Variability of skull morphometric characters in *Nyctereutes procyonoides*

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The raccoon dog (*Nyctereutes procyonoides*) is a medium-sized carnivore which spread over Eastern, Central and Northern Europe after its introduction into the European part of the former Soviet Union. The aim of the present study was to perform osteometrical analysis on Tadas Ivanauskas Zoological Museum specimens of raccoon dogs skulls collected in 1957, and compare the results of analysis with those obtained in 2005 in Lithuania and with osteometrical parameters from aboriginal Amur and Khabarovsk populations. In total, 36 skulls of raccoon dogs (20 males and 16 females) were used to examine any variations of skull morphometric characteristics with respect to sex. In total, 7 measurements were taken on each skull of the raccoon dog. The results of the analysis showed that males were larger than females and indicated some differences among raccoon dog skulls collected in different regions of Lithuania. The maximum condylobasal length of the *Nyctereutes procyonoides* found in 1957 and 2007 Lithuanian populations was larger than in aboriginal populations (Korablev et al., 2013). The mean values of measurements on interorbital constriction (IC), postorbital constriction (PC) and mandible height of skulls in the present study were lower that reported in specimens from the native range of the raccoon dog. The results of comparison analysis revealed higher value of index of raccoon dog skulls in males from Amur, while the lowest indices were observed in specimens from Khabarovsk and Lithuania.

Key words: *Nyctereutes procyonoides*, morphometry, skull

INTRODUCTION

The raccoon dog (*Nyctereutes procyonoides*) is a medium-sized carnivore, which spread over

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Eastern, Central and Northern Europe after its introduction into the European part of the former Soviet Union (Sutor, 2010; Kowalczyk et al., 2011; Kowalczyk et al., 2009). The raccoon dogs which have been introduced into Europe originate

from the progeny of the animals caught in the Amursk-Ussuria region (Ansorge et al., 2009). Also successful introductions occurred in the Baltic States like Latvia and Estonia.

In Lithuania, the predator was first recorded in 1948 in the eastern part of the country, and by 1960 it occurred throughout the country (Prūsaitė et al., 1988). It is believed that raccoon dogs came from neighbouring countries Belarus and Latvia where they were introduced in 1936 and 1948, respectively (Prūsaitė et al., 1988). The species has been declared as invasive since 1970.

The species' remarkable elasticity in ecological requirements makes it a good model for studies of intraspecific variation (Saeki et al., 2007). Comparative morphological investigations of non-metric skeletal characters are classical approach to answering questions about the relationships among species, often for classification and taxonomic distinctions (Sims, 2012). The non-metric characters offer the opportunity of utilising mammalian skulls kept in museum collections for genetic studies (Ansorge et al., 2009). Literature on comparative skull morphology of raccoon dogs is limited. Measurements of 71 skull, 38 of red fox and 33 of raccoon dogs, were analysed for skull morphology and their frontal sinuses (*sinus frontalis*) using comparative anatomy and computed tomography by Jurgelėnas et al. (2007). Jurgelėnas et al. (2011) studied skulls of raccoon dogs and red foxes based on determination of differences in the skull shape between sexes and species and did not find differences between form of skull of female and male raccoon dogs and red foxes. Kauhala et al. (1998) studied Finnish and Japanese raccoon dogs and found differences in craniometrical characteristics between samples from these two sites and noticed that the skulls of Finnish raccoon dogs were overall larger than those of Japanese raccoon dogs. Recent morphological research of raccoon dog has shown differences of skull measurements between native and introduced populations (Korablev et al., 2013). The aim of the present study was (1) to perform osteometrical analysis of skulls from raccoon

dogs collected in 1957, just after 10 years of their invasion to Lithuania, and (2) to compare the morphological characteristics of raccoon dogs performed in 2005 in Lithuanian population and (3) with those obtained from two indigenous populations in Amur and Khabarovsk regions (Korablev et al., 2013) by calculation of the index of raccoon dog skulls.

MATERIALS AND METHODS

In total, 105 raccoon dog skulls were collected in east, west and south Lithuania. The skulls of *Nyctereutes procyonoides* were collected in 1957 and were kept in Tadas Ivanauskas Zoological Museum in Kaunas. We could not include all the collected samples in analysis, because of absence of data about sex for 69 individuals. Overall, 36 skulls of raccoon dogs (20 males and 16 females) were used to examine any variations of skull with respect to sex. In total, 7 measurements were taken on each skull of the raccoon dog (Fig. 1). The measurements were obtained to the nearest 0.01 mm by a digital caliper. Skull index was calculated according to the formula (Onar et al., 1997; Onar, 1999): Zygomatic breadth ×100/Condylobasal length. Basic statistics was calculated with Statistica for Windows software (StatSoft 2004).

