LUTRA

Volume *Deel* 49 - Number *Nummer* 2 – December 2006

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Printed by Grafisch bedrijf Ponsen & Looijen bv, Wageningen ISSN 0024-7634

LUTRA

Journal of the Society for the Study
and Conservation of Mammals

Volume 49 – Number 2 – December 2006

L U T R A

Volume *Deel* 49 – Number *Nummer* 2 – December 2006

Lutra is a scientific journal published by the Society for the Study and Conservation of Mammals (VZZ). The society is dedicated to the study and protection of native mammals in Europe. Lutra publishes peer -reviewed scientific papers on mammals across all disciplines, but tends to focus on ecology, biogeography, behaviour and morphology. Although exceptions are made in some cases, Lutra generally publishes articles on mammal species native to Europe, including marine mammals. Lutra publishes full articles as well as short notes which may include novel research methods or remarkable observations of mammals. In addition Lutra publishes book reviews, and compilations of recent literature on mammals. Lutra publishes in British English as well as Dutch. Lutra publishes two issues per year and Lutra is indexed in 'Biological Abstracts' and 'Zoological Record' and 'Artik'.

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Stichting Publicatiefonds Lutra — Rob C. van Apeldoorn, Edgar A. van der Grift & Bauke Hoekstra
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website: http://www.vzz.nl

English language editing by: textualhealing.nl

Photograph cover by: Dominique Verbelen

Art: Elias Nauta (page 88, 102 and 114)

 ISSN 0024-7634

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Publish!

Some decades ago the slogan "Publish or perish" was a constant warning for many scientific institutes and those working in them. In a real struggle for survival many institutes merged or disappeared while others successfully adapted. Nowadays the first part of this slogan remains: "Publish!" - but in some respects the scope has altered. All actions supporting the conservation or protection of mammals need to be firmly rooted in good science, as we have pointed out in earlier editorials (e.g. *Knowledge is the key to protection*, issue 49 (1)). This dictum holds for all types of study from occasional notes to long term studies, as well as those that fall between. So, "Publish", for the sake of mammals, and for the sake of nature conservation.

Abstracts of papers published in *Lutra* from volume 43 (1) (2000) onwards are now available on the internet. Since last year the content of papers can also be read and downloaded online. This new service from the Society for the Study and Conservation of Mammals (VZZ) is attracting increased interest. In the first eight months since full texts became available on-line, electronic versions of the papers were viewed more than 5500 times. It has been interesting to analyse the frequency distribution of searches of papers made through this new medium (figure 1). Such statistics do not so much reflect the quality of the papers, but rather the interest of the reading public. These figures very clearly differ from the citation index: reflecting readership rather than scientific use in other papers. Clear patterns in the interest of visitors to www.vzz.nl/lutra/lutra.htm can be found: at present the paper *The wildcat (*Felis silvestris*) .nally recorded in the Netherlands* (Canters et al. 2005; issue 48 (2): 67-90) has been the most frequently requested (1370

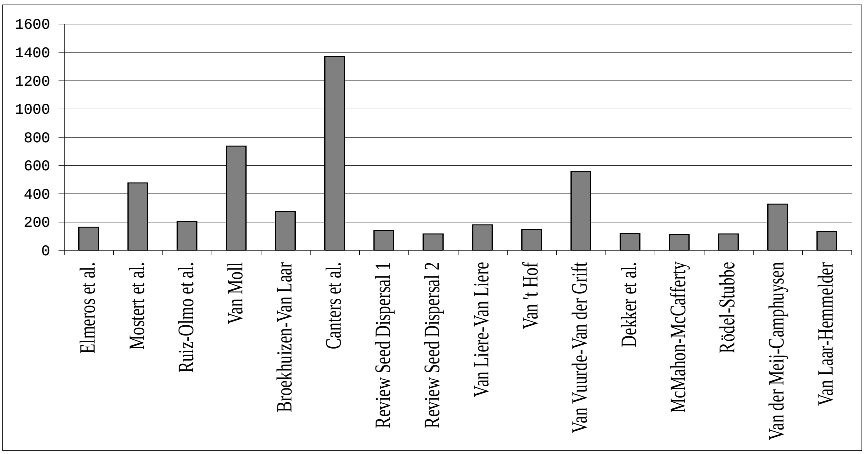

Figure 1. Frequency distribution of papers in Lutra volumes 48 (1), 48 (2) and 49 (1) viewed on www.vzz.nl.

times). This is probably the result of a press release by the VZZ office, something that we need to do more often when we have important statements about our native mammals that are of potential interest to the popular press. Runners up are Van Moll, Van Vuurde & Van der Grift and Mostert et al. with 737, 556 and 477 visits respectively. Even the least read articles have been viewed more than one hundred times.

If, however, the figures are corrected for time the papers were available online (as a relative frequency distribution), then *The distribution and diversity of whales and dolphins (Cetacea) in the southern North Sea: 1970-2005* (Van der Meij & Camphuysen 2006; issue 49 (1): 3-28) comes out as the most frequently requested paper (327 times; figure 2).

Many questions can be asked about this new cohort of electronic readers. “Who are they?” “How do they use the content?” “Which organisations (if any) are they affiliated to?” “What countries do they come from?” And so on. But the implications are clear: publish in Lutra these days and you will have a larger readership. And, as people come to use their computers more frequently to source material, and become more used to linking into, and between, the keywords in articles, they will find it easy to locate other papers with the same keywords. So authors: be warned of the possibility of overwhelming numbers of readers enjoying the fruits of your intellectual labours, after publication your e-mail boxes may become overloaded! For those who prefer reading Lutra in the armchair near the fireplace, hard copy versions still remain.

This issue of Lutra includes studies from abiotic (and biotic) variations through to studies of translocations. Verbeylen rings the alarm-bell over the status of the common dormouse in Flanders (Belgium), which she suspects to be severely threatened. Its distribution is currently limited to the region of Voeren, connected to Limburg (The Netherlands) where the species is also threatened. Warwick et al. describe the destiny of hedgehogs translocated from the Hebrides to Mainland Scotland. The results may encourage further translocation experiments, and counter evidence from earlier, less successful, hedgehog translocations. Van Wieren et al. give a striking example of fluctuations among brown hare populations, and the relationship of this with climatic factors and the frequency of flooding of a salt marsh. The authors reveal the wide fluctuations of brown hare populations in a relatively hostile environment. Finally, Boshamer and Bekker describe a special observation of a serotine: a high altitude summer record of a bat-species that seems to be under-recorded in the south of Europe.

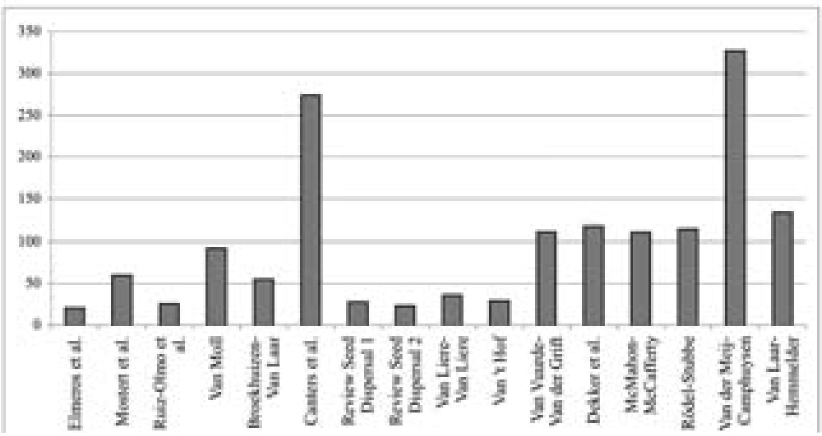

Figure 2. Relative frequency distribution of papers in Lutra volumes 48-1, 48-2 and 49-1 viewed on www.vzz.nl. after correction for time available online.

Status and conservation of the common dormouse (*Muscardinus avellanarius*) in the Province of Limburg (Flanders, Belgium)

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Abstract: The common dormouse (*Muscardinus avellanarius*) is a protected species in Flanders and is suspected to be severely threatened. Since there was insufficient knowledge on the status of the common dormouse in Flanders to propose and implement suitable protection measures, the Mammal Working Group of Natuurpunt started a census in the Flemish Province of Limburg in 2003. Historical data were collected and verified and a large number of forests were searched for signs of common dormouse presence: nests and eaten hazelnuts. In one forest nest boxes and tubes were set up. The new data indicate that the distribution of the common dormouse in the Province of Limburg is currently limited to the region of Voeren. Here signs of its presence were found in five forests, all at least partly forest reserves. In the other two Limburg regions with historical data, Hasselt and Tongeren, no indication of dormouse presence was found. As the Flemish common dormouse population appears to be on the verge of extinction, immediate action is required to save the last of them. Therefore, a complete mapping of distribution and a Population Viability Analysis were not waited for. Based on recent common dormouse observations and expert knowledge, concrete protection measures to improve habitat quality and connectivity are advised. A preliminary management plan for the development of the common dormouse metapopulation in the region of Voeren is proposed.

Keywords: Common dormouse, *Muscardinus avellanarius*, historical data, distribution, protection measures.

Introduction

The common dormouse (*Muscardinus avellanarius*) has declined in numbers and distribution in several countries (e.g. The Netherlands, Denmark, UK) due to its complex biological requirements (Foppen et al. 2002, Vilhelmsen 2003, Bright et al. 2006). It needs a well-structured vegetation to reach a wide variety of food items to survive throughout the year (Bright et al. 2006). Its limited dispersal ability and slow reproduction rate make the species vulnerable when habitat quality and thus population density is low (Juškaitis 2003, Bright et al. 2006). The common dormouse is a strictly protected species in Europe (Habitats Directive annex IV, Bern Convention annex III).

The species is also protected within the framework of Flanders' legislation (Royal Decree of 1980) and is classified as 'threatened' on the Flemish Red List of mammals (Criel et al. 1994). However, prior to 2004 no standardised censuses of the common dormouse distribution had been made in Flanders. Data on the viability parameters of the remaining populations, such as population size, reproduction and survival rates, and dispersal patterns, were lacking. Consequently, knowledge about the status of the common dormouse in Flanders was insufficient for proposing and implementing suitable protection measures. In other countries like the UK and The Netherlands censuses, basic ecological research, and protection measures have already taken place for many years (Foppen et al. 2002, Bright et al. 2006).

Historical data in Flanders comprise of very few scattered observations of individuals and nests (Mammal Database of the Flemish Mammal Working Group, Verkem et al. 2003). These data indicate that, at least up till a few years ago, there were still some common dormouse populations in the Flemish Provinces of Limburg and Brabant. However there was lack of recent data on the distribution and size of common dormouse populations in these provinces. For the Provinces of East-Flanders and West-Flanders the few observations may have concerned individuals that were unintentionally moved by human activities. There are no data to show whether or not these provinces have or had any permanent common dormouse populations. In the Province of Antwerp there are no historical or recent data.

In this article we describe the progress made by the Natuurpunt Mammal Working Group Flanders between 2003 and 2005 in verifying historical data, mapping present distribution and recommending protection measures for the common dormouse in the Flemish Province of Limburg.

Material and methods

Study area

In the search for possible remaining common dormouse populations, it is very helpful to have correct and detailed historical data. Thus, at the outset we attempted to verify as much historical data from the Mammal Database as possible by contacting the observers. By assessing these historical observations, based on the experience of the observer and the type of observation (for example animal sighting, nest, gnawed nuts), they were classified as either reliable or unreliable. The historical presence of common dormouse populations was accepted in those locations with one or more reliable observations. Several historical data concerned findings of nests completely constructed from the fluff of old man's beard (*Clematis vitalba*). Since there are now strong suspicions that nests of this material do not belong to common dormouse but to wood mouse (*Apodemus sylvaticus*) or bank vole (*Clethrionomys glareolus*), these data were classified as wrong. Extra data were collected by contacting specialists and field workers and by doing a thorough literature review.

We started our research in 2003 with an excursion to Teuvenerberg (Voeren, Province of Limburg), one of the few locations where we suspected the presence of a remaining population, as it is connected to the Dutch common dormouse population (Foppen et al. 2002). The search continued

Searching for common dormouse nests in old man's beard: not an easy job… *Photograph: Dominique Verbelen.*

in 2004 and 2005, when we carried out censuses in a range of forests in the Province of Limburg (figure 1, table 2, more details in Verbeylen 2004 and Verbeylen & Verbelen 2006). These locations were selected on a number of criteria: 1. presence of historical data (check for remaining populations), 2. proximity to forests with recent observations (in our case only Teuvenerbos), 3. potentially suitable forests according to a coarse analysis based on forest composition, area and age (deciduous forests of at least 20 ha which were established before 1775, Verbeylen 2004) and according to advice from the Forest Ecology and Treatment Team of the Research Institute for Nature and Forestry.

