8.13	0.47	5.84				

For explanations see Table 2.
Objaśnienia jak w tabeli 2.

Table 9. Statistical characteristics of the radius morphometrics in the raccoon dog
Tabela 9. Charakterystyka statystyczna wymiarów kości promieniowej jenota

Trait Cecha	Origin Pochodzenie	Sex Płeć	Body side Strona ciała	m (mm)	SD	V%	RA	FA	TpW	TZ
GL	Farmed raccoon dog Jenot hodowlany	F	L	89.61	2.53	2.83	0.24	0.130	0.386	0.752
			R	89.83	2.71	3.02				
		M	L	91.63	1.71	1.87	0.39	0.091	0.386	0.752
			R	91.99	1.79	1.94				
	Wild raccoon dog Jenot dziki	F	L	86.26	1.92	2.23	0.04	0.994	0.715	0.617
			R	86.31	3.10	3.60				
		M	L	84.75	5.41	6.38	2.47	–2.552	0.893	1.000
			R	86.84	1.87	2.15				
BP	Farmed raccoon dog Jenot hodowlany	F	L	11.71	0.44	3.77	–2.30	–0.312	0.032*	0.343
			R	11.45	0.38	3.30				
		M	L	11.73	0.50	4.24	1.11	–0.333	0.285	0.343
			R	11.86	0.42	3.56				
	Wild raccoon dog Jenot dziki	F	L	10.57	0.44	4.13	–0.18	–0.55	0.715	0.617
			R	10.54	0.43	4.06				
		M	L	10.70	0.40	3.79	0.64	–0.062	0.686	0.074
			R	10.77	0.40	3.68				
BD	Farmed raccoon dog Jenot hodowlany	F	L	14.43	0.76	5.28	1.37	0.362	0.241	0.752
			R	14.63	0.91	6.24				
		M	L	15.11	0.74	4.93	0.60	–0.055	0.260	0.182
			R	15.20	0.72	4.77				
	Wild raccoon dog Jenot dziki	F	L	13.96	0.68	4.85	1.28	–0.470	0.273	0.617
			R	14.14	0.54	3.82				
		M	L	14.56	0.44	3.02	1.33	–0.571	0.138	0.371
			R	14.76	0.33	2.26				
SD	Farmed raccoon dog Jenot hodowlany	F	L	7.02	0.51	7.30	–0.95	–0.127	0.203	0.343
			R	6.96	0.45	6.44				
		M	L	7.18	0.37	5.23	–1.56	–0.454	0.154	0.114
			R	7.07	0.30	4.23				
	Wild raccoon dog Jenot dziki	F	L	6.32	0.54	8.52	–0.31	0.034	0.144	0.612
			R	6.13	0.55	8.94				
		M	L	6.40	0.11	1.66	2.39	3.666	0.500	1.000
			R	6.56	0.35	5.34				

* – difference significant at $P \leq 0.05$.
* – różnica statystyczna na poziomie $P \leq 0,5$.

Table 10. Statistical characteristics of the ulna morphometrics in the raccoon dog
Tabela 10. Charakterystyka statystyczna wymiarów kości łokciowej jenota

Trait Cecha	Origin Pochodzenie	Sex Płeć	Body side Strona ciała	m (mm)	SD	V%	RA	FA	TpW	TZ
GL	Farmed raccoon dog Jenot hodowlany	F	L	108.68	3.56	3.28	0.20	–0.013	0.285	0.343
			R	108.90	3.54	3.25				
		M	L	111.51	2.32	2.08	0.30	–0.035	0.646	0.752
			R	111.85	2.28	2.04				
	Wild raccoon dog Jenot dziki	F	L	102.11	6.53	6.40	0.21	0.080	0.465	0.617
			R	102.32	6.83	6.67				
		M	L	105.55	2.38	2.25	0.02	0.292	0.686	1.000
			R	105.67	2.75	2.60				
SDO	Farmed raccoon dog Jenot hodowlany	F	L	12.57	0.43	3.45	4.88	1.033	0.007**	0.027*
			R	13.19	0.70	5.35				
		M	L	12.99	0.54	4.18	1.89	0.218	0.139	0.114
			R	13.24	0.60	4.57				
	Wild raccoon dog Jenot dziki	F	L	14.23	1.79	12.57	4.38	–5.535	0.465	0.617
			R	14.86	0.32	2.16				
		M	L	14.83	0.86	5.82	0.77	–1.044	0.500	1.000
			R	14.95	0.52	3.50				
DPA	Farmed raccoon dog Jenot hodowlany	F	L	15.67	0.80	5.09	–0.10	–0.583	0.959	0.752
			R	15.65	0.60	3.82				
		M	L	15.62	0.69	4.39	1.02	–0.044	0.333	0.752
			R	15.78	0.67	4.24				
	Wild raccoon dog Jenot dziki	F	L	13.04	0.54	4.13	–0.81	–0.750	0.715	0.617
			R	12.93	0.38	2.93				
		M	L	12.72	0.37	2.92	–1.43	–0.222	0.138	0.371
			R	12.53	0.20	1.59				

** – difference significant at P ≤ 0.01.
* – difference significant at P ≤ 0.05.
** – różnica statystyczna na poziomie P ≤ 0,01.
* – różnica statystyczna na poziomie P ≤ 0,05.

