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# The fat dormouse, *Glis glis*, in Lithuania: living outside the range of the European beech, *Fagus sylvatica*

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**Abstract.** Throughout most of the distributional range, the fat dormouse, *Glis glis*, relies heavily upon European beech as a key species in its habitat. In Lithuania however, situated beyond the continuous range of the beech, pedunculate oak becomes the essential tree in habitats of *G. glis*. In Lithuania, the dormouse activity season lasts from mid-May to mid-October, young are born during the short period from late July to mid-August, and the mean litter size is 5.9 young. Population density is low (0.8-2.0 ind./ha after hibernation and 1.2-4.8 ind./ha in autumn), but relatively stable. The mean body weights of adults (98 g after hibernation and 128 g before hibernation) are among the lowest across the range. Lithuanian dormice differ from those living in beech-dominated habitats by their lower population density and lower body weight. Such differences may be due to acorns being less suitable food for *G. glis* in comparison to beech nuts. In terms of inter-annual abundance dynamics, the *G. glis* population is comparatively stable as years in which dormice fail to reproduce are infrequent in Lithuania.

**Key words:** abundance dynamics, activity season, breeding, body weight, population density

## Introduction

The fat dormouse (*Glis glis*) has a global distribution that extends across Europe and through northern Turkey to the Caucasus, northern Iran and Turkmenistan (Amori et al. 2008). The distribution range of *G. glis* overlaps to a great extend with the range of the European beech (*Fagus sylvatica*), which is a key-species for *G. glis* in most parts of its distributional range (Bolte et al. 2007, Kryštufek 2010). Beech nuts, if they are present, are the main food source for dormice. Dormouse reproduction and population dynamics are closely related to the masting pattern of beech. In years when beech trees do not fruit, dormice skip reproduction (Schlund et al. 2002, Pilastro et al. 2003, Fietz et al. 2005, Ruf et al. 2006, Morris & Morris 2010).

Lithuania is situated on the northern periphery of the range of *G. glis* and outside the continuous range of the European beech (Bolte et al. 2007, Amori et al. 2008). Some small beech tree stands planted by Prussian foresters are present in the south-western part of Lithuania, but beech trees are absent in the localities where *G. glis* is known in the country. Thus, the *G. glis* populations in Lithuania exist in the absence of the main feeding plant – the beech – and, consequently, may have to cope with poorer environmental conditions. In a comparative study of five populations of *G. glis* across Europe, the lowest mean survival rates were found in the Czech Republic, this being the only study site dominated by oaks instead of beech trees as in the other areas (Lebl et al. 2011).

*G. glis* is one of the best investigated dormouse (Gliridae) species (reviews in Rossolimo et al. 2001, Kryštufek 2010). However, the absolute majority of these studies were carried out in central and southern parts of the range where dormice live in beech-dominated habitats. Very few studies on the ecology of *G. glis* have been carried out in the regions situated outside the range of the beech, e.g. in Lithuania, Latvia and Russia (Juškaitis & Šiožinytė 2008, Pilāts et al. 2009, Vekhnik 2011, Juškaitis et al. 2015). The aim of the present study was to investigate the ecology of *G. glis* in Lithuania, outside the range of the European beech, and to find differences to those dormice living in beech-dominated habitats.

## Material and Methods

Data on the ecology of *G. glis* in Lithuania have been collected since 1990 when studies of dormouse

distribution were initiated. The main material on the ecology of *G. glis* was collected at a study site situated in Rumšiškės forest located in central Lithuania (54°52′ N, 24°09′ E). The study site is covered by mixed forest stands dominated by 185-year-old pedunculate oak (*Quercus robur*), 180-year-old Scots pine (*Pinus sylvestris*) and 135-year-old Norway spruce (*Picea abies*) (each accounting for approximately 25 % by tree volume) with birches (*Betula pendula* and *B. pubescens*), lime (*Tilia cordata*), hornbeam (*Carpinus betula*) and aspen (*Populus tremula*) also present. Hazel (*Corylus avellana*) is the main shrub species forming the understorey.