RESULTS AND DISCUSSION

The descriptive statistics of different skull measurements on the skulls of 36 raccoon dogs is presented in Table. It was determined that males were larger than females in the population from Lithuania. Only two measurements: postorbital constriction (PC) and mandible height (MH*)* were larger among females than males of raccoon dogs. Our results showed that condylobasal length of raccoon dog skulls was 118.44 mm ± 1.15 in females and 119.79 mm ± 0.87 in males, while Korablev et al. (2013) revealed that CBL was 116.99 mm ± 0.38 in females and 118.67 mm ± 0.46 in males from Amur region and 118.58 ± 1.17 mm in females, 119.81 ± 1.28 mm in males from Khabarovsk
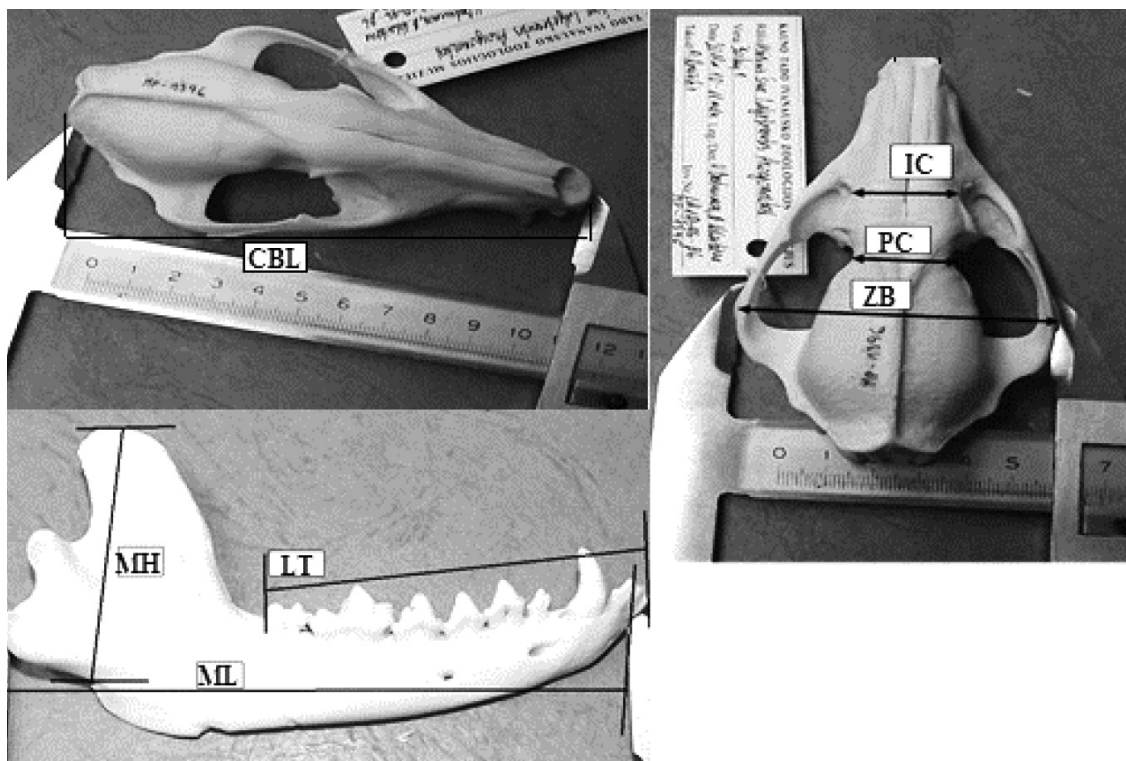
Fig. 1. Skull measurements taken from Lithuanian raccoon dog skulls. CBL = Condylobasal length, ML = Mandible length, ZB = Zygomatic breadth, LT = Length of lower tooth row, IC = Interorbital constriction, PC = Postorbital constriction, MH = Mandible height

krai. Jurgelėnas et al. (2005) reported that the mean CBL of *N. procyonoides* was 120 mm ± 0.26 for males and 120.28 mm ± 0.25 for females. The measurements obtained by Jurgelėnas et al. (2005) are slightly larger than those detected in our study. ML, ZB and LT were relatively longer in Lithuania than in Amur region and Khabarovsk krai. Accordingly, interorbital constriction and mandible height measurements were larger in populations from the native range than in Lithuania. According to Jurgelėnas et al. (2005), *Nyctereutes procyonoides* is slightly larger with a mean ML of 90.6 mm ± 0.22 for males and 88.8 mm ± 0.42 for females by comparing these results with other populations. Our results suggest that only difference between measurement in males and females in length of lower tooth row (LT) was found to be statistically significant. Jurgelėnas et al. (2005) noted that two mean values in males

and females of the raccoon dog differed significantly.

