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2

The Hazel Dormouse

Muscardinus avellanarius

First edition

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Cover photo: Hazel dormouse *Muscardinus avellanarius* (Linnaeus, 1758)
(photo by R. Juškaitis).

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Contents

1 Introduction

The hazel dormouse (*Muscardinus avellanarius*) has become of more interest to the public in the last few decades. One reason is its legal protection in Europe. The species has to be taken into consideration in any planning procedures that may interfere with woodlands – potential habitats of the smallest of our dormouse species. Over the same period several successful voluntary surveys looking for signs of the hazel dormouse, or the animals themselves, both in the UK and in Germany, reflect the broad interest in and sympathy for the species. It is easier to spread messages about woodlands, habitat connectivity and hedgerow conservation using the endearing and enigmatic hazel dormouse.

The hazel dormouse is also of academic interest: it is distinctive from other small mammals as it has low population densities and low reproduction rates connected with longevity; it has an interesting physiology (in that it undertakes hibernation); several aspects of its behaviour and biology are still unclear; and it is considered a flagship species e. g. for habitat fragmentation because of its strong arboreality.

Our knowledge of the dormice has grown rapidly over the last three decades. The majority of recent research carried out on hazel dormice has been published in English. The highest numbers of publications, produced between 1990 and 2010, came from the UK by Pat Morris and Paul Bright, and from Lithuania by the first author of this book. However, the complete list of published papers is long, due to numerous studies published for instance in Russian or German.

The German series "Die Neue Brehm-Bücherei" is a unique natural history series. Nearly 700 zoological and botanical monographs have been published to date. However, up until 2010 one about the hazel dormouse was missing from this compilation. This monograph probably wouldn't have been possible without the formation of the International Dormouse Conferences. The German dormouse specialist Heiko Müller-Stiess initiated the first meeting of scientists studying dormice in 1990. Since then, this community of scientists has met every three years to exchange the latest results and ideas. The subsequent International Dormouse Conferences took place in Italy in 1993, in Croatia in 1996, in Turkey in 1999, in Hungary in

2002, in Poland in 2005, in England in 2008 and again in Germany in 2011. Friendships and joint research projects emerged out of these conferences. We, the authors of this book, met for the first time at the Croatian conference. Ten years later we began discussions about the possibility of writing a monograph about our research objectives.

We were astonished by the broad variety of publications in the regional literature when we started writing the first edition of this book in German (Juškaitis & Büchner 2010). We tried to consider as much as possible, to condense the results of these studies without leaving too much unmentioned. Our book summarises the published research and collates the findings together with those from own long-term studies. We have tried to close a gap in the published literature by producing this monograph on an elusive species, looking at aspects of range, biology, ecology, behaviour and physiology. Further chapters are dedicated to the variety of methods that exist for detecting hazel dormice and recommendations for their conservation and methodological aspects of research. This is the first monograph about the hazel dormouse in which all these different aspects are summarised in one book.

The success of the first issue in German encouraged the publisher and us to think about an updated edition in English. We hope that this book stimulates ideas for further studies into this fascinating small mammal. We now look forward to new data and findings being generated on this charismatic species to generate fruitful discussions and new questions.

Fig. 1: Adult hazel dormice are roughly thumb-sized (photo by S. Büchner).

4 Morphology

4.1 Appearance, body measurements and body weight

Appearance and body measurements

The hazel dormouse is the same size as the house mouse (*Mus musculus*). It is one of the smallest members of the family Gliridae with an average head and body length of 75–80 mm in adults (Table 1). The tail is approximately 90 % of head and body length (averaging 67–72 mm), furred and bushy, but the hairs are shorter than those found on the tails of some other dormouse species, e. g. the edible dormouse or the garden dormouse (*Eliomys quercinus*). Dormice are sometimes found with shortened tails or, in very exceptional cases, totally broken tails (see chapter 4.4).

Table 1: Body measurements (mean, minimum and maximum in mm) of adult hazel dormice from different regions (the sexes are pooled).

Body measurements	Moldova (n = 30) Lozan 1970	France (n = 9–11) Saint-Girons 1973 cited in Papillon et al. 2000	Poland (n = 11) Sidorowicz 1959	Lithuania (n = 16) Juškaitis 2003e
Head & body length	79.6 68.0–87.0	74.4 66–82	75.1 69–80	75.0 67.8–85.7
Tail length	67.9 60.0–74.0	68.9 61–82	69.3 61–65	68.6 60.7–74.0
Hind foot length	–	15.6 14–17.5	15.7 14–17	15.9 14.5–17.0
Ear length	11.0 8.5–13.0	10.7 10–12	11.4 11–12	12.1 11.0–13.0

Fig. 5: Dormice can be sexed by measuring the distance between the anus and genital papilla (penis/urethral opening) which is greater in males (right) than females (left). The testes may be apparent in males in the breeding season (photos by S. Büchner).

