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THE MUSKRAT SKULL VARIATION OF MORPHOMETRIC PARAMETERS TO COMPARING PRIMARY AND SECONDARY INTRODUCENTS

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Summary: The muskrat is hunted animal for hunting trophies, fur and financial reasons in many countries. Morphometric parameters can vary in different populations of muskrat. The aim of this work was to perform morphometric parameters analysis of skulls of muskrat in Lithuania (secondary introducents) and to compare with primary introducents (Poland and Finland) with respect to sex and weight. According to Pankakoski et al. (1987), a total of 22 measurements were taken on each skull of muskrat. The skull measurements of secondary introducents (Lithuania) females were mostly larger than those of males ($p < 0.05$). But the muskrat skulls were longer and wider of males than of females of primary introducents (Finland and Poland). The mean values of measurements on condylobasal length (CL), braincase length (BL) and weight (BW) showed that were higher in Finnish and Polish than in Lithuanian populations of muskrat ($p < 0.05$). These can depend on adaptive changes: habitat quality, diet and others. The strong relationship between muskrat body weight and skull length were determined in Lithuania ($r = 0.72$, $p < 0.001$).

Key words: morphometry, skull, introducents, muskrat

Introduction

The muskrat (*Ondatra zibethicus* (Linnaeus, 1766)) is one of the semi-aquatic mammals which were introduced in various regions around the world from North America (Danell, 1996; Musser and Carleton, 2005). First muskrats were introduced as a precious furry animals, hunted animals for hunting trophies and for financial reasons from 1905 into Europe (Danell, 1978) and today occupy large part of Europe and Asia. No other introduced mammalian species has spread so widely and quickly as muskrat (Lever, 1985). Therefore, it is considered as one of the most successful introducents worldwide (Danell, 1996). High reproductive rate, fast increase of abundance, short colonization time, the type of ability to survive, adaptation to the climatic conditions resulted in successful spread of muskrat (Danell, 1996; Bobrov et al., 2008; Danilov, 2009; Skyrienė et al., 2012).

The data about the introduction of muskrats in Lithuania is very limited. It is known, that these rodents is the secondary introducents acclimatized from USSR (Arkhangelsk in 1954 and Kazakhstan in 1956) (Lavrov, 1957; Prūsaitė et al., 1988). Today, this semi-aquatic rodent are not only subsumed as invasive species, but also recognized as the pest, not only in Lithuania, but also in many European countries (Zachos et al., 2007, Genovesi and Scalera, 2008, Ruys et al., 2011). Hunting is permitted throughout the year in Lithuania (The rules of hunting in the territory of the Republic of Lithuania, order No. D1-768).

The literature about muskrat acclimatization into Finland and Poland as primary introducents is also very limited. The first muskrats to Finland were introduced from 1920 from North America and later from other European countries (Artimo, 1960). The muskrat spread naturally to Poland from Czech Republic in the 1920s, where the muskrat were introduced from North America (Brzeziński et al., 2010).

Morphometric parameters can vary in different populations of muskrat. Variability can reflect the historical background and connect with fitness of the population where the individuals can be determined by the nature influence of natural selection. Data on morphometry of muskrat are scarce. The morphometric parameters of skull of the Lithuanian (Prūsaitė et al., 1988) and Polish (Ruprecht, 1974) muskrats are available only in one source. The data about skull morphometry of Finnish muskrat is available in three sources (Pankakoski, 1983; Pankakoski and Nurmi, 1986; Pankakoski et al., 1987).

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The aim of this work was to perform morphometric parameters analysis of skulls of muskrat in Lithuania (secondary introducents) and to compare with primary introducents (Poland and Finland) with respect to sex and weight.

Material and Methods

The morphometric measurements of muskrat individuals hunted in various water bodies in Lithuania in 2011-2014 were analyzed. The heads of muskrats were boiled for 30 min, skulls were cleaned and dried. A total of 22 measurements were taken from each skull following methodology described by Pankakoski and Nurmi (1986) (Fig. 1). All investigated animals were adults. The coefficient of variation ($CV = 100[(1 + \frac{1}{4+n}) * \frac{s}{v}]$, where n is the sample size, s is standard deviation and v is the mean) was used to estimate the variability within populations (Pankakoski et al., 1987).

