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ECOLOGY OF THE EDIBLE DORMOUSE (*GLIS GLIS*) IN A WESTERN EDGE POPULATION IN SOUTHERN BELGIUM

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GLIS GLIS
POPULATION DYNAMICS
NEST BOXES
DIET
HOME RANGE
RADIO-TRACKING
MOVEMENT
EDGE OF DISTRIBUTION

ABSTRACT. – Population dynamics, diet and spatial use of the edible dormouse *Glis glis* were studied in a peripheral population in Belgium, on the western limit of its distribution area. The main results showed that the proportion of occupied nest boxes varied between 2 and 44 %. The dormice occupied nest boxes approximately between June and October. The densities of adults varied between 0.6 and 2.3/ha. Reproduction was observed in 2006 and 2007 but not in 2005. The results of the diet study revealed a basically herbivorous diet. Home range (MCP) of males varied from 0.68 to 1.23 ha and that of females from 0.37 to 0.71 ha. Marked individuals moved on average 252 m/night (range = 60-497 m/night). In general, these results are in accordance with those observed in other countries. Only few differences appeared and they concern mainly a smaller number of occupied nest boxes, a smaller density and a higher proportion of birds in the diet of the species.

INTRODUCTION

According to Lesica & Allendorf (1995), geographically peripheral populations are more likely to be imperilled than central populations. Presumably, the central populations experience favorable, optimal environmental conditions, whereas at borders less suitable habitats are available, and populations are likely to experience more stressful conditions (Hoffmann & Blows 1994). In range-edge populations of species, the scarcity of suitable habitat may thus be reflected in small and isolated populations by increased inbreeding, genetic drift and reduced gene flow implying lower genetic diversity (Lesica & Allendorf 1995). In the present work, we have studied a population of the edible dormouse living at the western limit of the species' geographical range in order to find out whether these edible dormouse populations present a different ecology related to their geographical position, and how this species could be adapted to this marginal environment.

The edible dormouse, *Glis glis* (Linnaeus, 1766), is an arboreal and nocturnal inhabitant of deciduous and mixed forests in central, eastern and southern Europe, in the Caucasus, and in the Near East in Turkey and northern Iran (Krystufek 1999). Its hibernation behavior made it sensitive to climate (Koppmann-Rumpf *et al.* 2003). Edible dormice are selective feeders, which must concentrate on the most nutritious food sources available according to the season (Gigirey & Rey 1999, Holisova 1968, Nowakowski & Godlewska 2006). Its specific trophic requirements made it sensitive to habitat containing a high diversity of suitable plant species in order to ensure continuity of food supplies through the changing seasons. The species should therefore be a suitable model for studying its

adaptation to a marginal environment.

Although the edible dormouse is usually common in southern Europe, it is rare in many parts of this area, particularly in the north where it is of conservation concern (Krystufek 1999). In Belgium, edible dormouse populations reach the western limit of their distribution where they are small and isolated, implying particular conservation concern. However, there are neither data nor previous studies on this species in Belgium that could either confirm or refute a particular ecology of these peripheral populations. This study will thus provide the first data on the population dynamics and ecology of the edible dormouse in Belgium. Such knowledge is of primary importance in understanding the ecology of this rare species and to develop conservation programs.

MATERIALS & METHODS

Study area: The study focuses on data from two study areas (Torgny, 49°31'N - 5°28'E and Camus 49°31'N - 5°31'E) in Belgian Lorraine (southern part of Belgium). Both sites are situated at around 300 m a.s.l. on the warm south-facing slopes of the cuesta bajocienne (elongated hills with asymmetric slope). This region is characterized by a milder climate than in the rest of the country and presents soils on calcareous sandstone. Both sites are mainly under mixed broad leaved woodland consisting mainly of oak (*Quercus* sp.), beech (*Fagus sylvatica*), hornbeam (*Carpinus betulus*), maple (*Acer* sp.) and ash (*Fraxinus excelsior*). The undergrowth was usually rich and formed mainly by *Corylus avellana*, *Rubus* sp., *Crataegus* sp., *Cornus sanguinea*, *Viburnum lantana*.