The required permits were obtained from the Forestry and Nature Department of the Flemish Government and the forest owners.

Census design and methods

In 2005, each forest was checked for the presence of optimal or marginal habitat patches, which were indicated on a map. We followed the Dutch habitat classification (table 1).

Different census methods were used to determine the presence of common dormouse. In the UK the use of nest boxes and tubes is strongly promoted as the best method to monitor (and protect) common dormice (Bright et al. 2006). However, since putting up nest boxes and tubes in many forest locations is expensive and not always allowed (especially not in forest reserves) we only used this method in one area (De Kevie, 2004-05) as a test case.

In the other forests we searched for eaten hazelnuts in the immediate surroundings of hazel trees (*Corylus avellana*). This is considered to be the most efficient census method for forests for which there are no data on common dormouse presence (Bright et al. 2006). Common dormice gnaw hazelnuts in a specific way, that can easily be distinguished from other species (Bright et al. 2006). This method has been used in several regions to conduct major surveys (e.g. the 'Große Nussjagd' in Saxony, Germany, and the 'Great Nut Hunt' in the UK, Büchner & Andy 2005, Bright et al. 2006).

In some years (e.g. 2005) hazelnuts are very scarce and common dormice also occur in sites without hazel. Therefore we also searched the edge vegetation of these forests for common dormouse nests to improve the chance of finding signs of their presence. In The Netherlands this is considered to be the most successful method (Foppen et al. 2002). Nests which were found that were doubtful cases were shown to Dutch specialists (Ruud Foppen, Ludy Verheggen, and Annemarie van Diepenbeek) for confirmation. Various nest features were noted (e.g. size, composition) according to Foppen et al. (2002) on the, for our purpose slightly adapted, Dutch census forms (Verheggen 2002). To provide a rough indication of where the animals are more likely to be found and thus probably most abundant, we included information on the length of the searched transect and the search effort, i.e. number of person-hours spent searching. In interpreting these data it should be remembered that nest searchers can only search certain types of habitat and will not locate nests in hollow trees or up in high bird nests. The method will thus underestimate the abundance and distribution of common dormice. It should also be noted that large search efforts are overrated since people search less thoroughly when they are in large groups, as opposed to small ones and that less suitable forests take less search time per km.

Since our goal was to map the distribution and not to monitor for several years, the surveys were not standardised. All seemingly suitable (in 2005 classified as marginal and optimal) habitat patches were searched as thoroughly as possible for nests. Searches for gnawed hazelnuts were made under the hazel trees passed on our route.

The search period was September-November, except for a few searches for hazelnuts in March-April 2006 and the censuses were carried out by volunteers of the Flemish Mammal Working Group.

All data (details and locations of historical and recent observations, study sites, covered transects, habitat quality , possible protection

Table 1. Common dormouse habitat classification according to Foppen & Nieuwenhuizen (1997).

Habitat type	Habitat class	Structure of brambles (or alternative shrubs[4])		Height of brambles (or alternative shrubs[4])		Transition zone between open land and forest
edges (of forests, open plots, forest paths and clearings) and small landscape elements (e.g. hedges, hedgerows, sunken roads)[1]	optimal	cover ≥ 50 % and width ≥ 100 cm	and	≥ 100 cm	and	clearly present, convex
	marginal	cover < 50 % and width ≥ 100 cm	or	< 100 cm	or	indistinct, concave
	unsuitable[3]	cover < 25 %	or	< 30 cm	or	indistinct, concave
forest plots and clearings[2]	optimal	cover ≥ 50 %	and	≥ 100 cm		
	marginal	cover < 50 %	or	< 100 cm		
	unsuitable[3]	cover < 25 %	or	< 30 cm		

[1] present over a length of at least 10 m
[2] present over an area of at least 10 are
[3] habitats that fall both into the marginal and unsuitable habitat class (e.g. cover 20 % and height 80 %) are classified as unsuitable
[4] dense berry- or fruit-bearing shrubs, e.g. old man's beard (*Clematis vitalba*), bracken (*Pteridium aquilinum*), hawthorn (*Crataegus monogyna*), blackthorn (*Prunus spinosa*), dog-rose (*Rosa canina*), broom (*Cytisus scoparius*)

Occupied common dormouse nest. *Photograph*: *Dominique Verbelen.*

measures, etc.) gathered during our research are stored in the Mammal Database (Access 2003), that is linked to a number of GIS-maps (ArcView 3.2)

Results

Historical data

Table 2 and figure 1 give an overview of the historical common dormouse data that remained after verification. This shows that the very limited historical data for the Flemish Province of Limburg is restricted to three main regions: Hasselt, Tongeren and Voeren. It is not known whether or not common dormice have been present in other Limburg regions in the past.

Habitat classi.cation
Since this was our first experience with assessing the suitability of habitat patches for common dormouse and as we did not use very detailed maps to indicate our findings in the field, the classification and indication of the size and length of habitat patches was quite coarse. Therefore the habitat maps were only useful to indicate the locations where nest searches should be carried out, not to calculate the exact amount of suitable habitat. Nevertheless, we can say that the amount of suitable habitat seems very small.

Present common dormouse distribution
Common dormouse presence was only confirmed for the region of Voeren (table 2, figure 1). Here we found signs in five neighbouring forests (Broekbos, Konenbos, and the three forest clusters: those of Teuvenerberg, Gulpdal, and Obsinnich, of Veursbos, Roodbos, and Vossenaerde and of Vrouwenbos, Stroevenbos, and Sint-Gillisbos). All of these forests are at least partly forest reserves. No signs were found in any

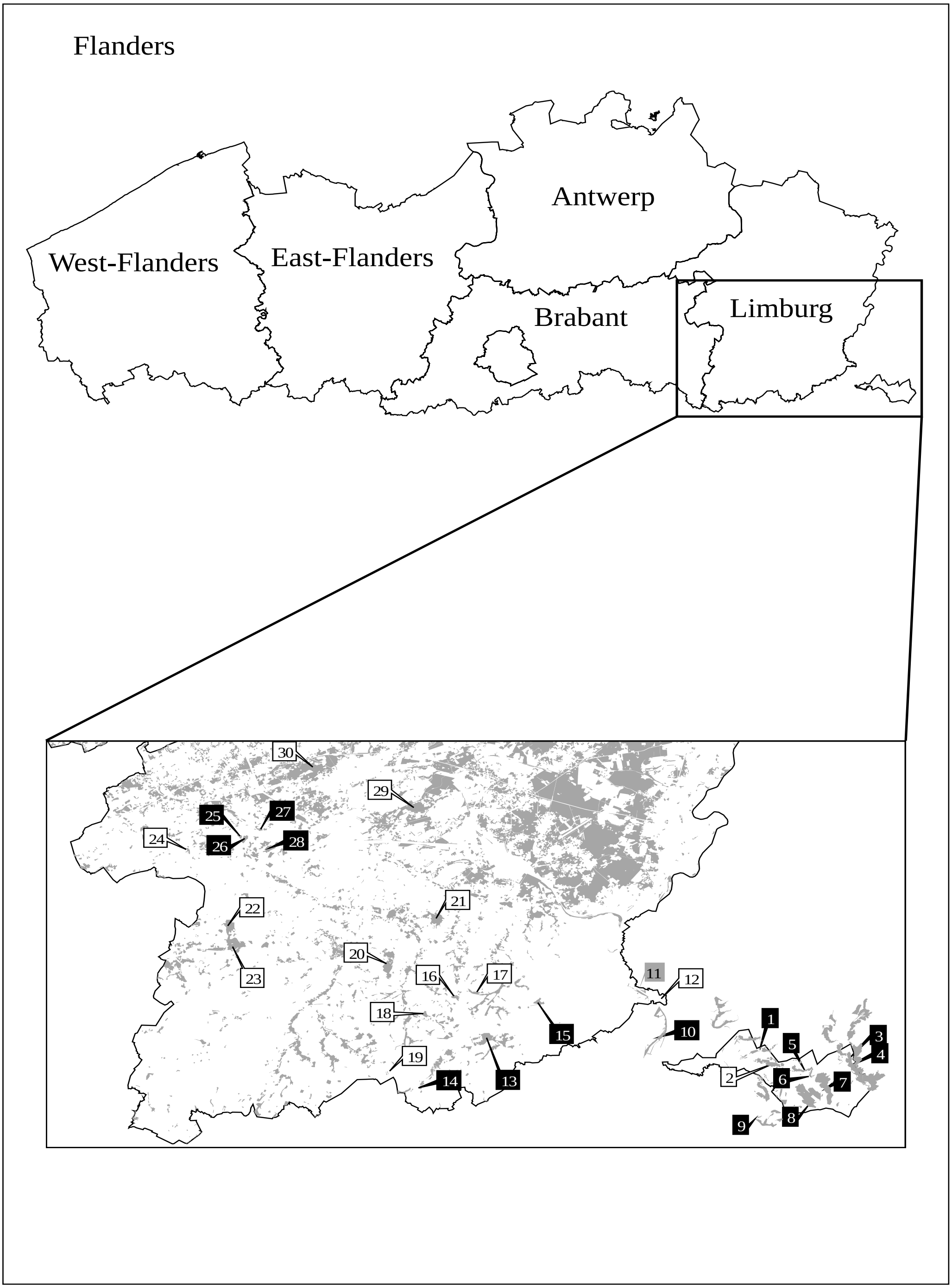

Figure 1. Locations of the historical common dormouse data and the study sites in 2003-05 in the Flemish Province of Limburg and neighbouring Walloon forests. White squares = patches without signs of common dormice during the censuses, grey squares = patches with possible signs, black squares = locations where historical and/or recent signs were found. Forests are shown as grey patches. Numbers correspond with table 2.

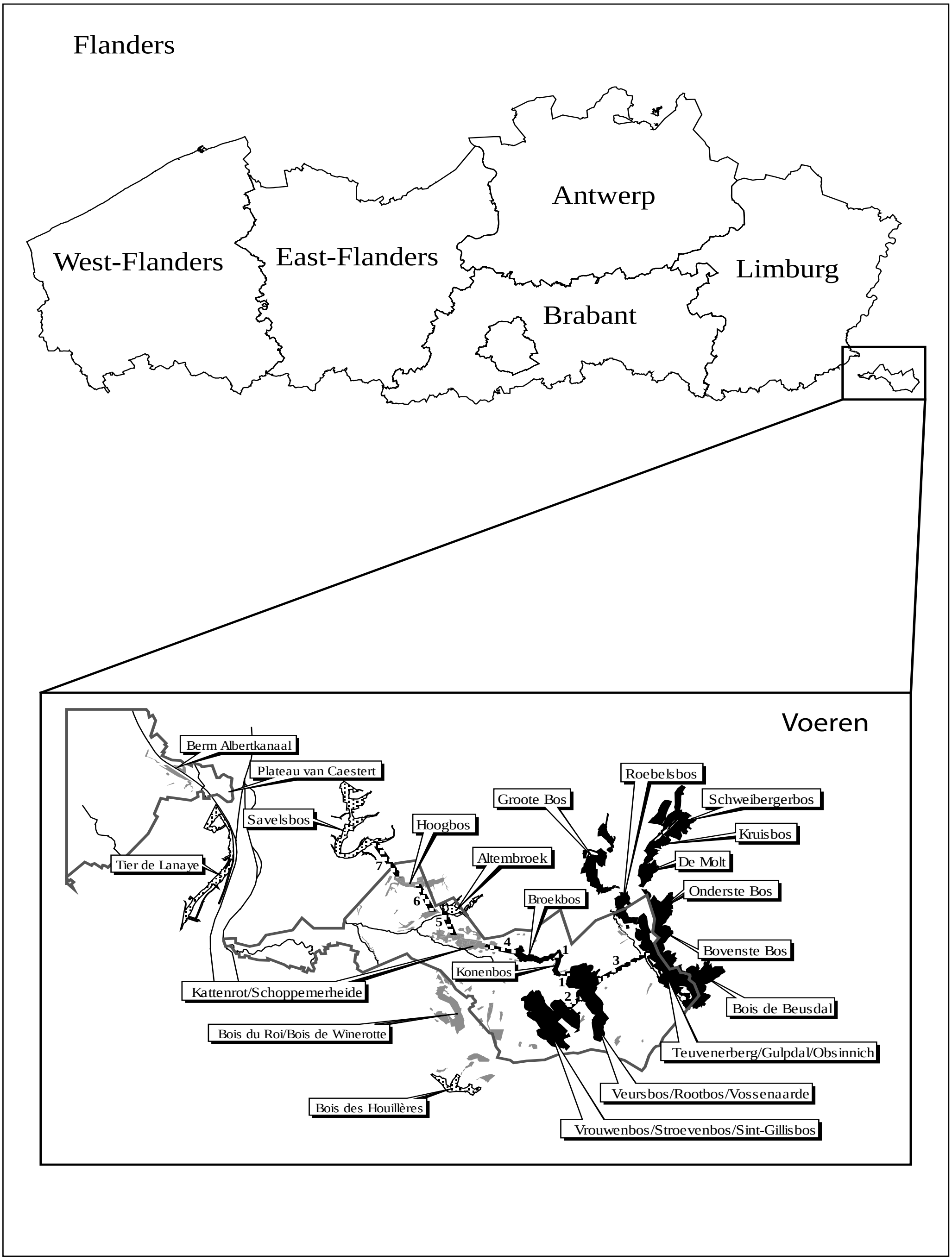

Figure 2. Preliminary vision for the development of a common dormouse metapopulation in the region of Voeren, with priorities (1 to 7) for the corridors (black dotted lines) to be constructed. Black patch = currently occupied forest, dotted black patch = potentially occupied forest with historical observations (Savelsbos = unoccupied), grey patch = potentially occupied forest without historical observations, black line = river. Dutch occupation data are based on Verheggen (2003).

