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Notes on variation in the baculum of *Martes foina* from Czech Silesia, Czech Republic (Carnivora: Mustelidae)

Poznámky k premenlivosti bakula kuny skalnej (*Martes foina*) z českého Sliezska (Carnivora: Mustelidae)

Alexander ČANÁDY[1] & Anna ONDERKOVÁ[2]

[1] Department of Zoology, Institute of Biology and Ecology, Faculty of Science, P. J. Šafárik University, Šrobárova 2, SK–041 54 Košice, Slovakia; alexander.canady@gmail.com
[2] Department of Microbiology, Institute of Biology and Ecology, Faculty of Science, P. J. Šafárik University, Šrobárova 2, SK–041 54 Košice, Slovakia; aonderkova@gmail.com

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Abstract. In this study we investigated variation in the baculum of the stone marten, *Martes foina* from the Czech part of Silesia (north-eastern Czech Republic). The aim of this study was to assess quantitative characteristics of the baculum size, relationships between measurements and description of the variability in baculum morphology. The study presents the morphological variation in six dimensional traits of the baculum based on an analysis of 15 specimens collected in the vicinity of Opava and deposited at the Šariš Museum Bardejov (Slovakia). The descriptive statistics revealed size variation of the bacula, while the statictic analysis (PCA) showed a strong positive correlation between morphological traits of the body and baculum.

Key words. Stone marten, size variation, os penis, Czech Silesia, Šarišské Museum Bardejov.

INTRODUCTION

The baculum (os penis) is a bone found in the penis of many species of mammals, including the family Mustelidae (Abramov 2002, Baryshnikov et al. 2003, Miller & Nagorsen 2008, Malecha et al. 2009, Krawczyk et al. 2011, Schulte-Hostedde et al. 2011, Vercillo & Ragni 2011). This bone varies greatly among species, and therefore has been widely used as a diagnostic trait in taxonomy (Baryshnikov & Abramov 1997, 1998, Abramov & Baryshnikov 2000, Baryshnikov et al. 2003). According to the abovementioned authors, the bacula of Mustelidae tend to be rather simple in structure with some more complex projections at the tip. In contrast, the morphological variability of baculum of the stone marten, *Martes foina* (Erxleben, 1777), from the Czech or Slovak Republics has not been investigated so far. The present study contributes to the knowledge of quantitative characteristics of the baculum size of the stone marten from Central Europe and describes its variability.

MATERIAL AND METHODS

Bacula used in this study are deposited in the collection of the Šariš Museum (Šarišské múzeum) in Bardejov, and all were collected in the vicinity of Opava, Silesia, Czech Republic, in the period 1960–1965.

The bones were collected by Tibor Weisz, a former curator of natural history at the Šariš Museum (see Hromada et al. 2015). Several possible sources of error were considered, therefore smaller bacula (from juvenile and subadult individuals; damaged during preparation or storage) were excluded and data obtained only from adult males were used for evaluation (n=15). The maturity in the specimens was examined according to the baculum weight and the presence of a baculum protuberance (see Soest & Bree 1970, Grue & King 1984, Elsasser & Parker 2008, Vercillo & Ragni 2011).

The length dimension of the bacula were taken with a digital calliper with the accuracy of 0.01 mm, and their weight was taken with digital scales to the nearest 0.01 gram. All specimens were measured and evaluated according to Čanády (2013, 2015), Čanády & Čomor (2013) and Čanády & Onderková (2016).

The obtained dataset (untransformed data) was evaluated using the following statistical parameters: minimum and maximum (min–max), mean (M), standard deviation (SD), standard error of the mean (SE) and coefficient of variation (CV). Normal distribution was tested by the three normality tests (the D'Agostino-Pearson Omnibus K^2 test and the Shapiro-Wilk *W*-test). Moreover, morphometric variation was examined by means of multivariate methods (Principal Component Analysis; PCA). Correlations between the baculum measurements were analysed using the Pearson Correlation Coefficient (r_p).

The analyses were performed using MS Excel 2003 for Windows XP and the statistical analysis system GraphPad Prism, version 5.01 (GraphPad Software, Inc., San Diego, California, USA); the principal component analysis was done using the Statistical Software OriginPro 8.6. (Microral Software Inc., Northampton, USA)..