Population dynamics: In May 2005, wooden nest boxes

Table I. – Summary statistics of the occurrence and sex-ratio of *G. glis* in nest boxes in Belgian Lorraine over three years. NB-number of nest boxes; NB*-number of nest boxes occupied by dormice; NB %-percentage of occupied nest boxes; NM-number of adult males; NF-number of adult females; NT-total number of adults (this number can be higher than the sum of adult males and females since some animals escaped before being sexed); NJ-number of juveniles. Nest boxes were not checked in October 2007.

Year	Month	NB	NB*	NB%	NM	NF	NT	NJ	sex ratio (M:F)
2005	June	85	0	0	0	0	0	0	0
	July	85	0	0	0	0	0	0	0
	Aug.	85	12	14.1	5	7	12	0	5:7
	Sept.	85	2	2.3	1	1	2	0	1:1
2006	June	83	3	3.6	3	0	3	0	3:0
	July	81	9	11.1	5	5	12	0	5:5
	Aug.	81	16	19.7	4	10	9	35	4:10
	Sept.	81	12	14.8	4	8	12	34	4:8
	Oct.	55 ¹	24	43.6	0	1	1	55	0:1
2007	June	81	2	2.5	2	0	2	0	2:0
	July	81	8	9.9	5	3	8	0	5:3
	Aug.	81	17	21.0	3	13	16	14	3:13
	Sept.	81	24	29.6	4	16	20	26	4:16

¹ Only Torgny was checked in October 2006

(30 x 15 x 15 cm with 33 mm entrance holes) were dispersed at average intervals of 50 m over an area of 8 ha in Camus and 21 ha in Torgny. Average density of nest boxes per ha was 3.2 in Camus and 2.4 in Torgny. Their exact number is given in Table I. They were placed > 3 m above the ground, on suitable trees. During three years (2005, 2006 and 2007), the nest boxes were checked every 2 weeks from May to September (and to October in 2006). Dormice were sexed and weighed to the nearest gram. The number of young in a nest box was taken to be the litter size, provided all young were of a weight prior to dispersal (< 41 g) (Burgess *et al.* 2003). Body weight was used to identify independent juveniles and adults in the autumnal population.

Diet: The whole amount of faeces found during a check of a nest box was treated as a single sample. All droppings were collected inside or on top of nest boxes. 93 samples were thus collected from around 85 nest boxes (in Torgny and Camus) in years 2006 and 2007, every two weeks between June and September.

The method used for faecal analysis followed Nowakowski & Godlewska (2006). The collected material was conserved in 95 % ethyl alcohol. Faeces were dried on filter paper for 15 min, placed on a glass, soaked with water, and then delicately separated under a microscope with tweezers and preparation needle. Visible and recognizable food remains were segregated into the following groups: remains of arthropods, feathers, seeds, fleshy fruits, nuts and plant fibres. Remains of arthropods were collected, dried, counted and identified. In the remaining classes of food only presence in a sample was recorded.

Spatial activity: The results relate to data from 3 radio-tracking sessions in Torgny during activity seasons of dormice in

2005 and 2006. Together our results yielded 35 dormouse/nights of data (3 males and 2 females) (Table II). Dormice were captured in nest boxes. Each animal was weighed and sexed. Individuals were fitted with radio transmitters (from Biotrack, Wareham, Dorset, England) that weighed on average 3.5g, which represents less than 5 % of their body mass as recommended by Cochran (1969). Dormice were released at the capture site within 1 hour; during this time they were kept in glass boxes and their behavior was observed to see if any problems appeared following collar fitting. Every individual was radio-tracked using a TRX1000S receiver (Wildlife material Inc.), three-element Yagi antenna and headphones. Collars were removed from the dormice after approximately one week of tracking.