Basic statistics was calculated with Statistica 6.0. Differences between estimates (for weight, sex) were tested using Student's t test for independent variables. Correlation coefficient and linear regression were tested between body weight and CL, CV and mean.

Fig 1. The 22 measurements of muskrat skull (CL–condylobasal length; UML–upper molar row length; DL–diastoma length; IW–interorbital width; BW–braincase width; SSL–sagittal suture length; RW–rostrum width; ZW–zygomatic width; BL–braincase length; LML–lower molar row length; FIL – foramen incisivum length; MH1-MH6–mandible heights 1-6; ML1-ML5–mandible lengths 1-5 (Pankakoski et al., 1987)).

Results

Skull measurements of muskrat show that females' skulls were larger than males' in the population from Lithuania (Table 1). However, the differences between measurements in females and males were statistically significant for CL (condylobasal length), BW (braincase width), BL (braincase length), MH3 and MH5 (mandible height 3 and 5). Only 5 measurements: mandible length ML1, ML2, ML3, ML5 and mandible height MH2 were larger for males of muskrat than females.

The results showed that condylobasal length of muskrat skulls was 62.0 mm for females and 59.6 mm for males. The females' skulls were 2.4 mm longer than males in Lithuania. However, skulls of muskrat males (63.4 mm) were 1.1 mm longer than those of females (62.3 mm) in Finland (Pankakoski and Nurmi, 1986). Polish researchers found that males' skulls were slightly larger than those of females (Ruprecht, 1974).

The zygomatic width (ZW) was 1.6 mm wider of females (37.7 mm) than males (36.1 mm) in Lithuania. However, the skulls of Finnish muskrat were wider in the case of males (ZW=38.8 mm) than females (ZW=38.1 mm) for 0.7 mm (Pankakoski and Nurmi, 1986).

Table 1. Morphometric data of muskrat skull differences between females and males in Lithuania, and mean values of Lithuanian and Finnish* muskrats

Character	Lithuania		t-test (p)	Mean (Lithuania)	Mean (Finland)*
	Females	Males			
CL	62.0±1.64	59.6±3.21	0.019**	60.3±3.02	62.8±1.98
DL	21.2±0.91	20.4±1.85	0.108	20.7±1.65	21.8±0.90
UML	15.5±0.34	15.4±0.70	0.273	15.4±0.61	16.4±0.63
IW	6.8±0.73	6.5±0.58	0.215	6.6±0.63	6.8±0.41
BW	27.0±0.72	25.9±1.99	0.044**	26.3±1.72	26.8±1.09
SSL	14.0±1.35	13.3±1.06	0.146	13.6±1.17	12.8±0.92
RW	13.2±0.85	12.6±1.15	0.095	12.8±1.09	12.2±0.56
FIL	12.3±0.97	12.3±1.17	0.474	12.3±1.09	12.7±0.67
ZW	37.7±1.69	36.1±2.56	0.060	36.6±2.39	38.7±1.54
BL	37.1±1.07	35.8±2.20	0.047**	36.2±1.95	37.7±1.19
LML	15.4±0.28	15.3±0.83	0.286	15.3±0.71	15.5±0.47
MH1	6.3±0.81	5.9±0.99	0.184	6.1±0.93	4.2±0.68
MH2	5.8±0.69	5.9±0.78	0.334	5.9±0.74	4.6±0.67
MH3	10.7±0.58	9.6±1.74	0.019**	9.9±1.57	10.9±0.52
MH4	13.5±0.62	13.0±0.90	0.115	13.2±0.83	12.9±0.83
MH5	19.7±0.28	18.5±2.13	0.035**	18.8±1.84	17.6±0.92
MH6	22.5±0.33	22.2±1.61	0.293	22.3±1.33	22.0±1.12
ML1	28.0±1.09	28.2±1.86	0.377	28.1±1.63	31.5±1.07
ML2	29.3±2.48	30.7±2.24	0.128	30.3±2.35	36.6±1.46
ML3	33.4±0.56	34.5±2.64	0.077	34.2±2.25	36.2±1.11
ML4	39.6±1.45	38.9±2.76	0.241	39.1±2.40	42.3±1.34
ML5	38.9±0.95	39.9±2.75	0.133	39.5±2.35	42.2±1.50

