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Morphological variability of baculum (*os penis*) in the polecat *Mustela putorius*

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Abstract. The study presents the morphological variation in three traits of the baculum (*os penis*) in the polecat (*Mustela putorius* Linnaeus, 1758), based on an analysis of 108 males (7 juveniles and 101 adults) collected in NE Slovakia between 1958-1978. Adult individuals had a significantly larger baculum (length, width and distal tip size) than juveniles. All three measured baculum traits correlated significantly with each other. However, these relationships only explained from 10% (width – distal tip size relationship) up to 51% (length – width relationship) of the variance between the studied traits. Therefore, evolutionary analysis based on baculum variation should take into account not only baculum size, but also base width, which may be a measure of baculum developmental stage. Moreover, coefficients of variation were 10.2%, 30.2% and 11.4%, respectively for length, width and distal tip size of the baculum, much greater than the known variation of cranial measurements. Therefore, more data on the variability among individuals, as well as between measured traits, are needed for a better understanding of the evolutionary processes which influence baculum size and shape.

Key words: *Mustela putorius*, age effect, individual variability, *os penis*, Slovakia

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I. INTRODUCTION

The mammalian baculum, or *os penis*, is extremely morphologically diverse, both in shape and size (BARYSHNIKOV et al. 2003). The baculum shows great morphological diversity especially in carnivores, even in closely related species (HOSKEN et al. 2001; BARYSHNIKOV et al. 2003; RAMM 2007). The reason for such morphological variation is not clear and two primary hypotheses exist (LÜPOLD et al. 2004). One is that variation is simply a pleiotropic by-product of phylogenetic divergence. On the other hand, the second group of hypotheses explains bacular differences in light of the role of *os penis* in copulation (MILLER et al. 1999; KELLY 2000; BARYSHNIKOV et al. 2003; RAMM 2007).

Both groups of hypotheses have been analysed in evolutionary phylogenetic studies (HOSKEN et al. 2001; BARYSHNIKOV et al. 2003; RAMM 2007). However, authors generally take into account only one baculum measurement – the length. Moreover, they have tended to use only one mean value per species and do not use information on intraspecific variability of baculum size (BARYSHNIKOV et al. 2003). However, it is well known that the baculum varies markedly between individuals within a species (REINWALDT 1961; MILLER & BURTON 2001; DYCK et al. 2004).

One of the species in which baculum size and shape have been described (SUMIŃSKI 1968; WALTON 1968; KIERDORF 1996; BARYSHNIKOV et al. 2003; FERGUSON et al. 2006) is the polecat (*Mustela putorius* LINNAEUS, 1758). This species can be found throughout most of Europe. Polecats prefer lowlands and foothills and inhabit farmland, wooded river banks and dales, and in Central Europe they often occur near human settlements (BLANFORD 1987; WOLSAN 1993). The polecat is widespread in Slovakia. It is considered to be vermin and can be hunted during winter at present (ADAMEC 2003), but in the past polecats were hunted year round. Because the polecat is hunted throughout most of its range, bone material is relatively easy to obtain. Comparisons of the species with other carnivores based on good sample sizes have been published together with descriptions of the main morphological parameters, including information on the baculum. Studies have examined the influence of age on baculum size (SUMIŃSKI 1968; WALTON 1968; WOLSAN 1993), regeneration pattern, or described general characteristics of the *os penis*, such as length (KIERDORF 1996), and evolutionary relationships with other mustelids (BARYSHNIKOV et al. 2003; FERGUSON et al. 2006).

In this paper we present the results of an investigation of baculum size and shape in the polecat. The main objectives are:

1) to provide general data on quantitative characteristics of baculum size;

2) to test the relationships between three measurements of baculum size;

3) to describe the variability in polecat baculum morphology.

II. MATERIAL AND METHODS

This analysis is based on 108 males (7 juveniles and 101 adults). The polecats were collected in NE Slovakia, near the town of Bardejov (49º03´N-49º27´N; 20º30´E-21º47´E), in the transition region between the Eastern and Western Carpathians.

