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# Morphometric variability of *Apodemus uralensis* in Slovakia (Rodentia: Muridae)

Morfometrická variabilita ryšavky malookej (*Apodemus uralensis*) na Slovensku (Rodentia: Muridae)

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**Abstract**. Morphometric variability was studied in samples of three populations of *A. uralensis* collected in the eastern part of Slovakia (Pieniny Mts., Košická kotlina basin and Východoslovenská nížina plain) during the period 1992–2006. Twenty-eight skull and dental variables were measured and evaluated in 98 skulls (31 from the Košická kotlina basin, 47 from the Východoslovenská nížina plain and 20 from the Pieniny Mts.) with regard to geomorphological divisions of Slovakia. The average values of skull and dental variables varied fairly among the orographic units of Slovakia. ANOVA/Kruskal-Wallis tests showed differences in the cranial variables between the geomorphological units of the country.

**Key words**. Craniometry, *Apodemus uralensis*, measurements, Slovakia.

## INTRODUCTION

European wood mice of the genus *Apodemus* are, with a few exceptions, sibling species widely distributed in the western part of the Palaearctic region. According to Frynta et al. (2001) and Janžekovič & Kryštufek (2004) the relationships within the subgenus *Sylvaemus* remained poorly understood until very recently.

The pygmy field mouse, *Apodemus uralensis* (Pallas, 1811), inhabits a wide geographical range in Central Europe, the Baltic region and east through western Russia and Ukraine to eastern Kazakhstan, the Altai Mts., north-west China and south to the Caucasus region and northern Turkey. The eastern and southern boundary of the range in Central Asia is yet unresolved (Musser & Carleton 1993, Mitchell-Jones et al. 1999, Wilson & Reeder 2005). More detailed information concerning the distribution and ecology of the species in Slovakia was summarized by Krištofík (2012).

Apart from molecular and biochemical analyses (Meždzerin & Zagorodniuk 1989, Vorontsov et al. 1992, Orlov et al. 1996, Filippucci et al. 1996, 2002, Meždzerin 1997, Macholán et al. 2001, Çolak et al. 2005), many reports were published on the variation of cranial and external

characteristics in the pygmy field mice populations (e.g., Kratochvíl & Zejda 1962, Hamar et al. 1966, Haitlinger & Ruprecht 1967, Steiner 1968, Haitlinger 1972, Spitzenberger & Bauer 2001, Frynta et al. 2001, Vohralík 2002, Lashkova & Dzeverin 2002, Lashkova 2003, Balčiauskienė et al. 2004, Zagorodniuk 2005, Czrkész 2005, Çolak et al. 2007).

Knowledge on morphological variability of populations from Slovakia was presented by Mošanský (1988), Hýbelová (2009), Pavelková (2010) and Baláž et al. (2012). Despite the above-mentioned papers, information on the morphometric variability of *A. uralensis* within the Slovak Republic is still insufficient. The main aim of the study was to ascertain whether the pygmy field mouse exhibits differences in skull measurements among populations from three geomorphological units of Slovakia (Košická kotlina basin, Východoslovenská rovina plain and Pieniny Mts.).

## MATERIAL AND METHODS

The material of *A. uralensis* evaluated in this study originates from field trapping carried out in three geomorphological units of Slovakia: Košická kotlina basin, Východoslovenská nížina plain and Pieniny Mts., during the years 1992–2006 (Mazúr & Lukniš 1978). After the external morphometric measurements were taken, the heads were detached from the body and biologically prepared using *Dermestes* larvae. In order to obtain a greater degree of cleanness the skulls were blanched in 3% hydrogen peroxide. Identification of the mice was based on diagnostic characters described by Steiner (1968) and Pelikán (1970). All skulls are deposited in the collections of the Institute of Parasitology, Slovak Academy of Sciences in Košice.

Skull measurements included 28 skull- and dental variables. Skull measurements were taken with a digital calliper with accuracy of 0.01 mm, while dental measurements with a stereomicroscope Olympus SZ 400. Only adult individuals were measured to minimize the effect of allometric variation associated with growth. To avoid unwanted variation due to potential asymmetry, the right side was always measured in paired characters.