Table 2. Sites with reliable historical common dormouse data ("history", for more details see the Mammal Database of the Natuurpunt Mammal Working Group Flanders, Verkem et al. 2003) and study sites searched for common dormouse signs in 2003-05 in the Flemish Province of Limburg and neighbouring Walloon forests. Per year and study site the number of nests (N), possible nests (N?) and sightings of common dormice (S), and the presence of eaten hazelnuts (H) is given. Between square brackets the length of the searched transect (km) and the search effort (number of people x minutes spent searching / 100) is given (? = unknown). Non-overlapping transects are given on the same line, partially overlapping transects searched on different dates are given on separate lines. The numbers correspond with the locations in figure 1.

n°	Location	Municipality	History	2003	2004	2005
1	Altembroek	Voeren	middle nineties[1]			0 [3.24;3.6]
2	Kattenrot/ Schoppemerheide	Voeren				0 [1.04;2.4]
3	Teuvenerberg/ Gulpdal/Obsinnich	Voeren		10-15 N + 2 S [?;±60]	7N+4 S + H [2.34;48.0] 5 N + 6 S [?;?]	3 N [2.31;5.5] 6 N + 1 N? + 1 S [7.73;47.4] H [0.81;2.1]
4	Sinnich (castle attic)	Voeren	1973[2]			
5	Broekbos	Voeren				1 N [1.66;1.5] H [0.17;4.2]
6	Konenbos	Voeren				2 N + 1 S [2.23;1.5] 1 N + 1 S [0.64;1.2]
7	Veursbos/Roodbos/ Vossenaerde	Voeren	before 1971[3], 1992[4]			2 N + H [7.13;5.3]
8	Vrouwenbos/ Stroevenbos/ Sint-Gillisbos	Voeren	1995[5]			1 N [11.66;13.0]
9	Bois des Houillères	Warsage (Wallony)	before 1971[3]			
10	Tier de Lanaye	Lanaye (Wallony)			1 N + 2 N? + H [0.91;39.6]	0 [6.54;3.6]
11	Berm Albertkanaal	Riemst			2 N? [0.66;±12]	0 [1.68;12.6]
12	Plateau van Caestert	Riemst			0 [0.34;±7] 0 [3.41;?]	0 [5.74;6.9]
13	De Kevie	Tongeren	2001[6]		0 [4.06;±25]	0 [?;?]
14	Lauw (church)	Tongeren	1998[7]			
15	Grootbos	Tongeren	1970-76[8]			0 [4.83;9.0]
16	Hasselbos	Tongeren				0 [2.51;1.2]

n°	Location	Municipality	History	2003	2004	2005
17	Wijngaardbossen	Tongeren				0 [2.54;1.2]
18	Kolmontbos	Tongeren			0 [2.42;?]	0 [3.18;2.8]
19	Mergelgroeve Vechmaal	Heers			0 [3.25;25.2]	
20	Belle-Vuebos	Kortessem/ Borgloon			0 [3.27;?]	0 [8.01;4.6]
21	Jongenbos	Kortessem/ Diepenbeek				0 [6.18;4.5]
22	Mielenbos/ Mierhoopbos	Sint-Truiden				0 [?;1.1]
23	Provinciaal Domein Nieuwenhoven	Sint-Truiden			0 [6.93;?]	0 [3.75;0.9]
24	Harlaz-Olmenhof	Herk-de-Stad				0 [2.37;1.8]
25	Wijerstraat	Hasselt	1984-91[10,11]			0 [0.61;0.6]
26	Bundersbos	Hasselt	1985[10,11]			0 [2.07;0.8]
27	Holrakkerbos	Hasselt	2001[11]			
28	Herkenrodebos	Hasselt	1972-90[9,10,11,12]		0 [2.13;?] 0 [3.06;14.4]	0 [5.78;2.9]
29	Koebos/Arboretum Bokrijk	Genk				0 [?;1.8]
30	Vogelzangbos	Heusden-Zolder				0 [?;1.8]

[1] pers. comm. Norbert Huys
[2] Van Winckel 1973
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[7] Mammal Working Group
[8] pers. comm. Eugène Stassen
[9] Evers 1972
[10] Lefevre 1991
[11] pers. comm. Alex Lefevre
[12] pers. comm. Rik Jacobs

other searched forests in the Flemish Province of Limburg, except for two possible nests in Riemst in 2004. Just across the linguistic frontier, in Tier de Lanaye (Wallony), we also found some signs of common dormice presence in 2004, but not in 2005.

Population densities seem very low, since in 2005 in total only 16 (+ 1 possible) different nests were found. In 2004 adult as well as sub-adult individuals were observed. In 2005 only adult individuals were seen, but the size of several nests (1 nest of 12 cm diameter each in Konenbos, Teuvenerberg, and Veursbos) indicates that reproduction did take place.

Discussion

The common dormouse: a very rare and threatened species in Flanders

All forests with historical data and some neighbouring forests in the Flemish Province of Limburg were searched at least once in the period 2003-05, except for the Holrakkerbos, which is on the census list for 2006. These censuses show that the common dormouse is still present in at least five forests in the region of Voeren, but may have disappeared from the regions of Hasselt and Tongeren. To be more certain of this, we will continue our search in these last two regions for several more years.

Censuses in a number of potentially suitable forests outside these three regions did not reveal any common dormouse observations. Therefore future censuses will be limited to forests with historical data and within a certain distance of these. Firstly, forests within 250 m of the forests with historical presence of common dormice will be inventoried, since this is a feasible dispersal distance. After this, suitable forests within 1500 m of historical populations will be checked for presence, since this is the maximal dispersal distance reported in the literature (Bright et al. 1994). In the region of Voeren we started limited monitoring in 2006 of the forests with a known presence of common dormouse presence.

In 2005 we also conducted in a comparable census in 27 forests in the Province of Flemish Brabant, in collaboration with the Flemish Brabant Union for Nature Study (BRAKONA), the Provincial Government and the Dijleland Nature Study Group (Verbelen et al. 2006). Unfortunately no more common dormouse signs in this province were found, but this search will continue for the next few years.

The causes of the decline are probably to be found in habitat fragmentation and a strong decrease in the amount of suitable habitat, e.g. after the cessation of coppice management, which has led to a more closed canopy and the disappearance of most of the understorey. Additionally, current land use patterns reduce smooth, species rich transitions between forests and open lands, giving rise to very sharp transitions.

Towards a conservation management plan

Although the common dormouse presence in the region of Voeren is more widespread than we first suspected, it is still very limited. A Population Viability Analysis (PVA) should be performed shortly, to provide more insight into possible conservation measures, as has already been done in the Netherlands (Foppen & Nieuwenhuizen 1997). Here a model (LARCH) based on variables that quantify habitat quality, size, and isolation was used to show which networks are presently and potentially sustainable. To properly perform a PVA, we feel that a more complete mapping of the common dormouse distribution, a detailed map of the locations and quality of small landscape elements and a more refined habitat quality map are required. These should also include data from adjacent regions in neighbouring countries. The habitat quality maps could be obtained using printed aerial photographs to indicate the exact location of habitat patches in the field.

We will, however, not wait until the distribution is completely mapped, since it might then be too late to save the last Flemish common dormice. Due to the very limited presence of optimal habitat patches we can be fairly certain that,

Corridor with gaps connecting Konenbos and Veursbos/Roodbos/Vossenaarde. *Photograph: Dominique Verbelen.*

at present there is no sustainable network for the common dormouse in the region of Voeren. In addition the very low density of nests in Flanders (only a few) in comparison with The Netherlands (several dozen over the same edge length, Foppen et al. 2002) indicates that conserving and improving habitat quality in the surroundings of currently occupied habitat patches is of utmost urgency for the short-term survival of the common dormouse in Flanders. For this reason drawing on expert judgement, we have proposed a preliminary habitat management plan to create a more viable common dormouse metapopulation by improving habitat quality and connectivity in the region of Voeren, taking Dutch and Walloon neighbouring forests into account. Using this plan, some measures can be taken immediately.

The study site of Teuvenerberg-Gulpdal-Obsinnich is connected to the Dutch common dormouse population, which is potentially – and possibly even presently – sustainable (Foppen & Nieuwenhuizen 1997). Two other study sites, Vrouwenbos-Stroevenbos-Sint-Gillisbos (212 ha) and Veursbos-Roodbos-Vossenaerde (172 ha), are large forests that may be potentially sustainable. In these three study sites improving habitat connectivity is less urgent and the focus should be on improving habitat quality. Since 20 ha of well-developed forest is regarded as the minimum area for a viable population (Bright et al. 2006), the two smallest study sites Broekbos (36 ha) and Konenbos (10 ha) cannot be regarded as potentially sustainable. In these forests, improving habitat quality should be supplemented by connecting these forests to each other and to the nearest large forest Veursbos/Roodbos/Vossenaerde (corridor 1 in figure 2).

Within these study sites, three activities can contribute to improving the sustainability of the population. Improving habitat quality is most urgent for the presently occupied habitat patches. Secondly, the quality of, and connectivity to, potential habitat patches within 250 m of recent observations should be improved, as 250 m is a feasible dispersal distance for common dormice (Foppen & Nieuwenhuizen 1997, Verheggen 1997). Thirdly, the same should be done for potential habitat patches further than 250 m from recent observations. At most locations, an improvement of habitat quality implies improvement of the quality of edges and wood rows. Well-developed forest edges with a gradual transition zone and a high fruit-bearing shrub density can be created by measures such as cutting trees, setting back fences and adapting cattle grazing intensity. These management options had a positive impact on common dormouse populations in the Netherlands (Foppen et al. 2002). Verbeylen & Verbelen (2006) have provided detailed maps with concrete measures to improve habitat quality in the five Flemish study sites occupied by common dormouse, based on detailed management options described by Verheggen (1997) and Bright et al. (2006).

To extend this network and make it more robust, more connections can be made: corridor 2 (feasible due to short distance), corridor 3 (less feasible due to long distance, it would require stepping stones), and corridors 4 to 7 (priorities may change in future if common dormice are found in Kattenrot/Schoppemerheide, Altembroek or Hoogbos) (figure 2). The network could even be extended to Walloon forests, such as the Bois du Roi, Bois de Winerotte, and Bois des Houillères. Connection to Tier de Lanaye is probably not feasible due to too many, and too large, barriers (River Maas, Albert-Channel, A2 Motorway).

The forest reserves and neighbouring properties in the region of Voeren will play a key role in the survival of the common dormouse in Flanders. Since the forest reserves are managed by the Flemish government, which has European obligations to protect this Habitats Directive species, implementation of the most urgent protection measures should be feasible in the short term.

Acknowledgements: This research would not have been possible without the dedication of the volunteers of the Natuurpunt Mammal Working Group Flanders. We also want to thank our Dutch colleagues for their advice, the Forestry and Nature Department of the Flemish Government and the forest owners for the permission to carry out the censuses. We would also like to thank LIKONA, the Provincial Government of Limburg, and the Forest Ecology and Treatment Team of INBO for their financial and logistical support.

