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Morphological parameters of the population of the mole *Talpa europaea* L. from Northern Poland

Ewa Żurawska-Seta

Department of Zoology, University of Technology and Life Sciences J. i J. Śniadeckich
Ks. A. Kordeckiego 20, 85-225 Bydgoszcz, Poland
e-mail: ezurawskaseta@mail.utp.edu.pl

Abstract: The European mole is one of the most common mammals in Poland. It is small, with long pointed snout and covered in velvety coat. In general, males are larger than females, although as there is such a considerable amount of overlap between the sexes in both length and weight, these criteria are not reliable for sexing individuals. Moreover, the external genitalia of males and females are very similar in size and shape. The aim of this study was to evaluate morphological parameters of the population of the European mole and to assess their usefulness in sexing individuals. The research was carried out in pomorskie and kujawsko-pomorskie voivodship during three six-month periods: from August/September one year to February the following year in 2005–2008. There were obtained and analysed morphometrical data of 256 individuals. The results showed that there were differences between males and females in body size, with the exception of the tail length. Very characteristic was the considerable divergence between males and females in the anogenital distance. There was a high correlation between the anogenital distance and the sex. Thus, sexual dimorphism of anogenital distance seems to be really helpful in ascertaining the sex of the European mole, especially outside the breeding season when the vagina is completely closed and in a case of juveniles.

Key words: mole, *Talpa europaea* L., morphological parameters, sexual dimorphism

Introduction

The mole *Talpa europaea* L. inhabiting Poland is a small mammal that spend almost all its life underground. It is well adapted to this kind of lifestyle because of several morphological and anatomical features that were created during evolution. Its streamlined, cylindrical body, with elongated head and pointed hairless, fleshy, bright-pink snout, is covered in a velvety thick short black coat, with the exception of feet, snout and mouth. The tail is short, covered in thin hairs, which are sensory, and is held semierect. The mole has short large spade-like forelimbs, which enable it to dig (Kowalski 1971; Pucek 1984; Gorman and Stone 1990; Niethammer and Krapp 1990; Witte 1997; Nowak 1999).

There is only slight sexual dimorphism. In general, males are larger than females, although as there is such a considerable amount of overlap between the sexes in both length and weight, these criteria are not reliable for sexing individuals. The external genitalia of males and females are very similar in both size and shape, with the exception of the breeding period. Female genitalia, clitoris, looks like male genitalia, penis, and that is why it is often defined as pseudopenis (Gorman and Stone 1990; Witte 1997). Depending on season the sexual organs of both sexes vary in size and development. Distinct changes of internal and external sexual organs are observed during the mating season. Apart this time the genitalia are minimal (Lofts 1960; Kowalski 1971; Setchell 1981; Stone 1986; Gorman and Stone 1990). A vaginal orifice is clearly visible during rutting season as a small semilunar furrow. After the delivery, the vaginal orifice is merge, and when the period of the lactation past, it is already noticeable only as a small shaped like a half-moon scar, that prevents getting of lumps of earth to body cavities (Kowalski 1971; Witte 1997). There are 4 pairs of teats in females, but they are visible only during lactation (Stone 1986; Witte 1997).

The aim of this study was to gather and evaluate information about morphological parameters of the population of the European mole and to assess their usefulness in sexing individuals apart from the breeding period and in case of young.

Methods

The research was carried out in Northern Poland in pomorskie voivodship in Kępice in the neighbourhood of village called Warcino and in kujawsko-pomorskie voivodship in the neighbourhood of Chełmno, during three six-month periods: from August/September one year to February the following year in 2005–2008.

Morphometrical data of 256 adults individuals were collected, including 126 males and 130 females. Animals were caught using live traps, in areas were visible sights of moles presence and activity (molehills, surface tunnels) were observed. The sex of caught animals was defined on the base of morphological features like the body shape and presence of the semilunar scar remains after vaginal orifice merging. The young individuals, with unknown sex, were not been taken into consideration in analyses.

Moles were weighed, using spring balance (Pesola Medio Line) to the nearest 1 g, and measured to the nearest 1 mm using digital calliper (Sylvac), and released in the place of catching. Morphometrical measurements were conducted in accordance to Polish rules described in the Key of Polish Mammals (Pucek 1984). The measurements included:

1. The body length – from the end of the snout to the anus;
2. The tail length – from the anus to the end of the tail, without the brush at the end of the tail;
3. The anogenital distance – from the anus to the base of outside sexual organs;
4. The foot length – from the end of the heel to the end of the longest finger, without the claw;

Database was statistically analysed. The variability between males (N = 130) and females (N = 126) was assessed using Student's two-sample t-test, with the level of significance accepted as $\alpha = 0.05$, after previous verification of the normality (whether the distributions of the residuals were normal) using Shapiro-Wilk test and the equality (homogeneity) of variances (whether the variance of data in groups were the same) using Levene test. Analysis of regression and correlation were used to identify the relationships between variables. The strength of linear dependence between analyzed variables was measured by the Pearson product-moment correlation coefficient. The method of least squares was applied in regression analysis (Sokal and Rohlf 1995; Stanisz 2005, 2006; Kala 2005; Łomnicki 2006).