The material consisted of 98 skulls (31 from the Košická kotlina basin, 47 from the Východoslovenská nížina plain, 20 from the Pieniny Mts.) which were evaluated as recommended by Reutter et al. (1999), Frynta et al. (2001) and Vohralík (2002): LCr – greatest length of skull; LCb – condylobasal length; LN – length of the nasal bone; LF – length of the face; FI – length of the foramina incisiva; LD – length of the upper diastema; LOSD – length of the upper molar row at alveoli; LOID – length of the lower molar row at alveoli; $LM^1$ – length of the first upper molar; $LM_1$ – length of the first lower molar; $LM^{1–3}$ – length of the upper molar row; $I^1$–$M^3$ – rostral length, i.e. taken as the distance between the prosthion and the most aboral point on the crown of the third upper molar (cf. Vohralík 2002); BULL – length of the tympanic bulla; PALL – length of the palatal bone; LMd – mandible length; LaZ – zygomatic width; LaN – braincase width; Ocb – occipital width; IBW – interbullar width, i.e. shortest distance between the external auditory openings; LaI – interorbital width, i.e. minimum distance; LaR – rostral width, i.e. the maximum distance; $LaM^1$– width of the first upper molar; $LaM_1$ – width of the first lower molar; $WI^1$ – width of the incisor; BCH – braincase height; RH – rostral height; AMd – mandible height; $CI^1$ – thickness of the incisor.

The obtained data set (untransformed data) was evaluated using the following statistical characteristics: mean (M), minimum and maximum (min–max), standard deviation (SD), standard error of the mean (SE) and coefficient of variation (CV). The normal distribution was tested by the D'Agostino-Pearson omnibus $K^2$ test and Shapiro-Wilk normality tests. Before other analyses, measurements were log-transformed to reduce intra-sample variation and to improve normality. ANOVA variance analysis was used for validation of statistical significance of variability among geomorphological units of Slovakia. In variables still displaying considerable deviations from normality and/or homogeneity of variance after the transformation, the non-parametric Kruskal-Wallis test was used instead of ANOVA. A confidence level of 95% was accepted as significant. Statistical comparison on the data used standard methods (McDonald 2008). All 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).

## RESULTS

Different cranial variables of pygmy field mice populations from three geomorphological units of Slovakia were measured and evaluated. Using classical methods of descriptive statistics, we evaluated the variability of the cranial traits of adult individuals (Tables 1–3). The coefficient of variance (CV) can be seen as an indicator of sample homogeneity. Overall, the values of the CV for several traits were higher than 5%, indicating a generally larger variability. The results confirmed that the least variable traits were mainly skull size: the total skull length (LCr) and the condylobasal length (LCb). Similarly, the molar-size variation was smaller than 5.0% and together with the smaller values of standard deviations showed that molars belong among the

Table 1. Morphometric data (mm) of adult *Apodemus uralensis* from the Košická kotlina basin. Legend: N – number; min, max – interval of margins; M – mean; SD – standard deviation; SE – standard error of the mean; CV – coefficient of variance

Tab. 1. Morfometrické údaje (mm) dospelých jedincov *Apodemus uralensis* Košickej kotliny. Legenda: N – počet; min, max – interval hraníc; M – priemer; SD – smerodajná odchýlka; SE – štandardná chyba priemeru; CV – koeficient variácie