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Samenvatting

Status en bescherming van de hazelmuis *(Muscardinus avellanarius)* in de provincie Limburg (Vlaanderen, België)

De hazelmuis (*Muscardinus avellanarius*) is een soort die in Vlaanderen beschermd en vermoedelijk sterk bedreigd is. Omdat haar status in Vlaanderen onvoldoende bekend was om geschikte beschermingsmaatregelen voor te stellen en uit te voeren, startte de Zoogdierenwerkgroep van Natuurpunt in 2003 een inventarisatie in de Vlaamse provincie Limburg. Historische gegevens werden ingezameld en geverifieerd en een groot aantal bossen werd geïnventariseerd, door te zoeken naar hazelmuisnesten en aangeknaagde hazelnoten. In één bos werden nestkasten en nestbuizen opgehangen. De gegevens wijzen erop dat het huidige verspreidingsgebied beperkt is tot de Voerstreek. Hier werden hazelmuissporen gevonden in vijf bossen, die allemaal op zijn minst gedeeltelijk aangewezen zijn als bosreservaat. In de andere twee Limburgse regio's met historische waarnemingen, Hasselt en Tongeren, werd geen spoor van hazelmuizen gevonden. Aangezien de Vlaamse hazelmuispopulatie sterk bedreigd lijkt, wordt niet gewacht met aanbevelingen voor beschermingsmaatregelen, tot het verspreidingsgebied volledig in kaart gebracht is en een leefbaarheidanalyse uitgevoerd is. Op basis van recente verspreidingsgegevens worden concrete beschermingsmaatregelen geadviseerd om de habitatkwaliteit en -connectiviteit te verbeteren. Deze maatregelen betreffen voornamelijk het verbeteren van de kwaliteit van randvegetaties en houtkanten. Goed ontwikkelde bosranden met een graduele overgangszone en een hoge dichtheid aan vruchtdragende heesters kunnen gecreëerd worden door maatregelen als het kappen van bomen, terugzetten van omheiningen en aanpassen van de begrazingsintensiteit. Daarnaast wordt ook het aanleggen van verbindingen tussen bezette habitatplekken en tussen bezette bossen via goed ontwikkelde corridors geadviseerd. Een voorlopig beheerplan voor de ontwikkeling van een hazelmuismetapopulatie in de Voerstreek wordt voorgesteld.

Received: 31 May 2006
Accepted: 17 July 2006

– HAZELMUIS –

Survival and weight changes of hedgehogs (*Erinaceus europaeus*) translocated from the Hebrides to Mainland Scotland

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Abstract: Hedgehogs (*Erinaceus europaeus*) are being killed on the Uists, in the Outer Hebrides, Scotland, in an attempt to improve the breeding success of ground nesting birds. Translocation of hedgehogs was considered as an option, but dismissed on welfare grounds. The principal concern was that translocated animals would starve. The present study set out to test this hypothesis. Twenty hedgehogs from the Uists were released on the Scottish mainland at Eglinton Country Park, Irvine and radio tracked for a month to ascertain whether or not the animals were going to starve in their new environment. Seven of the twenty radio tracked hedgehogs showed significant weight gains, five maintained their weight, and three lost weight. Two of the hedgehogs that lost weight died during the study. There were three early deaths from predation and drowning, one from a pre-existing tumour. If these deaths and the individual that vanished on the first night are removed from the analysis the results indicate an 80% survival rate one month after translocation. If all early deaths by predation and drowning are attributed to the unfamiliarity of the translocated hedgehogs with the terrain, the survival rate is 67% one month after translocation. The data also indicate that there is an advantage for females to weigh at least 550 g on release. Although conclusions should be drawn with care due to the limited sample size, study period and research approach our study suggests that concerns over the welfare of translocated hedgehogs are not well-founded, thus questioning the principal objection to such an undertaking.

Keywords: hedgehogs, radio-tracking, translocation, cull, Uists, wildlife management.

Introduction

Hedgehogs (*Erinaceus europaeus*) are being killed on the Uists, in the Outer Hebrides, Scotland, in an attempt to improve the breeding success of ground nesting birds. The Uists support an internationally important bird fauna, with at least 17,000 pairs of nesting waders, including about 25% of the total UK breeding population of dunlin (*Calidris alpina*) and ringed plover (*Charadrius hiaticula*) (Fuller et al. 1986).

A study by Jackson & Green (2000) suggested that nesting success had significantly declined during the 1980s and 1990s, following introduction of hedgehogs to South Uist in 1974. Although other predators were also present, notably an introduced population of American mink (*Mustela vison*), hedgehogs were implicated in significant levels of nest predation. Experimental removal of hedgehogs resulted in improved nesting success (Jackson 2001) and several possible courses of action were considered (Uist Wader Project 2002). Scottish Natural Heritage (SNH) is ultimately responsible for wildlife conservation on the islands and decided to attempt the eradication of the hedgehog population by capture and humane destruction. In four successive years (2003-2006), SNH has conducted hedgehog removals, with the animals being humanely killed by lethal injection after being found by employees, walking through the fields at night equipped with powerful torches. A six-week capture 'window' in April and May was used; any earlier and most animals would be still hibernating and later might entail deaths of lactating females and consequent starvation of their young. In the four years of operation SNH have killed 658 hedgehogs.

The decision for such culling was opposed by

"Uist Hedgehog Rescue" (UHR), a consortium of NGOs comprising of the British Hedgehog Preservation Society, Advocates for Animals, Hessilhead Wildlife Rescue Trust and International Animal Rescue. While accepting that hedgehogs were a problem and should be removed, UHR argued that they should not be killed, but be captured and taken to the mainland to be released alive.

The decision to kill the hedgehogs, as opposed to translocating them, was taken partly because of a fear that translocated hedgehogs might suffer in some way. SNH stated that moving animals to the mainland would be cruel as it will cause many slow and lingering deaths due to starvation, injury or illness (Uist Wader Project 2002; G. Anderson, personal communication). These assumptions, however, run counter to the results of recent studies of translocated hedgehogs, which show substantial survival rates among animals that have spent long periods in captivity (Morris et al. 1993, Morris 1998, Reeve 1998). Even juveniles with no experience of independent life in the wild can cope well with release in unfamiliar sites (Morris & Warwick 1994, Morris 1997). Several animals removed from the Uists in previous years that were marked and released on the mainland are known to have survived at least until the following year (A. Christie, Hessilhead Wildlife Rescue Trust, personal communication).

Our objective is to test the claim that translocated hedgehogs might suffer unacceptably and die as a result of translocation. The study can be best described as a pilot-study in which we follow up what happened to a sample of animals translocated from the Uists to the mainland in April 2005. Hence this was not a classic experiment with controls, but an investigation into what would happen to the animals if released following the protocols envisaged by the parties that are in favour of translocating instead of culling the Uist hedgehogs.

During the health check, conducted on the hedgehogs while unconscious, the state of their teeth was checked. *Photograph: Hugh Warwick.*

Methods

Hedgehog translocation

Twenty female hedgehogs were used for this study. They had been found on the Uists between 1st and 23rd April 2005 and were likely to be only recently out of hibernation. UHR volunteers and local members of the public, principally on South Uist, obtained the animals. UHR provided a briefing to everyone collecting hedgehogs for translocation before accepting them into the 'bounty scheme', in which £20 was paid for each hedgehog found and delivered to a reception centre in a healthy state. The hedgehogs were then transported to the mainland and held at Hessilhead Wildlife Rescue Trust until the start of the study. The staff at Hessilhead release 200-300 hedgehogs back into the wild, each year, excluding >700 translocated Uist hedgehogs in the years 2002-2005 that also passed through the hospital (A. Christie, personal communication).

Female hedgehogs were used as they are known to travel less far each night (Reeve 1982, Morris 1988), thereby making it possible to monitor a larger sample than if males had been included. Using only a single sex also removed one source of potential variables in the results of the study.

On the evening of the 27th April 2005 the 20 hedgehogs were given a health check under anaesthetic (isoflurane), as advocated by Sainsbury et al. (1996). They were weighed, had their temperatures taken (electronic rectal thermometer), had their teeth checked and were also

Eglinton Country Park, in which the Uists hedgehogs were released. *Photograph: Hugh Warwick.*

searched for signs of injury and ecto-parasites. Un-fit animals would not be released, following the protocol for the proposed translocation programme.

The hedgehogs were left at Hessilhead for a night to recover from the anaesthetic. On 28th April the first ten hedgehogs were taken by car, in cardboard pet carrying cases, to the release site at Eglinton Country Park (OS Grid Reference 232120,642280). This 400 hectare site was chosen after the recommendation of staff at Hessilhead and a reconnaissance trip carried out in April 2005 that revealed it to be a varied and suitable habitat. The second batch of ten was released on the 30th April. The principal reason for staggering the release was to assist the radio-trackers to become familiar with the site. The animals were released at two sites within the park. One was at the base of a hill in an area of mown grass rides and 20+ year-old mixed woodland. The second location was in a pasture about 400 metres away, to the north and beyond a small river. Half of the animals from each batch were released at each site.

Radio-tracking and sampling

While the hedgehogs were unconscious for the health check a radio transmitter ('Biotrack', Wareham, Dorset, weight 10 g) was attached. A small group of spines on the back of the hedgehog were clipped to create a flat bed, on to which the transmitter was glued using epoxy resin applied to the front and sides of the transmitter. The glue did not touch the animal's skin, the points of attachment being the uncut spines surrounding the transmitter. The transmitter's unique radio frequency became the animal's identity number used in this paper.

The radio-transmitters were applied to the hedgehogs while they were still unconscious, following their health check. They were kept warm on heating pads and held firmly as they awoke to allow the glue to set. *Photograph: Hugh Warwick.*

The hedgehogs were monitored every day and night for four weeks. The intention was to capture and weigh the animals nightly and to locate their daytime resting places. In practice, it was not always possible to find all the hedgehogs every night. In part this was due to the speed and radial nature of their dispersal, but sometimes animals were temporarily unrecoverable from thick shrubbery. The other main cause of incomplete data was hedgehogs being active among livestock that the researcher had been asked not to disturb.

The radio-tracking was carried out using a TRX-1000S receiver (Wildlife Materials Inc, Illinois, USA) and a Folding 3-Element Yagi Directional Antenna. Daytime resting sites were identified, mainly to assist the evening work, as they indicated whether the hedgehogs had moved substantial distances since the last time they were located. At night the position of each hedgehog was noted and its position recorded as six-digit coordinates taken from a 1:10,000 OS map. Each animal was weighed at each capture using a 'Pesola' spring balance (weighing to 1000 g, with 10 g divisions), giving an indication of general body condition and confirming that the animals were or were not maintaining their weight by successful feeding. Body mass was taken to be the clearest indication of general health and the ability to thrive. If the animals were failing to thrive in their new environment this would either reduce the amount they ate, or they would cease to feed. Either way their body weight would decline.

Hedgehog 234, found with head bitten off on the day after release. Probably killed by a dog as it was found in an area frequented by dog-walkers. *Photograph: Hugh Warwick*.

After four weeks the radio-transmitters were removed from the hedgehogs after their final weight had been taken. The transmitters were removed using sharp-nosed wire cutters to sever the spines attached to the device.

Any indigenous hedgehogs found were also weighed and given an individually recognizable identification mark with spots of paint on the spines. All observed interactions between indigenous hedgehogs and translocated females were documented.

Analysis

The three hedgehogs that all died within a week of release (234, 274, 204), and the one that disappeared within 48 hours (337), were excluded from the analysis of trends in weight changes due to insufficient data points. Hedgehog 395, which was known to have died of disease (see below), was also excluded from the analysis. The weights of all the remaining 15 hedgehogs were plotted against time, with their weight at release assigned to day 0 in each case. Simple linear regressions were calculated for each animal using Microsoft Excel. The regression slopes indicate weight gain/loss per day for each individual. The null hypothesis would be that weights neither increased nor decreased with the passage of time (i.e. the slope of the calculated regression line does not differ significantly from zero). This was tested by ANOVA and statistical significance of the observed difference was measured by F values and deemed significant where $F<0.05$.

Results

Weight gain in captivity

Following capture in the Uists, all but one of the hedgehogs showed substantial weight gains in captivity, up to about 50% in two and over 30% in four others (table 1). Mean weight gain was

Table 1. A comparison of the initial weight (at capture) with the actual weight at release, final weight from the field and the fate of the translocated hedgehogs.

Animal	Date of capture	Capture weight (g)	Release weight (g)	% weight change in captivity	Last weight in field (g)	% weight change in field	Fate
204	18-Apr	470	606	29			Drowned on day 5.
213	23-Apr	458	542	18	510	-6	Returned to rescue centre on day 26; died on day 27. Cause of death: diarrhoea.
234	15-Apr	520	684	32			Killed by predation on day 1.
243	17-Apr	450	570	27	630	11	Survived.
253	04-Apr	535	656	23	850	30	Survived.
267	20-Apr	510	564	11	630	24	Survived.
274	06-Apr	355	539	52			Killed by predation on day 4.
284	23-Apr	550	599	9	630	5	Survived.
295	13-Apr	405	529	31	590	12	Survived.
305	24-Apr	510	535	5	380	-29	Returned to rescue centre on day 13; died on day 14. Cause of death: unknown.
314	18-Apr	475	576	21	710	23	Survived.
326	01-Apr	620	610	-2	750	23	Survived.
337	16-Apr	735	802	9			Vanished.
344	18-Apr	515	616	20	850	38	Survived.
355	18-Apr	480	563	17	630	17	Survived.
363	11-Apr	465	560	20	510	-9	Returned to rescue centre on day 10 with ticks; then re-released on day 21.
374	18-Apr	425	634	49	690	9	Survived.
385	11-Apr	365	497	36	430	-13	Survived.
395	15-Apr	550	647	18	490	-24	Died on day 15, tumour on bladder.
404	10-Apr	540	722	34	820	14	Survived.