Among the bones of the thoracic girdle in carnivores of a soft walk, the humerus is particularly interesting due to the passive submission to the load of the body weight. Most studies on the effect of symmetry and asymmetry of the bones constituting the pectoral girdle and the bones of the forelimb concentrate on the analysis of their elements in bipedal organisms, which use their upper limbs in manual activities. An example would be the presence of left-sided asymmetry in the forelimb of captive chimpanzees (Hopkins 2008). However, the factors predisposing to the formation of asymmetry include genetically determined plasticity of the bones and some local agents, such as varying load, and differences in blood supply and innervation. The data presented in Table 11 reveal directed asymmetries in particular parts of the studied bones in both foxes and raccoon dogs. The presence of incidental, statistically significant asymmetries can only be explained with variable, individual manner of behavior, although there are reports on left-sided asymmetry in the hind limb of dogs (Chase et al. 2004) and in red foxes, in which right-sided asymmetries in the humerus and left-sided in the radius and the ulna have been found (Kharlamova et al. 2010).

Table 11. Number of left- and right-sided traits (total significant and non-significant) in females and males of the red foxes and raccoon dogs in the studied bones of the pectoral girdle
Tabela 11. Liczba cech lewo- i prawostronnych (istotnych i nieistotnych statystycznie razem) u samic i samców lisów i jenotów w badanych elementach szkieletu obręczy piersiowej

Origin Pochodzenie	Scapula Łopatka				Humerus Kość ramienna				Radius Kość promieniowa				Ulna Kość łokciowa			
	F		M		F		M		F		M		F		M	
	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
FRF	1	4	1	4	3	4	7	0	1	3	2	2	0	3	2	1
WRF	4	1	4	1	6	1	7	0	3	1	2	2	2	1	0	3
FRG	1	4	3	2	6	1	2	5	2	2	1	3	1	2	0	3
WRD	3	2	2	3	3	4	2	5	2	2	0	4	1	2	1	2

Explanations: – Objaśnienia: L – left body side – lewa srona ciała; P – right body side – prawa strona ciała; FRF – farmed red fox – lis pospolity hodowlany; WRF – lis pospolity dziki; FRD – farmed raccoon dog – jenot hodowlany. WRD – wild raccoon dog – jenot dziki.

CONCLUSIONS

As a result of the study it can be concluded that the asymmetry of the forelimb bones occurs sporadically and mainly in farmed animals. Origin and sex of the animals influenced all the analyzed metric characteristics of selected bones. In the humerus of the red foxes we found primarily left-sided asymmetry, which occurred frequently also in the dimensions of the other analyzed bones. The statistical analysis of the impact of the side of the body on the metric characters of the bones in raccoon dogs indicates the presence of asymmetry only occasionally in the farmed animals. The results lead to a conclusion that the management of furbearing animals under a shed housing system may lead to asymmetry in the skeleton within the pectoral girdle.

REFERENCES

Alpak H., Mutuş R., Onar V. 2004. Correlation analysis of the skull and long bone measurements of the dog. Aaa. Anat. 186, 323–330.

Aubry K.B., Statham M.J., Sachs B.N., Perrine J.D., Wisely S.M. 2009. Phylogeography of the North American red fox: vicariance in Pleistocene forest refugia. Mol. Ecol. 18, 2668–2686.

Baranowski P., Wojtas J. 2011. Asymmetry of selected foraminal, shape and cribrosity features in the head skeleton of wild and farm chinchillas (*Chinchilla laniger*). Bull. Vet. Inst. Pulawy 55, 787–793.

Cavallini P. 1996. Variation in the social system of the red fox. Ethol. ecol. & Evol. 8, 323–342.

Cavallini P. 1997. Internal organ masses of the red fox *Vulpes vulpes*: data from the wild. Acta Theriol. 42 (1), 91–98.

Cavallini P., Santini S. 1996. Reproduction of the red fox *Vulpes vulpes* in Central Italy. Ann. Zool. Fennici 33, 267–274.

Chase K., Lawler D.F., Adler F.R., Ostrander E.A., Lark K.G. 2004. Bilaterally Asymmetric Effects of Quantitative Trait Loci (QTLs): QTLs That Affect Laxity in the Right Versus Left Coxofemoral (Hip) Joints of the Dog (*Canis familiaris*). Am. J. Med. Genet. A. 124A (3), 239–247.

Felska-Błaszczyk L., Baranowski P., Seremak B., Pęzińska K., Nowak P., Lasota B., Stelter O. 2013. Domestication of the red fox (*Vulpes vulpes*) reflected in metric characters of selected thoracic girdle bones. Acta Sci. Pol., Zootechnica 12 (2), 15–30.