RESULTS AND DISCUSSION

Descriptive statistics of the studied baculum variables (Table 1) conform with results of previous studies (e.g. Malecha et al. 2009, Schwery et al. 2011, Čanády 2013, Čanády & Čomor 2013, 2015) showing that the baculum weight together with the width were more variable than the baculum length. This may be caused by various ages in the collected martens – the baculum stops its length growth, but continues in the bulk growth with age (Schwery et al. 2011). The positive correlations between the bacular size parameters (length and width dimensions) as well

Table 1. Descriptive statistics of baculum traits of the stone marten, *Martes foina* (in mm; n=15). Legend: min–max – range margins; M = mean; SD = standard deviation; SE = standard error of the mean; CV = coefficient of variance; LeBa = length of the baculum; DvWp = dorso-ventral width of proximal epiphysis; LtLtWp = latero-lateral width of proximal epiphysis; DvWd = dorso-ventral width of distal epiphysis; LtLtWd = latero-lateral width of distal epiphysis; WeBa – weight of the baculum (g)
Tab. 1. Základná štatistika meraných znakov penisovej kosti kuny skalnej *Martes foina* (v mm; n=15). Vysvetlivky: N – počet; min–max – okraje rozpätia; M – priemer; SD – štandardná odchýlka; SE – štandardná chyba priemeru; CV – koeficient variácie; LeBa – dĺžka bakula; DvWp – dorsoventrálna šírka proximálnej epifýzy; LtLtWp – laterolaterálna šírka proximálnej epifýzy; DvWd – dorsoventrálna šírka distálnej epifýzy; LtLtWd – laterolaterálna šírka distálnej epifýzy; WeBa – hmotnosť bakula (g)

measurement	min–max	M±SD	SE	CV
LeBa	50.88–63.66	56.01±3.83	0.99	6.8
DvWp	2.02–5.79	3.80±1.07	0.28	28.2
LtLtWp	1.53–4.31	2.73±0.84	0.22	31.0
DvWd	3.61–6.46	4.42±0.73	0.19	16.5
LtLtWd	1.54–2.60	2.13±0.33	0.09	32.0
WeBa	0.26–0.74	0.43±0.15	0.04	33.9

Table 2. Pearson's correlations between bacular traits of the stone marten. For legend see Table 1. Correlation values are listed under the diagonal, while the p-values above the diagonal. The correlations with significant p-values are bold typed
Tab. 2. Pearsonová korelačná matica medzi meranými znakmi baculum kuny skalnej. Skratky rozmerov bacula viď tab. 1. Číslo nad uhlopriečkou predstavuje hodnotu korelácie, číslo pod uhlopriečkou hodnotu p. Korelácie so štatisticky významnými p hodnotami sú zvýraznené tučne

	LeBa	DvWp	LtLtWp	DvWd	LtLtWd	WeBa
LeBa		0.17	**0.01**	**0.03**	0.27	**0.00**
DvWp	0.38		**0.00**	**0.04**	0.92	**0.00**
LtLtWp	0.44	0.81		0.01	0.31	**0.00**
DvWd	0.55	0.54	0.62		0.30	**0.00**
LtLtWd	0.30	0.03	0.28	0.28		0.33
WeBa	0.74	0.78	0.82	0.78	0.27	

with the baculum weight (Table 2) could explain their relationship to provide mechanical support during copulation and direct interaction with the female reproductive tract (e.g. Baryshnikov et al. 2003, Krawczyk et al. 2011, Čanády 2013, Čanády & Čomor 2013, 2015). It should be