23%. The weight loss of the one animal that lost weight (no. 326) was 1.6%, well within normal daily fluctuations for an animal this size.

Survival after translocation

Hedgehog 337 was released, but no trace of it was ever found again due to either radio transmitter failure or very rapid dispersal. Six of the released hedgehogs died in or soon after the study period. Hedgehogs 234 and 274 were found dead one and five days after release respectively, with injuries indicating predation by dog or badger (*Meles meles*). Hedgehog 204 drowned in the river six days after release. Hedgehog 395 was found dead on day 15; a post mortem examination showed a distended bladder associated with a large tumour. Hedgehog 305 maintained her weight for a week before starting to lose weight and subsequently dying after return to the wildlife hospital on day 13. Hedgehog 213 was brought

Table 2. Regression analysis of weight gain/loss against time for 15 female hedgehogs tracked for up to 28 days after translocation (in order of daily weight gain). CC = correlation coefficient; **: P<0.01; *: P<0.05; NS: P>0.05.

Hedgehog	Weight gain/loss (g/day)	Number of days sampled	Sampling period (days)	r^2	CC	*P*
344	5.6	17	28	0.79	0.89	**
253	4.4	23	28	0.71	0.82	**
404	3.9	21	28	0.70	0.86	**
326	3.6	20	28	0.58	0.72	**
314	2.9	23	28	0.56	0.75	**
374	2.8	20	28	0.39	0.63	**
355	1.9	23	28	0.25	0.50	*
295	0.5	18	28	0.03	0.17	NS
267	0.4	21	28	0.42	0.09	NS
363	0.3	11	18	0.004	0.07	NS
243	-0.5	28	28	0.014	-0.21	NS
284	-1.2	25	28	0.14	-0.58	NS
213	-2.3	19	25	0.26	-0.51	*
385	-4.0	20	28	0.57	-0.76	**
305	-11.9	10	13	0.75	-0.87	**

back to the wildlife hospital on day 26 and died soon after.

If the three early deaths from predation and drowning, the animal that died from a pre-existing tumour and the individual that vanished on the first night are removed from the analysis the results indicate an 80% survival rate one month after translocation. If all early deaths by predation and drowning are attributed to the unfamiliarity of the translocated hedgehogs with the terrain, the survival rate is 67% one month after translocation.

Weight gain after translocation

Besides the hedgehog that vanished the first night, the data from the hedgehogs that died early from predation, drowning or from the pre-existing tumour on the bladder were incomplete and thus not included in the weight gain analysis. Of the remaining 15 released female hedgehogs eleven gained weight and four lost weight during the study period (table 1). Of the hedgehogs that gained weight one animal (hedgehog 344) was 38% heavier at the end of the study compared to its release weight, and four others gained in weight by at least 20%. Of the animals that lost weight, one animal (hedgehog 305) had lost almost 30% of its body weight, while the others lost 13% or less (table 1).

Based on significant differences in weight gain/loss the animals can be divided into three groups (table 2): (1) Seven animals (hedgehog 344, 253, 404, 326, 314, 374, 355), showed average weight gains of between 1.9 and 5.6 g per day over the 4-week study period. Their weight gains were consistent and statistically significant when tested against the baseline ‘no change in weight’. (2) Five animals (hedgehog 295, 267, 363, 243, 284), showed only small daily increases in weight, or small losses. Their weight changes, however, were not significantly different from staying the same. (3) Three animals (hedgehog 385, 213, 305) showed a statistically significant trend towards weight loss during the study period. For hedgehog 385 and 305 no particular cause of weight loss could be assessed. Hedgehog 213 appears to have lost weight particularly on the last two nights. Until then her body weight had remained relatively constant, fluctuating by only about 5% around the mean. However, she had been frequently active in daylight, often a sign of illness, and she was taken back into captivity on the 25th day, and died there soon after. A post mortem revealed that she had suffered severe diarrhoea.

Figure 1. Weight changes in translocated hedgehogs in relation to initial release weight.

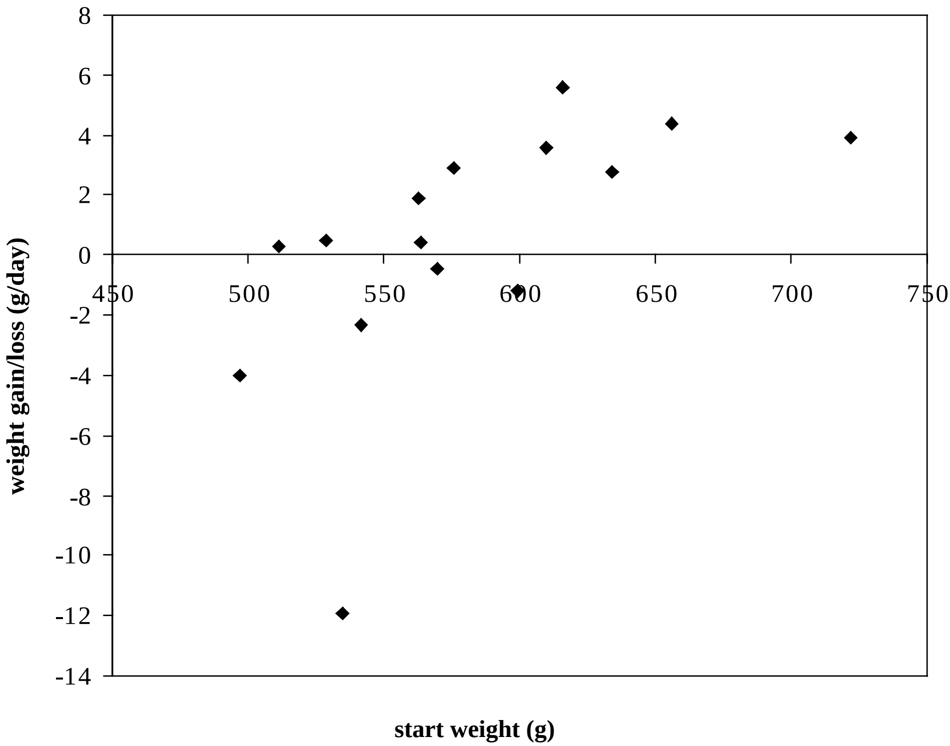

Figure 2. Percentage change in body weight in the field compared with the time spent in captivity prior to release.

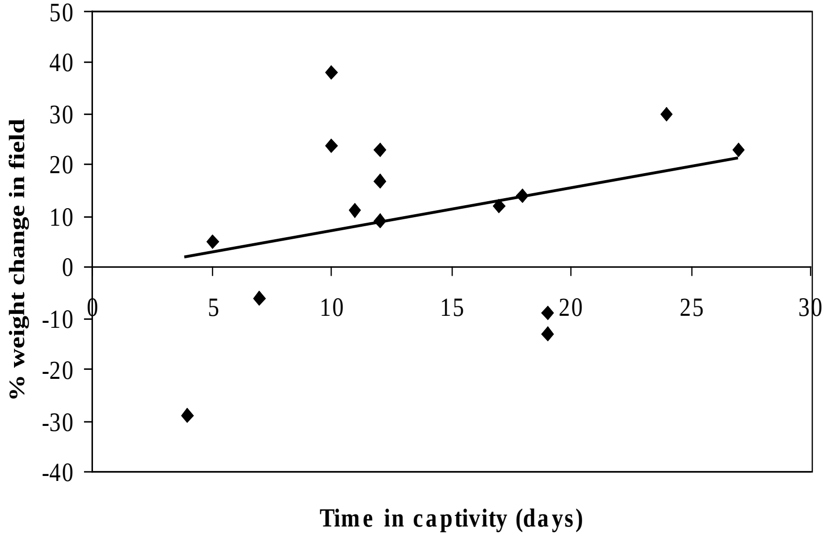

Table 3. Weights (g) of indigenous male hedgehogs caught during the study.

Male	Weight (g) Capture 1	Capture 2	Capture 3	Capture 4	Capture 5	Capture 6	Capture 7	Capture 8
1	830	850	830	790	870	-	-	-
2	900	920	910	-	-	-	-	-
3	760	760	730	-	-	-	-	-
4	730	-	-	-	-	-	-	-
5	870	830	840	840	850	820	820	850
6	960	980	970	-	-	-	-	-
7	810	850	-	-	-	-	-	-
8	870	-	-	-	-	-	-	-
9	810	-	-	-	-	-	-	-

Table 4. Association matrix showing which of the released females were found with each of the indigenous male hedgehogs encountered on the site. Numbers in the grid refer to the number of nights that particular hedgehogs were found together.

Females	Males 1	2	3	4	5	6	7	8	9
204	-	-	-	-	-	-	-	-	-
213	-	-	-	-	-	-	-	-	1
234	-	-	-	-	-	-	-	-	-
243	-	-	-	-	-	-	-	-	-
253	-	-	-	-	-	-	-	-	-
267	-	-	1	-	-	-	-	-	-
274	-	-	-	-	-	-	-	-	-
284	1	-	-	1	-	-	1	-	-
295	-	-	-	-	4	-	-	-	-
305	-	1	-	-	-	-	-	-	-
314	1	-	-	-	-	-	-	-	-
326	-	-	-	-	-	2	-	-	-
337	-	-	-	-	-	-	-	-	-
344	1	-	-	-	-	-	-	-	-
355	-	-	-	-	-	-	1	-	-
363	-	-	2	-	2	1	-	-	-
374	-	-	-	-	1	-	-	-	-
385	1	2	-	-	-	-	-	-	-
395	-	-	-	-	-	-	-	-	-
404	-	-	-	-	-	-	-	-	-

Trends in weight change should also be viewed in relation to normal hedgehog weights at this time of year, when females generally weigh between 400 and 600 g. Several of the Uist animals used in the present study exceeded 600 g because we selected the largest animals available on the assumption that their fat reserves and general body condition were likely to be optimal. In figure 1 initial body weights at the moment of release are plotted against mean change per day during the study. All animals that lost weight were less than 600 g at the time of release. Of these, the three animals that lost most weight (>2 g per day) were less than 550 g at the start. Two others with a release weight of less than 550 g gained weight, but weight gain was less than 0.5 g per day. One of these (hedgehog 363) was temporarily taken back into captivity for ten days after she was found with a severe tick infestation. This might suggest that animals weighing less

Hedgehog 385 by a very busy road. It was disturbed in the day to check that the signal was not coming from a corpse. *Photograph: Hugh Warwick.*

than about 550 g should not be released without a period of fattening up in captivity.

Another contention has been that the amount of time spent in captivity may have an impact on the survival of translocated hedgehogs (Molony et al. 2006). As figure 2 indicates, there was no correlation (correlation coefficient = 0.31) between the amount of time spent in captivity and the percentage weight change in the field for the translocated hedgehogs from the Uists.

Weight gain of indigenous hedgehogs

Nine indigenous male hedgehogs were found during the study. All but one (male 8) discovery of an indigenous male was made in conjunction with a radio-tracked female. No wild female hedgehogs were found during the study. The weights of each male hedgehog (table 3), while not presenting enough data to analyse robustly, do not suggest that the resident male population of hedgehogs was losing weight following the release of 20 females. For animals we captured two times or more (male 1, 2, 3, 5, 6 and 7) the mean change in weight between the first and last measurement was about +8 g.

Interactions with indigenous hedgehogs

The released animals appeared to interact normally with the indigenous male hedgehogs found in the study area during the study period. April is the beginning of the hedgehog breeding season, when pairs may be expected to perform ‘courtship’ rituals (Morris 1983). Eleven of the released females were found consorting with wild males at various times. Hedgehog 295 was found courting with male 5 on four occasions and hedgehog 363 twice with male 3, twice with male 5 and once with male 6. Table 4 shows an association matrix from which it is evident that both males and females were behaving promiscuously, as is normal (Reeve & Morris 1986).

Discussion

The limited resources available precluded a longer study period. However, our data supports the assumption that twenty-eight days is long enough to observe signs of starvation in translocated hedgehogs or other acute responses to the translocation. Observed daily movements and interactions with indigenous hedgehogs also suggest that the length of the study period was sufficient to indicate whether the translocated animals were adapting to life in their new surroundings.

Limited resources did not allow for the monitoring of the indigenous population as a control. Only accidental encounters with indigenous hedgehogs were used to collect data on weight changes in the native population. Therefore we cannot draw conclusions as to the impact of the translocation on the welfare of individuals in the native population beyond that presented by these data. And this was additionally limited by the absence of any data from indigenous females. However, the data that was collected from the native population did not suggest any weight loss.