Results

The body weight of individuals varied from 60 g to 116 g, on average 87.1 g, but males were heavier than females (N_{males} = 126, $N_{females}$ = 130; Student's two-sample t-test t = 13.70; $p < 0.001$; fig. 1). The males weight ranged from 65 g to 116 g, on average it was 92.8 g (*SD* = 10.8 g). About 38% of males weighted between 91–100 g. The females weight ranged from 60 g to 104 g, on average it was 81.7 g (*SD* = 10.4 g), and it was about 11 g lower than mean weigh of males. About 35% of females weighted between 81–90 g.

The length of the body ranged from 98 mm to 165 mm, on average 131.3 mm, but males were larger than females (t = 10.19; $p < 0.001$; fig. 2). The body length of males varied from 111 mm to 165 mm, on average it was 137.8 mm (*SD* = 11.3 mm). The body length of 34% of males was between 131 and 140 mm and the body length of 31% of males was between 141 and 150 mm. The body length of females ranged from 98 mm to 150 mm, mean about 124.7 mm (*SD* = 9.3 mm).

There were high positive correlation between these two features (Pearson correlation coefficient r = 0.87; according to Guilford's scale it is the range: 0.71–0.90; $p < 0.001$). Analyses showed, that about 75% of variability of body weight can be explained by variability of body length (coefficient of determination r^2 = 0.75). The linear regression model was as follows: THE WEIGHT = 8.56 × body length – 25.04 ± 5.95, where the error of estimate for the parameter b_1 was assessed on 3%, and for independent variable on 16%. There was a moderate, but statistically significant correlation between the body size and sex (R = 0.50; the Guilford's scale: 0.41–0.70; $p < 0.001$).

The next analysed morphological parameter was the tail length (fig. 3). The mean length of tail ranged from 23–38 mm, about 30.5 mm (*SD* = 3.7 mm) on average in males and 20–35 mm, about 29.2 mm (*SD* = 3.4 mm) on average in females. But differences between males and females in the length of tail were not statistically significant (t = 0.93; p = 0.37). The tail length had not statistically significant influence on body weight (r = 0.06; p = 0.34). However, there was low, but statistically significant correlation between the tail length and the body length (r = 0.13; the Guilford's scale: 0.21–0.40; p = 0.032). The tail length constituted about 19% of body length. The mean foot length ranged from 20.2 mm (*SD* = 2.1 mm) in males and 18.9 (*SD* = 1.4 mm) in females and the difference was statistically significant (t = 5.77; $p < 0.001$; fig. 4).

The distance from the anus to the base of the external genitalia was the last, but not least morphological feature that was analysed. The anogenital distance varied from about 10.6 mm (*SD* = 1.1 mm) in males to about 3.1 mm (*SD* = 0.9 mm) in females and the difference was statistically significant (t = 62.81; $p < 0.001$; fig. 5). There was a moderate correlation between the anogenital distance and the body length (r = 0.51; according to Guilford's scale it is the range: 0.41–0.70; $p < 0.001$). However, only 26% of the variability of the anogenital distance can be explained by the variability of body length (coefficient of determination $r^2 = 0.26$). But there was a high ($R = 0.87$; the Guilford's scale: 0.71–0.90) and statistically significant ($p < 0.001$) correlation between the anogenital distance and the sex.

Discussion

The obtained ranges of morphological parameters are similar to those presented in the Key of Polish Mammals (Pucek 1984) and in foreign-language literature, but in this case they are not identical (Van der Brink 1972; Stone and Gorman 1985; Stone 1986; Niethammer and Krapp 1990; Stone and Gorman 1991; Macdonald et al. 1997; Witte 1997; Nowak 1999).

The divergences can be caused by various factors. Firstly, there are methodological differences in performing measurements. In Poland, the body length is measured from the tip of the snout to the anus. In contrast, in countries of Western Europe this measurement is performed from the tip of the snout to the base of the tail, while in the United States the length of the body of small mammals is measuring with the tail length – from the tip of the snout until the end of the tail, without hair at the end of it. Thus, it is not possible to refer directly to data presented in foreign literature and to make straight comparisons, nor to draw a conclusion concerning the body length and the length of the tail.