A large number of hunters led by T. WEISZ, collector of Šarišské Museum Bardejov (SMB), collected the polecat specimens during the years 1958-1978. Polecats were collected throughout the year, with a peak in between November and March. All specimens were weighed and measured (body length, tail length, foot length, ear length). Bacula were removed from the bodies, put into 5% ammonia for at least 24 h to soften the flesh and then boiled, brushed clean and bleached with hydrogen peroxide (WALTON 1968). They were then washed in water, air-dried to a constant weight and kept in museum boxes. Bones were measured according to a standard procedure by the authors of this paper (Fig. 1). For more information on establishing the collection and the types of measurements see TRYJANOWSKI et al. (2002) and HROMADA et al. (2003).

Polecats were aged according to skull and dental differences between age classes (after BUCHALCZYK & RUPRECHT 1977), as well as size and shape of the baculum (after SUMIŃSKI 1968 and WALTON 1968). However, because sample size for juveniles was strongly limited, we only used data from young individuals when investigating differences between juveniles and adults (see results). For other analyses only data obtained from adults were used.

Statistical analysis was performed using the statistical package SPSS 12 PL. All traits had a normal distribution (KOLMOGOROV-SMIRNOV test, $P>0.08$ in all cases) and therefore parametric tests were used (ZAR 1999). We used $P<0.05$ as a threshold for statistical significance.

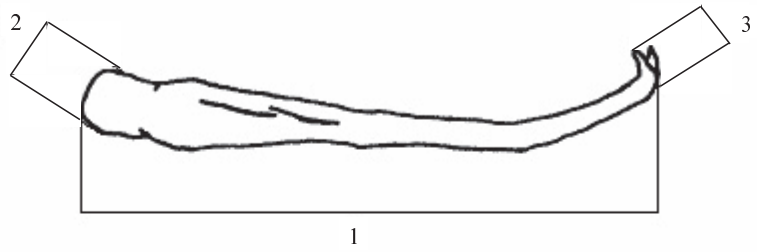

Fig. 1. Measured traits on the polecat baculum; 1 – maximum length, 2 – base width, 3 – distal tip size.

III. RESULTS

Adult individuals have significantly larger bacula than juveniles (Table I).

Table I

A comparison (mean ± SD) of measured baculum traits between juvenile and adult individuals of the polecat (sample sizes given in brackets)

Measured trait	Juveniles	Adults	*t*-test	P
Baculum length (mm)	29.20±5.59 (7)	39.38±4.03 (101)	- 6.29	<0.0001
Baculum width (mm)	2.87±0.82 (7)	4.80±1.45 (101)	- 3.46	<0.001
Distal tip size (mm)	3.74±0.88 (7)	5.18±0.59 (101)	- 5.99	<0.0001

Coefficients of variation (defined as the ratio of the standard deviation to the mean) as a measure of trait variability (see LÜPOLD et al. 2004) were established only for adults, and were 10.2%, 30.2% and 11.4% for baculum length, width and distal tip size, respectively.

In adults, all three measured *os penis* traits correlated significantly with each other. The correlation between length – width was r = 0.769 (Fig. 2A), length – distal tip size r = 0.491 (Fig. 2B), and width – distal tip size r = 0.319; sample size was 101 and all are significant at P<0.001. Although these correlations were significant, they only explained from 10% (width – distal tip size relationship) to 51% (length – width) of the variance between studied traits.

IV. DISCUSSION

Our findings show substantial variability in the measured characters of the polecat baculum (*os penis*). One source of such differences between baculum was age: juveniles had smaller *os penis* than adults in all three analysed traits. This is typical for the polecat (WALTON 1968; BUCHALCZYK & RUPRECHT 1977; WOLSAN 1993), as well as for other mammals (REINWALDT 1961; SUMIŃSKI 1968; MILLER et al. 1999; MILLER & BURTON 2001). The obtained measurements were similar to those presented in other studies (WALTON 1968; BUCHALCZYK & RUPRECHT 1977). However, even if juveniles were excluded from the analyses, variability was high. This is because the baculum grows and the shape of the basal knob changes over the life of the male (WALTON 1968), and maybe even partially regenerates after trauma in old individuals (KIERDORF 1996). Therefore it is assumed