| dimension | N | M | min–max | SD | SE | CV |
|---|---|---|---|---|---|---|
| LCr | 31 | 22.14 | 21.00–23.46 | 0.56 | 0.10 | 2.52 |
| LCb | 31 | 21.43 | 20.34–23.03 | 0.57 | 0.10 | 2.67 |
| LaZ | 31 | 11.38 | 10.73–12.05 | 0.30 | 0.05 | 2.67 |
| LaN | 31 | 10.63 | 10.16–11.17 | 0.27 | 0.05 | 2.49 |
| BCH | 31 | 7.68 | 7.08–8.31 | 0.33 | 0.06 | 4.29 |
| IBW | 29 | 8.74 | 8.18–9.04 | 0.23 | 0.04 | 2.58 |
| LaI | 30 | 3.79 | 3.39–3.99 | 0.11 | 0.02 | 2.96 |
| Ocb | 31 | 10.21 | 9.85–10.80 | 0.23 | 0.04 | 2.21 |
| LN | 31 | 7.17 | 6.55–7.72 | 0.37 | 0.07 | 5.15 |
| FL | 30 | 10.87 | 10.25–11.62 | 0.38 | 0.07 | 3.53 |
| FI | 30 | 4.34 | 4.01–4.99 | 0.25 | 0.05 | 5.78 |
| LD | 31 | 5.52 | 5.14–6.07 | 0.23 | 0.04 | 4.26 |
| LaR | 31 | 3.22 | 2.99–3.70 | 0.15 | 0.03 | 4.80 |
| RH | 31 | 3.84 | 3.65–4.08 | 0.11 | 0.02 | 2.78 |
| LOSD | 31 | 3.26 | 3.04–3.74 | 0.14 | 0.02 | 4.38 |
| $LM^1$ | 29 | 1.55 | 1.50–1.72 | 0.05 | 0.01 | 3.44 |
| $LaM^1$ | 31 | 1.05 | 1.00–1.08 | 0.02 | 0.00 | 2.16 |
| $LM^{1–3}$ | 31 | 3.10 | 2.93–3.39 | 0.12 | 0.02 | 3.72 |
| $WI^1$ | 31 | 0.61 | 0.55–0.65 | 0.02 | 0.00 | 2.72 |
| $CI^1$ | 31 | 1.11 | 0.95–1.25 | 0.07 | 0.01 | 6.65 |
| $I^1–M^3$ | 30 | 9.93 | 9.37–10.50 | 0.26 | 0.05 | 2.65 |
| BULL | 31 | 3.88 | 3.50–4.20 | 0.17 | 0.03 | 4.40 |
| PALL | 31 | 3.84 | 3.40–4.40 | 0.24 | 0.04 | 6.15 |
| LMd | 30 | 9.96 | 9.19–10.62 | 0.34 | 0.06 | 3.38 |
| AMd | 30 | 5.59 | 5.22–6.22 | 0.22 | 0.04 | 3.98 |
| LOID | 30 | 3.16 | 2.93–3.55 | 0.15 | 0.03 | 4.62 |
| $LM_1$ | 30 | 1.42 | 1.30–1.53 | 0.06 | 0.01 | 4.42 |
| $LaM_1$ | 30 | 0.88 | 0.77–1.00 | 0.05 | 0.01 | 5.58 |

Table 2. Morphometric data (mm) of adult *Apodemus uralensis* from the Východoslovenská nížina plain (for legend see Table 1)
Tab. 2. Morfometrické údaje (mm) dospelých jedincov *Apodemus uralensis* Východoslovenskej nížiny (legenda viď tab. 1)

| dimension | N | M | min–max | SD | SE | CV |
|---|---|---|---|---|---|---|
| LCr | 47 | 22.22 | 21.20–23.55 | 0.55 | 0.08 | 2.45 |
| LCb | 47 | 21.48 | 20.10–22.78 | 0.57 | 0.08 | 2.67 |
| LaZ | 45 | 11.48 | 10.22–12.48 | 0.54 | 0.08 | 4.74 |
| LaN | 47 | 10.85 | 10.17–11.39 | 0.31 | 0.05 | 2.90 |
| BCH | 46 | 7.62 | 7.05–8.45 | 0.28 | 0.04 | 3.66 |
| IBW | 47 | 8.45 | 8.03–9.43 | 0.33 | 0.05 | 3.74 |
| LaI | 47 | 3.84 | 3.15–4.08 | 0.16 | 0.02 | 4.17 |
| Ocb | 47 | 10.24 | 9.26–11.02 | 0.30 | 0.04 | 2.88 |
| LN | 46 | 7.28 | 6.08–7.80 | 0.26 | 0.04 | 3.62 |
| FL | 46 | 11.39 | 10.62–12.25 | 0.38 | 0.06 | 3.35 |
| FI | 47 | 4.34 | 4.02–4.62 | 0.15 | 0.02 | 3.39 |
| LD | 47 | 5.75 | 5.14–6.20 | 0.22 | 0.03 | 3.90 |
| LaR | 47 | 3.16 | 2.77–3.49 | 0.17 | 0.03 | 5.43 |
| RH | 47 | 3.95 | 3.38–5.77 | 0.30 | 0.04 | 7.70 |
| LOSD | 47 | 3.24 | 2.92–3.56 | 0.14 | 0.02 | 4.29 |
| $LM^1$ | 47 | 1.58 | 1.45–1.75 | 0.08 | 0.01 | 4.78 |
| $LaM^1$ | 47 | 1.05 | 0.97–1.12 | 0.04 | 0.01 | 4.02 |
| $LM^{1–3}$ | 47 | 3.14 | 2.93–3.33 | 0.10 | 0.01 | 3.03 |
| $WI^1$ | 47 | 0.62 | 0.56–0.67 | 0.02 | 0.00 | 3.71 |
| $CI^1$ | 47 | 1.10 | 1.00–1.30 | 0.06 | 0.01 | 5.04 |
| $I^1–M^3$ | 47 | 10.16 | 9.50–10.75 | 0.27 | 0.04 | 2.65 |
| BULL | 46 | 3.83 | 3.50–4.10 | 0.15 | 0.02 | 4.00 |
| PALL | 47 | 3.87 | 3.50–4.20 | 0.19 | 0.03 | 4.87 |
| LMd | 44 | 10.06 | 9.36–10.92 | 0.32 | 0.05 | 3.17 |
| AMd | 44 | 5.58 | 5.06–6.15 | 0.25 | 0.04 | 4.50 |
| LOID | 46 | 3.14 | 2.83–3.36 | 0.11 | 0.02 | 3.41 |
| $LM_1$ | 46 | 1.39 | 1.30–1.60 | 0.06 | 0.01 | 4.29 |
| $LaM_1$ | 46 | 0.90 | 0.80–1.00 | 0.04 | 0.01 | 4.50 |

