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Distribution and habitat selection of *Myotis bechsteinii* in Luxembourg: implications for forest management and conservation

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A b s t r a c t . Bechstein's bat, *Myotis bechsteinii* is a European tree-dwelling vespertilionid bat species, which has to be considered as index species for old growth broadleaved woodland. However factors affecting density and habitat selection are still poorly understood. Therefore 22 representative woodland areas in Luxembourg that are located in the central geographic range of the Bechstein`s bat, were analysed. During 76 nights, forest dwelling bats were registered by intensive mist netting, 47 Bechstein bats were radio-tracked to identify tree-roosts and 24 individuals were radio-tracked on 3-5 consecutive nights to determine their foraging areas. In total 14 reproduction areas and 12 nursery colonies were localized, with the number of females ranging between 20–70 individuals (mean 34 ± 18.1 ind.). The distribution of Bechstein's bat revealed to be uneven and to be significantly positively correlated to mean temperature and the presence of *Melico-Fagetum* forest with a marked amount of old oak trees. Nevertheless the height, the mean precipitation and the occurrence of *Luzulo-Fagetum* forest is negatively correlated to the occurrence of *M. bechsteinii*. Altogether, 78 tree-roosts from nursery colonies were identified. Colonies use a day-roost complex and show a significant preference for woodpecker holes. Female Bechstein's bats foraged on a mean area of 46 ha (MCP) with small core feeding areas (mean: 2.1 ha) which show no, or only a small overlap with each other. Roosting and feeding sites are characterised by canopy and understorey structures similar to native woodlands. The results of this study leads to a scientific data base for conservation and long time monitoring for this bat species.

Key words: Bechstein's bat, radio-tracking, tree roosts, foraging, core areas

Introduction

Bats (Chiroptera) are one of the oldest mammalian orders and most diverse in terms of physiological and behavioural adaptations that enable them to successfully inhabit different ecosystems. With more than 1 100 species worldwide, they are found in all terrestrial habitats, except deserts and polar region (S i m m o n s & C o n w a y 2003). All over the world bats are distributed mainly in forests and some species are recognised as key species for ecosystem services like seed dispersal, pollination and predation (P a t t e r s o n et al. 2003, K a l k a & K a l k o 2006). However, despite the fact that nearly all bat species in Europe use forests to meet some or all of their life-history requirements (D i e t z 2007) up to now very little is known about the ecosystem functions of European bats. It can be assumed that bats acting as nocturnal insect predating mammals play a major role at the top of food chains in forests (L a c k i et al. 2007) especially pregnant and lactating females consume more than two

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third of their individual body mass in arthropods per night (Encarnação & Dietz 2006). Habitat quality and food supply in particular affect the distribution of sexes of bats, reproduction rate, as well as size, number and distribution of nursery colonies (Speakman et al. 1991).

Forests are not only used as feeding areas but also as roosting sites. Tree holes are regularly occupied for rearing young, for mating or as interval roosts during nightly foraging flights or during migration (Boye & Dietz 2005, Ormsbee et al. 2007). Some species even hibernate in hollow trees like the noctules (*Nyctalus noctula*, *N. leisleri*) (Gebhard & Bogdanowicz 2004). Overall bats spend more time roosting than on any other activity and roost availability influences the diversity of bat communities (Humphrey 1975). Therefore destruction of roosts through forest management is one factor responsible for population declines (Racey & Enwistle 2003, Hayes & Loeb 2007).

The medium-sized Bechstein's bat (*Myotis bechsteinii* Kuhl, 1817) is a tree-dwelling bat-species which is largely restricted to deciduous forests in Europe (Mitchell-Jones et al. 1999). While males are solitary, females occupy tree holes to form maternity colonies during summer to communally raise their young (Kerth et al. 2001). Distribution of Bechstein's bat in Europe is insular and factors affecting density and habitat selection are still poorly understood.

As all of the bat species in Europe, Bechstein's bat is listed in Annex IV of the Habitat Directive (European Council Directive 92/43/EEC) for strict protection. For this, conservation-oriented research programme are necessary to identify and monitor key habitats. Furthermore the key habitat functions including favourable roost sites and foraging habitats both strongly influencing the reproduction success of female bats can be assessed. The main goal of this case study was to assess the distribution of the Bechstein's bat in Luxembourg and to find out relevant characteristics of the distribution and habitat selection of nursery colonies of this endangered species, finally to define conservation guidelines in forest management practice.

Study Area

Luxembourg is situated in Western Europe between Belgium, Germany and France with a maximal distension of 82 km from north to south and 57 km from east to west. This small country is mainly divided into four cultivation regions representing the northern ("Oesling") and the southern ("Gutland") both taking up the main part of the country and the two smaller regions "Minette" in the southwest and the "Moselle valley" in the southeast. These cultivation regions are divided into 18 growing districts as spatial units distinguished by their geology, topography, soils, climate, natural vegetation, current forestation and forest site conditions (Administration des Eaux et Forêts 1995, 2003).

