ECOLOGICAL, TAXONOMICAL AND CONSERVATION BIOLOGICAL INVESTIGATION OF SOUTHERN BIRCH MOUSE (*SICISTA SUBTILIS TRIZONA*)

Theses of the Doctoral (PhD) Dissertation
by
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Introduction and aims

The first known specimen of the southern birch mouse (*Sicista subtilis trizona* Frivaldszky, 1865) in Hungary was collected by S. PETÉNYI in 1843 near Tiszafölvár. However, living specimen had not occurred since 1936 until our successful trapping. My PhD work belongs to the latest stage of the researches, which began by the discovering of the first *Sicista subtilis* skulls in owl pellets of Borsodi-Mezőség Landscape Protected Area by ENDES (1982). Unfortunately, comprehensive investigation aiming at the detailed studying of the most momentous, probably the last population of the subspecies, which is endangered by extinction could be started only a decade later. The research was started by systematic owl pellet collection from 2000, due to which 370 skull-remains have turned up from 14 localities till nowadays. The discovery of 140 *Sicista* remains in owl pellets resting in two attics for years collected in 1998 meant the first revolutionary step in the project (CSERKÉSZ 2007). This has also attracted the attention of the wider professional public. On the request of the Ministry of Environment and Water (now Ministry of Rural Development) the Southern Birch Mouse Action Plan (CSERKÉSZ 2004) has been prepared and was accepted in 2004. However, it was based on only little data collected by indirect methods, still headed the investigations, called the attention for the importance of the protection and also made concrete proposals of conservation. Live-trapping trials have happened since 2002 in the supposed habitat of the species, but there were not opportunities for big-scale trapping at that time due to the poor financial resources. This inconvenient situation has been changed by winning a call for an application by the National Office for Research and Technology (NKFP6-115/2005) in 2005. Ecological studies could be continued more intensively by Bükk Mammalogical Society, while genetic investigation could be started in the Molecular Taxonomic Laboratory (MTL) of the Hungarian Natural History Museum (HNHM). The project succeeded soon: on the 21st of June 2006 the first living birch mouse was caught in Borsodi-Mezőség.

I can only hope that my dissertation is not just a documentation of the last *trizona* population and its extinction, but it can help –besides the recognising – the renewing spreading of the species.

Taxonomic aims

- Craniometrical description of *S. subtilis trizona* and its comparison with the other European *Sicista* taxa.
- Clarifying the taxonomic status of *trizona* subspecies living in the Carpathian Basin; sampling and putting up the financial resources for genetic investigations carried out in MTL of HNHM.
- Clearing up the 'Polish *Sicista*-question' arising in the meantime: which species or subspecies of *Sicista* is living in Poland?

➢ Consequently proving the *trizona* to be separate species.

Ecological aims

- Identifying the habitat preference of the southern birch mouse.
- Description of the terrestric small vertebrate community living in the habitat of the birch mouse.
- Searching for weather indicators: identifying the influencing weather factors of the population dynamics of the community of the small terrestrial vertebrates – including the birch mouse.
- Searching for indicator species the population dynamics of which is similar to that of southern birch mouse therefore are usable for indicating that.

Conservation biological aims:

- Mapping of localities not just in the known habitat of Borsodi-Mezőség, but in the former possible habitats of Hortobágy and Kiskunság.
- Exploration of the causes of the decrease of population and the factors actually endangering.
- Developing a protocol, which is capable for preventing a further decrease in population size.
- Determining the methods of conservation treatments, and monitoring their effects.

➢ Consequently compiling an action plan, and starting its execution.

Methods

Taxonomy

My taxonomical investigations are essentially based on classical craniometrical measurements: 6 cranial and 11 dental sizes were taken on. Most of the measured birch mouse skulls originate from Borsodi-Mezőség and the Mammalia Collection of the HNHM. 42 skulls from Poland (Lublin Table-land) were also included into the research, which were derived from owl pellets, too (list of localities in Poland see in CSERKÉSZ et al. 2009). As a complement data of Ukrainian and Romanian skulls were also analysed.

Morphometric differences were examined by Discriminant Function Analysis (DFA), by counting Mahalanobis distances (D^2). Multivariate Hotelling T^2 and Student t-tests were used for testing the differences in taxa and in age-groups.