Positions of marked individuals were calculated through the triangulation method. Azimuths were recorded at < 5 min intervals at distances < 100 m from radio-collared individuals. These positions were used to calculate the individual's position using L.O.A.S. 3.4 (Ecological Software Solutions, CA, USA) that calculated error ellipse to 95 % confidence with a maximum likelihood estimator. Estimated locations with an error ellipse greater than 0.05 ha (approximately 10 % of the dormouse home range) were rejected. Animals were tracked during 6 to 8 nights, from sunset to sunrise, and fixes were taken approximately every hour. In total, a minimum of 50 positions were reached for each individual (Table II) which is the minimum number that should be collected for reliable kernel estimates (Seaman *et al.* 1999).

A number of locations ranging from 6 to 10 were taken each night for each animal. The sum of linear distances between successive radio fixes was used to estimate the total minimum distance dormice moved each night. Radio-tracking data were analyzed using an animal movement analysis extension (Hooge &

Table II. – Number of sampled nights, locations recorded, tracking period, home ranges (HR) calculated by minimum convex polygon (MCP) and kernel estimators, average distance travelled/night and longest distance travelled from the nest-site/night of five *G. glis* in Torgny. Standard error (S.E.) and range of distances are also shown.

	Number of nights	Number of locations	Mean number of locations per night	2005			2006			MCP (ha)		Kernel (ha)	
				J	J	A	J	J	A	100 %	95 %	95 %	50 %
Males													
B2 (a)	8	66	8	■					1.23	1.01	1.2	0.12	
B4 (a)	7	56	8		■				0.72	0.39	0.61	0.05	
B18 (b)	6	52	8				■		0.68	0.25	0.28	0.03	
Females													
B3 (a)	7	50	7		■				0.37	0.26	0.35	0.04	
B25 (a)	7	60	8				■		0.71	0.56	0.51	0.06	
TOTAL													

	Distance travelled/night (m)			Longest distance travelled from the nest-site/night (m)		
	Mean	S.E.	Range	Mean	S.E.	Range
Males						
B2 (a)	312	50	60 - 497	98	13	79 - 140
B4 (a)	224	33	103 - 394	50	6	26 - 69
B18 (b)	189	34	104 - 265	63	9	31 - 87
Females						
B3 (a)	166	19	93 - 233	43	5	16 - 59
B25 (a)	328	26	201 - 398	98	5	81 - 119
TOTAL	252	19	60 - 497	72	6	16 - 140

Circumstances/fate of individuals that caused end of monitoring: (a) individual recaptured to after end of field study; (b) collar removed by the animal.

Eichenlaub 2000) in the Arcview 3.2 GIS program (Esri, CA, USA). We calculated home-range size using 100 % and 95 % minimum convex polygon (MCP; Mohr 1947) because only these methods provided data comparable to other studies (Harris *et al.* 1990). Moreover, to describe more accurately the shape and size of the home range, we choose the fixed-kernel estimator (Harris *et al.* 1990) with a level of smoothing selected by least-squares cross validation (Seaman *et al.* 1999). We used the 95 % kernel to describe the area actually used by the animals, and the 50 % kernel for the intensively used area. Autocorrelation of data, which assumes underestimation of home range sizes, was not taken into account because several recent studies refuted this principle (Blundell *et al.* 2001).

RESULTS

Population dynamics

Results of the nest box survey are summarized in Table I. The two localities have been pooled in order to increase sample size. The proportion of nest boxes found occupied on each visit varied between 0 and 44 %. It was lower during the non-reproductive year (2005) and higher in October 2006 and September 2007. On average, 13.2 %

of the nest boxes contained dormice (mean occupied nest boxes) although in autumn (September and October), one fifth of the nest boxes were occupied (mean = 22.6 %).