The submontaneous "Oesling" comprises 32% of the territory and is situated on a high plateau of the greater Ardenne area (average altitude: 450 m). It is characterised by Lower Devonian schist soils of poor quality, high annual precipitation of 850–1 000 mm and a low mean annual temperature of 7.0–8.5°C. The Oesling has a short vegetation period of 150 days. The hill slopes are covered by spruce (*Picea abies, Pseudotsuga menziesii)* and extensive former oak coppice forests (*Quercus robur*) (total: 55 % of the wooded area of the country), while meadows, pastures and arable land occur predominantly in the river valleys and on the plateaus.

The "Gutland" covers 68% of Luxembourg and mainly consists of a Jurassic-Triassic sandstone formation with gently rolling uplands and broad, shallow valleys (average altitude: 350 m). In comparison to the "Oesling" the "Gutland's" climate is milder and drier with precipitations of 700–850 mm/year and mean annual temperatures of 8.0–9.5°C. Due to the more favourable climate the "Gutland's" vegetation period lasts nearly 190 days. The "Gutland" contains fertile agricultural territory, meadows, pastures and arable land (70%) and extended deciduous forests (30%, *Fagus sylvatica*, *Quercus robur*, *Carpinus betulus*).

The "Minette" region is an extension of the Lorraine iron ore basin and sporadic elevations reach up to 400 m. These elevations are covered on their top by beech forests (*Asperulo-Fagion*) while the fertile soils of the "Minette" basin are used as grassland for agriculture. The land use is characterized by contiguous settlements and industrial facilities (47% of the surface) and presents a secondary geomorphology due to the iron mining industries during the last 150 years. The "Moselle valley" is a climatic favourable grape-growing region with relicts of calciferous beech forests (*Cephalanthero-Fagion*).

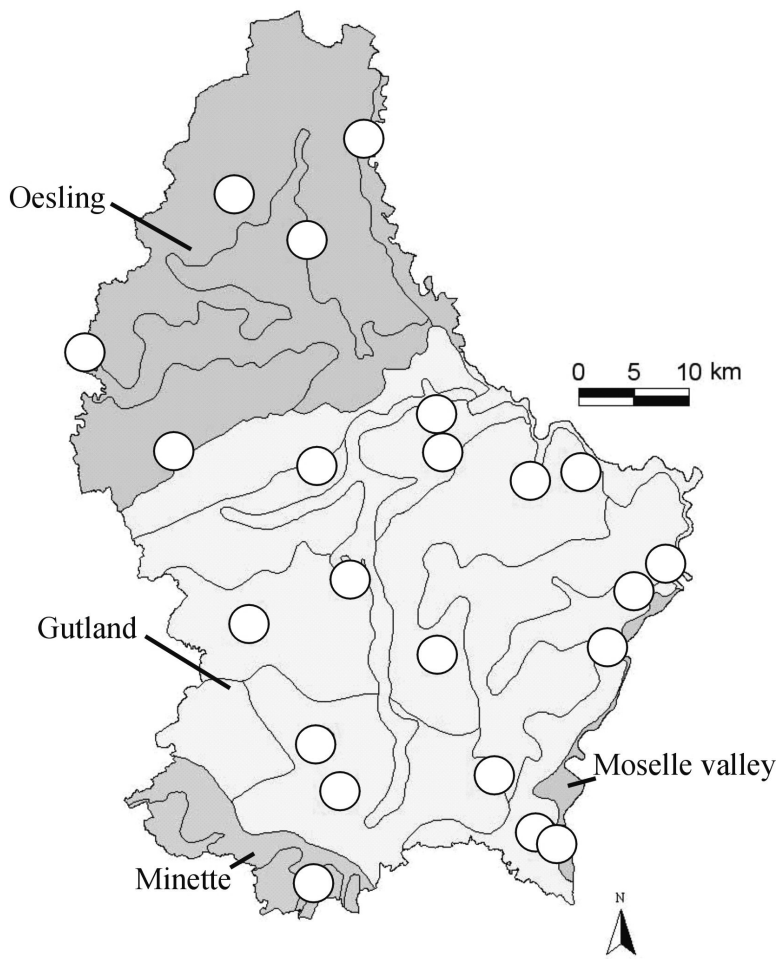

Fig. 1. Overview of the 22 study sites in Luxembourg distributed randomly in forest massifs in 13 different cultivation districts.

To assess the distribution and the habitat selection of *Myotis bechsteinii,* 22 representative forest areas from 13 different growing districts of Luxembourg were investigated between 2004 and 2006 (Fig. 1). While all selected forest areas are actually subject to regular forestry management, nine of these investigation areas are proposed as *"Réserves Forestières Intégrales*", totally protected from human interventions.