The comparative analysis revealed that index of raccoon dog skulls was the highest in males from Amur, while the lowest index was observed in Khabarovsk and Lithuania (Fig. 2). Variation of skull morphometric characteristics can depend on the sampling period of skulls series.

The results of analyses indicated some differences among raccoon dog skulls collected in different regions. Generally, the maximum condylobasal length of the *Nyctereutes procyonoides* found in this study was larger than that previously reported by Korablev et al. (2013). The mean values of the three of seven characters (IC, PC, and MH) were lower that those found in the study from native range of the raccoon dog (Korablev et al., 2013).

The important factors for size variability are historic invasion process (introduction

Table. Descriptive statistics for females and males of the raccoon dogs from Lithuania (present data and Jurgelėnas et al., 2005 and populations from native range Korablev et al., 2013)

			CBL	ML	ZB	LT	IC	PC	MH
					Our data				
Lithuania 1957	F	Max-min	124.60–105.10	97.20–62.10	70.60–57.30	62.30–53.50	25.30–18.70	23.30–18.10	48.20–31.80
		M ± ER	118.44 ± 1.15	87.82 ± 2.04	66.71 ± 0.81	58.91 ± 0.53	22.23 ± 0.40	20.31 ± 0.36	38.21 ± 0.92
	M	Max-min	126.20–114.10	98.40–58.40	74.20–63.40	65.30–57.30	26.20–19.20	23.00–15.50	42.10–32.80
		M ± ER	119.79 ± 0.87	91.66 ± 1.86	68.39 ± 0.61	60.51 ± 0.49	22.80 ± 0.44	19.66 ± 0.47	38.49 ± 0.43
		Diff.p <	NS	NS	NS	0.04	NS	NS	NS
					Jurgelėnas et al., 2005				
Lithuania 2005	F	M ± ER	122.8 ± 0.25	88.8 ± 0.42	69.2 ± 0.27	45.3 ± 0.25			38.5 ± 0.15
	M	M ± ER	120 ± 0.26	90.6 ± 0.22	67.9 ± 0.21	45.9 ± 0.22			38.9 ± 0.20
					Korablev et al., 2013				
Amur	F	Max-min	108.96–124.49	92.26–79.07	62.04–75.93	47.88–38.63	27.32–37.20	17.51–29.30	41.86–52.87
		M ± ER	116.99 ± 0.38	85.51 ± 0.32	66.24 ± 0.30	43.79 ± 0.22	31.55 ± 0.23	19.89 ± 0.18	47.67 ± 0.25
	M	Max-min	109.97–128.38	95.27–79.06	62.07–74.72	49.48–38.73	27.68–39.38	17.25–30.49	41.34–55.97
		M ± ER	118.67 ± 0.46	86.72 ± 0.42	67.83 ± 0.30	43.77 ± 0.22	32.58 ± 0.23	20.41 ± 0.21	48.66 ± 0.29
Khabarovsk	F	Max-min	112.96–123.86	90.68–83.28	61.87–73.76	46.18–41.68	28.54–37.61	18.94–22.68	44.95–52.03
		M ± ER	118.58 ± 1.17	86.76 ± 0.95	66.49 ± 1.34	44.12 ± 0.59	30.80 ± 0.95	20.50 ± 0.40	49.21 ± 1.15
	M	Max-min	113.19–124.84	83.10–93.48	73.39–62.58	46.43–43.58	27.81–36.99	8.63–22.73	43.62–54.25
		M ± ER	119.81 ± 1.28	87.93 ± 1.27	67.80 ± 1.18	45.34 ± 0.33	32.37 ± 1.10	20.39 ± 0.40	49.09 ± 0.99