most conservative characteristics. Moreover, the overlaps of values of the measured variables were high and were different for each trait in the different parts of the country.

Results of the analysis revealed statistically significant differences in several variables among the three geomorphological units (Table 4). Statistical differences between populations of the Východoslovenská nížina plain and the Košická kotlina basin were found particularly in LaN, FL, LD and RH.

Similarly, between samples from the Východoslovenská nížina plain and the Pieniny Mts. a high difference in the mean values was also observed for FL, LaR, $CI^1$, $I^1–M^3$ and LOID. A similar difference in the mean values of several traits (LaI, LMd and LOID) was observed between samples from the Košická kotlina basin and the Pieniny Mts.

## DISCUSSION

Data on the morphology of skull and dental traits of *A. uralensis* (*microps*) from the European distribution range and from the territory of eastern Turkey were published by several authors (e.g., Pachinger 1962, Kratochvíl & Zejda 1962, Zejda 1965, Hamar et al. 1966, Haitlinger & Ruprecht 1967, Steiner 1968, Haitlinger 1972, Mošanský 1988, Spitzenberger & Bauer 2001, Frynta et al. 2001, Çolak et al. 2007, Baláž et al. 2012). In Slovakia, Kratochvíl & Rosický (1952) described what was originally thought to be a new species, *Apodemus microps*, from the surroundings of Šaca (Košická kotlina basin), but it was later identified to be a synonym of *A. uralensis* (Vorontsov et al. 1992, Krištofík 2012). Presence of an isolated population of the species in the Liptovské Tatry Mts. (Western Tatra Mts.) mentioned by Mošanský (1963, 1995) is interesting. These individuals had a smaller body size compared to populations living in the highland and lowland areas of Slovakia. Based on these observations, the author predesignated

Table 3. Morphometric data (mm) of adult *Apodemus uralensis* from the Pieniny Mts. (for legend see Table 1)
Tab. 3. Morfometrické údaje (mm) dospelých jedincov *Apodemus uralensis* Pienin (legenda viď tab. 1)