At the study site, 50 nestboxes put up at 30-50 m intervals along forest roads and rides have been present since 1990, and they were inspected twice a year (in late May-early June and in early September) in the period 1990-2014. In June 2011, 93 new nestboxes were set up in a grid system at 50 m distances between boxes over an area of 18 ha. About 60 % of the old nestboxes (put up in the lines) fell within the area covered by the new nestbox grid.

The nestboxes in the grid were inspected every fortnight from the first half of May until the end of October in 2012-2014 and in September to October 2011. During every nestbox control, *G. glis* individuals found were sexed, aged (adults, yearlings, juveniles), weighed (to the nearest 1 g) and marked with PIT-tags or ear tags. In total, 209 individuals were marked, out of which 116 individuals were recaptured. Lactating females found in nestboxes with young were not usually weighed in order to minimize disturbance. The age of the young in litters was estimated according to their physical development (Storch 1978). Females were classified as reproductive if they were found with young or with clearly visible nipples during August-September.

The number of adult dormice living at the study site was estimated by the minimum-number-alive method (MNA, Krebs 1999). In calculations of MNA and population density, yearling dormice were attributed to adults. Spring and autumn densities of *G. glis* were calculated by dividing the numbers of individuals known to be alive from May to mid-July and from mid-August to October, respectively, by the effective trapping area (Krebs 1999). The effective trapping area was considered to be 26 ha, and it was calculated by adding a 40 m boundary strip to the sides of the area containing nestboxes, except 350 m along an overgrown clearing. The width of the boundary strip was equivalent to one half of the mean distance moved by marked dormice between nestboxes.