Ecology and conservation biology

The exclusive usage of one method is unsuitable in comprehensive mammalogical research; therefore more different methods were used parallel during my work. On the study area both the selective pitfall trapping – the most usable method for catching *Sicista*, both the box-trapping – giving a comprehensive knowledge of the population dynamics of the common small mammals in the area – were used monthly from March to November between 2006 and 2010. A work period took 6 days and 5 nights. Plastic, 20x8x10 cm sized box-traps were used in a 7x7 m quadrant. Besides this, pitfall trapping was carried out at 15 localities. The 20 cm long pitfalls with a diameter of 10 cm made from PVC tubes were dug into the soil in such a way that the edges of the tubes were in the ground level.

Five specimens caught during the trappings were kept in terrarium at different times for a two month long investigation period each aiming at basic ethological observations.

The data derived from these four different methods were analysed by uni- and multivariate statistics for describing patterns and trends of population dynamics and activity. Relative frequency (Ni x 100 / $N_{\sum}$ where $N_{\sum}$ means the whole number of the mammalian preys and N_i means the number of specimens of the ith species) was used for the quantitative characterization of the occurrences from owl pellet. The frequency of the birch mouse, the shrews and amphibians were analysed by the numbers of catching and numbers of specimens during a trap period, and by the value standardised to 100 trap-nights of these two parameters.

The estimated density of the frequent small mammals marked by tattoos is expressed by the value of specimen/ha by using of MARK software (COOCH & WHITE 1998). Effects of the

weather factors were examined by multivariate linear regression, by canonical correspondence analysis and by Pearson's correlation coefficient. Habitat preference of the southern birch mouse is characterised by the usage of Ivlev-index (IVLEV 1961).

Eight variants of precipitation: 1) annual, 2) spring, 3) monthly amount, 4) amount during the trapping period, 5) amount at the time of catching, 6) average thickness of the winter snow covering, 7) annual amount of previous year and 8) spring amount of previous year, and four variants of temperature: 1) annual, 2) spring, 3) summer and 4) winter mean were taken into analysis of the role of the precipitation in case of the birch mouse.

Results and discussions

As a result of the research the following theses can be drawn:

Taxonomy

1. On the basis of the 17 measurements it was demonstrated that morphometrical the Hungarian *trizona* population is the smallest between the investigated European *Sicista subtilis* populations, while the Ukrainian *nordmanni* is the largest. In case of the European populations of *S. subtilis* a west-to-east trend of size increase was observed (r=0.98; p=0.01).
2. Due to the DFA the *trizona* and *nordmanni* subspecies are clearly separated in the morphometric space (there is only a negligible overlap). However, the ellipse of *nordmanni* is completely contained the points of *S. severtzovi*. Therefore the craniometrical analysis supports the separate species status of *trizona*, but does not support it in case of *severtzovi* (this taxon was raised to species rank after discovery of its peculiar karyotype (SOKOLOV et al. 1987, KOVAL'SKAYA et al. 2000, cf. KOVAL'SKAYA et al. 2011).
3. Based on the cluster analysis of Mahalanobis distances, the Polish population is situated the furthest from the *nordmanni*/*severtzovi* group, while the closest to the *trizona*. According to these results the recently found Polish population belongs to species *S. subtilis*, but based on the results of DFA it is not *S. subtilis nordmanni*, as it was preliminary assumed on the basis of its biogeography. Mostly it is a morphometric version or a new subspecies of *S. subtilis*. Craniometrically it is more similar to the Hungarian *trizona* population, so it is also possible that *trizona* occurs also in Poland.

Ecology

1. Creating a GIS from the datasets of owl pellet collections has made the facilities for well-aimed trapping. As a result of it we managed to catch a living southern birch mouse in 2006, which was followed by trapping 84 specimens till nowadays due to the systematic trappings of the last 5 years.
2. Experimental trappings in different habitat types show that the southern birch mouse has a preference for plumeless thistle-rich ruderal vegetation (*Carduetum acanthoidis* Felföldy 1942), P_x=0.98; and for creeping thistle-rich weed vegetation (*Cirsio lanceolati-arvensis* Morariu 1943), P_x=0.83. These high and dense vegetation types having similar structures provide sufficient covering and protection even if in drought for the mice leading a basically hidden life.
3. Subspecies *nordmanni* occurs exclusively in dry steppe in Ukraine (M. RUSIN and I. ZAGORODNIUK, pers. comm.), so there is a difference between the subspecies also in case of habitat preference.
4. Based on the terrarium observations birch mice feed on the tiny seeds of *Carduus acanthoides* and *Cirsium arvense*, which partly can be another explanation for binding to the thistly ruderal areas.
5. Due to stepwise multivariate linear regression the amount of the spring precipitation of the actual year and the annual precipitation amount of the previous year have an effect on the population dynamics of southern birch mouse (R^2=0.988, ANOVA F value is 82.8 (p=0.01) considering the model).
6. Increasing reproduction rate and decreasing mortality due to favourable conditions have together a one-year delayed effect on population size in consequence of dragging feedback because of the low reproduction rate.
7. The frequency data derived from both owl pellets and trappings show that southern birch mouse has greater frequency only after years when annual amount of precipitation is more than 650 mm. Similar observations have been reported about Ukrainian populations (SELYUNINA 2003).
8. Population dynamics controlled by precipitation is characterizing primarily the small mammals living in desert, half-desert, typically dry areas (e.g. BEATLEY 1976, FICHET-CALVET et al. 1999, SHENBROT & KRASNOV 2001). So this feature of the population dynamics of the southern birch mouse implies that the species originates from the dry Ukrainian-Russian steppes, and its precipitation related dynamics also derives from there.