For comparative purposes between years and seasons, an index of abundance is given as the number of individuals (ind.) per 100 nest boxes (NB) (Fig. 1). Number of adults was lowest in October 2006 (1.8 ind. per 100 NB) and highest in September 2007 (24.7 ind. per 100 NB). Number of juveniles was highest in October 2006 (102 ind. per 100 NB).

We attempted to estimate adults' density in absolute terms for years 2006 and 2007 in both sites. These were calculated on the basis of the average number of adults found during each nest box checking session. These estimations give an adult density of 1.2/ha - 1.3/ha for Torgny and 0.6/ha - 2.3/ha for Camus (respectively in 2006-2007).

No dormice were found in nest boxes in May. First appearance of dormice occurred in June and they made extensive use of the nest boxes from July to end of September. Births occurred mainly during the two first weeks of August. Females were found currently with young until the end of September. We rarely found adults in October.

During the activity season, different sex ratios were observed among the non-juvenile edible dormice

Fig. 1. – Changes in number of *G. glis* (per 100 nest boxes) according to month over three seasons. Adults are shown as black shaded columns and animals born in the same year as grey ones.

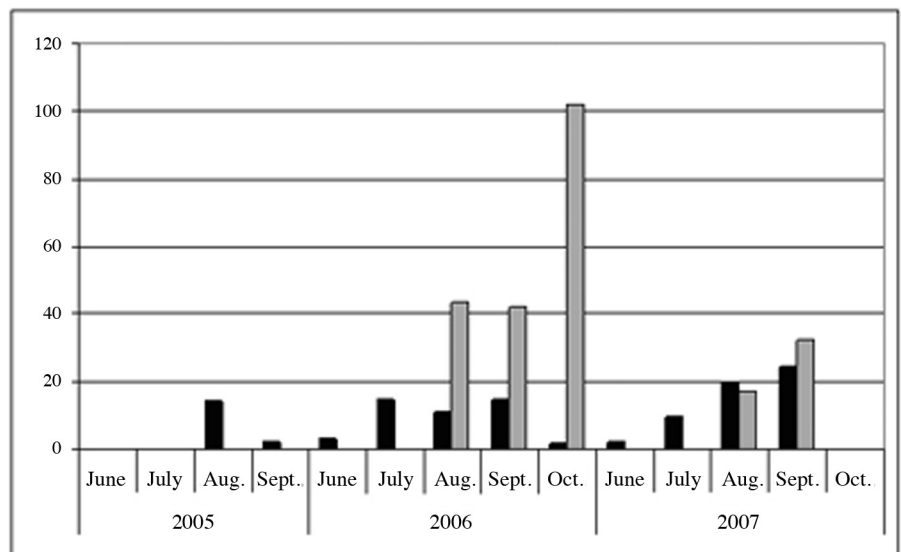
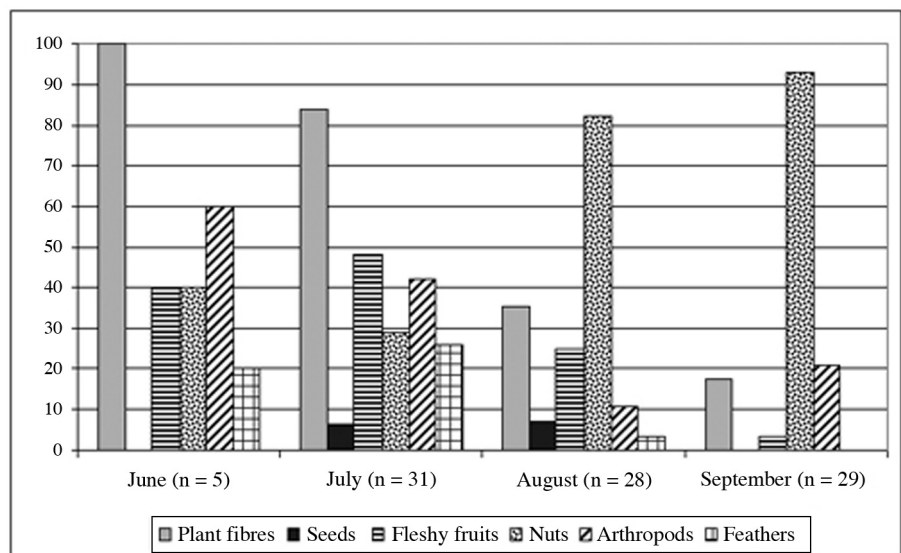


Fig. 2. – Percentage of samples of faeces (n = 93) of *G. glis* containing different types of food in successive months of the activity period.