Fig. 6: Female hazel dormice have four pairs of nipples (photo by G. Augustin).

The eyes of dormice are relatively large. In comparison with other dormouse species, the ears are smaller and rounder. The blackish whiskers are 28–32 mm long (Ognev 1947). Females have four pairs of nipples (one pectoral, one abdominal and two inguinal), which are only clearly visible during the breeding period (Fig. 6).

Data from Anděra (1987), from former Czechoslovakia, show that the average body size of hazel dormice increases with age. One year-old dormice are larger in size than subadults (two to three months-old) and smaller

6 Hibernation

The hazel dormouse belongs to the family of dormice for which hibernation gave them their name (from old French: "dormir" = to sleep). Hibernation is a special state that the body can undergo, differing from sleep, when all vital functions are reduced to a minimum. Physiologically, hibernation is characterized by lowering the body temperature close to the ambient temperature, a clearly reduced metabolic rate and arousals through activating the mechanisms that warm the body (Wilz & Heldmaier 2000). Bouts of torpor during hibernation last for several days, weeks or even months and are considered prolonged periods of torpor (Körtner & Geiser 2000).

Hibernation is an adaptation which enables animals to outlast unfavourable environmental conditions. Hibernators can be classified as either food or body fat accumulating animals. A common hamster (*Cricetus cricetus*) for instance is a typical food collector and stays lethargic for only a few days, waking up regularly to feed. A hamster needs a huge storage of food for successful overwintering (Weinhold & Kayser 2006). A hazel dormouse gets by exclusively by drawing on accumulated body fat reserves. In some Mediterranean regions, e. g. along the central Italian coast and in Sicily, food is available throughout the whole year and the ambient temperatures are much higher than in the north. Therefore hazel dormice do not hibernate there, they just enter daily torpor more frequently (Sarà et al. 2001, Panchetti et al. 2004).

Older publications determined that the main trigger for hibernation is the ambient temperature. For instance, Eisentraut (1956) stated a critical hibernation temperature for the hazel dormouse of 15–16 °C. However, it is now clear that several factors can trigger the onset of hibernation. There are circaannual rhythms, probably synchronised by the photoperiod. König (1960) showed, in a laboratory experiment on edible dormice, that under short-day conditions (6 hours of daylight) the animals had already started to accumulate body fat reserves in July, and to moult from summer to winter fur. Under long-day conditions (12 hours of daylight) the body masses stayed nearly stable and the edible dormice kept their summer fur even after permanent moulting.

Wild adult hazel dormice males always begin to moult and accumulate body fat reserves at the same time of the year, regardless of the ambient temperatures. In Lithuania, they reach their maximum body weight by the end of September. Depending on the autumn weather they continue to be active during the first week of October or they may start to hibernate – a clear indication of a circaannual rhythm.

Further exogenous factors like food shortage may also strengthen dormice' readiness for hibernation as it was shown in captive experiments with the Japanese dormouse and the edible dormouse (Otsu & Kimura 1993, Wilz 1999). Early disappearance of edible dormice from nest boxes was recorded in the wild in the years when food – beech nuts and acorns – was very scarce or absent in autumn (Vietinghoff-Riesch 1960).

A study by Pretzlaff & Dausmann (2012) showed that hazel dormice can readily adjust to the onset and end of hibernation, depending on the temperature of the relevant months. Dormice aroused earlier from hibernation when the winter was shorter, indicating the ability to adapt to changing environmental conditions.

Hibernation in hazel dormice follows the same pattern as in other true hibernators: bouts of torpor are regularly interrupted by periodic arousals and brief normothermic periods (Fig. 21). This condition continues in Central Europe from October/November to April/May. Hazel dormice try to