A sample size of 20 animals was considered to be the maximum number that could be radio-tracked in this pilot-study, given the facilities and equipment available, and given the desire to locate each animal at least once every night. There was also a limit to the number of female hedgehogs that could be captured in the three weeks prior to the start of the study. A larger sample was desirable as it would have generated a more robust study. However, previous experience indicated that, without more trackers and better receivers, there was a high probability that many hedgehogs would soon be lost due to the trackers' inability to keep up with so many animals if they dispersed radially into the surrounding countryside.

In the rescue centre, prior to release, all but one of the animals gained weight substantially (table 1). While weight loss is not specifically an indicator of stress, weight gain is an indicator of low stress. This would suggest that the capture, transportation and confinement prior to release raised no major welfare concerns.

Visiting Eglinton Country Park in early April raised concerns about the danger posed by the busy dual carriageway on the southern boundary to the park. However, during the subsequent study, none of our radio-tracked animals was killed on local roads, despite heavy traffic. The combination of positive factors in the park, including good mixed habitat and hedgehogs having been seen there by park rangers suggested it was a suitable location for release. Species with similar dietary requirements were also present, e.g. moles (*Talpa europaea*) and curlews (*Numenius arquata)*, suggesting that suitable food was available.

Two released animals were lost to predators, one being killed but not eaten, another being consumed totally, apart from the skin. Dog predation on hedgehogs released into suburban parkland has also been reported by Doncaster (1994). Predation by badgers is also possible (and eliminated 25% of released juvenile hedgehogs in a previous study; Morris & Warwick 1994), but badgers had not been seen locally. The remains of two indigenous (i.e. non-Uist) hedgehogs were also found, suggesting that predation was not uncommon here. These cases of predation of translocated hedgehogs may be regarded as accidental losses, not related to the origin of the animals, together with one (hedgehog 204) that drowned. However, a relation with the translocation cannot be completely excluded.

One animal (hedgehog 395) that died during the study period had a tumour, probably already present when the study began, and was thus excluded from the analysis. For two others (hedgehog 213 and 305) it could not be assessed with certainty whether their illness was present before the start of the study. Hence these animals were included in the analysis.

Notwithstanding the losses, this study clearly showed that seven out of the 20 animals increased their body weights significantly, despite the unfamiliar terrain, an indication that their release was successful. A further five managed to sustain their weight. Thus more than half of the animals released failed to fulfil the prediction of SNH that translocation leads to slow and lingering death. Given that criterion, they could be said to have been translocated successfully. The Scottish Society for the Prevention of Cruelty to Animals, who have supported the cull while they remain satisfied that the welfare of the hedgehogs was not greatly compromised, defines a successful translocation as one with 60% survival (M. Flynn, personal communication). If the three accidental losses are removed, along with the one with a pre-existing tumour and the hedgehog that vanished, the sample size reduces to 15. Of these, 80% were successfully translocated from the Uists to the mainland, i.e. with maintaining or increasing their body weight.

It is tempting to try to identify potential 'winners' and 'losers' based on body weights before release. However, as consideration of figure 1 makes clear, a firm distinction is difficult. While it is true that all the animals whose body weight exceeded 600 g at release were survivors, using this weight as the cut off below which animals ought not be released would mean that the majority of hedgehogs at this time of year fell into that category. Most wild hedgehogs weigh substantially less than this in April, and many probably die, but a large proportion must survive. Thus it seems unlikely that a simple body weight measure can be used with confidence to predict survival of translocated hedgehogs, except for the largest animals. However, it does appear that a weight greater than 550 g is advantageous (in females at least).

Conversely, the smaller hedgehogs can be identified as liable to be at risk. The two smallest animals in the present study gave greatest cause for concern. Hedgehog 363 was released weighing 511 g and showed a mean weigh gain of 0.3 g/day but this is including ten days of fattening up in the wildlife hospital. Hedgehog 385 was released weighing 497 g and underwent a steady and statistically significant weight loss during the ensuing three weeks. It may be the case that female hedgehogs weighing less than 500 g in April are not viable. If so, then large numbers must die naturally, as a significant proportion of the population are this size or smaller. In fact, annual mortality among adult hedgehogs is about 30% (Morris 1983), probably concentrated in the early months of the year, so losses among hedgehogs translocated in April must not only be expected, but also accepted as entirely normal.

April must be a challenging time for hedgehogs. Not only is the weather unpredictable, affecting availability of macro invertebrates for food, but this is also the end of the hibernation period. Hedgehogs will have roused from hibernation with their fat reserves depleted. Small animals, especially juveniles from the previous year who entered hibernation weighing perhaps only 450-500 g, will have their reserves practically exhausted; those entering hibernation weighing less than 450 g are unlikely to survive the winter (Morris 1984). Mortality, especially among these yearlings, must be high in natural circumstances. Translocation could add to their problems, but may also alleviate them if the animals are released in better feeding sites. Crucially, releases should not take place in areas where suitable food is naturally scarce (e.g. on acid sandy soils) or during periods of dry weather, especially in habitats liable to dry out quickly (e.g. limestone grassland), restricting food availability.

The policy of killing Uist hedgehogs rather than translocating them to the mainland is based on the principles of density dependent population regulation. In effect this means that the mainland could not support more hedgehogs then it would do so naturally, and any additional animals released into existing populations would result in corresponding mortality as numbers will be readjusted to match the carrying capacity of the habitat. The present study, however, offers no support for this idea. If food resources (for example) were a limiting factor, then none of our animals should have maintained or gained weight, but the majority of them did. Hence the claim that translocation of hedgehogs from problem areas such as the Uists might involve welfare problems is not justified by the present study.

Acknowledgements: We are grateful to Douglas Walker for radio-tracking and data analysis; Andy and Gay Christie and their staff at Hessilhead Wildlife Rescue Trust; the rangers at Eglinton Country Park, many of who came out looking for hedgehogs, and especially George Clarke; Kay Bullen and volunteer helpers on the Uists. We acknowledge support provided by the British Hedgehog Preservation Society, and through them the many hundreds of generous donors who wished to have such a study as this conducted. We are also very grateful to Mary Morris for her assistance with data analysis and to Dr P. Bright (Royal Holloway, University of London) for the loan of equipment.

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Samenvatting

Overleving en veranderingen in lichaamsgewicht van egels (*Erinaceus europaeus*) die zijn overgebracht van de Hebriden naar het vasteland van Schotland

Egels (*Erinaceus europaeus*) worden gedood op de Uist-eilanden in de Hebriden, Schotland, in een poging het broedsucces van grondbroedende vogels te verbeteren. Verplaatsing van de egels is als mogelijkheid overwogen, maar verworpen op basis van aspecten van dierenwelzijn. De belangrijkste zorg was dat de verplaatste dieren zouden verhongeren. Dit onderzoek is gestart om deze hypothese te testen. Twintig egels van de Uist-eilanden zijn losgelaten op het Schotse vasteland in Eglinton Country Park, Irvine, waarna de egels voor de duur van een maand met behulp

van radiotelemetrie zijn gevolgd om te bepalen of de dieren wel of niet verhongeren in hun nieuwe leefomgeving. Zeven van de twintig gezenderde egels laten een significante toename in lichaamsgewicht zien, bij vijf bleef het gewicht min of meer gelijk en drie verloren gewicht. Twee van de egels die gewicht verloren stierven tijdens de studie. Drie egels stierven in een vroeg stadium van het onderzoek door predatie en verdrinking. Eén egel stierf als gevolg van een reeds voor de aanvang van de studie aanwezige tumor. Als deze gestorven egels en het individu dat verdween op de eerste nacht na loslating niet mee worden genomen in de analyse is sprake van 80% overleving één maand na de verplaatsing van de egels. Als alle vroege sterfgevallen als gevolg van predatie en verdrinking worden toegeschreven aan de onbekendheid van de verplaatste egels met het terrein is sprake van 67% overleving één maand na de verplaatsing. De gegevens suggereren dat vrouwelijke egels die meer dan 550 g wegen op het moment van verplaatsing in het voordeel zijn. Hoewel conclusies met enige voorzichtigheid moeten worden getrokken als gevolg van het beperkte aantal gevolgde egels, de relatief korte onderzoeksperiode en de onderzoeksaanpak, suggereert onze studie dat zorgen over het welzijn van verplaatste egels weinig onderbouwd zijn, en er aldus vraagtekens kunnen worden gezet bij het belangrijkste bezwaar om egels van Uist naar het Schotse vasteland te verplaatsen.

Received: 30 December 2005
Accepted: 8 October 2006

Climatic factors affecting a brown hare (*Lepus europaeus*) population

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Abstract: This study focuses on the possible effects of climatic factors and the frequency of flooding on variation in the size of a population of brown hare (*Lepus europaeus*) living on a salt marsh on the Wadden Sea island of Schiermonnikoog, the Netherlands. Between 1995 and 2003 an annual count was made each November in a 600 ha study area covering the eastern part of the island. Hare numbers and the change in hare numbers were correlated with a number of parameters, for rainfall, temperature and flooding. The number of hares negatively correlated with total rainfall and the number of months in which rainfall exceeded 100 mm. The change in hare numbers negatively correlated with the same two factors, as well as total rainfall in the reproductive period, the number of months in the reproductive period in which total rainfall exceeded 100 mm, and the number of days in a year that the sea level was > 200 cm above Normal Amsterdam Level. Temperature had no effect. Density independent factors appear to explain a substantial part of the variation found in hare numbers, but it is hypothesized that this variation is superimposed on a hare population that is also, in principle, regulated by density.

Key words: brown hare, *Lepus europaeus*, counts, population dynamics, climate, flooding, density independent factors.

Introduction

Densities of the brown hare (*Lepus europaeus*) vary enormously throughout its distribution range in Europe. The spring density can be as low as 3 hares/100 ha (e.g. Frylestam 1979, Pegel 1986, Panek & Kamieniarz 1999, Kilias & Ackermann 2001) and as high as 105 hares/100 ha (Pegel 1986). Low densities are generally attributed to present day intensive agricultural practices (little diversity in crops and habitats and intensive mechanisation), while high densities are associated with mild climates, nutrient rich soils and varied vegetation (Pielowski & Pucek 1976, Pegel 1986, Zörner 1996). Discounting long term changes, spring densities within any given area appear to be generally stable, with moderate to fairly large fluctuations around a long term mean. This suggests that hare populations are subject to some form of density dependent regulation and both Pegel (1986) and Frylestam (1979) have found strong evidence for this. Yearly variations, then, can be hypothesized to be primarily related to variations in the effects of density independent factors such as temperature, rainfall and disease.

Autumn density has also been used as an indicator of population size. Many authors have found a positive correlation between autumn density and temperature (Andersen 1952, Bresinski 1976, Spittler 1976, Eiberle 1984, Smith et al. 2005), and a negative one with rain in spring (Andersen 1952, Bresinski 1976, Spittler 1976, Smith et al. 2005). It is well known that rainfall can have a negative effect on juveniles in the early stages of their lives (Zörner 1996, Häcklander et al. 2002). During heavy rain leverets lie exposed to the elements and death by hypothermia poses a serious risk. In some areas, such as on the island of Schiermonnikoog, one of the Dutch Frysian islands in the Wadden Sea and the location of the field work on which this paper is based, strong winds regularly occur. Long wet spells, such as the storms that occur in November, might also increase the mortality rate of adult hares, through increasing the incidence of parasites. In 1995 we inspected 25 hares that were shot during the last permitted hunt and found almost all of them to be carrying at least two types of parasites; most commonly long worms, pseudotuberculosis and coccidiosis (van Wieren, unpublished data). Although many parasites can be found in clinically healthy hares, it is suspected that wet conditions favour their incidence, especially of coccidiosis, increasing mortality rates (Barré et al. 1977, Eiberle 1984, Zörner 1996). The stochastic effects of disease have never been quantified.

In this study we focus on a hare population living on the salt marsh of the island of Schiermonnikoog. Although this population lives in a natural environment with no human influence, and is almost free of predators, autumn densities can vary considerably. We hypothesize that this variation is mainly due to density independent factors. The most important of these is thought to be irregular flooding of the salt marsh during the hares' reproductive period. Such floods are caused by the combined effects of a high tide together with strong (north) westerly winds. We assume that leveret mortality on the salt marsh during the suckling period can be very high when these floods occur, especially when the whole salt marsh is flooded. Our central research question therefore is: to what extent can variations in the incidence of flooding, as well as temperature and rainfall, explain variations in autumn hare densities on this salt marsh.

Study area

The island of Schiermonnikoog is situated ca. 5 km north of the coast of the Netherlands. The study area lies on the eastern part of the island, and consists of about 600 ha of mainly salt marsh, with sand dunes in the north. Mammalian predators are absent, except for a few feral cats. Potential avian predators include marsh harrier (*Circus aeruginosus*) and common buzzard (*Buteo buteo*). Hares were introduced on the island in 1896 and subject to hunting until 1995, when hunting was banned as the study area had become a national park. Average autumn density of hares during the study period (1995-2003) was 80/100 ha.