* - Pankakoski et al., 1987; ** - statistically significant

This study shows that the primary introducents of muskrat from Finland (CL=62.9 mm and ZW=38.71 mm) (Pankakoski et al., 1987) and Poland (CL=62.3 mm and ZW=37.3 mm) (Ruprecht, 1974) had longer and wider skulls (by condylobasal length and zygomatic width) than secondary introducents – Lithuanian muskrat (CL=60.3 mm and ZW=36.6 mm). However, native population of muskrat in USA (in

Lousiana) (CL=65.5) (Gould and Kreeger, 1948) had 5.2 mm longer skulls than Lithuanian muskrats, and 2.6 mm longer than Finnish, and 3.2 mm longer than Polish. The width (ZW=40.9 mm) (Gould and Kreeger, 1948) were 4.3 mm wider than Lithuanian; 3.6 mm and 2.19 mm than Polish and Finnish muskrat, respectively. Other skull measurements were also larger in native population of muskrat in North America than in populations of muskrat in Europe.

The results showed a positive and highly significant correlation between body weight and CL (condylobasal length) in the population of muskrat in Lithuania (Fig. 2 and Fig. 3). The strongest correlation was found between CL and body weight in muskrat females ($r=0.77$) (linear regression equation: $\text{skull}=51.9636+0.0122024*\text{body weight}$) and males ($r=0.71$) (linear regression equation: $\text{skull}=48.6384+0.0139263*\text{body weight}$).

The differences between sex and weight of muskrat skull size were found also in Finnish muskrat. The muskrat males in most cases (averaged data) were larger than females (Pankakoski, 1986). There is no other available data for comparison with the neighbors.

Fig 2. The body weight dependence on condylobasal length (CL, mm) of muskrat females in Lithuania

Fig 3. The body weight dependence on condylobasal length (CL, mm) of muskrat males in Lithuania

The coefficients of variation are lowest for upper molar row length (UML) (CV=4.01), lower molar row length (LML) (CV=4.7) and condylobasal length (CL) (CV=5.06); the highest are for mandible heights 3 and 1 ((MH3) (CV=16.05) and (MH1) (CV=15.58)) for Lithuanian muskrat (Fig 4.).

Fig 4. Dependence of coefficient of variation (CV) on mean of trait in 22 muskrat skull measurements in Lithuania

In Finnish muskrat, the lowest values of CV were determined for LML (CV=3.05), ML3 (CV=3.06) and CL (CV=3.15) and the highest for MH1 (CV=16.37) and MH2 (CV=14.75) (Fig 5.).

In larger variables the coefficient of variation (CV) of muskrat skulls were moderately negatively correlated with the mean, but the smallest measurements the variability increased sharply in Lithuania and in Finland (Fig 4, Fig 5). CV increased with a decreasing mean value of the trait, but this cannot alone explain the great variability in the small traits. The dependence of the CV on the mean of the trait were statistically highly significant in Lithuania and Finland ($p < 0.05$).

Fig 5. Dependence of coefficient of variation (CV) on mean of trait in 22 muskrat skull measurements in Finland (by Pankakoski et al., 1987)

Conclusion

Time which has passed since the introduction of muskrat shaped animals phenotype and body size lengths. In Lithuania, on average, females' skulls of muskrat are larger than males. But the opposite findings were found for Finnish and Poland muskrats. The body mass of muskrat is strongly correlated with skull size of primary and secondary introducents. However, the skull size was larger for primary introducents of muskrat than for secondary. The skull size variability can be historic invasion process (introduction and immigration) and depend on climatic parameters which are as selective factor (Ruprecht, 1974).

Furthermore, the temperature and food are the factors determining changes of skull size of introduced species during their adaptation to the new conditions (Cerevitinov, 1970). Ecological conditions of morphological variation in the landscapes of muskrats play an important role as well. Habitat conditions and the degree of isolation of similarity can be the reason why there are slight differences between populations (Ruprecht, 1974).

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