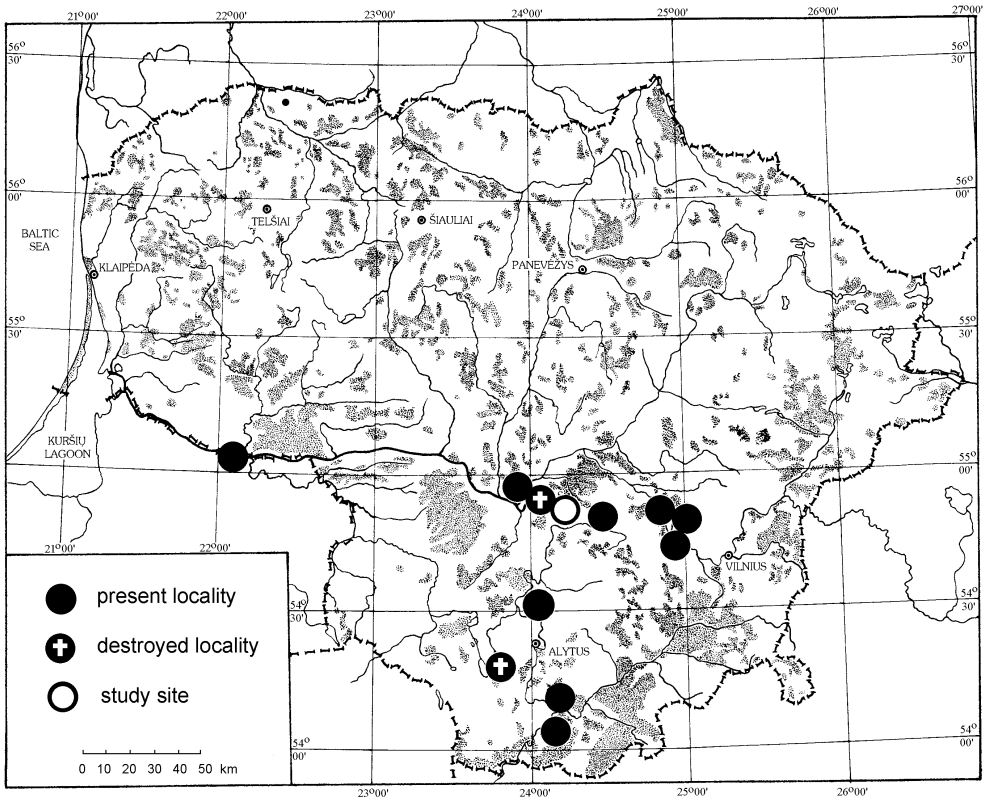


**Fig. 1.** Localities of *G. glis* in Lithuania.

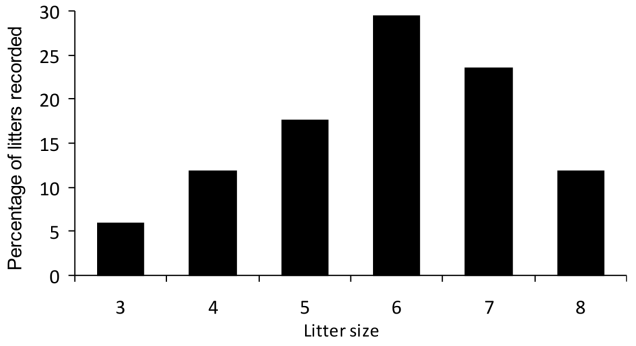


**Fig. 2.** Litter size of *G. glis* (n = 17) at the study site in Lithuania (2011-2014).

The abundance dynamics of *G. glis* during 1990-2014 were evaluated using the index of abundance – the percentage of nestboxes used by dormice in autumn (Juškaitis 2000). Nestboxes were considered used by dormice if the animals themselves or signs of their activity (nests, food remains, excrement) were found. Statistical analyses were performed using the STATISTICA 7.0 program package. Mean values are presented as mean ± SD.

## Results

*Distribution of G. glis in Lithuania*

*G. glis* is a rare species in Lithuania: only ten localities of *G. glis* are known at present, and they are concentrated in the southern part of the country along the two biggest rivers – the Nemunas and Neris (Fig. 1). Dormice are extinct in two localities where they were recorded in 1936, and presumably in some other sites. The westernmost locality for *G. glis* is situated in the Rambynas regional park and was only discovered in 2007. This discovery extended the known distribution range of *G. glis* (Amori et al. 2008) by about 120 km to the north-west. In nine out of the ten localities, *G. glis* occupy mature mixed forests with old pedunculate oaks and old hazels.

*Activity season*

In the Lithuanian populations, the activity season of *G. glis* lasts from mid-May until mid-October, i.e. five months. The earliest overwintered *G. glis* was recorded in nestbox in the valley of the River Dūkšta on 15 May. At the Rumšiškės study site, the first dormice were recorded on 19 May, although signs of *G. glis* activity were already present in several nestboxes on the same date. The end of the active season differs between sexes and age classes. The majority of adult male *G. glis* leave the nestboxes in the first half of September, while the activity of adult females lasts until late September. The latest record for yearlings found in nestboxes was on 5 October, while juveniles remain active until mid October. The latest record of a juvenile was on 27 October, but this case is exceptional. In some years, the dormouse activity season is shorter, with all dormice leaving the nestboxes already in the second half of September. Such early starts to hibernation were observed in 2012 and 2014, and could be related to the low masting of oak in these years.

*Breeding*

The main breeding period of *G. glis* is rather short: young were born from 28 July to 13 August with half of the litters (53 %) born in the first ten days of August. Only a few juveniles found living independently appeared to be born outside this period. The number of young in litters was three to eight with most cases being of six and seven young (Fig. 2), the mean litter size was 5.9 ± 1.5 young (n = 17). In litters of adult females, the mean number of young was 6.5 ± 1.0 (n = 14), while the mean litter size of yearling females was 4.7 ± 1.5 young (n = 3).

In the *G. glis* population monitored, breeding was recorded every year during 2011-2014. The majority of adult females (90 %, n = 20) and three out of 15 yearling females bred. However in this population over the longer time frame, juveniles were not recorded during nestbox controls in September 2004, 2005, 2008 and 2010.