Material and methods

Hare counts

Between 1995 and 2003, a count of hares was made each November. The counts started about 2-3 hours before low tide. At the onset of the count the observers formed a line across the width of the whole island at the most westerly boundary of the study area and slowly moved eastwards across the island, driving out the hares by making noise (figure 1). Each counter only counted the hares that passed him on the right, crossing the line of counters. On the shores of the Wadden Sea, the North Sea, and the eastern end of the island the hares were counted by experienced counters who counted the hares passing along the outward boundaries of the line. The number of counters varied from 34 to 48 (average 37). At its widest the observed area was 3000 m, giving an average maximum distance between counters of 81 m. The number of counters was not corrected for a number of reasons. Firstly because in the part of the transect where the distance between counters was largest, the density of hares was very low (Kuijper 2004). Secondly because where the number of hares started to increase (Kuijper 2004) the width of the vegetated part of the island was less than 1800 m, decreasing the maximum width to an acceptable maximum of 50 m, which decreased more further to the east. Finally, because on average more than 20 % of hares are counted by only two counters (those going out to the shore and the sand flats at the end of the island). These three reasons are likely to make intra-count variation between counters highly variable and possibly as variable as the inter-count variation between counters.

Environmental data

The Vrije Universiteit, Amsterdam, collects temperature and rainfall data for the island and

Figure 1. A line of counters during a hare count. *Photograph: Sipke E. van Wieren.*

Table 1. Data collected on dependent and independent variables during the study period 1995-2003. Year = November previous year-October that year; Number = total number of hares counted; N(jx-(jx-1)) = change in hare numbers in two successive years jx and (jx-1); mmtot = yearly total rainfall in mm; mmtot(3-10) = total rainfall in the period March-October; mmtot(11-2) = total rainfall in the period November-February; n>100mm = total number of months in which total rainfall exceeded 100 mm; n>100mm(3-10) = total number of months in the period March-October in which total rainfall exceeded 100 mm; Tm(5-9) = average maximum temperature in the period May-October (all temperature measurements in °C); Tm(3-5) = average maximum temperature in the period March-May; Tm(4) = average daily maximum temperature in April; Tm(5) = average daily maximum temperature in May; n>180cm = number of days in year that the sea level equalled or exceeded +180 cm NAP (Normal Amsterdam Level); n>180cm(4-9) = number of days in the period April-September that the water level equalled or exceeded +180 cm NAP; n>200 = number of days in year that the water level equalled or exceeded +200 cm NAP; n>200cm(4-9) = number of days in the period April-September that the water level equalled or exceeded +200 cm NAP.

Year	1996	1997	1998	2000	1999	2001	2002	2003
Number	550	596	445	479	500	379	320	553
N(jx-(jx-1))	250	46	-151	34	21	-121	-59	233
mmtot	509	682	862	725	801	837	974	748
mmtot(3-10)	376	457	683	459	444	613	571	507
mmtot(11-2)	133	225	176	266	357	248	403	273
n>100mm	0	1	3	0	2	2	4	0
n>100mm(3-10)	0	0	3	0	1	2	1	0
Tm(5-9)	17.7	19.8	18.4	19.4	18.7	18.7	19.6	20.7
Tm(3-5)	9.5	11.9	12.7	12.6	13.3	11.1	12.9	13.8
Tm(4)	11.8	10.5	12.1	12.4	13.3	11	12.5	13.8
Tm(5)	12.4	15.9	16.4	15.9	17.6	15.5	16.4	16.4
n>180cm	8	14	17	14	21	8	21	6
n>180cm(4-9)	1	5	2	0	0	3	0	1
n>200cm	4	6	13	7	11	6	10	3
n>200cm(4-9)	0	2	1	0	0	1	0	1

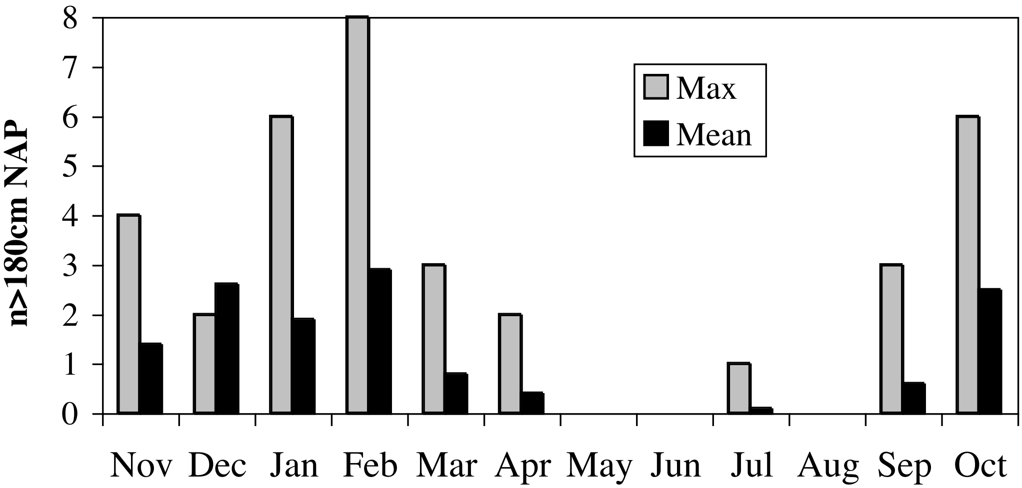

Figure 2. Mean and maximum number of inundations per month of the salt marsh of the island of Schiermonnikoog (1995-2003).

Table 2. Simple correlations (Pearson) between the number of hares counted and the change in hare numbers in two successive years, and a selection of independent variables. * = $P<0.05$, ** = $P<0.01$. For legend see table 1.

	Number	n(jx-(jx-1))
Year	-0.48	-0.11
n(jx-(jx-1))	0.70*	1.00
mmtot	-0.80*	-0.73*
mmtot(3-10)	-0.65	-0.79*
mmtot(11-12)	-0.50	-0.24
n>100mm	-0.77*	-0.78*
n>100mm(3-10)	-0.59	-0.82**
Tm(5-9)	0.13	0.18
Tm(3-5)	-0.14	-0.24
Tm(4)	-0.01	0.33
Tm(5(	-0.24	-0.48
n>180cm	-0.39	-0.54
n>180cm(4-9)	0.33	-0.18
n>200cm	-0.49	-0.75*
n>200cm(4-9)	0.37	-0.14

their database was used in the analysis. Data on sea-levels were provided by the Ministry of Transport, Public Works, and Water Management (www.waterbase.nl) in cm (relative to NAP -Normal Amsterdam Level). The independent variables derived from these databases are given in table 1. When the sea level reaches 180 cm above NAP, most of the salt mash is flooded; at 200 cm above NAP, the whole salt marsh, and the lower parts of the sand dunes, are flooded. These variables are thought to particularly have an effect on juvenile mortality. However, as the timing and length of the reproductive period are not precisely known, there is some degree of arbitrariness in the time specificity of some of the variables chosen (for a list of the variables used and their meaning, see table 1). It is thought that the whole reproductive season runs from March to October, hence the variables mmtot (3-10) and n>100mm (3-10) are used. Most leverets are probably born between April and October (van Wieren, unpublished data), and hence the variables n>180cm(4-9) and n>200cm(4-9) are used to catch major catastrophic events in this period. The Tm variables try to capture the effects of average maximum summer temperatures, Tm(5-9), spring, Tm(3-5), and the months when the growing season on the salt marsh starts: April, early start, Tm(4), and May, late start, Tm(5).

Data analysis

This large number of (partially auto-correlated) variables warrants a cautious approach. First, simple correlations (Pearson) between dependent and independent variables were calculated. Thereafter only those variables, which were significantly, and best correlated in their class (temperature, rainfall, flooding), were used in a stepwise multiple regression analysis. All the variables used in this analysis were normally distributed.

In 1995, 300 hares were counted. This count was held immediately after the last hunting season, a year in which hunting was almost twice as intensive as normal. For this reason this data was excluded from further analysis regarding numbers, but not for the analysis related to changes in numbers, since the production of leverets can be expected to be a significant factor in the net change in numbers from one year to the next.

Results

The number of hares counted in the period 1996-2003 varied from 320 to 596 (table 1), with an average of 429. Fluctuations in numbers were quite large, with 1996 and 2003 standing out as good years and 1998 and 2001 as years with a substantial net decrease in hare numbers. Rainfall, temperature and flooding data for the study period are given in table 1. Total yearly rainfall varied from 509 to 974 mm. In all years the salt marsh was flooded a number of times, with many more inundations in the winter period than in the breeding season (table 1, figure 2), although some inundations did occur in the breeding season, notably in 1997. Correlations between numbers and yearly change in numbers, and the independent variables are given in table 2. Neither the number, nor the change in numbers were correlated with year. The number of hares correlated negatively with total yearly rainfall and the number of months when total rainfall exceeded 100 mm. The change in hare numbers correlated negatively with total rainfall, the number of months in which total rainfall exceeded 100 mm, the total number of months in the reproductive period in which total rainfall exceeded 100 mm, and the number of days in a year when inundations above 200 cm NAP occurred. Regression analysis with variable selection showed that the number of hares was most closely related to total rainfall:

Number = - 0.536 (mmtot) + 888.8 (r^2=0.64, P<0.05)

For a stepwise regression on changes in hare numbers, the total number of months in the reproductive period in which total rainfall exceeded 100 mm and the number of days in a year when inundations above 200 cm NAP occurred were selected. This procedure only selected the rainfall variable in the model:

Change in hare numbers = - 107.5 (n>100mm (3-10)) + 125.7 (r^2=0.67, P<0.05)

Discussion

The autumn density of the hare population on this island (ca. 70 hares/100 ha) is high compared to populations of hares studied on mainland Europe (e.g. Panek & Kamieniarz 1999, Kilias & Ackermann 2001) and is comparable with the population density on two other Wadden Sea islands: Föhr (Pegel 1986) and Ven (Frylestam 1979). These islands share some important characteristics: an absence of main predators, of heavy traffic, and a low levels of human use. On the island of Schiermonnikoog the hares live in a natural environment and are protected from hunting.

The study revealed that density independent factors do seem to influence the population size and density. However, no effect was found for temperature, contrary to a number of authors who have identified a positive correlation between temperature in the reproductive season and autumn density (Andersen 1952, Bresinski 1976, Spittler 1976, Eiberle 1984). Flux (1967) found that cold springs led to females starting their breeding later, producing fewer litters and having fewer young per litter. There was a weak negative correlation of May temperatures on the change in hare numbers (r=-0.48), but this relation was not significant. Possibly, the relative small differences between summer and winter temperatures in this maritime climate may explain the lack of a temperature effect. Rainfall had the most effect on variations in hare numbers. Hare numbers were affected by yearly total rainfall and the number of months with rainfall above 100 mm, but the change in numbers was also negatively related to total rainfall in the reproductive season, as has been found by other authors (see introduction).

All variables related to the flooding of the salt marsh correlated negatively with the change in hare numbers, but this was only significant with regard to the frequency of floods above 200 cm NAP. Contrary to expectations, there was no noticeable effect from spring/summer inundations. Thus, extreme high tides do have an effect and we suspect that these effects might be greater than detected in these calculations. This is because we only have autumn counts and there are no available data to allow a more detailed analysis of the effect of calamities, such as a flood, and because we do not know when the precise peak in reproduction occurs. Although hares can breed throughout most of the year (Zörner 1996), the period March-May is considered the most important for increases in hare populations (Hewson 1964, Pegel 1986). While we have seen juvenile hares as early as February we think that the peak breeding season on the salt marsh will not be before April, as the growing season starts late in this rather cold and wet environment. Various authors have reported the strong effect of short periods of bad weather when the young are being suckled (Martinet & Moret 1971, Tournut 1971, Spittler 1976, Hackländer et al. 2002) and a single flood may have occurred at such a time but gone undetected in this study. Although most inundations of the salt marsh happen outside the breeding season (figure 2), some do occur in that period, although they are infrequent. To demonstrate the potential (joint) effects of a number of variables on the change in hare numbers the two good years, 1995 and 1996, can be compared with the two bad years, 2002 and 2003 (table 1). Higher values for all factors were recorded in the two years which saw the strongest net decrease in hare numbers.

From the above it is clear that rainfall and flooding do affect the hare population on the island of Schiermonnikoog. It is likely that the irregular strong winds, and parasites, both of which occur in conjunction with wet periods, are additional factors which contribute to the wide variations in hare density. The operation of these density independent factors, appear to act as primary controls on the population, before it reaches limits set by the availability of food. A preliminary study estimated that there is enough food in the study area in early spring for about 1500 hares (van Wieren, unpublished data). As most hare populations in Europe seem to be regulated by density dependent factors (cf. Frylestam 1979, Pegel 1989), we conclude that this island population can persist under high levels of stochasticity.