(Table I). It tended to be male biased in June and female biased in August and September. No reproduction was observed during 2005 (no litter found in nest-boxes). Average litter size over years 2006 and 2007 was 4.9 ($N = 21$, $SD = 0.85$, range = 4-6).

Diet

The results revealed a basically herbivorous diet. Samples consisted mainly of nut pulp (66 %) and plant fibres (49 %) while fleshy fruits were found in 27 % and seeds in 4 % of the total sample. Nevertheless, remains of arthropods were present in 27 % of the total sample while bird feathers were found in 11 % of the faecal samples.

There is a high proportion of samples that included plant fibres in June and July (100 % and 84 %) compared to August and September (36 % and 17 %) (Fig. 2). The

proportion of samples that included fleshy fruits varied also from 48 % in July to 3 % in September, and those with nuts from 93 % in September to 29 % in July. Nut remains found in nest boxes belonged principally to hazel (*Corylus avellana*), oak (*Quercus* sp.), beech (*Fagus sylvatica*) and hornbeam (*Carpinus betulus*). As to animal remains, arthropods were found in samples during all the activity period with a peak in June (60 %) although this result must be taken with caution due to the small sample size of this month. Except for June, the proportion of samples that included arthropods varied from 42 % in July to 11 % in August. Feathers were mainly present at the beginning of the summer from 20 % in June to 26 % in July. The majority of recognizable remains of arthropods in faeces of the edible dormouse were parts of Coleoptera – they comprised 47 % of all these items.

Spatial activity

The incremental area (MCP method) analysis showed that 50 fixes were necessary to describe the home range of an edible dormouse (Fig. 3). This number of fixes was obtained for the 5 animals tested. Using all valid locations (MCP 100 %) the home range of males varied from 0.68 to 1.23 ha and female's from 0.37 to 0.71 ha. No clear differences of home range estimates were observed between males and females but small sample size hampered statistical comparison between sexes. However, we noticed a higher estimate for male B2. Except for male B4, kernel and MCP (both with 95 % of valid locations) produced comparable estimates. Kernel allowed visualization of the intensity with which each animal used its home range. Intensively used area estimates were similar for all animals (from 0.03 to 0.06 ha) except for male B2 (Table II).

Marked individuals moved on average 252 m/night (range = 60-497 m/night) (Table II) but significant differences were detected between animals (ANOVA; $F = 3.904$, $p = 0.012$). No significant difference was observed between males and females (t Test; $t = 0.0604$, $p = 0.952$). The greatest mean distance travelled from the nest-site/night was 72 m/night (range = 16-140 m/night) (Table II). No difference was found between males and females (t Test; $t = 0.197$, $p = 0.845$).

DISCUSSION

Population biology of the edible dormouse

In the northern and central parts of its distribution area, the edible dormouse may generally face energetic problems that prevent yearly reproduction (Bieber 1998, Krystufek *et al.* 2003, Pilastro *et al.* 2003). It has been suggested that general reproductive failure could be associated with years of poor beech seed production (Bieber 1998). We have noticed a lack of reproduction in 2005 in Belgium. It is suspected that local failure of the beech crop was a primary factor causing the observed breeding failure, although seed production was not thoroughly monitored in this study.