Methods

From 2004–2006 the 22 study sites were investigated during 76 nights by mist netting and detector transects. 47 individuals were radio-tracked to identify out day-roosts. Additionally 20 of the reproductive females and 4 males were radio-tracked on 3–5 consecutive nights to determine foraging areas. All investigations were made between May and the beginning of August.

Mist netting

Bats were caught during 76 mist net sessions (total length per session: 100 m) usually lasting from dusk to dawn. Captured bats were weighed to the nearest 0.1 g using a digital scale (Kern) and their forearm length was measured with dial callipers (accuracy: 0.1 mm). The age of the bats was determined by evaluating the closure of the epiphysis (Anthony 1988), the length of the wrists, the abrasion of the teeth and, in the style of studies on *Myotis daubentonii* (Richardson 1994), by the expression of a chin spot. For the determination of the reproductive status the methods described by Racey (1974, 1988) were used. Accordingly, pregnant bats could be determined through palpation of the abdomen and lactating bats were identified by a bare patch around the nipples that were due to suckling their young. The males were classified to be in pre-spermatogenesis, beginning of spermatogenesis and advanced spermatogenesis through assessing the size of the testes, the distension of the epididymis and the coloration of the *tunica vaginalis testis* (Racey 1974, Encarnação et al. 2004).

Telemetry

For radio-tracking 0.4 g LB-2 radio-transmitters (Holohil Systems, Canada) were used. Their weight represented 1.5–5.7% of the Bechstein's bats' body mass. Thus, the transmitters' weight was usually well below, or only slightly above, the 5% mass threshold which is suggested for radio telemetry studies (Aldridge & Brigham 1988). All transmitters were attached between the shoulder blades using Skin-Bond® surgical adhesive. During the tracking period two observers monitored the bat simultaneously from different locations and took bearings at 5-minute intervals using hand-held 2-element Yagi antennae and modified Yaesu FT-290 receivers (adapted by K. Wagener, Cologne, Germany). The position of the bat was determined by triangulating the synchronous measured signal directions. The field workers co-ordinated their simultaneous bearings using trigger signals from Casio DB-31 watches, and they remained in contact using hand-held FM-radios. If one person lost contact with the bat, the other either tried 'homing-in on the animal' (White & Garrott 1990), or simulated cross-triangulation by taking a bearing in one position and then moving nearly 50 m or one minute before taking the second bearing. This was only possible with any reasonable accuracy when the animal was foraging in a small area.

Home ranges were calculated as Minimum Convex Polygon (MCP) with the software Tracker Version 1.1 (Camponotus AB ©1994). Foraging areas were defined to be 95% kernels

and main feeding grounds correspond to 50% kernels. Kernels were calculated by the fixed kernel method (Hooge & Eichenlaub 2000) using the *ArcView* Extension *Animal Movement*. The smoothing factor h was estimated with least-squares cross validation.

Habitat analyses

The aim of this habitat analysis was to find out abiotic and biotic factors significantly influence the occurrence of *Myotis bechsteinii* in Luxembourg. For this, climatic data (mean annual temperature and rainfall), geological data (landscape relief, height above sea level), as well as vegetation data (forest vegetation maps) were correlated with the results of occurrence of Bechstein's bat using *ArcView*, Version 3.2, ESRI, Canada.

Statistical analysis was carried out at a 100 m radius around the mist-netting points and roosting trees of *M. bechsteinii*. After a test on normal distribution, the correlation of different abiotic and biotic factors to the occurrence of Bechstein's bat was realized by a Pearson-product-moment-correlation. Used and available habitats were compared by Mann-Whitney-U-test. The Chi-square-test was used to assess occupied and available tree roosts. For this, available tree roosts were mapped in one investigation area ("Friemholz") during winter time when foliage is not developed. Occupied roosts were localised by radio-tracking as described above. The significance level was put to $p < 0.05$.

Results

In total 399 bats from 13 species were captured with mist-nets. Bechstein's bat was the second most commonly captured bat species with 107 individuals representing 26.8% of all captured bats (Fig. 2). The mean capture success of Bechstein's bat was 1.7 individuals/100 m mist net per night. The dominating species caught with the mist nets (n = 169) was the house-dwelling greater mouse-eared bat (*Myotis myotis*). The tree-dwelling species *Myotis nattereri* and *Plecotus auritus* were captured with a rate of 0.3 and 0.2 individuals/100 m mist net per night.

Bechstein's bats were recorded in 17 of 22 investigation sites however the distribution of the species revealed to be uneven. While individuals of *M. bechsteinii* were successfully caught in all investigated forests of the growing region of the "Gutland" (mean capture success: 37.8 ± 33.6%) and "Minette" (mean capture success: 57.1 ± 0%), not a single individual of this species was detected during mist netting sessions conducted in the forests of the "Oesling" region in the northern part of Luxembourg (Fig. 3). The differences in capture success in the two main Luxembourgian growing regions "Gutland" and "Oesling" were significant (Mann-Whitney-U-test, $p<0.001$).