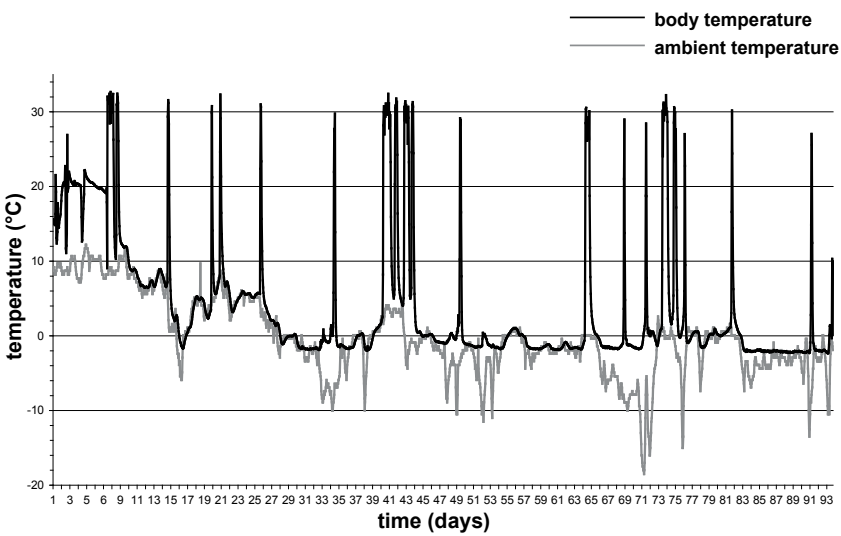

Fig. 21: Daily body temperature of a hibernating hazel dormouse under natural conditions between 17.11.2009 and 17.02.2010 (with kind permission of I. Pretzlaff & K. H. Dausmann, University Hamburg Biozentrum Grindel).

10 Nests and nest sites

10.1 Summer nests

During the summer, hazel dormice build tightly woven ball-shaped nests with an entrance hole on the side (see Fig. 36). When a dormouse is in its nest, the entrance hole is usually open, though occasionally it is slightly closed (Wachtendorf 1951). However, Kahmann & Frisch (1950) stated that "when a hazel dormouse tarries in the nest, it 'plugs' the entrance hole slightly from the inside."

The diameter of their nests usually varies between 6–12 cm (Wachtendorf 1951) but can be as small as 4.5 cm or as large as 15 cm (Vilhelmsen 1996). Breeding nests are built by females and they are larger (diameter between 10–15 cm) than nests used by males, subadults or non-breeding females (Kahmann & Frisch 1950, Wachtendorf 1951, Berg & Berg 1998, Foppen et al. 2002, Wolton 2009).

Wachtendorf (1951) suggested classifying summer dormouse nests according to the nest structure and nest material used. He described four types of nest, and this classification is still used now:

a) Mixed nests are formed of leaves from trees or shrubs together with grass and these materials are used almost equally to construct the nest walls (Fig. 36);

b) Grassy nests comprise a dense sphere of dry grass leaves (sometimes also containing a few stalks) and are characteristically found in habitats with a high proportion of coniferous trees (Fig. 37);

c) Foliage nests are plaited from dry or fresh leaves from trees or shrubs, although sometimes grasses are also used as a supplementary material (Fig. 38);

d) Layered nests have two distinct layers: an outer layer usually made of tree or shrub leaves and an inner layer made from finer vegetation (Fig. 39). Such nests are only made by females and are used for breeding.

Fig. 36: Mixed nest in nest box (photo by R. Juškaitis).

Fig. 37: Grassy nest (photo by S. Büchner).

Fig. 38: Foliage nest (photo by S. Büchner).

Fig. 39: Layered nest in nest box (photo by R. Juškaitis).

Dry dormouse nests are so well insulated, that a hazel dormouse inside the nest only needs to use 55 % of its energy budget to maintain its body temperature compared to the energy it would need to use up outside the nest. Layered nests that are used for raising young seem to be better insulated than other types of nests. But generally nests constructed from foliage have the best insulation qualities whether the nest is made purely of foliage or if it is a layered nest (Sury 1985). So the inner layer of a layered nest must therefore have a different purpose. Wachtendorf (1951) describes: "the inner layer like a soft bed, which is very thin on top but with a bottom layer that is often up to 1 cm thick." Sury (1985) reasoned that the inner layer is constructed to ensure stability, softness and durability.

The main materials used for nest building are grasses and the leaves of trees and shrubs. Strips of bark and ferns are two more types of nesting material often used by dormice. Dormice will also occasionally use the leaves of herbaceous plants, and in very rare instances moss. The different types of plant species that are used to construct nests depend on the vegetation

11 Feeding

All dormice (Gliridae), including the hazel dormouse, characteristically lack a caecum (Ognev 1947, Storch 1978). This suggests that they may be less well adapted to digest cellulose using enteric symbionts than other small mammals (Pflumm 1989). This is an important trophic limitation, which means that the hazel dormouse is less able to exploit more readily available foods such as leaves, bark or roots. Instead, the dormouse is considered to be a selective feeder that concentrates on finding the most nutritious food sources available, such as flowers, fruits, seeds and insects (Richards et al. 1984, Bright & Morris 1993), though it does supplement its diet with more easily digestible young leaves and buds (Juškaitis 2008a, Eden 2009).