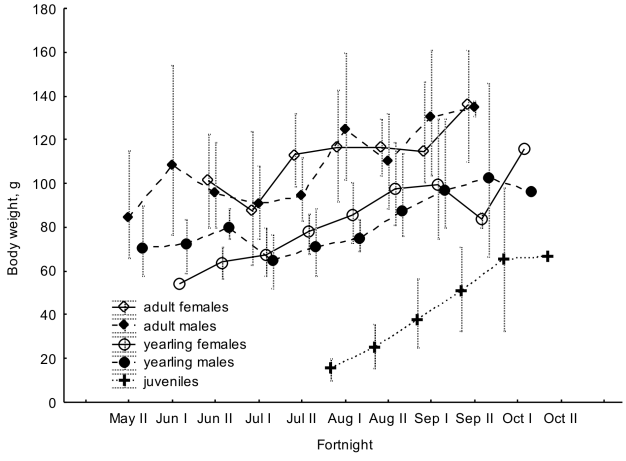


**Fig. 3.** Dynamics of mean body weight of *G. glis* in adult males (n = 77) and females (n = 34), yearling males (n = 83) and females (n = 42), and juveniles (n = 289) at the study site in Lithuania (2011-2014). Minimum and maximum are provided along the mean estimates.

*Body weight dynamics*

The body weight of *G. glis* changes during the course of the activity season (Fig. 3). After hibernation, adult *G. glis* weighed on average 98 ± 24 g (range

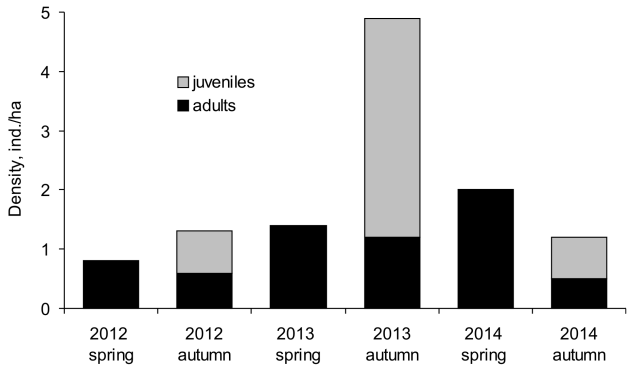


**Fig. 4.** Density dynamics in the population of *G. glis* at the study site in Lithuania.

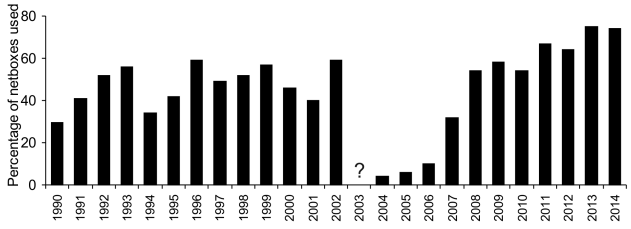


**Fig. 5.** Abundance dynamics in the population of *G. glis* according to the percentage of nestboxes used at the study site in Lithuania. Note: nestboxes were not inspected in autumn 2003.

63-154 g, n = 22). The mean body weight of yearlings was 68 ± 9 g (range 54-90 g, n = 34), and it differed significantly from the mean weight of adults (Mann-Whitney U-test, Z = 5.618, $p < 0.001$).

Before hibernation, adult *G. glis* weighed on average 128 ± 19 g (range 102-161 g, n = 25), while the mean body mass of yearlings (105 ± 19 g, range 83-146 g, n = 16) was still significantly less than in adults (Mann-Whitney U-test, Z = 3.833, $p < 0.001$). At this pre-hibernation stage, juveniles reached a mean body weight of 66 ± 10 g (range 42-98 g, n = 50). The maximum recorded body weight of *G. glis* before hibernation (197 g in adult male) was at the study site in 2007, a year with exceptionally good crop of hazel.