With the help of radio-tracking in total 12 nursery colonies were localized in the "Gutland" with the number of females ranging between 20–70 individuals (mean: 34 ± 18.1 ind.). In three sites only males were captured (Fig. 3). One of these is the "Grünewald" the largest beech forest in the central part of the country localized in the "Gutland".

By studying the abiotic factors influencing the distribution of the species, the results showed that the occurrence of Bechstein's bat has a negative correlation to increasing height (Pearson-product-moment-correlation: $r^2 = 0.45$; $p < 0.01$). Bechtein's bat maternity roosts were found between 205 and 345 m (mean: 292 m). The occurrence of Bechstein's bat was also found to be negatively correlated to increasing mean precipitation ($r^2 = 0.34$; $p < 0.01$), but significantly positively correlated to mean temperature ($r^2 = 0.20$; $p < 0.05$).

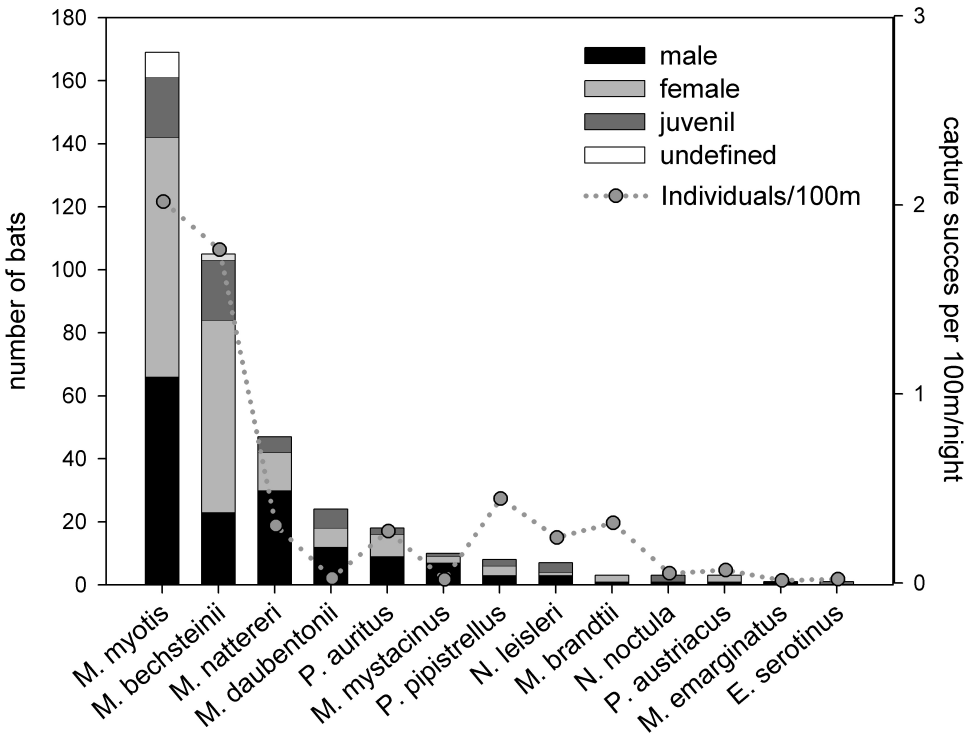

Fig. 2. Number of sympatric bat species to *Myotis bechsteinii* captured with mist-nets in representative forest areas in Luxembourg from 2004-2006 (n=399).

Habitat analysis showed that Bechstein's bat got caught significantly more often in the presence of forest vegetation consisting of *Melico-Fagetum* with old oak trees (Pearson-product-moment-correlation: $r^2 = 0.27$; $p < 0.05$) while the occurrence of *Luzulo-Fagetum* forests was found to be negatively correlated to the occurrence of the species ((Pearson-product-moment-correlation: $r^2 = 0.21$; $p < 0.05$, Fig. 4). An increasing proportion of *Melico-Fagetum* within the 100m radius of mist netting places was likely to increase the probability of capture success of *M. bechsteinii* ($r^2 = 0.11$, $p = 0.07$). The females´ capture success correlated much more strongly with *Melico-Fagetum* ($r^2 = 0.05$, $p = 0.06$) than the capture success of males ($r^2 = 0.06$, $p = 0.54$).