Table 7: Food preferences of the hazel dormouse in different seasons (except the Mediterranean region) (according to Juškaitis 2007a).

Preferred food	Common food	Other potential food
Spring (April–May)		
Hawthorn, honeysuckle and oak flowers; aspen and birch catkins; conifer strobiles; bird eggs	Tree and shrub flowers and buds; insects	Leaf-buds; young leaves and shoots; acorns, hazel nuts and beech mast from the preceding year
Summer (June–August)		
Insects (aphids and caterpillars); honeysuckle and bramble flowers; blackberries, raspberries and honeysuckle berries; glossy buckthorn and yew fruits; hazel nuts	Strawberries, bilberries; haws and rowan fruits	Vegetative parts of some plants, e. g. honeysuckle, spindle tree
Autumn (September–November)		
Hazel nuts; blackberries; glossy buckthorn, rowan and yew fruits	Blackthorn sloes; haws and rowan fruits; acorns; ash, maple and sycamore keys	Hornbeam and birch seeds; winter buds and catkins; insects

Hazel dormice are active from early spring until late autumn, and the diet of these animals varies with the availability of different foods throughout this period (Table 7). In differing parts of its range, the available food

plants vary, but dormice consume analogous parts of these plants (e. g. Lozan 1970, Airapetyants 1983, Bright & Morris 1993, Juškaitis 2007a). They prefer the reproductive parts of the plant (buds, catkins, flowers, berries, and seeds), to the vegetative parts (leaf-buds, leaves, and shoots) (Juškaitis 2007a).

When the first hazel dormice emerge from hibernation in early April, foods such as buds and catkins are already available in the forest. Hazel flowers very early and its catkins can be consumed by early-emerging dormice (Likhachev 1971). At the end of April, captive dormice willingly ate aspen (*Populus tremula*) and willow catkins as well as willow and raspberry buds. In May, they ate oak, ash (*Fraxinus excelsior*) and maple (*Acer platanoides*) inflorescences, and birch catkins (Juškaitis 2008a).

By the time dormice emerge from hibernation in England, hawthorn (*Crataegus monogyna*) is in flower. Dormice typically seek out its flowers (Fig. 49a), choosing those with well-developed pollen that is not yet mature (Richards et al. 1984, Bright & Morris 1993). When the hawthorn flower is over, dormice move to other plants such as oak, sycamore (*Acer pseudoplatanus*), broom (*Sarothamnus scoparius*), honeysuckle, and sweet chestnut (*Castanea sativa*). Direct observations suggest that dormice eat only the most nutritious parts of flowers such as honeysuckle nectaries (Fig. 49c) and hawthorn anthers. Tree utilization by dormice closely follows the flowering and fruiting phenology and possibly insect availability on sycamore and oak (Bright & Morris 1993).

Pollen grains have a hard coat which is relatively resistant to decay and undigested pollen can be found in dormouse faeces. In May, yellow dormouse faeces containing undigested pollen are often found in nest boxes (Fig. 50). Studies in Lithuania showed that the pollen originated from Norway spruce trees (Fig. 49b). Spruce and Scotch pine (*Pinus sylvestris*) strobiles are a favourite food of dormice during this period (Juškaitis 2007a). Dormice in Britain are also known to have consumed male conifer cones, with yellow faeces found in nest boxes (P. Rudlin & R. Trout, pers. comm.). In central Italy, radio-tagged dormice were recorded in pine (*Pinus* sp.) trees, where they probably fed on pine strobiles (F. Panchetti, pers. comm.). Pollen from Rosaceae species (bramble or rowan), wild garlic (*Alium ursinum*)

Fig. 49: a) Hawthorn flowers are one of the most prevalent foods in spring. **b)** Young strobili from spruce trees are eaten in their entirety by hazel dormice. **c)** Hazel dormice mainly eat the nectaries of honeysuckle. **d)** Blackberries are an important food source. **e)** The glossy buckthorn provides fruit for dormice over a long period. **f)** Hazel dormice undertake special excursions to find and eat the fruits of yews. **g)** Hazel dormice eat hazel nuts directly from the tree or shrub. The unwanted shells are usually scattered beneath the shrubs (photos by R. Juškaitis and S. Büchner).


a


b


c


d


e


f


g

15 Survey methods

15.1 Signs of hazel dormice

The presence (or absence) of the hazel dormouse in an area is often unknown. If nothing recent is known about them a good starting point would be to enquire in museums, among ornithologists and foresters. However, observations by ornithologists and foresters need to be double-checked; they often confuse dormice with wood or yellow-necked mice. Sometimes even individual rich populations are unknown to locals. However, very valuable information may be obtained from people checking bird nest boxes or people who ring owls (especially Tengmalm's owl).