| dimension | N | M | min–max | SD | SE | CV |
|---|---|---|---|---|---|---|
| LCr | 20 | 22.32 | 21.36–23.02 | 0.42 | 0.09 | 1.86 |
| LCb | 20 | 21.49 | 20.43–22.15 | 0.47 | 0.11 | 2.21 |
| LaZ | 20 | 11.41 | 10.75–11.82 | 0.32 | 0.07 | 2.82 |
| LaN | 20 | 10.82 | 10.34–11.24 | 0.22 | 0.05 | 2.00 |
| BCH | 19 | 7.78 | 7.50–8.09 | 0.17 | 0.04 | 2.21 |
| IBW | 20 | 8.83 | 8.46–9.23 | 0.26 | 0.06 | 2.89 |
| LaI | 19 | 3.88 | 3.68–4.08 | 0.10 | 0.02 | 2.50 |
| Ocb | 20 | 10.24 | 9.87–10.51 | 0.18 | 0.04 | 1.79 |
| LN | 20 | 7.17 | 6.64–7.59 | 0.33 | 0.07 | 4.63 |
| FL | 20 | 11.00 | 10.00–11.75 | 0.39 | 0.09 | 3.54 |
| FI | 20 | 4.22 | 3.89–4.55 | 0.21 | 0.05 | 5.06 |
| LD | 20 | 5.63 | 5.28–5.87 | 0.15 | 0.03 | 2.69 |
| LaR | 20 | 3.31 | 3.11–3.61 | 0.13 | 0.03 | 4.07 |
| RH | 20 | 3.85 | 3.67–3.98 | 0.11 | 0.02 | 2.75 |
| LOSD | 20 | 3.29 | 3.00–3.68 | 0.14 | 0.03 | 4.32 |
| $LM^1$ | 20 | 1.56 | 1.45–1.62 | 0.06 | 0.01 | 3.69 |
| $LaM^1$ | 19 | 1.04 | 1.00–1.07 | 0.03 | 0.01 | 2.43 |
| $LM^{1–3}$ | 19 | 3.17 | 2.97–3.30 | 0.09 | 0.02 | 2.75 |
| $WI^1$ | 20 | 0.61 | 0.57–0.62 | 0.01 | 0.00 | 2.44 |
| $CI^1$ | 20 | 1.15 | 1.02–1.25 | 0.06 | 0.01 | 4.99 |
| $I^1–M^3$ | 19 | 10.09 | 9.75–10.37 | 0.17 | 0.04 | 1.73 |
| BULL | 20 | 3.89 | 3.70–4.00 | 0.10 | 0.02 | 2.54 |
| PALL | 20 | 3.87 | 3.50–4.30 | 0.19 | 0.04 | 4.99 |
| LMd | 20 | 10.20 | 9.73–10.63 | 0.23 | 0.05 | 2.28 |
| AMd | 20 | 5.50 | 5.17–5.76 | 0.17 | 0.04 | 3.17 |
| LOID | 20 | 3.27 | 3.00–3.50 | 0.12 | 0.03 | 3.73 |
| $LM_1$ | 20 | 1.42 | 1.30–1.57 | 0.07 | 0.02 | 4.94 |
| $LaM_1$ | 20 | 0.89 | 0.80–0.97 | 0.04 | 0.01 | 4.74 |

Table 4. Comparison of cranial and dental traits in *Apodemus uralensis* from three geomorphological units of Slovakia: Košická kotlina basin (KK), Východoslovenská rovina plain (VSN) and Pieniny Mts. (Pien) with differences between them indicated ($^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$). Independent posthoc Bonferroni's (ANOVA) and Dunn's (Kruskal-Wallis test) Multiple Comparison Tests were used to compare the variables

Tab. 4. Porovnanie morfometrických znakov medzi troma geomorfologickými jednotkami Slovenska: Košická kotlina (KK), Východoslovenská rovina (VSN) a Pieniny (Pien) s naznačenými štatistickými rozdielmi. ($^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$). Na porovnanie premenných boli použité Bonferroniho (ANOVA) a Dunnov (Kruskal-Wallis test) posthoc testy

| dimension | test value / hodnota testu | p | Multiple Comparison Test |
|---|---|---|---|
| LCr | 0.73 | 0.48 | |
| LCb | 0.09 | 0.92 | |
| LaZ | 0.46 | 0.63 | |
| LaN | 5.75 | 0.00** | VSN-KK** |
| BCH | 2.28 | 0.11 | |
| IBW | 1.35 | 0.26 | |
| LaI | 8.04 | 0.02* | KK-Pien* (K-W) |
| Ocb | 0.98 | 0.61 | |
| LN | 1.54 | 0.46 | |
| FL | 18.24 | <0.0001*** | VSN-KK***, VSN-Pien** |
| FI | 3.25 | 0.04* | |
| LD | 10.9 | <0.0001*** | VSN-KK*** |
| LaR | 6.79 | 0.00** | VSN-Pien** |
| RH | 8.69 | 0.01* | VSN-KK* (K-W) |
| LOSD | 2.59 | 0.27 | |
| $LM^1$ | 2.44 | 0.30 | |
| $LaM^1$ | 2.57 | 0.28 | |
| $LM^{1–3}$ | 2.80 | 0.07 | |
| $WI^1$ | 2.11 | 0.35 | |
| $CI^1$ | 9.48 | 0.01** | VSN-Pien** (K-W) |
| $I^1–M^3$ | 7.86 | 0.00*** | VSN-Pien** |
| BULL | 1.39 | 0.25 | |
| PALL | 0.37 | 0.77 | |
| LMd | 3.48 | 0.04* | KK-Pien* |
| AMd | 1.00 | 0.37 | |
| LOID | 7.89 | 0.00*** | VSN-Pien***, KK-Pien** |
| $LM_1$ | 7.58 | 0.02* | |
| $LaM_1$ | 1.24 | 0.29 | |