Roosting sites

Through radio-tracking a total of 78 *M. bechsteinii* day roosts were found. They belonged to 12 maternity colonies located during this study. Over 90% of the nursery roosts were found in old oaks, followed by beeches, hornbeams and other deciduous trees to a lesser extent. Roosting sites were situated dominantly in living trees only 13% of the roosting sites were located in dead trees. Bechstein's bat showed a clear preference for woodpecker holes (81.4%) in tree trunks (73.5%) over crevices or branch break offs. Both great and middle spotted woodpecker (*Picoides major* and *P. medium*) holes as well as green and grey woodpecker (*Picus viridis* and *P. canus*) holes were used. Bechstein's bats were never found in a roost behind tree bark. Tree diameter at breast height of maternity trees was larger than 40 cm and mostly between

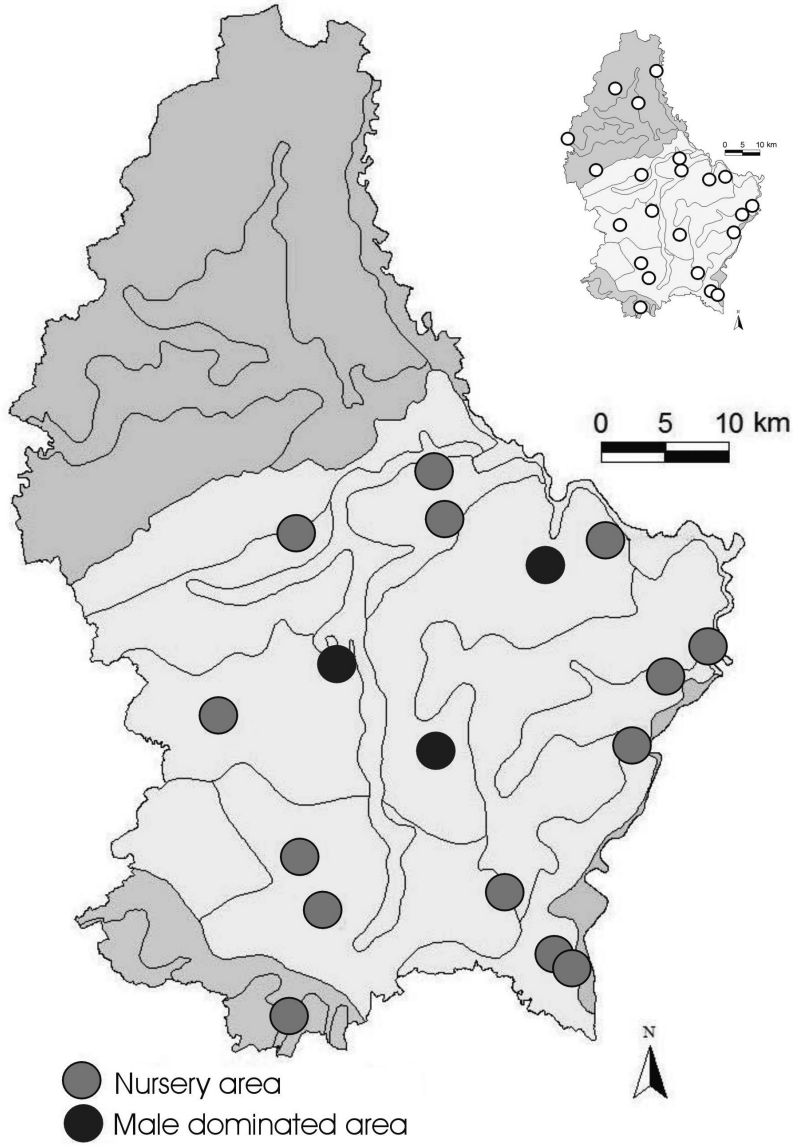

Fig. 3. Distribution of the Bechstein's bat in Luxembourg resulted from systematic mist-netting and radio-tracking and compared to the investigation sites (little map).

60 – 80 cm. Roost chosen by maternity colonies were situated generally between 5–25 m with the roost entrance directed south-eastwards (66.6%). Comparing the 56 tree roosts used by two nursery colonies of *M. bechsteinii* in the study area of the "Friemholz" forest to the 350 potential roosts mapped within the same forest, roosts used by females showed no significant differences compared to available roosts in regard to roost tree species ($X^2 = 3.47$, d.f. = 2, $p > 0.05$). 93% of occupied tree-roosts were found in oaks which is the most common tree species in the investigation area of the "Friemholz" forest. In contrast, females choose woodpecker holes significantly more often as roost than would have been expected due to