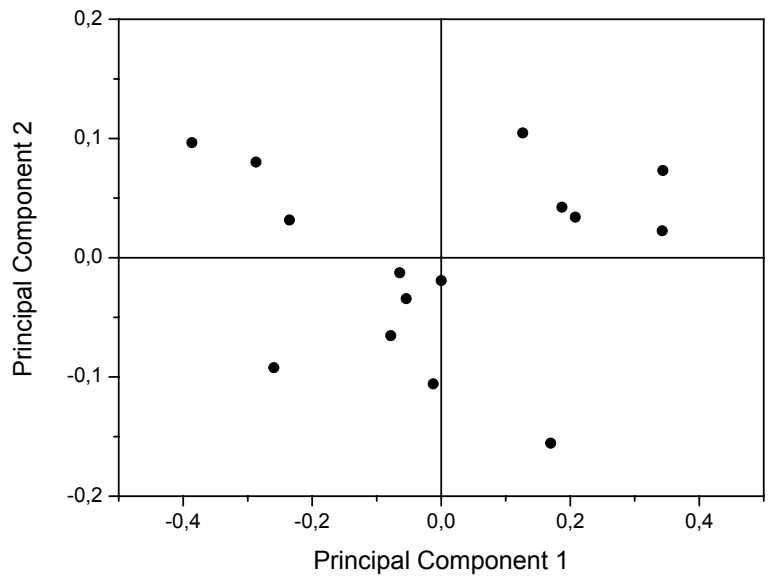

Fig. 1. Results of the Principal Component Analysis for the body length and baculum variables (PC1 vs. PC2).
Obr. 1 Výsledky analýzy hlavných premenných (PCA) pre dĺžku tela a merané znaky penisových kosti (PC1 a PC2).

Table 3. Loading values of the Principal Component Analysis (PCA) for the three main components (PC1–PC3) in the stone marten, *Martes foina*; their eigenvalues, percentage (variability %) and cumulative percentage (cumulative %). For legend see Table 1

Tab. 3. Hodnoty latentných koreňov a záťaží jednotlivých rozmerov pre prvé tri hlavné komponenty (PC1–PC3), ako aj ich percentuálne a kumulatívne percentuálne vyjadrenie. Skratky rozmerov bacula viď tab. 1

	PC1	PC2	PC3
LeBa	0.07	0.16	–0.18
DvWp	0.54	–0.46	0.03
LtLtWp	0.56	–0.08	0.60
DvWd	0.21	0.33	–0.41
LtLtWd	0.07	0.76	0.46
WeBa	0.59	0.27	–0.48
eigenvalue	0.05	0.01	0.00
percentage (%)	79.9	9.5	5.9
cumulative (%)	79.9	89.4	95.3

also noted that the increasing width might at least partially explain a continued increase in bacular weight after the growth in length stagnates. Moreover, this fact may be indicative of the functional role of the baculum and the ability of the female to detect individual differences in male genital morphology through the female reproductive tract. Females may be more sensitive to baculum width than length and utilize that sensitivity to discriminate between mates, which might lead to stronger selection for baculum width (see Tasikas et al. 2009).

Moreover, results of the Principal Component Analysis (Table 3, Fig. 1) indicate that the baculum width is more variable and may be more influenced by sexual selection than the baculum length. The results showed the first two principal components (PC1, PC2) explain a majority (89.4%) of the variation: PC1 explains 79.9% of the total variance and was correlated mainly with baculum weight (WeBa), dorso-ventral width (DvTWp) and latero-lateral width (LtLtWp) of the proximal epiphysis of baculum. The second component (PC2) accounted for only 9.5% of the total variance and was positively correlated with dorso-ventral width of the distal epiphysis (DvWd), and negatively with dorso-ventral width of the proximal epiphysis (DvWp). Finally, the third principal component (PC3) accounted for only 5.9% of the overall variation and was highly associated with the laterolateral width of the proximal end (LtLtWp).

In conclusion, data obtained in this study were consistent with data from the abovementioned authors who have confirmed that the width dimensions of baculum are more variable than the length dimension. Nevertheless, to confirm the above statements, further analyses based on a larger sample are needed to fully understand the importance and function of the baculum.

SÚHRN

V práci sú prezentované výsledky morfometrického výskumu penisových kostí (bakula) kuny skalnej (*Martes foina*) z územia okolia Opavy (české Sliezsko). Materiál pozostávajúci z 15 penisových kostí bol

získaný zo zbierok Šarišského múzea v Bardejove. Celkovo bolo vyhodnotených šesť metrických znakov. Výsledky analýz potvrdili variabilitu v meraných znakov ako aj koreláciu medzi viacerými znakmi.

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