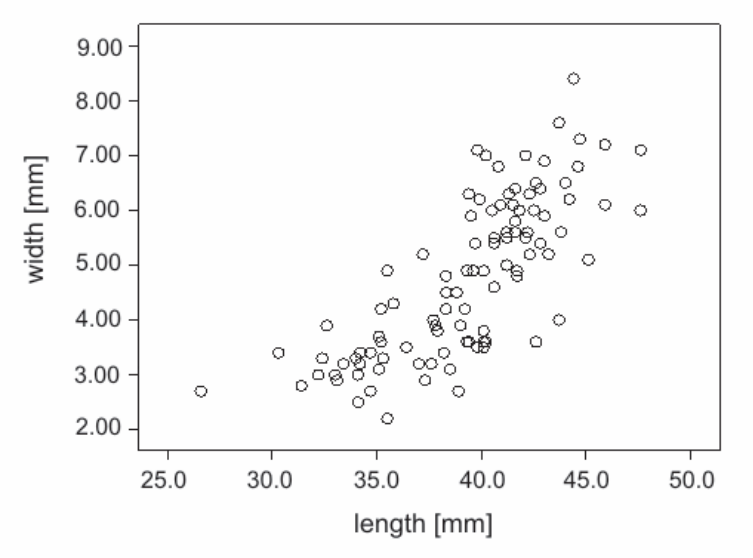

Fig. 2A. Relationship between baculum length and width.

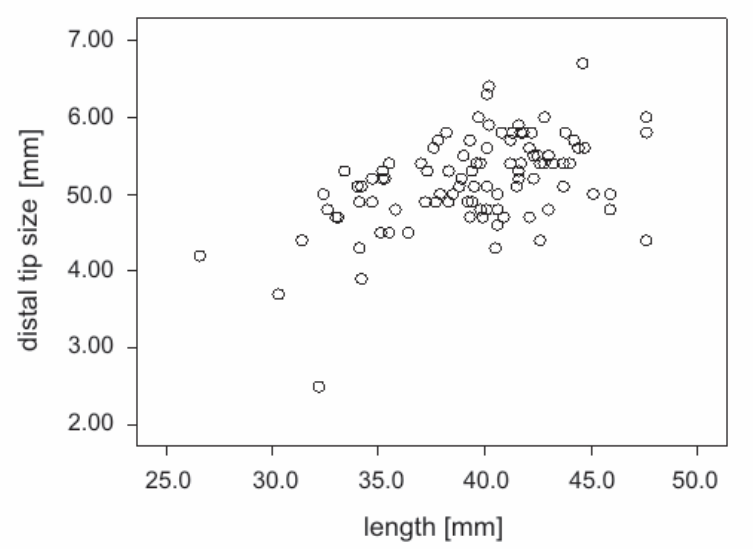

Fig. 2B. Relationship between baculum length and distal tip size.

that baculum shape and size is related to the testosterone level of an individual (MILLER et al. 1999; KELLY 2000; MILLER & BURTON 2001; DYCK et al. 2004).

Although PATTERSON (1983) indicated that bacula varied no more than other bones, we have found that, in the polecat, the coefficient of variation of the measured penicular traits is generally at least twice that of cranial measurements (CV up to 7%, see: BUCHALCZYK & RUPRECHT 1977; DE MARINIS 1995). However, recent studies on mammals (MILLER et al 1998; OOSTHUIZEN & MILLER

2000; MILLER & BURTON 2001; MILLER & NAGORSEN 2008) revealed higher size variability in bacula than in other skeletal elements. These findings can be attributed to less functional constraint for the baculum than for limb bones or mandibles (MILLER & BURTON 2001). It is unlikely that females would choose a male solely on bacular characteristics, but the *os penis* accounts for a large fraction of penile size so must be one source of biologically significant information that females appraise during copulation (MILLER & BURTON 2001). Also several interspecific studies proposed that sexual selection is a force behind the evolution of penile/bacular size and shape (HOSKEN et al. 2001; LARIVIÉRE & FERGUSON 2002; LÜPOLD et al. 2004). MILLER & BURTON (2001) and MILLER & NAGORSEN (2008) suggested that positive allometry and high variation of bacula imply that the size of the *os penis* is an indicator of male quality.

However, we have found that the most variable trait is not baculum length, often used in comparative analyses (HOSKEN et al. 2001; RAMM 2007), but baculum width, which was not even taken into account when the shape of the baculum was described (e.g. BARYSHNIKOV et al. 2003). On the other hand, we have found statistically significant correlations between the three measured baculum traits. Although correlations were significant, only 10% of the variance was explained in the case of the relationship between width and distal tip size. Therefore, evolutionary analyses limited only to one baculum size trait, i.e. length (HOSKEN et al. 2001; RAMM 2007, but see: MILLER & NAGORSEN 2008), may not adequately address the total variability of this bone.

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