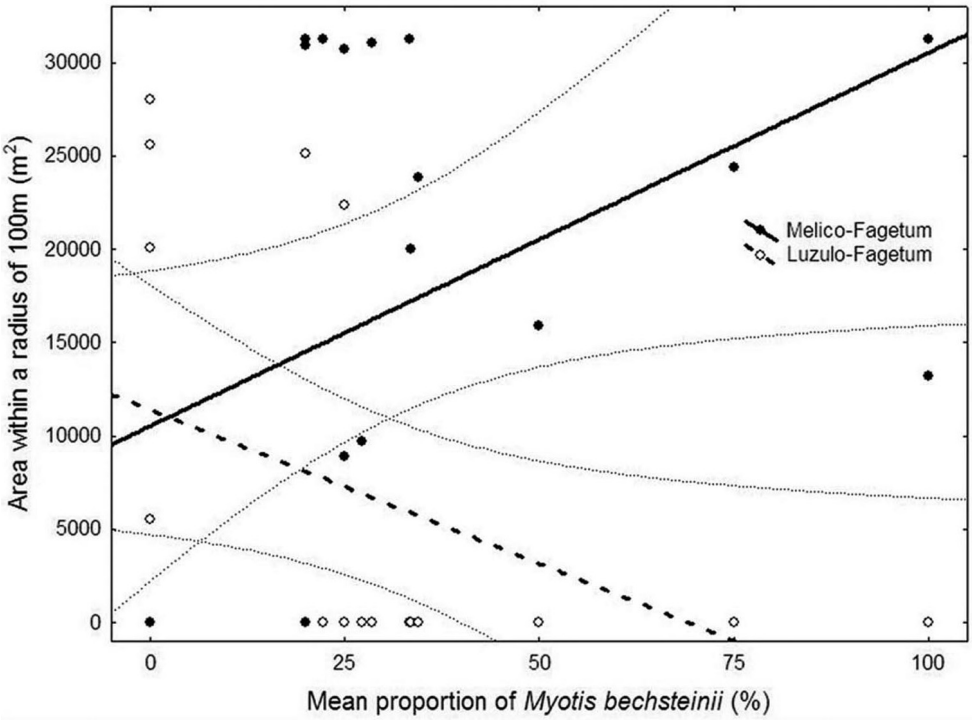

Fig. 4. Correlation of the occurrence of Bechstein's increases significant with the presence of *Melico-Fagetum* beech forest and decreases with *Luzulo-Fagetum* plant community.

roost type availability (X^2 = 12.64, d.f. = 3, $p < 0.05$). In comparison, males roosted more frequently in beeches and hornbeams (60%) and in crevices (80%) than would have been expected due to the availability of roosts in these tree species (X^2 = 2.804, d.f. = 2, $p < 0.05$) and of this roost type (X^2 = 7.82, d.f. = 3, $p < 0.05$). Males were also found in branch-situated roosts more often (40%) than expected (X^2 = 6.00, d.f. = 1, $p < 0.05$).

Radio tracking showed that a single maternity colony of *M. bechsteinii* used a pool of at least 34 trees during a seasonal activity period. The distance between the tree-roosts ranged between 11 – 798 m with a mean of 327 m (± 182 m) (Fig. 5).

It was found that under natural conditions consecutive days spend by females in the same roost increased from pregnancy period (mean 1.5 days, range 1.3 – 4.0 days) to lactation (mean: 3.3 days) up to post-lactation period (mean: 4.8 days). Males (n = 4 males) in contrary stayed for a mean time of 6.6 days (range: 4.5 – 10 days) in the same day roost.

Foraging areas

Radio-tracking revealed that female Bechstein's bats foraged within a mean home range of 46 ha (MCP) (range: 16.1 – 34.7 ha) including small core foraging areas (50% kernel) of 2.1 ha (range: 1.7 – 2.6 ha) (Table 1). Each bat revisited the same foraging area over several nights. Most individual foraging areas showed no, or only a small overlap with each other. In the majority of cases female bats had two foraging areas, one of them close to the day-roost (< 500 m) and a further one within 1 km. For one maternity colony in the "Friemholz" a home

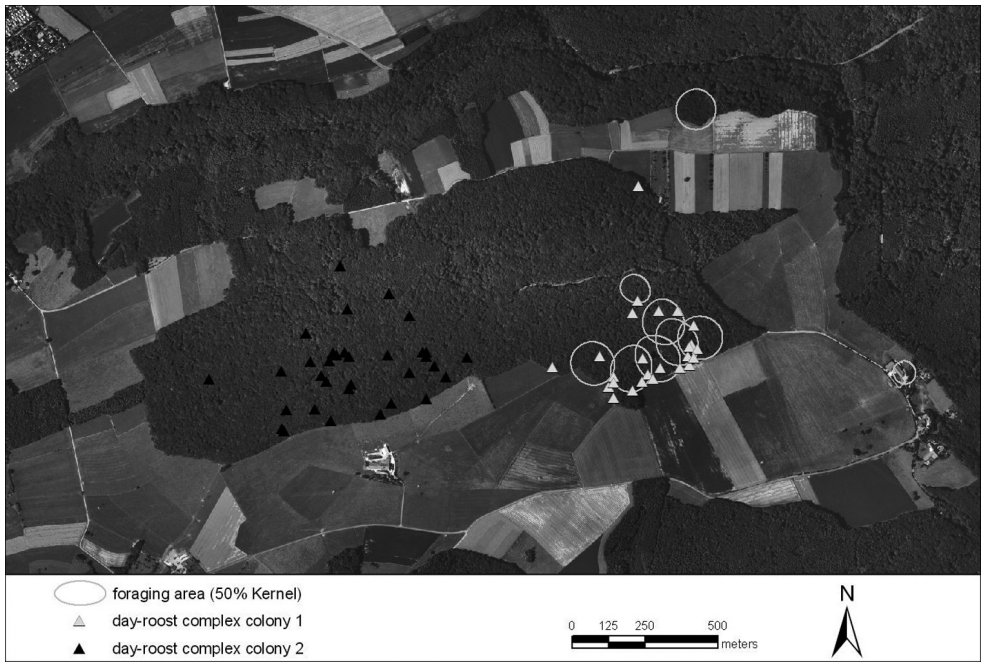

Fig. 5. Investigation area of the "Friemholz" with day-roost complexes of two nursery colonies and core feeding areas (50-Kernel) from seven females of the colony in the eastern part of the forest.

