Hibernation cavities used by the edible dormouse, *Glis glis* (Gliridae, Rodentia)

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A b s t r a c t . Studies were made of the shape, volume and depth below ground level of hibernation cavities used by free-living and captive edible dormice, *Glis glis* (Linnaeus, 1766). Most of the cavities (77 out of 83) were occupied by a single animal. Sixty of them had a characteristic oval shape and were analysed in detail. The volume of cavities in free-living dormice ranged from 429 cm^3 to 1174 cm^3 (median = 670 cm^3, Q1 = 605.5 cm^3, Q3 = 855 cm^3, N = 17) and in captive animals from 293 cm^3 to 2211 cm^3 (median = 837 cm^3, Q1 = 571 cm^3, Q3 = 1055 cm^3, N = 43). No correlation between body mass of hibernating dormice and volume of their cavities was found. A tendency for male cavities to be larger than female ones was evident, although the differences were not statistically significant. Comparison of volumes of cavities made by free-living versus captive dormice, as well as captive adults versus subadults also did not reveal significant differences. Cavities of free-living dormice were found between 18 and 70 cm underground (median = 30 cm, Q1 = 25 cm, Q3 = 40 cm).

Key words: underground cavity, hibernacula, oval-shaped burrow, volume of cavities

Introduction

Burrowing has long been used by mammals (D a m i a n i et al. 2003, L u o & W i b l e 2005) and many species dig burrows for different functions. These include shelter, foraging, nesting, giving birth and caring for young, food storage and hibernation (R e i c h m a n & S m i t h 1990, E i s e n b e r g & K i n l a w 1999). Some species, such as marsupial moles (Notoryctidae), true moles (Talpidae), golden moles (Chrysochloridae), mole rats (Bathyergidae), tuco-tucos (Ctenomyidae), gophers (Geomyidae), blind mole rats and zokors (Spalacidae), produce elaborate burrows and spend almost all of their lives below ground (K o w a l s k i 1971, N e v o 1979, N o w a k 1999). However, for most mammals, the basic function of a burrow is to provide shelter and these species build relatively simple structures (R e i c h m a n & S m i t h 1990).

The soil is a good insulator, buffering burrow occupants from extreme variations exhibited in the environment above ground (R e i c h m a n & S m i t h 1990). These insulating qualities of the soil are evidently advantageous for animals descending into torpor or hibernation. This is why hibernating mammals often dig special deep burrows for the winter (F e l d h a m e r et al. 1999). Most burrowing hibernators are found in the Order Rodentia, especially in the Family Sciuridae (i.e. ground squirrels, *Spermophilus*; prairie dogs, *Cynomys*; chipmunks, *Tamias*; marmots, *Marmota*), and also in the Heteromyidae, Dipodidae and Gliridae (F e l d h a m e r et al. 1999, N o w a k 1999). The edible dormouse, *Glis glis* (Linnaeus, 1766) belongs to this last family. It is a small, long-lived, arboreal mammal. From late spring until the autumn, the edible dormouse lives and uses shelters above ground (Vietinghof-Riesch 1960, Gaisler et al. 1977). For hibernation, they use mainly underground burrows (Vietinghof-Riesch 1960, Storch 1978, Morris & Hoodless 1992) although the variety of their winter shelters is broad (review in Vietinghof-Riesch 1960). To date, there have been no detailed investigations of underground cavities dug by edible dormice.

The aims of this study are: (1) to describe the hibernation cavities of edible dormice (their shapes, dimensions and how deep they are placed underground) and (2) to find if there are differences between cavities dug by individuals of different body size, males versus females, adults versus young and captive versus free-living dormice. It is expected that smaller and lighter individuals should make smaller cavities.

Material and Methods

Both free-living and captive edible dormice were studied during the years 1998-2003. Captive animals came from the Sierakowski Landscape Park (SLP) (52°38' N, 16°7' E), from the Roztocze Środkowe region of Poland (RS) (50°38' N, 23°08' E) and from the Szczecin Lowland (SzL) (53°50' N, 15°21' E). Dormice from SLP were kept in outdoor cages (length – 110 cm, width –100 cm, height – 120 cm; with 90 cm thick layer of soil at the bottom), and dormice from RS and SzL were kept in outdoor cages (160 cm x 120 cm x 230 cm; with 50 cm thick layer of soil at the bottom).

Free-living dormice were studied in SLP and in the Szczeciński Landscape Park (SzLP) (53°17' N, 14°46' E). In this latter place, the dormice had been reintroduced, coming originally from SLP, the "Buczyna Szprotawska" reserve (51°30' N, 15°40' E) and the Wzniesienia Elbląskie Lanscape Park (54°17' N, 19°30' E). All free-living dormice were adult animals. They were fitted with radio-collars (which amounted to no more than 5% of the animal's body mass) in July, August and September and monitored until they started hibernation.