Several direct and indirect methods are available to obtain reliable proof of the presence (or absence) of dormice (see also Bright et al. 2006).

Gnawed nuts and kernels

A quick and cheap method of finding dormice is to search for the characteristic gnawed hazel nuts (Hurrell & Mcintosh 1984). After opening a nut, the hazel dormouse enlarges the hole by gnawing along the edge of it. The result is a nearly perfect round hole with tooth marks parallel to the edge (Fig. 78).

Birds crack the nuts and leave broken shells. Squirrels often break the shell into two halves. Young squirrels need to learn how to do this and break the shell into pieces. Voles and other species of mice gnaw holes in hazel nuts with transverse tooth-marks on the cut edge (Hurrell & Mcintosh 1984, Bright & Morris 1989, Büchner et al. 2002). Edible dormice break pieces out of the shell; they leave a short narrow mark made by incisive teeth on the surface of the nut. Sometimes, when the shell is very thick, edible dormice may also gnaw parallel to the edge of the hole like hazel dormice, but the marks of the large incisors are easily identifiable. Garden dormice leave cracked shells too (R. Tester, pers. comm.). Only the tooth marks of the forest dormouse are similar to those made by a hazel dormouse.

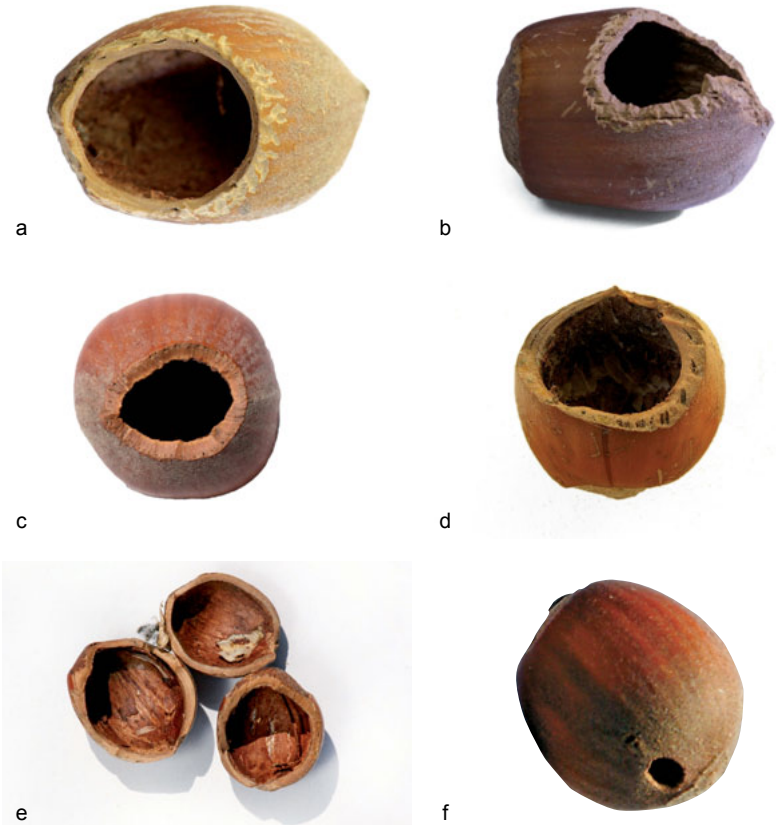

Fig. 78: Gnawed hazel nuts: **a)** tooth marks made by a hazel dormouse, **b)** a yellow-necked mouse, **c)** a bank vole, **d)** an edible dormouse, **e)** hazel nut shells cracked open by squirrels, **f)** a hole drilled by a nut weevil (*Curculio nucum*) (photos by S. Büchner and R. Juškaitis).

Hazel nuts are sought after by many animals in late summer when the nuts are still green. From August onwards the fresh nut shells can be found. Therefore the best time to look for gnawed hazel nuts is in early autumn. The relatively bright shells lay on top of the leaf litter and are easy to find. The shells persist at least until the next summer but gradually decay making it harder to determine what species opened the nut. Hazel dormice eat their nuts directly in the canopy of the hazel shrubs and do not collect nuts. The shells are therefore scattered beneath their feeding places.

The efficiency of this method depends on the fructification of hazel and therefore works especially well in mast years. Obtaining records of hazel