Table 1. Home ranges (MCP), core feeding sites (50 %-Kernel) and distances between day-roosts and core feeding sites revealed by radio-tracking in five investigation sites.

Area	MCP [ha]		Core area		Distance		Individuals
	mean	SD	mean	SD	mean	SD	
Friemholz	34.7	± 21.3	2.0	± 1.4	232	± 207	9
Gilsdorf	20.2	± 8.7	2.6	± 0.6	278	± 196	2
Houwald	16.8	± 7.1	2.1	± 0.4	378	± 190	3
Buchholz	18.6	± 7.6	2.4	± 0.7	196	± 131	4
Bettembourg	16.1	± 3.0	1.7	± 0.1	493	± 117	2

range (MCP) of about 299 ha was calculated including forest with foraging areas and open landscape that was only crossed to reach the foraging area in the woodland.

Foraging areas of Bechstein's bats are characterised by deciduous forests with a marked amount of old oak trees, often covering more than 40% of the stands and presenting a closed (>75%) but light canopy. Furthermore the core feeding areas presented a vertical structured under-storey with trees of different ages (e.g. hornbeam, beech) and a partly developed herbaceous plant layer (Fig. 6). All radio-tracked females used woodland for foraging. Only one was found hunting insects in a cowshed between two woodland areas.

Discussion

The main goal of this research was to assess systematic data on the distribution of the tree-dwelling Bechstein's bat in Luxembourg's forests and study factors influencing the habitat

Fig. 6. Typical feeding site from a female Bechstein's bat characterised by old oaks, closed but light canopy and differently structured under-storey.

suitability of this species. To date conservation relevant information on the ecology of this endangered species is scarce (Schlapp 1990, Wolz 1992, Schofield & Morris 1999, 2000, Greenaway & Hill 2004) and related principally to genetic analysis (Kerth et al. 2001) and studies on behavioural ecology of maternity colonies mainly in artificial roosts (e.g. Kerth & König 1999, Kerth et al. 2004).

The fact that Bechstein's bat had been the second most commonly caught bat species during this study confirms the assumption that it is a key for old grown broadleaved forest ecosystems (Baagøe 2001). The results verify or affirm that systematic mist–netting using mist-nets length ≥ 100 m positioned in forests in combination with radio-tracking are efficient methods to gain high quality data for scientific conservation programme and long-term monitoring of this species. In contrast to surveys using artificial bat roosts, the methods applied in the present study could serve as a standardized methodology to assess objective and realistic data on the distribution and population size of *M. bechsteinii* in the future. Due to the finding of several maternity colonies it was possible to identify specific regions as reproduction centres which enables the application of precise conservation measures. Estimations of colony size and relative abundance of bats are challenging but constitute essential elements for reliable assessments of the conservation status and provide baselines crucial for the identification of future population trends (Racey & Enwistle 2003).

The revealed uneven distribution of Bechstein's bat in Luxembourg has led to statistical analysis of factors influencing the distribution of the species and its reproduction centres. Analyzing abiotic and biotic factors showed that the distribution of Bechstein's bats is influenced by the mean annual temperature and precipitation, height, forest vegetation and species specific habitat requirements as tree composition, tree age and number of woodpecker holes.

The study confirmed for the first time with systematic mapping, that *Myotis bechsteinii* is a warm temperate bat species, as assumed previously (B a a g ø e 2001, S p i t z e n b e r g e r 2001). Bechstein's bat shows a significant preference for roosting sites situated at favourable climate conditions at low average height (mean: 292 m) covered with beech forest (*Melico-Fagetum*) with old oaks. The negative correlation of the roosting sites of *M. bechsteinii* to *Luzulo-Fagetum* forest vegetation, to increasing mean annual precipitation and to height was clearly established. For this, the distribution of the Bechstein's bat mirrors the different climate and habitat conditions of the different growing regions of Luxembourg.

Except when swarming in front of winter quarters during autumn, Bechstein's bat was not found within the forest sites in the "Oesling" growing region (northern part of the country). Although accounting for 55% of the wooded area of Luxembourg (spruce forests 50%, former oak coppice forests 35% and beech forest (mainly *Luzula-Fagetum)* 15%), this region is characterised by a high average height of 450 m, a rough climate with high annual precipitation of 850 – 1 000 mm and a low mean annual temperature of 7.0 – 8.5 °C.