these individuals as a new species or subspecies of *A. microps* under the working name *Apodemus parvulus*. The name *A. parvulus* was proposed only conditionally and was not accompanied by a proper description; it should therefore be considered as a nomen nudum (Vohralík 2002). Similarly, Vohralík (2002) described a subspecies, *Apodemus uralensis cimrmani*, representing an isolated population from northwestern Bohemia based on the different length of the upper molar row, the length and width of the first upper molar and the length of the foramina incisiva. Based on the above-mentioned data, the taxonomic affiliation of the isolated populations of *A. uralensis* in Central Europe as well as in the entire distribution range of the species remains

unclear (Niethammer & Krapp 1978, Meždžerin & Zagorodniuk 1989, Vorontsov et al. 1992, Fillipucci et al. 1996, Orlov et al. 1996, Meždžerin 1997, Frynta et al. 2001, Macholán et al. 2001). From the area of Eastern Europe and adjacent Asia, small forms of the genus *Apodemus* were earlier described as a new subspecies or species of the race lines of the species *sylvaticus* and *flavicollis* (Meždžerin 1997, Zagorodniuk et al. 1997 etc.). The problem of determination of European species of the genus *Apodemus* (subgenus *Sylvaemus* – *A. flavicollis*, *A. sylvaticus* and *A. uralensis*, syn. *A. microps*) is very complex due to the large overlap of taxonomic characteristics (somatic, skull and dental traits) and it belongs among frequently discussed issues in mammalian taxonomy (Mošanský 1957, Niethammer & Krapp 1978, Pucek 1981, Macholán 1996, Reutter et al. 1999, Anděra & Horáček 2005, Janžekovič & Kryštufek 2004, Cserkész 2005, Barčiová & Macholán 2009 etc.). In the last decades, several authors (Sikorski 1982, Frynta et al. 2001, Reutter et al. 2001, Macholán et al. 2001, Fillippucci et al. 2002, Nová et al. 2002) have investigated the intra- and interspecific variability of *Apodemus* species by using various molecular and genetic methods.

Baláž et al. (2012) presented a morphometric analysis of *A. uralensis* from the Podunajská rovina plain (western Slovakia). Based on the variation coefficient, the authors showed that the values of the length of the *foramen incisivum* (FI) had the largest variability of the characteristics measured on the skull. These results were in accordance with our results for individuals from the Košická kotlina basin and the Pieniny Mts., where the values of the coefficient of variation were high in the observed trait although not the highest. The latter authors confirmed that the length of the third upper molar ($M^3$) had higher variability and the lowest variability was obtained for the postorbital breadth (LaI). Similarly, for the lower jaw they showed that the highest values of the variation coefficient occurred in the coronoid height of the mandible (AMd). The observation of the above mentioned authors confirmed the statements by Janžekovič & Kryštufek (2004) that the smaller molars of *A. uralensis* correspond with the direct dependence between body size and molar size. Compared with the results of Baláž et al. (2012), our samples were shown to be smaller in almost all common features.

Comparing our results with those published by Kratochvíl & Zejda (1962), Spitzenberger & Bauer (2001), Frynta et el. (2001), and Zagorodniuk (2005), it was found that mice from the eastern parts of the distribution range (the southern Ural) showed higher mean values than those from Central Europe. The pygmy field mice from eastern Slovakia had smaller mean values in almost all traits.

## SÚHRN

Morfometrická analýza ryšavky malookej (*Apodemus uralensis*) bola študovaná na 98 lebkách. Jedince boli odchytené v priebehu rokov 1992–2006 v troch geomorfologických celkoch na východnom Slovensku (Pieniny, Košická kotlina a Východoslovenská nížina). Celkovo bolo meraných 28 lebečných znakov pomocou digitálneho posuvného meradla Digital Caliper s presnosťou 0,01 mm. Multivariačné analýzy variancie (ANOVA / Kruskal-Wallis test) potvrdili signifikantné rozdiely vo viacerých skúmaných znakoch medzi jednotlivými geomorfologické celkami.

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