The average proportion of occupied nest boxes (13.2 %) was low compared to other studies: in Slovenia (24.1 % - Krystufek *et al.* 2003), in Germany (25 % - Vietinghoff-Riesch 1955), in Moravia (25 % - Gaisler *et al.* 1977), in Lithuania (30-60 % - Juskaitis 2000) and in Sicily (34-80 % - Milazzo *et al.* 2002). The index of abundance varied from 1.8 to 24.7 ind. per 100NB, depending on the years. The higher adult abundance found in 2007 compared to 2006 could be due to new recruits from 2006. The high number of juveniles in October 2006 compared to adults' can be explained by the early start of hibernation of adults, as is known to occur in other countries (Krystufek *et al.* 2003, Bieber & Ruf 2004). The estimates

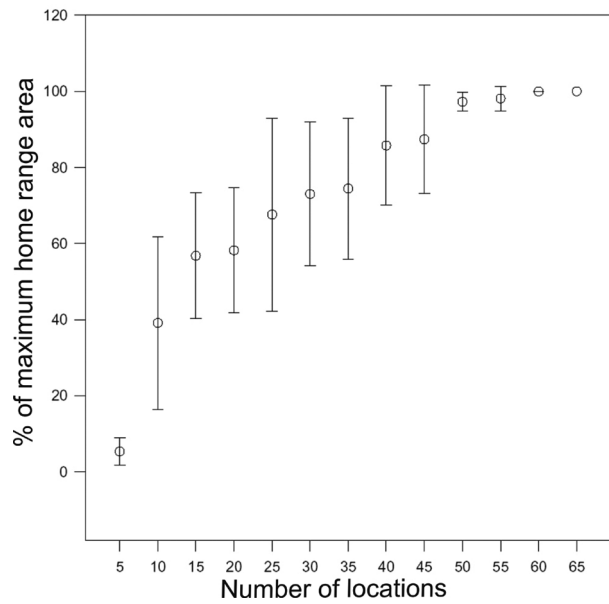


Fig. 3. – Incremental analysis of percentage maximum home range area against number of consecutive locations for convex polygons round all the locations (N = 5 animals). Bars correspond to 95 % confidence intervals.

of adult density calculated in absolute terms (between 0.6 and 2.3 ha⁻¹) are comparable to those calculated in some places in Italy (1 ha⁻¹ - Pilastro 1990), in England (0.6-1.8 ha⁻¹ - Hoodless & Morris 1993) and in Moravia (> 1 ha⁻¹ - Gaisler *et al.* 1977) but, generally, smaller than in other studies (Slovenia - Krystufek & Zavodnik 2003, Germany - Vietinghoff-Riesch 1955, Poland - Jurczyszyn 1995 and Caucasus - Ognev 1963). However, this estimation is probably too low because only part of the dormice living in the study area can be found in nest boxes during single controls. In general terms, the length of the activity period is comparable to that from more central populations (Gaisler *et al.* 1977, Koppmann-Rumpf *et al.* 2003, Bieber 1998).

Diet of the edible dormouse

Nuts are a highly nutritious food that enables edible dormice to accumulate the body fat required to survive during the winter. Usually, nuts are found in autumn in edible dormouse diet (Gigirey & Rey 1999, Holisova 1968) but in our area last year's nuts are present in June, as is the case in the eastern edge of its range (Russia - Ivashkina pers comm).

The large amounts of arthropod remains detected in June (60 %) but also in July (40 %) and the part of samples containing feathers (from 20 to 24 %) during the same period could reflect a response to the high energy demand over the sexual activity, in view of the fact that no energy-rich plant foods are available at this time, as previously suggested by Franco (1990) and Gigirey & Rey (1999). The consumption of animal food during this

period is also found in other studies (Castroviejo *et al.* 1974, Gigirey & Rey 1999, Nowakowski & Godlewska 2006) although detection of feathers is especially noticed in the north of the distribution area of the species (Adamik & Kral 2008a, 2008b, Juskaitis 2006, Koppman-Rumpf *et al.* 2003, Nowakowski & Golewska 2006). Might less favourable environmental conditions drive dormouse to have more carnivorous habits? This has already been suggested by Franco (1990) for a sub-optimal habitat consisting mainly of Norway Spruce. In the same manner, a very high proportion of fungi – as a source of proteins – is observed in dormouse diet in the eastern edge of their distribution (Russia - Ivashkina pers comm). However, a comparative study analyzing a higher sampling rate from peripheral and central populations is essential to confirm this kind of hypothesis.