In the "Gutland" region, favourable woodlands for the Bechstein's bat are covered by old grown deciduous forest with a high percentage of old oaks (> 140–160 years old) and a high density of woodpecker holes. The density of tree-holes as potential roosting sites in woodlands with maternity colonies of this species revealed to be as high as 8.9–20.0/ha (F r a n k 1997, own unpublished data, E n c a r n a ç ã o et al. 2005).

Female Bechstein's bats from a maternity colony hunted in distinct non-overlapping feeding sites close to the day roost (< 500 m). This confirms results from Bavaria (Germany), where it was shown that 5 consecutively radio-tracked Bechstein's bats maintained their individual foraging areas close to day roosts within and even between the years (K e r t h et al. 2001). This behaviour is due to more stable resource exploitation by a gleaning hunting strategy used predominately by Bechstein's bat than by an aerial hawking hunting strategy of other bat species, needing flexible hunting areas because of non-regular distribution of ephemeral food resources (K e r t h et al. 2001). This behaviour is also known from other vespertilionid bats of similar morphology and body size like *Plecotus auritus* (E n t w i s t l e et al. 1996, D i e t z 2007) for example. High quality feeding sites enable bats to gain enough prey to cover their energy during pregnancy and lactation (K u n z & S t e r n 1995). Maternal investment is reflected in a drastic increase in food consumption (K u n z 1974, A n t h o n y & K u n z 1977, E n c a r n a ç ã o & D i e t z 2006). It is likely that in order to secure sufficient food intake females become territorial during energy intensive reproduction periods (R y d e l l 1986, D i e t z & K a l k o 2007) leading to small individual feeding sites (K e r t h et al. 2001).

In contrast to studies with artificial bat boxes of specific volume and microclimate, the obtained results reflect the spatial distribution of clusters of maternity roosts, the selection of day roosts, the spatial partition of feeding sites and colony size under natural conditions.

The distribution of roosting sites of *M. bechsteinii* under natural conditions appears to depend more on the nesting activity of woodpeckers than to be influenced by ambient temperature as described for artificial roosts (K e r t h et al. 2004). It was found that tree roosts in woodpecker holes show surprisingly stable thermal conditions, with temperatures varying from only 19.6–21.6 ± 3.3°C (SD) during a summer period (32 days in July and August). Hence effects of ambient temperature appear to have only a small influence on roost choice by forest dwelling bats. The obtained results also show that a widely closed canopy is therefore important for the stability of thermal conditions within day roosts and

in the forest stand as for the feeding sites in proximity to the roosting sites. Additionally under-storey and cover around tree roosts of Bechstein's bat lower the risk of predation for emerging bats (own observations). It can be concluded that the ideal forest structure for roosting sites is identical to the one for the feeding sites. Stable thermal conditions under an unevenly aged closed but light canopy with a structured under-storey caused by old oaks, influences both microclimate and the insect density as potential prey.

Small distances between day roost and feeding sites and small core hunting areas, as identified by the present study, reflect favourable habitat structures for Bechstein's bat. This species is able to exploit very different prey items within a short range because it has a short, broad wing anatomy and the low wing loading enables it to fly slowly, manoeuvrably and to hover (Norberg & Rayner 1987). It is able to use different foraging strategies from aerial hawking up to gleaning (Wolz 1992, Siemers & Swift 2006) in a small three-dimensional core feeding site. This flight ability may be to a disadvantage under unfavourable habitat conditions, when feeding sites are fragmented and widely distributed. In this case the costs of commuting will increase because of the species specific wing morphology (Norberg 1994). This leads to the assumption that Bechstein's bats in habitats with a high connectivity between day-roosts and feeding habitats benefit from lower energy requirements and greater reproductive success.

Correlation of IUCN conservation status (Temple & Terry 2007, 2009) with extinction risk of bats indicate that bat species with broader wings are more threatened than bats with narrow or intermediate wing morphology (Safi & Kerth 2004). Like *M. bechsteinii,* most of the broad winged bats feed mainly in forests (Boye & Dietz 2005) and forest management activities can have both a direct and indirect impact on the habitat suitability for bats zoonosis (Guldin et al. 2007). While large-scale clear-cutting or even-aged timber cutting by the shelterwood method leads to a low species abundance due to poor natural structure (tree holes, feeding structures, prey density), the dense natural regeneration or replanting results in a lack of free areas between the tree trunks for aerial hawking hunting and the loss of the possibility of ground gleaning for bats. In contrast uneven aged shelterwood cutting with a high amount of closed canopy and under consideration of tree-holes, dead and decaying wood trees leads to habitat requirements affecting a higher density of Bechstein's bat. Conservation guidelines with *Myotis bechsteinii* as a target species are in generally favourable for other forest-dwelling bat species in central Europe.

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