The body mass of adult dormice and dimensions of their hibernation cavities (Fig. 1) were measured in September and October, one to three weeks after the animals started hibernation. Captive young of the year (offspring of dormice from RS which were born in captivity) were not dug out and weighed in the autumn, but their cavities were measured the following year in the middle of May.

Both captive and free-living animals were weighed using a Pesola balance to the nearest 2g. Measurements of cavities (A – length, B – width, C – height) and the distance between the surface of the soil and the bottom of the cavity (underground depth) were measured by means of a flexible tapemeasure to the nearest 0.5 cm. After excavation and weighing free-living dormice were put into nestboxes attached to neighbouring trees.

The volume of oval cavities was calculated according to the formula: $V = 4/3\ \Pi\ abc$, where a, b and c are respectively ½ of A, B and C. To be sure that correct results were obtained using this formula, the volume of six cavities was measured by another method. These six cavities – after measurements of A, B and C – were filled with plastic balls (diameter 6 mm) and then their volumes were checked in a measuring cylinder. The volumes obtained by these two methods differed slightly (difference: mean = 2.7%, min = 0.8%; max = 5.5%) but the differences were not significant (Wilcoxon matched-pairs signed rank test: $Z = 0.524$; $p = 0.6$).

When data was collected from three dormice, each making cavities in different years, only one randomly chosen cavity per dormouse was used for comparison. Statistical analyses were performed using Statistica 6.0 for Windows. The studies were approved by the Polish Ministry of the Environment and accepted by the local ethical commission.

Results

The walls of cavities excavated by dormice were intact, with no obvious way in. There was neither nesting material nor loose earth in any of the cavities. Dormice dug hibernation cavities of different shapes, but most of them were oval, and to some degree they were similar to each other (Fig. 1).

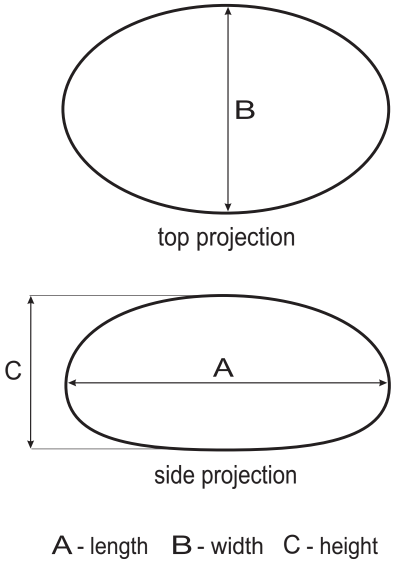

Fig. 1. The shape of oval cavities of edible dormice.

Cavities used by free-living dormice

All cavities of free-living dormice were occupied by single animals. Seventeen of the 27 cavities had an oval shape. The shape in the remaining 10 burrows was distorted by thick tree roots and large stones forming part of their walls.

Hibernation cavities of dormice were found between 18 and 70 cm underground (median = 30 cm, Q1 = 25 cm, Q3 = 40 cm, N = 27). One animal that hibernated considerably deeper than the others (70 cm below the surface) was found in the back wall of a disused burrow originally dug by a badger, *Meles meles* (Linnaeus, 1758). Eighteen out of 27 cavities were found close to roots of old trees.

Dimensions of oval cavities varied: *A* from 12 to 20 cm (median = 16 cm, Q1 = 13 cm, Q3 = 18 cm), *B* from 9 to 12 cm (median = 11 cm, Q1 = 10 cm, Q3 = 11.5 cm) and *C* from 5 to 11 cm (median = 8 cm, Q1 = 7 cm, Q3 = 9 cm). The volume of oval cavities ranged from 429 cm^3 to 1174 cm^3 (median = 670 cm^3, Q1 = 605.5 cm^3, Q3 = 855 cm^3, N = 17).

No correlation was found between body mass of hibernating dormice and the volume of their oval cavities (Spearman's rank correlation: $r_s = 0.062$, P = 0.8, N = 17).

Although the body mass of free-living males differed from that of females (males: median = 124.0 g, N = 8; females: median = 100.0 g, N = 9; Mann-Whitney test: Z = 97.5, P = 0.016), there were no significant differences between the volumes of their hibernation cavities (males: median = 682 cm^3, N = 8; females: median = 622 cm^3, N = 9; Mann-Whitney test: Z = 83.5, P = 0.3) (Fig. 2).