9. In case of frequency patterns common spadefoot *(Pelobates fuscus*) and common shrew (*Sorex araneus*) show correlation in annual level with southern birch mouse according to stepwise multivariate linear regression (R^2=0.98; F=82.8; p=0.01) inside the terrestrial small mammal community of the area. Increase in population size of *Pelobates fuscus* also shows the one-year delayed feedback characteristic for birch mouse, the cause of which is also the long-continued reproduction period. The conclusion of the investigations of the other frequent small vertebrates is that the frequent common spadefoot and common shrew can be a good indicator of the population dynamics of the southern birch mouse.
10. Considering the monthly dataset there is also a significant correlation between the frequency of the southern birch mouse and common spadefoot (r=0.71; p=0.0002), while in the same case there is only a marginal correlation (r=0.32; p=0.08) between the common shrew and the mouse. Also marginal, but negative correlation was found between the annual frequency data of the mouse and the bi-coloured white-toothed shrew (*Crocidura leucodon*).
11. Based on the stepwise multivariate linear regression maximum daily temperature and maximum atmospheric pressure during the active period have an effect on the activity of the specimens kept in captivity (R^2=0.34; F=6.06; p=0.006). Terrarium observations show that cooling connected to precipitation keeps the mice in their underground nests, and then the warming following increases their activity. Weather can synchronise the single activities of the mice. This observation party explains the undulating trapping successes and grouped catches experienced in field, but does not interpret the summer aestivation, which was detected once by a specimen was held in captivity.

Conservation biology

1. We have modelled the potential occurrence and density of southern birch mouse by overlapping cartographic databases in a GIS illustrating the preferred environmental parameters, which was explored during the PhD research. According to it the southern birch mouse could have been common in the eastern plains of Hungary and potentially could have occurred spotted in plains of Transdanubium. It is likely that is was the most frequent in Hortobágy and Kiskunság.
2. In accordance with the area calculation done on the reconstructed map of the area, which is derived by using the historical occurrence data and modelled map of potential occurrence, southern birch mouse could have lived in 51.037 km^2, in the 55% of the

actual area of the country until 1926. Today it must live only in 100 km^2 of Borsodi-Mezőség, which is 0.2% of the previous area. However, the area of the known habitats is only 5.5 km^2. It means that the birch mouse has become extinct from more than 99% of the former habitat.

3. By summarising the international and national results, the conclusion can be drawn that 100% of the worldwide population of subspecies *trizona* can be found in Borsodi-Mezőség Landscape Protected Area. General backwardness and isolation of the area is the reason for the fact that the last population of the subspecies has been subsisting here. No other environmental, natural, landscape or anthropogenic circumstance could be identified; nothing else makes this area special.
4. The cover of weed vegetation and the average annual frequency of the birch mouse show significant positive correlation ($r=0.91$; $p=0.02$). So both natural processes, such as gradual desiccation of the area due to lack of precipitation, as well as anthropogenic effects, such as improper land use (mechanical mowing, over-grazing) cause decreasing in population size.
5. A significant difference can be observed, however, in case of resettling: after the mechanical crushing of vegetation mice appeared again 26 month later in their habitat in a detectable number. But when covering increases again due to precipitation supply on the dry and unmowed area, relatively quickly – 3-4 month later – mice appear anew.
6. Currently the primary endangering factor of the population is that the exact area of the mouse is not known even now. Accordingly it can happen that habitat with high density disappears due to improper land use. In possibly the last refuge of *trizona*, the protected area of Borsodi-Mezőség, rate of cropping area should be tempered in short-time, and traditional, mosaic-structured grassland management should be favoured. Grazing in moderate intensity is a requirement for the subsisting of the southern birch mouse.
7. There is only one known population of *trizona*, hence it can be declared that the southern birch mouse is one of the most endangered species of Hungary, which is also drifted nearby extinction.

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