*Population abundance and its dynamics*

During 2012-2014, the spring population density ranged from 0.8 ind./ha to 2.0 ind./ha and autumnal density from 1.2 ind./ha to 4.8 ind./ha. An evident increase in dormouse abundance was observed in autumn 2013 (Fig. 4).

According to the index of abundance – percentage of nestboxes used, the population of *G. glis* was comparatively stable in the periods 1990-2002 and 2008-2010 (Fig. 5). Unfortunately, nestboxes were not inspected in autumn 2003, and it is not clear what happened that year. An evident decrease of abundance was recorded in 2004, and it was only in 2008 that the abundance was restored to the average level. Some increase in abundance was recorded in the period 2011-2014.

## Discussion

*G. glis* living outside the range of the European beech differ from dormice living in beech-dominated habitats by their lower population density, lower body weight and comparatively stable inter-annual abundance dynamics. Some peculiarities of the *G. glis* ecology in Lithuania may however be related to geographically-defined climatic conditions. For example, both dormouse activity and breeding season are shorter here in comparison to central and southern parts of the range (e.g. Kryštufek et al. 2003, Pilastro et al. 2003, Bieber & Ruf 2009). Meanwhile, the mean litter size of Lithuanian dormice (5.9 young) takes an intermediate position from across the range (4.8-6.8 young, reviews in Rossolimo et al. 2001, Kryštufek 2010).

In Britain, an introduced population of *G. glis* also occurs on the northern periphery of the range in similar geographical latitude to the Lithuanian populations (51°40′ N and 54°04′-55°03′ N respectively). However, the British population of *G. glis* lives in beech woodland and is distinguished by higher population density, much higher inter-annual fluctuations of abundance, the skipping of reproduction in non-masting years of beech and the very high body weights of individuals (Burgess et al. 2003, Morris 2008, Morris & Morris 2010). All the characteristics mentioned above are similar to populations of *G. glis* living in beech-dominated forests in central parts of the dormouse range. So in this case, considerable differences between *G. glis* populations living on the northern periphery of the range at similar geographical latitude occur, the differences in Britain probably determined by the beech-dominated habitat and milder maritime climate.

Outside the range of the beech, pedunculate oak becomes the most important tree in the habitats of *G. glis*. Mature oak trees grow in nine out of the ten known *G. glis* localities in Lithuania. Oak trees are indispensable components of dormouse habitats in Latvia and Russia, and reproduction of *G. glis* is directly related to the fruiting of oak trees (Pilāts et al. 2009, Vekhnik 2011).

Food availability and its quality determine the body mass of *G. glis* before hibernation, and seeds rich in lipids are the main food resource used by dormice (Fietz et al. 2005). Acorns of pedunculate oak have

very low lipid and protein content (3.4 % and 0.9 % respectively) in comparison to beech nuts (41.5 % and 22.8 % respectively, Fietz et al. 2005). Such differences would mean that acorns are less suitable food for *G. glis* when compared to beech nuts, and acorns are less preferred by dormice. For example in the year when the masting of beech and oak were similar in the northern Caucasus, *G. glis* fed on beech nuts, but did not feed on acorns at all (Donaurov et al. 1938).

According to the mean body weight after hibernation (98 g in adults), Lithuanian dormice are among the smallest across the distributional range. Smaller body weights were recorded in the Samara region of Russia (79-93 g, Vekhnik 2011) where beech trees are also absent. The highest mean body weights of *G. glis* were recorded in Britain (circa 140 g, Morris 2008) and in Slovenia (124 g, Kryštufek 2001). Mean body weights in central Germany (107 g, Bieber & Ruf 2009), south-western Germany (105 g, recalculated from Fietz et al. 2005) and Austria (99-101 g, Lebl et al. 2010) take intermediate positions.