Moreover, the body size of individuals of the same species may vary considerably depending on the latitude and climate condition, especially temperature. According to the Bergman's (1847) rule, individuals belonging to one kind living in low temperatures, in cooler climatic zones are usually larger than the ones living in a warmer climate. The smaller proportion of the surface of the body to the body weight, provide them the smaller warmth loss from the organism. Research conducted in United Kingdom showed that there were differences in body size between moles inhabiting coasts of the north-eastern Scotland in the neighbourhood of Aberdeen, and moles living in south England in the neighbourhood of Oxford. The body weight of moles from Scotland ranged from 100 g in males and 75 g in females and they were larger than moles living in England, which weight from 86 g in males and 72 g in females (Stone and Gorman 1985; Macdonald et al. 1997).

Environmental factors have considerable influence on morphology. The previous study proved that the size of body and skull are changeable and depending on environmental circumstances (Świecimski 1960; Pucek 1984). For example, moles from Tatra Mountains showed many differences in comparison with the lowland population of *T. europaea*. Moles inhabiting in Tatra Mountains had smaller body, slender skull and narrower brain case than population living in other parts of Poland (Świecimski 1960). Świecimski (1960) sporadically observed unilateral or bilateral blindness and small value of the condylobasal length. This suggested that moles inhabiting in Tatra Mountains could be related to *Talpa caeca* Savi, 1822 living in high mountains in the south of Europe. However, detailed analyses of other systematic features showed that moles living in Tatra Mountains belonged to subspecies *T. europaea europaea* Linnaeus, 1758 and not to *T. caeca* Savi, 1822. To summarise, the specificity of the mountain environment effected on forming certain features into the similar manner at these two different species.

The results attained in this study indicate that there were statistically significant differences between males and females in body size. Males were larger than females, what is in harmony with general rule in mammals' world (Pucek 1984). All authors are consistent in this aspect and pointed out the divergences between sexes by giving separate ranges of body weight and body length for males and females. Nevertheless, it is strongly underlined that there is a great amount of overlap between sexes in both length and weight. Thus, these criteria are not reliable for sexing individuals (Van der Brink 1972; Stone and Gorman 1985; Stone 1986; Niethammer and Krapp 1990; Stone and Gorman 1991; Macdonald et al. 1997; Witte 1997; Nowak 1999).

Moreover, the external genitalia of females characterise significant masculinisation, what additionally distinguish sexing individuals outside the breeding season (Gorman and Stone 1990). The results obtained in this study showed that there was very characteristic divergence between males and females in the distance from the anus to the base of the external genitalia. There were similar results in previous research (Skoczeń 1958, Gorman and Stone 1990; Witte 1997; Whitworth 1999). However, authors are not unanimous in a case of the size of this feature. According to Skoczeń (1958) the anogenital distance in females ranges from 2–3 mm outside the breeding season to about 5 mm during matting period. It is connected with development and opening of vagina orifice. The mean anogenital distance in males is constant within all year around and it amount to 10–13 mm. In contrast, Gorman and Stone (1990) claim that the anogenital distance in females is always well under 4 mm, whereas in males it is more than 5 mm.

Previous studies showed that sexual dimorphism of anogenital distance could be caused by the effect of hormones, similarly to the masculinization of female sexual external organs. There are observed the masculinization of female external genitalia in other species of mammals as well, in Spotted Hyena *Crocuta crocuta* for example (Frank et al. 1990; Place and Glickman 2004), but also in other species of moles from genus *Talpa, Scapanus, Condylura* and *Neurotrihus* (Whitworth et al. 1999; Rubenstein et al. 2003; Zurita et al. 2003; Place and Glickman 2004). Some investigators claim that it is connected with special areas within ovaries of female moles – an ovarian interstitial glands (OIG) that produce and secrete testosterone (Deanesly 1966; Suzuki and Racey 1978; Gorman and Stone 1990; Beolchini et al. 1999; Whitworth et al. 1999). Ovaries of female moles consist of the cortical part, built and functioning the same as ovaries of other female mammals, and the core, containing among others Leydig cells, which are characteristic for male gonads and are responsible for producing and secreting testosterone and other androgens important for sexual development and puberty. However, there were not well developed and fully differentiated Sertoli cells, critical for the support and control of the process of the spermatogenesis in testicles of males (Deanesly 1966; Suzuki and Racey 1978; Gorman and Stone 1990; Beolchini et al. 1999; Whitworth et al. 1999; Zurita et al. 2003; Barrionuevo et al. 2004; Place and Glickman 2004). Apart from *T. europaea*, the ovarian interstitial glands are also present in ovaries of females other species from genus *Talpa*: *T. romana*, *T. occidentalis* and *T. stankovici* (Jiménez et al. 1988, 1990, 1993, 1996; Sanchez et al. 1996; Beolchini et al. 1999; Zurita et al. 2003; Barrionuevo et al. 2004). Research among moles from a New World, *Scapanus, Condylura* and *Neurotrihus*, confirmed that there was a considerable divergence between sexes in anogenital distance within species with OIG - *Condylura cristata* and *Neurotrihus gibbsi*. In contrast, the species without OIG – *Scapanus* spp. – were not demonstrating the sex dimorphism in anogenital distance (Rubenstein 2003). Thus, it seems that anogenital distance can be good feature for sexing *T. europaea*, especially outside the matting period and in case of juveniles.