Gortázar C., Ferreras P., Villafuerte R., Martín M., Blanco J.C. 2003. Habitat related differences in age structure and reproductive parameters of red foxes. Acta Theriol. 48 (1), 93–100.

Graham J.H., Freeman D.C., Emlen J.M. 1994. Antisymmetry, directional asymmetry, and dynamic morphogenesis. Dev. In.: Its Origins and Evolutionary Implications, 123–139.

Gugołek A. 2013. Jenot (*Nyctereutes procyonoides*) [The raccoon dog (*Nyctereutes procyonoides*)]. Zwierz. futer. 2/2013, 10–11. [in Polish.]

Hallgrimsson B. 1993. Fluctuating asymmetry in *Macaca fascicularis*: a study of the etiology of developmental noise. Inter. J. Primat. 14 (3), 421–443.

Henneberg M. 1974. An attempt to the metod of investigations and interpretations of asymmetry in long bones. [Próba znalezienia metody badania i interpretacji asymetrii kości długich kończyn]. Prz. Antropol. 40, 1, 113–126. [in Polish.]

Hopkins W.D. 2008. Brief communication: locomotor limb preferences in captive chimpanzees (*Pan troglodytes*): implications for morphological asymmetries in limb bones. Am. J. Phys. Anthropol. 137 (1), 113–118.

Kharlamova A.V., Trut L.N., Chase K., Kukekova A.V., Lark K.G. 2010. Directional Asymmetry in the Limbs, Skull and Pelvis of the Silver Fox (*V. vulpes*). J. Morphol. 271 (12), 1501–1508.

Kowalczyk R., Zalewski A., Jędrzejewska B., Ansorge H., Bunevich A.N. 2009. Reproduction and mortality of invasive raccoon dogs *Nyctereutes procyonoides* in Białowieża Primeval Forest (Poland). Ann. Zool. Fennici 46, 291–301.

Mohammad Nafi Solaiman Al-Sabi, Chriél M., Hammer Jensen T., Enemark H.L. 2013. Endoparasites of the raccoon dog (*Nyctereutes procyonoides*) and the red fox (*Vulpes vulpes*) in Denmark 2009–2012 – A comparative study. Inter. J. Parasit.: Parasites and Wildlife 2, 144–151.

Monchot H., Gendron D. 2010. Disentangling long bones of foxes (*Vulpes vulpes* and *Alopex lagopus*) from arctic archaeological sites. J. Archeol. Sci. 37 (4), 799–806.

Nowicki W. 2005. Comparison of biometric characters of aorta branches in farm and wild fox (*Vulpes vulpes* L.). Folia Biol. (Kraków) 53 (suppl.), 35–38.

O'Regan H.J., Kitchener A.C. 2005. The effects of captivity on the morphology of captive, domesticated and feral mammals. Mammal. Rev. 35 (3 i 4), 215–230.

Siegel M.I., Doyle W.J., Kelley C. 1977. Heat stress, fluctuating asymmetry and prenatal selection in the laboratory rat. Am. J. Phys. Anthrop. 46 (1), 121–126.

Święcicka N., Kubacki S., Zawiślak J., Gulda D., Monkiewicz M., Drewka M. 2011. Jenot i szop pracz jako gatunki ekspansywne w Polsce [Raccoon dog and raccoon as expansive species in Poland]. Prz. Hod. 6/2011, 10–12. [in Polish.]

Tomkins J.L., Kotiaho J.S. 2001. Fluctuating asymmetry. Encyclopedia of Life Sciences, 1–5. http://users.jyu.fi/~jkotiaho/Publications/ELS01.pdf, last accessed 23 Sept., 2013.

Vos A. 1995. Population dynamics of the red fox (*Vulpes vulpes*) after the disappearance of rabies in county Garmisch-Partenkirchen, Germany, 1987–92. Ann. Zool. Fennici 32, 93–97.

ACKNOWLEDGEMENTS

The study was financed by the National Centre for Research and Development (NCBiR), grant no. 12-0140-10.

Abstract. The aim of the study was to determine the effect of origin and sex on the presence of symmetry or asymmetry in selected skeleton elements of the thoracic limb in wild and farmed fox and in wild and farmed raccoon dog. The study involved 20 farmed foxes (10 males and 10 females), 24 wild foxes (15 males and 9 females), 20 farmed raccoon dogs (10 males and

10 females) and 12 wild raccoon dogs (6 males and 6 females). The following right- and left-side skeletal parts of the pectoral girdle (*cingulum membri thoracici*) and the thoratic limb were dissected from all individuals: the shoulder blade (scapula), the humerus, the radius, and the ulna. The bones were measured using a digital caliper. The study showed that the asymmetry of the forelimb bones occurs sporadically and chiefly in farmed animals. The studied sources of variation (the origin of animals and sex) influenced all the analyzed metric characteristics of the bones. A left-sided asymmetry was found in the humeri of foxes, and was also present in the other skeletal parts. The results prompt a conclusion that the management of animals under the shed housing system may lead to asymmetry of the skeleton within the pectoral girdle.