The mean dormouse body weight before hibernation is much higher in beech-dominated habitats, e.g. in Croatia (228 g, Grubešić et al. 2004), Slovenia (203 g, recalculated from Kryštufek & Flajšman 2007), Germany and Austria (135-167 g, Fietz et al. 2005, Kager & Fietz 2009, Lebl et al. 2010), than outside the range of the beech, e.g. in Lithuania (128 g) and Samara region of Russia (105-114 g, Vekhnik 2011).

The lower body weight of *G. glis* living outside the range of the beech may be determined not only by the poorer feeding conditions, but also by the smaller body size of dormice belonging to a different subspecies. According to Storch (1978), dormice belonging to the subspecies *G. glis glis* occur in western, central and eastern Europe, with east European dormice a little smaller than the western and central European. A larger subspecies *G. glis postus* is described from Croatia (Storch 1978). Dormice belonging to this subspecies probably also live in Slovenia, and the introduced British dormice may have ancestries from the larger subspecies as well.

The population density of *G. glis* in different habitats is related directly with the abundance and diversity of food and presence of shelters (Airapetyants 1983, Rossolimo et al. 2001). In Lithuania and Latvia, dormouse densities are only 1-2 ind./ha before the breeding season, and can reach up to 5 ind./ha after a good breeding season (Pilāts et al. 2009, present study). Meanwhile in beech-dominated forests, densities can be much higher – up to 4-20 ind./ha (Jurczyszyn 1994, Kryštufek et al. 2003, Ruf et al. 2006). Judging from the highest densities recorded – 30 and even 50 ind./ha (Donaurov et al. 1938, Rossolimo et al. 2001) – the best habitats for *G. glis* occur in the Caucasus. Many different fruiting trees grow there together with the oriental beech (*Fagus orientalis*) whose nuts are dominant among the vegetable foods used by *G. glis* (Donaurov et al. 1938). Thus, dormouse densities are much higher in beech-dominated mixed forests with diverse fruiting trees than in mixed forests with oak trees.

*G. glis* are strongly specialised pulse resource consumers and reproduce only in years when seeds (e.g. beech nuts) are available. After emergence from hibernation, males of *G. glis* anticipate future food availability and may entirely skip gonadal growth and reproduction in those years when the beech crop is absent (Bieber & Ruf 2009, Lebl et al. 2010). This causes inter-annual fluctuations of abundance of *G. glis* which are most pronounced in beech dominated forests, where beech nuts are the single main food source (Kryštufek 2010). The presence of other fruiting trees (e.g. oaks *Quercus robur* and *Q. petrea*) together with the beech trees mitigates such fluctuations (Schlund et al. 2002, Bieber & Ruf 2009). In the Caucasus, where many other suitable feeding plants grow together with beech trees, abrupt inter-annual fluctuations of abundance of *G. glis* are absent (Donaurov et al. 1938).

At the eastern periphery of the *G. glis* range, a different mechanism regulating the reproduction of *G. glis* was discovered recently. The majority of both males and females were reproductively active every year, but mass resorption of embryos was observed in females in the years when the crop of oak was absent or scant (Vekhnik 2010, 2011). It is very likely that such a mechanism regulating the reproduction of *G. glis* acts also in other populations of this species outside the range of the beech.

In Lithuania, the inter-annual fluctuations of *G. glis* abundance in mixed forests with oak trees are mitigated by the presence of some supplementary food sources. If acorns are absent or scarce, pregnant females may feed on hazelnuts, as well as on seeds of birch and soft mast like raspberries (*Rubus ideus*) and glossy buckthorn (*Frangula alnus*) depending on their availability in particular years (Juškaitis et al. 2015). It seems dormice fail to reproduce in Lithuania only in very poor years when both pedunculate oak and supplementary feeding plants do not fruit, but such cases are infrequent in Lithuania. This would explain the absence of frequent and abrupt inter-

annual fluctuations of abundance in the population of *G. glis* investigated. Further studies should reveal whether some peculiarities exist in demographic and socio-spatial structures of *G. glis* populations living outside the range of the beech.


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