Acknowledgements: We would like to thank all the people who voluntarily helped with the hare counts during the study period. We thank the WBE Schiermonnikoog for their enthausiasm and support with the counts.

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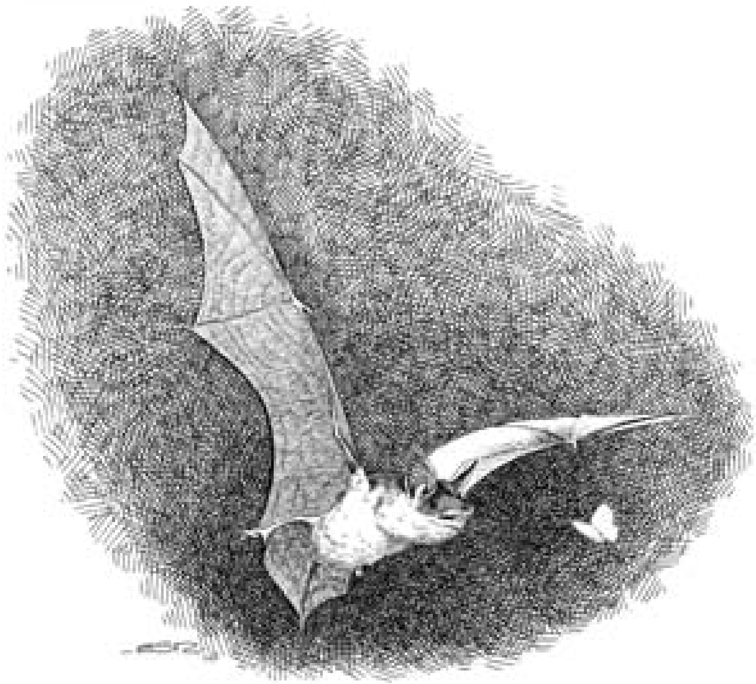
Samenvatting

De invloed van klimaatfactoren op een hazenpopulatie ***(Lepus europaeus)***

Deze studie richt zich op de mogelijke effecten van klimaatfactoren en overstromingsfrequentie op de variatie in de omvang van een hazenpopulatie (*Lepus europaeus*) op de kwelder van het waddeneiland Schiermonnikoog. Van 1995 tot 2003 werden in november hazen geteld in het meest oostelijke deel van het eiland (600 ha). Het aantal hazen en de verandering in het aantal hazen werden gecorreleerd met een aantal neerslag-, temperatuur-, en overstromingsparameters. Het aantal hazen was negatief gecorreleerd met de totale jaarlijkse neerslag en met het aantal maanden waarin de neerslag groter was dan 100 mm. De jaarlijkse verandering in het aantal hazen was negatief gecorreleerd met de totale neerslag, het aantal maanden waarin de neerslag groter was dan 100 mm, de totale neerslag in de voortplantingsperiode, het aantal maanden in de voortplantingsperiode waarin de neerslag groter was dan 100 mm, en het aantal dagen in het jaar waarin het zeeniveau hoger kwam dan 200 cm boven NAP. Temperatuur had geen aantoonbaar effect op de hazenpopulatie. Dichtheidsonafhankelijke factoren verklaarden een substantieel deel van de gevonden variatie in het aantal hazen en we kunnen concluderen dat deze hazenpopulatie zich weet te handhaven onder overheersende stochastische processen.

Received: 24 April 2006
Accepted: 7 November 2006



Summer observation of serotine (*Eptesicus serotinus* Schreber, 1774) at 1481 m altitude in the Republic of Macedonia
Results of a mammal survey in Galicica National Park (I)

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This paper reports a summer observation of serotine (*Eptesicus serotinus* Schreber, 1774) at high altitude in south-east Europe. On 31 July and 3 August, 2006, the presence of three serotines was established in the southern part of the Republic of Macedonia. The serotines (photo 1) were caught in an 18 m mist-net stretched out horizontally over an artificial cattle pool (the "Walled pond"). The pool is situated in an almost treeless valley in the Galicica Mountains, east of Lake Ohrid (coordinates 41° 01' 50" N, 20° 51' 07" E), at an elevation of 1481 m (figure 1).

Details of the bats, such as sex, forearm length and dental status, as well as parasite takings during the captures are given in table 1. Based on the interphalangeal articulations all animals were adults. Their dental status indicated that two of the bats, respectively a male and a female, were rather old while the third, also a male, was one year old.

Both of the males had small testicles, and neither showed signs of sexual activity; the female obviously had suckled a young in the same year. The males and the post-lactating female did not indicate the immediate presence of a nursery colony.

During the nights in the mountains, the sky was partly clouded on 31 July and temperatures stayed between 17.5 and 16° C. On 3 August the sky was partly clouded, with temperatures dropping from 18 to 13.5° C.

This mist-net session was part of 14 sessions performed by the field study group of the Dutch Society for the Study and Conservation of Mammals (VZZ). During eight nights at ten different locations, a total of 52 bats were caught in mist-nets. Apart from the serotines these included: *Myotis blythii* (*n*=12), *M.* cf. *aurascens* (*n*=4), *M. myotis* (*n*=11), *M. myotis/blythii* (n=3), *Nyctalus leisleri* (*n*=10), *Pipistrellus pipistrellus* (*n*=1), *Plecotus* cf. *auritus* (*n*=5), and *Miniopterus schreibersii* (*n*=3) (Buys 2006). During the workshop in the Republic of Macedonia no bat-detector observations of serotines have been

Table 1. Data on serotine (*Eptesicus serotinus*) captures; FA: forearm length (mm); W: weight (g).

Date	Sex	FA	W	Dental status	Parasites present
31 July 2006	Male	51.6	29.0	extensive wear	yes
3 August 2006	Female	54.7	34.0	extensive wear	yes
3 August 2006	Male	51.1	27.0	no signs of wear	no

Photo 1. Serotine (*Eptesicus serotinus*); female, Republic of Macedonia, 3 August 2006. *Photograph: Jeroen van der Kooij.*

recorded.

In addition to the bats a nightjar (*Caprimulgus europaeus*) was captured, indicating the narrow time gap between the onset of drinking by nightjars and by bat species All animals were released afterwards.

The serotine captures are noteworthy because there are only few observations of this species from higher altitudes. In mountainous areas of Central Europe the serotine is quite commonly reported from areas under 1000 m elevation (Baagøe 2001). During a survey in Switzerland, Stutz (1989) found the species mostly at lower elevations, between 210 and 433 m. Spitzenberger (1993), during a survey for bats in summer roosts in Carinthia (Austria) between 300 and 1500 m elevation, found serotine roosts up to a maximum of 700 m. One breeding colony was found at 879 m and there were some (undocumented) observations between 900 and 1000 m. Hibernacula were reported at higher elevations of up to 1200 m. Ognev (1962) reported one observation from the Southern Alps (5000 feet), but did not specify the season or type of shelter Also Benda et al. (2003) mentioned a record at 1540 m in Bulgaria from the LednicataCave near Gela in the Smoljan District, Rhodope Mountains, without providing further details.

Cited observations from literature of serotines thus mention maximum altitudes of 879 m for nursery colonies and 1200 m for hibernacula. The Macedonian summer serotine observations discussed here differ from others in the literature, because they did not part of a nursery colony and because they were captured by a different method: mist-nets. This may account for the higher altitude of our observations. Furthermore, it is likely that the relatively southerly location of our study area may partly explain the occurrence of the species at high altitude.

The serotine is a widespread and common bat, distributed across most of Europe, through to

Figure 1. The Republic of Macedonia in Southeast Europe with the location of Galicica National Park (rectangle).

Central Asia. Although the number of reported serotines in countries around the Mediterranean is lower than in north-western European countries (Catto & Hutson 1999), this seems to be based on an observers' effect rather than genuinely lower numbers (Benda et al. 2003). In addition bat-detectors are more widely used in north-western Europe than in Mediterranean countries.

On the same expedition J. Willemsen and J. P. Bekker also collected a sub-adult male serotine as a road casualty at the A1 Motorway in Croatia, 14 km West of Slavonski Brod (45° 09' 33'' N, 17° 50' 12'' E; altitude 88 m) on the August 5, 2006. This find fills a gap in the map of the distribution of the serotine developed by Catto and Hutson (1999).

Kryštufek and Petkovski (2003) describe the serotine as widespread, but uncommon in the Republic of Macedonia and mention just five observations in the country. The distribution and numbers of serotines at high altitudes, especially in southern Europe, are unclear; a combined effort of research with mist-netting, identifying nursery colonies, listening with bat-detectors and visiting hibernation sites, although difficult because of extremely hidden nature of these sites, could contribute to improving knowledge of the whereabouts and distribution of this bat species.

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Samenvatting

Tijdens twee vangacties met mistnetten in het Galicicagebergte, tussen het Ohridmeer en het Prespameer in de Republiek Macedonië, werden drie laatvliegers (*Eptesicus serotinus*) gevangen op 1481 m hoogte. Het betreft een zomerwaarneming van dieren die niet zijn gebonden aan een kraamkolonie.

Received: 4 September 2006
Accepted: 14 November 2006

Book Reviews

Fox research in the dunes from 1979 till 2000

Vossenonderzoek in de duinstreek van 1979 tot 2000. J. Mulder 2005. Report 2005.72, Society for the Study and Conservation of Mammals (VZZ), Arnhem, The Netherlands. 78 pp. ISBN 90-73162-78-5.

Foxes are one species of wild animals which attract much social attention, and have been the subject of much research, since their presence frequently conflicts with human interests and activities. In the countryside, foxes are black-listed because of the damage they do to poultry, and their role as a competitor with hunters further stigmatises the species. During the second half of the previous century, foxes were identified as the main vector responsible for the spread of sylvatic rabies throughout Europe. While oral immunisation provided a sound solution for this problem, a new and even greater risk to human life has been detected as being linked with foxes: the fox tape worm *Echinococcus multilocularis.* Always a target for hunters and poultry keepers, the threats that foxes pose to human health are often used to strengthen public opposition to the species. And if that is not enough, some conservationists are now drawing increased attention to the possible negative effects that foxes' predatory activities could have within some ecosystems.

For some people all this provides sufficient reason to actively manage the species (by hunting), even in nature reserves. Others emphasise that we should accept the fox as a natural predator, or at least have more patience in judging foxes' impact on the ecosystem. It is unlikely that these two divergent views will ever be reconciled, the positions are too polarised and the debate has been going on for too long, with no resolution. However, through thoroughly studying the ecology of foxes, a better understanding of the technical aspects of different potential management options can be gained.

The present report by Mulder brings together three intensive studies on foxes in the Dutch dunes, dating from between 1979 and 2000. Two of them were conducted by the author himself, and the third by A. Swaan. The report is especially interesting because it covers such a long research period. Short research periods (project research) are an inherently restrictive factor when studying the population ecology of animals that live for a (relatively) long time. Here, by applying modern methods (for the spatial analyses) the earlier research results could be made comparable with those from the more recent studies. In addition these populations are also quite unique in that they have never been hunted, since they became settled in the area at the end of the 1960s.

The report is well structured in ten chapters, which cover two substantive topics: food choice and predation, and habitat use and population dynamics. The chapter concerning food ecology summarises the earlier reports, which comprehensively analysed this issue. In this respect no important new insights are introduced, but the findings are brought together in an accessible overview. The rabbit clearly remains the main prey of the dune foxes, despite an important population decline due to VHS. The arrival of the new predator in the dunes, did coincide with some unmistakable changes in the populations of a number of prey species, but the exact role that foxes played in these changes cannot be so readily defined.

Population dynamics are extensively dealt with across five chapters, which provide by far the most interesting new information, particularly through giving consideration to fluctuations over a lengthy period of time. The topics that are highlighted include habitat use, dispersion and itinerant foxes, population composition, population density, reproduction and sex ratio.

Having been started as a new established population, in a suitable habitat and never having been being hunted, the population appears to have remained in a dynamic situation for some decades. Territorial behaviour and the accompanying density-dependent parameters (such as litter size, proportion of females taking part in reproduction, natural mortality, etc.) are convincingly presented as driving forces and limiting factors. However, the question of the precise drivers of these internal dynamics remains, at least, partly unexplained: for example it is unclear whether changes in social organisation (number of animals per territory) are a result or (at least partly) a cause of these changes. The fox continues to challenge scientists, although it is quite acceptable to suppose that the changing density of the main prey (rabbit) plays a key determinant in the population dynamics.

Overall this is a very valuable reference document for everyone dealing with or thinking about fox management. It shows that a population, which is not being hunted, regulates itself perfectly without causing ecological disasters. So, it should be remembered that patience is an honourable human quality.

In summary: foxes will undoubtedly always remain unpredictable up to a certain extent, even to scientists with many years experience in studying them. What holds true in one place or time may not always simply be translated to another place or time. The values of several parameters will differ according to local circumstances. In this respect, note for instance that, in Flanders, the dune area only covers 0.22 % of the total area.

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