C a v i t i e s u s e d b y c a p t i v e d o r m i c e

Fifty (out of 56) cavities were occupied by single dormice and only in six of them were the animals hibernating communally (two animals per burrow). The dimensions of 43 oval cavities with single occupants ranged: *A* from 12 to 22 cm (median = 15 cm, Q1 = 13 cm, Q3 = 18 cm), *B* from 7 to 16 cm (median = 11 cm, Q1 = 10 cm, Q3 = 12 cm) and *C* from 5 to 13 cm (median = 9 cm, Q1 = 8 cm, Q3 = 10 cm). The volume of these oval cavities ranged from 293 cm^3 to 2211 cm^3 (median = 837 cm^3, Q1 = 571 cm^3, Q3 = 1055 cm^3, N = 43).

In captive animals body masses of males and females did not differ from each other (males: median = 133.0 g, N = 10; females: median = 142.0 g, N = 18; Mann-Whitney test: Z = 130.0, P = 0.5). Although there were visible differences between median volumes (Fig. 2) of their hibernation cavities (males: median = 981.5 cm^3, N = 10; females: median = 675 cm^3, N = 18), they were not significantly different (Mann-Whitney test: Z = 181.5, P = 0.08).

Volumes of cavities of adults (RS) and subadults (RS) – which overwintered for the first time – did not differ (captive adult: median = 942 cm^3, N = 17; captive subadults: median = 735 cm^3, N = 9; Mann-Whitney test: Z = 238.0, P = 0.7) (Fig. 2).

During these studies only three adult dormice made cavities for more than one hibernation period. The volumes of cavities of these individual animals were different in different years (Fig. 3). Statistical analysis was not performed because of sparse data.

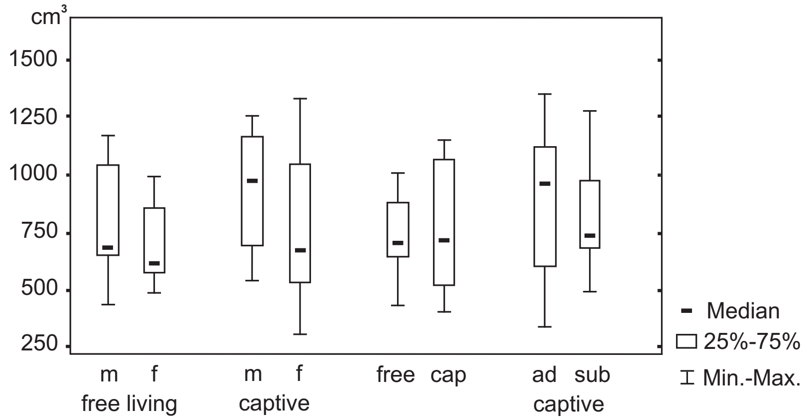

Fig. 2. Volumes of oval cavities of edible dormice compared in pairs: 1- free-living males versus free-living females, 2- captive males (m) versus captive females (f), 3- free-living (free) versus captive (cap), 4- captive adults (ad) versus subadults (sub).

C o m p a r i s o n o f c a v i t i e s u s e d b y f r e e - l i v i n g a n d c a p t i v e d o r m i c e

A comparison of free-living and captive dormice from the same population (SLP) did not reveal significant differences in body mass (free-living: median = 124.0 g, N = 9; captive: median = 134.0 g, N = 11; Mann-Whitney test: Z = 77.5, P = 0.2), how deep they bury

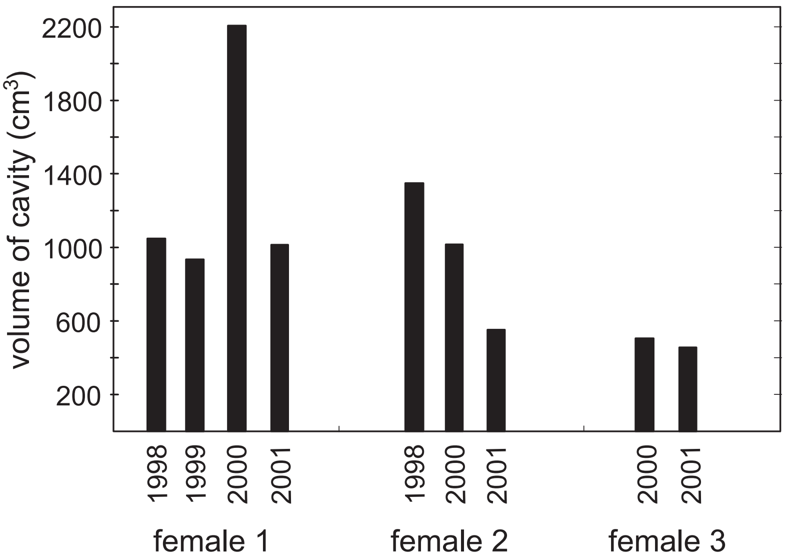

Fig. 3. Volumes of oval cavities build in different years by the three edible dormice.

themselves (free-living: median = 30 cm, N = 9; captive: median = 30 cm, N = 11; Mann-Whitney test: Z = 92.0, P = 0.9) or in the volume of their hibernation cavities (free-living: median = 691 cm^3, N = 9; captive: median = 706 cm^3, N = 11; Mann-Whitney test: Z = 89.5, P = 0.7) (Fig. 2).