Home ranges and movements of the edible dormouse

Our home range estimates for the males in Torgny are similar to those of Jurczyszyn (2006) in Poland but smaller than the estimates in UK by Morris & Hoodless (1992). Our female home range is similar to those of Jurczyszyn (2006) in Poland and those of Morris & Hoodless (1992). It is very likely that differences in ecological variables, such as forest structure and food resources, might account for the discrepancies observed in home range across studies. It is also likely that seasons, years of no reproduction and density of population could play a role in the space use of the species (Jurczyszyn & Zgrabczynska 2007). Individuals appeared to travel only as far as was necessary to find suitable food, as was the case in animals monitored by Morris & Hoodless (1992).

Conclusion

This study shows the first results obtained for the ecology of the edible dormouse in Belgium in the western limit of its distribution.

Differences in the ecology of the edible dormouse were expected in Belgian populations compared to more centrally populations because they are supposed to experience less favorable environmental conditions as they live in a peripheral situation. It has been shown that mean annual home range size of Tawny owl females, *Strix aluco*, was much larger in northern edge populations than reported in any other study (Sunde *et al.* 2001). In the same way, ranges of Mt. Graham red squirrels, *Tamiasciurus hudsonicus*, in a peripheral population were nearly 10 times the size of red squirrels from other locations (Koprowski *et al.* 2008).

However, very small variations of dormouse ecology were found in Belgium as compared to more central populations. These differences appear mainly in a smaller number of occupied nest boxes, a smaller density and a higher proportion of birds in the diet of the species. Nev-

ertheless, these differences are not straightforward and studies with a greater sampling effort are necessary to confirm this hypothesis. Therefore, in general, the ecology of the edible dormouse in Belgium is in accordance with features in other countries. At first sight, it seems that ecological factors on a small scale (habitat quality, food resources, nest-hole availability, etc.) explain the difference of results between studies more easily than the large scale geographical position of the population (peripheral versus central distribution). However, due to the absence of beech – one of the main dormouse feeding plants – in the northern parts of the *G. glis* range, we could expect very different results in the northern part of *G. glis* distribution (Lithuania, Latvia, Belarus and Russia) in comparison to central parts of the range.

Nevertheless, edible dormouse populations in Belgium are scattered, of small density, fragmented and restricted to the southern edge of the country (Hürner H unpublished data). Moreover, recent genetic studies show a very low genetic diversity in Belgian populations (Hürner *et al.* 2009; Hürner *et al.* in preparation). These facts tend to show that other factors than those taken into account in our study played a role in structuring ecologically and genetically peripheral populations of dormice in Belgium. Deforestation, the abandoning of fruit-tree cultivation, replacement of deciduous woodlands with coniferous ones, intensification of agriculture and habitat fragmentation are thus probably affecting *G. glis* populations in Belgium. However, there are suitable habitats for *G. glis* in the northern part of the country. In fact, the distribution of *G. glis* in Belgium is strongly related to the Belgian Lorraine region characterized by a milder climate due to its protection from the north winds by its border with the Ardennes Massif. Climate may be a factor strongly influencing dormouse distribution (Bright 1995). It has been shown that low temperatures and rain in summer reduce the activity of hazel dormouse, *Muscardinus avellanarius*, induce torpor and delay of reproduction (Bright *et al.* 1996, PW Bright unpublished data).

The study of these factors could help determine what traits are responsible for species borders at the ecological level and understand why these peripheral dormice populations are rare, isolated and genetically depauperated at the northern edge of their range.

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