Conclusions

The obtained results of morphological parameters of the population of the mole in Northern Poland are similar to those presented in the Key of Polish Mammals (Pucek 1984). There were statistically significant differences between males and females in body size (except the length of the tail). However, for the sake of great overlapping of these parameters they are not enough indicator allowing for sexing moles. But very characteristic was the considerable divergence between males and females in the anogenital distance. Accordingly, sexual dimorphism of anogenital distance seems to be really helpful in ascertaining the sex of the European mole, especially outside the breeding season when the vagina is completely closed and in the case of young individuals.

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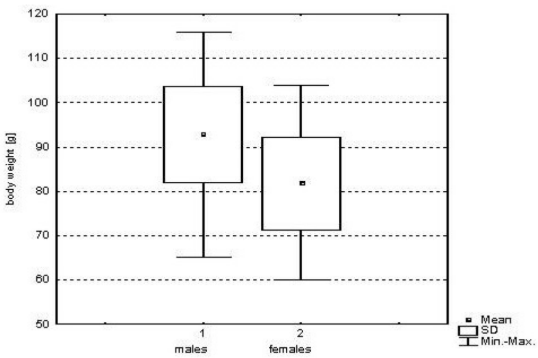

Fig. 1. The body weight of males (1) and females (2)

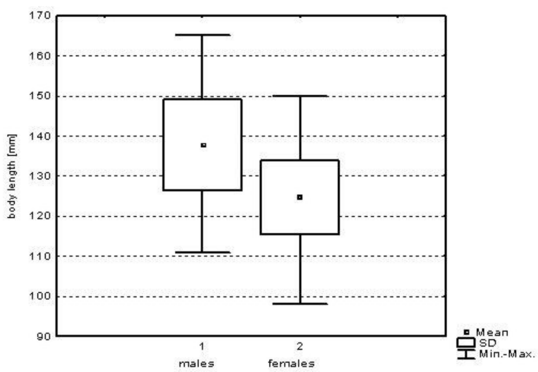

Fig. 2. The body length of males (1) and females (2)

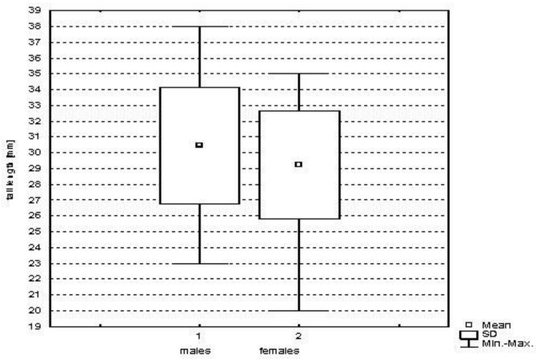

Fig. 3. The tail length of males (1) and females (2)

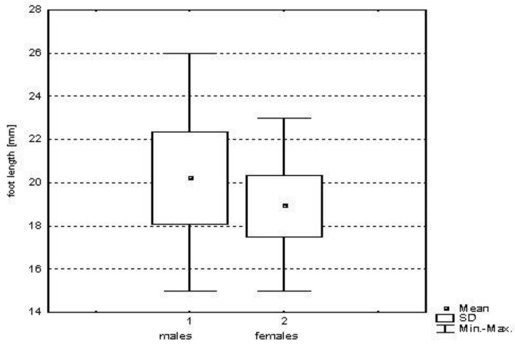

Fig. 4. The foot length of males (1) and females (2)

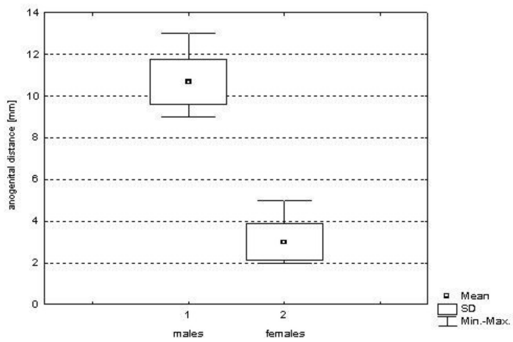

Fig. 5. The anogenital distance of males (1) and females (2)

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