F = females; M = males; M ± ER = mean and standard error; max-min = maximum and minimum; CBL = condylobasal length; ML = mandible length; ZB = zygomatic breadth; LT = length of lower tooth row; IC = interorbital constriction; PC = postorbital constriction; MH = mandible height; $p < 0.05$
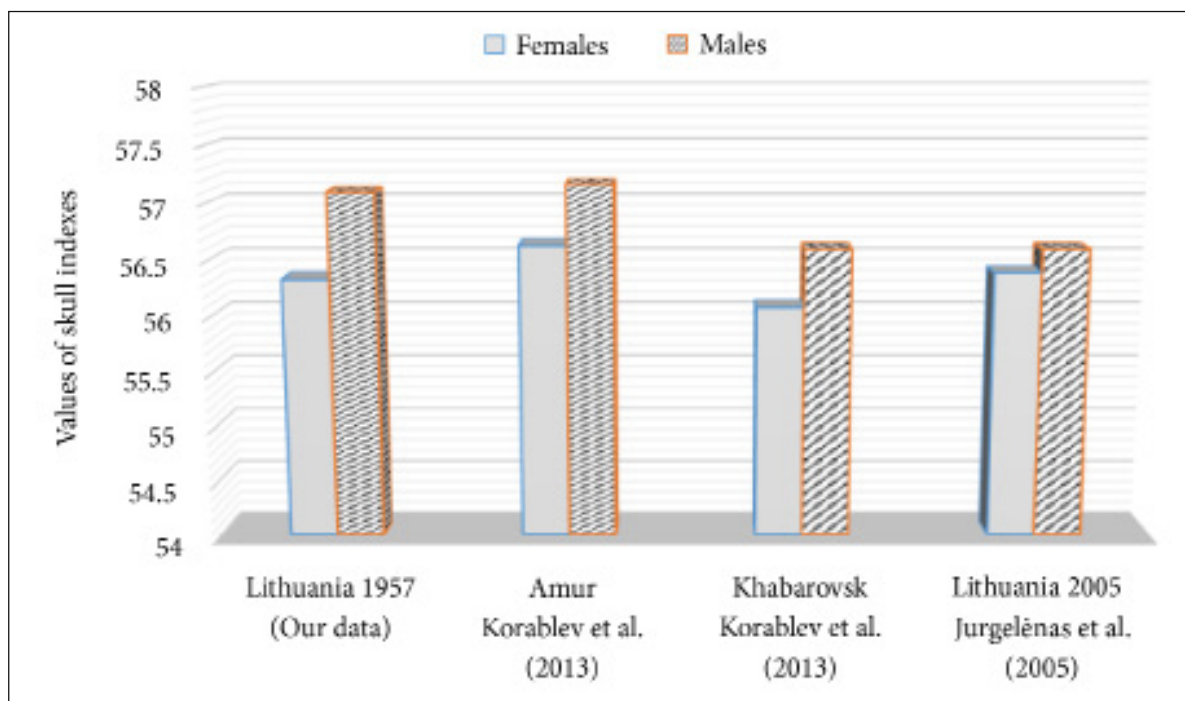
Fig. 2. Comparison of skull indices

and immigration), number of animals in invasion populations and stochastic factors (Korablev et al., 2013; Ansorge et al., 2009). According to Judin (1977), it is probable that all animals introduced within the former Soviet Union are progeny of population from Amursk region. Combination of separate population into the metapopulation in European Russia has influenced their morphological specificity (Korablev et al., 2013). The differences in skull variation most probably could arise from differences in the diet, adaptation to local environment as well as availability of food and climatic parameters.

ACKNOWLEDGEMENTS

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USŪRINIŲ ŠUNŲ (*NYCTEREUTES PROCYONOIDES*) KAUKOLIŲ MORFOMETRINIŲ DUOMENŲ SKIRTUMAI

Santrauka

Usūrinis šuo (*Nyctereutes procyonoides*) yra vidutinio dydžio mėsėdis, kuris plinta per Rytų, Vidurio ir Šiaurės Europą po jo introdukcijos į europinę buvusios Sovietų Sąjungos dalį. Šio darbo tikslas – panaudojant Tado Ivanausko zoologijos muziejuje esančias usūrinių šunų kaukoles, surinktas 1957 metais, atlikti osteometrinę analizę ir palyginti analizės rezultatus, gautus 2005 metais Lietuvoje, bei osteometrinius aborigeninių „Amur" ir „Khabarovsk" populiacijų parametrus. Iš viso tyrimui panaudotos 36 usūrinių šunų kaukolės (20 patinų, 16 patelių), matavimams atrinkti septyni kaukolės matmenys priklausomai nuo individų lyties. Analizės rezultatai rodo kaukolių matmenų skirtumus tarp usūrinių šunų patinų ir patelių Lietuvoje. Usūrinių šunų apatiniai žandikauliai buvo ilgesni 1957 ir 2007 metais Lietuvos populiacijų nei aborigeninių populiacijų (Korablev ir kt., 2013). Tarp orbitalinio pločio, už orbitalinio pločio ir žandikaulio šakos aukščio gauti matmenų vidurkiai buvo mažesni Lietuvoje, nei buvo nustatyta gimtajame usūrinių šunų areale. Palyginamosios analizės rezultatai rodo usūrinių šunų patinų iš Amūro srities didesnius kaukolės indekso rezultatus, o mažiausi kaukolės indeksai buvo būdingi pavyzdžiams iš Chabarovsko krašto ir Lietuvos.

Raktažodžiai: *Nyctereutes procyonoides,* morfometrija, kaukolė