There were also no significant differences between adult free-living and adult captive dormice (disregarding where they come from) in the volume of their cavities (free-living: median = 670 cm, N = 17; captive: median = 826.5 cm, N = 28; Mann-Whitney test: Z = 352.5, P = 0.37).

Discussion

According to Vietinghof-Riesch (1960), Morris & Hoodless (1992) and Morris (1997), edible dormice usually hibernate in the soil. However, Vietinghoff-Riesch (1960) quoted a broad range of other types of winter shelters such as hollows in trees, nestboxes, caves, hunting lodges, hives, buildings located close to the woods etc. Vogel (1997) reported that a group of 11 dormice hibernated in a wooden screw container – lying on iron screws – in a military depot. Observations have also been obtained in Poland that edible dormice overwinter in cellars, attics and below the floor of buildings (M. Jurczyszyn, unpublished). Sometimes these animals have been found hibernating in nestboxes as late as November. However, none of the free-living dormice (in the author's radio-tracking studies) hibernated anywhere other than in underground shelters, although they could have chosen hollows in old trees (many trees were more than 200 years old), nestboxes or, as in the Sierakowski Landscape Park, in buildings. Based on these results, it is supposed that in central Europe edible dormice prefer burrows to other shelters for hibernation.

In this study, as well as in studies by Vietinghoff-Riesch (1960), every hibernating dormouse lay in the burrow curled up, with the tail bent over its head and with limbs drawn in.

According to Vietinghoff-Riesch (1960) edible dormice lie in cavities covered with a small amount of loose earth. Morris & Hoodless (1992) also mentioned that they found loose earth in dormouse hibernation cavities. The present study also suggested, after checking the first few cavities, that dormice had covered their fur with soil as reported early by Vietinghoff-Riesch (1960). However, when cavities were excavated more carefully, it was discovered that there was no loose soil inside, walls were robust and the fur of the dormice was clean. It appears that the soil that sprinkled hibernating animals resulted from the digging necessary for examining the cavity closely.

Morris & Hoodless (1992) reported from England on two individual edible dormice, which hibernated about 40 cm underground. Most of the wild dormice in the present study hibernated at a similar depth. It is interesting that each of the animals studied by Morris & Hoodless (1992) was accompanied by two other edible dormice. In the present study, communally hibernating dormice were found only in a group of captive animals, but not among free-living ones. Marin & Pilastro (1994) found that during the summer only close kin female edible dormice nest and breed communally. It is possible also that hibernation cavities are occupied mainly by kin dormice and in the free-living dormice studied here, there were no such individuals. However, even in the captive animals of the present study, communal hibernation was not frequent (in only 6 out of 56 burrows) although many young dormice came from the same litter and the relatively small space in the cages should favour this kind of behaviour. Two out of 6 dormice, which shared hibernation cavities came from the same litter, but no such information is available on the other four individuals.

In the light of these studies, in a strictly statistical respect, the volumes of oval-shaped burrows do not depend on sex, body mass or age of animals. However, a tendency for males to have larger cavities compared to females is evident especially in captive dormice. On the other hand, no differences were found between free-living and captive dormice with respect to the volume and depth of burrows. This was surprising because captive animals could always dig in loose soil in contrast to free-living individuals, which sometimes were found in compacted soil. The soil properties could influence energetic costs of digging by dormice, as for other burrowing rodents (Vleck 1979, Luna et al. 2002).

The dormice studied here came from several populations. Some were from localities about 500 km apart. However, most of the dormice, independent of where they came from, dug oval burrows of similar shapes at least in soil without significant obstacles (i.e. thick roots, stones, walls of cages). On one occasion an active dormouse was found in a cavity that had just been started. This cavity looked like a slightly wider burrow that is normally tubular; the cavity was still being elongated. Based on this observation, it seems that dormice simply widen a relatively long burrow. When a burrow is being reconstructed into a hibernation cavity it becomes wider but also shorter because of soil accumulation. Once completed, however, the length of a cavity remains longer than its width, resulting in the characteristic oval shape of dormouse hibernation cavities.

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