Conservation of the lesser horseshoe bat (*Rhinolophus hipposideros* Bechstein, 1800) (Mammalia: Chiroptera) in Belgium. A case study of feeding habitat requirements

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ABSTRACT. The aim of this study was to determine the habitat use of the last important Belgian colony of *Rhinolophus hipposideros*, Bechstein, 1800, one of the most endangered bat species in Europe. During 71 evenings from April to August 1998, ultrasound detection was performed and, in late August, a female horseshoe bat was caught and fitted with a radio transmitter. The results showed that hedgerows and woodlands with bushes and coppice are key foraging habitats. They also highlight the importance of the presence of a network of wooded elements connecting the maternity roost with the foraging areas. To assure long-term protection of this colony, strong habitat conservation measures should be taken in a radius of up to 1-2 km around the roost.

KEY WORDS: *Rhinolophus hipposideros*, habitat use, bat detector, radiotracking, conservation.

INTRODUCTION

Over the last 40 years, most of the bat populations in the western Paleartic region have declined (STEBBINGS & GRIFFITH, 1986) On a more local scale, several species are now considered as either extinct, endangered or at least vulnerable. In north-western Europe, the lesser horseshoe bat, *Rhinolophus hipposideros*, was formerly widespread and quite common. At present, along with the barbastelle, *Barbastella barbastellus*, it is probably the most endangered species (BEZEM et al., 1957; SLUITER et al., 1963; STEBBINGS & GRIFFITH, 1986) Extinct in the Great Duchy of Luxembourg and the Netherlands (DAAN 1980), populations of the lesser horseshoe bat are at a very low level in northern France as well as in western Germany (DUBIE & SCHWAAB, 1997; BIEDERMAN, 1997). In Belgium, its numbers are estimated at no more than 200-250 individuals whereas, in the past, it was one of the most widespread species, and one of the most ringed (FAIRON, 1977).

Aware of this overall deteriorating situation, the authorities and some conservation groups began to protect hibernation caves and nurseries from the late 1970s. Moreover, on both international and national (or regional) levels, some legal protection was progressively given to the species themselves as well as their habitat (Bern Convention, EC Directive 92/43, annex 2, Bonn Convention). However, though essential to the preservation of viable bat populations, these measures did not have the expected effects and no restoration of the most vulnerable species occurred. In the meantime, the rural landscape changed, lands were drained, hedges removed and small-scaled agricultural landscapes disappeared. It is difficult to assess the impact of landscape modifications on the population dynamics of *R. hipposideros*, as the feeding habitat requirements of the species are poorly known (GAISLER, 1963, MCANEY & FAIRLEY, 1988; MITCHELL-JONES, 1995). It became a species of special concern under the European Bats Agreement (e.g. species selected for Consistent Monitoring and proposed as a Priority Species for Autecological Studies).

By studying the feeding grounds of the last important Belgian colony of the lesser horseshoe bat, we intend to characterise the main landscape features that are of importance for the species. Then, from the observations, some management and conservation measures will be proposed.

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MATERIAL AND METHODS

Study area

The nursery is located at Revogne, a small village at the border of the karstic zone of the Famenne region (Belgium, UTM coordinates: 31 U FR 4651). The bat colony, comprising 60 adults, has been established, in the cellar of a 19th century castle-farm for 25 years. The surroundings are mainly permanent grazing meadows with a dense network of hedgerows. Deciduous or mixed pine woods are located on the top of nearby hills.

Methods

Bat detectors are widely used to record the presence of bats (BAAGOE, 1989; LIMPENS 1993) or to study their behaviour (FENTON, 1982; JONES et al., 1992). They are also used to study their habitat use (WALSH et al., 1995; BOONMAN, 1996; MOTTE, 1997; MOTTE et al., 1998). These devices transform the bat echolocation calls into audible signals and allow the detection of target individuals without disturbing them. Since the lesser horseshoe bat is considered a highly disturbance-sensitive species (MCANEY & FAIRLEY, 1988), the choice of this survey method seemed fully justified.

The apparatus (Pettersson Elektronik AB, D-980) was used in heterodyne mode, and tuned to 108-113 kHz, which is the specific frequency of the echolocation calls of the lesser horseshoe bat (BARATAUD, 1996; JONES & RAYNER, 1989; TUPINIER, 1996). This frequency is higher than those used by other bat species living in Belgium, therefore precluding any risk of confusion.

The ultrasonic calls *of R. hipposideros* are of low intensity and cannot be detected at more than 5-6 m, even with a high-performance detector working in optimal conditions: no wind, no rain, open field and fully charged batteries (pers. obs.). Furthermore the calls of rhinolophid bats could be more directional than those of vespertilionids species. As a consequence, the signal received from a flying bat is often incomplete and sometimes hardly detectable.

In order to find the precise location of the feeding grounds, the direction taken by the bats when leaving their roost was observed first. Each route was then followed until either the contact was lost or a hunting area was discovered. If lost, the contact was searched for during the next night exactly at the same place or at a distance varying from 10 to 20 meters. In that way, an area of about 300 hectares around the nursery roost (1 km radius) was explored, during 71 evenings from May to mid August 1998. Records were made from 10 min before dusk till 90 min after, while crepuscular light allowed us to identify the flight direction taken by the detected bat.

To confirm previous results, and as the colony seemed thriving, it was decided to catch only one adult female and to fit it with a radio transmitter (Holohil LB-2T; weight: 0.65 gram i.e. 10 % of the bat weight). This choice was the result of a trade-off between the pertinence of tracking more individuals and the high sensitivity of the species to disturbance. We are aware that the radio tracking results only relate to a single individual. However, with regards to the status of the species and the lack of knowledge about foraging habitat requirements, data accumulated are discussed below.

The experiment was run in August, after the juveniles had been weaned.

The animal was caught at dusk when leaving the roost. A home-made butterfly net was placed just outside the entrance of the roost. The transmitter was glued to the middle of the animal's back (Histoacryl surgical glue: Braun). The bat was then tracked for 11 nights, from 6 to 17 August 1998, using a single Stobo XR 100 receiver (GFTmbh) with a 3-element Yagi aerial using the "homing-in" method (WHITE & GARROTT, 1990). The bat was pursued either by car or on foot. The activity area of the monitored bat was estimated in accordance with the minimum area method (WHITE & GARROTT, 1990). It was then divided in 0.25 ha cells ($n = 219$) where habitats were characterised with seven variables (Table 1). Using a χ^2 test (SPIEGEL, 1961) correspondences between habitat characteristics and the presence of a foraging area were established.

RESULTS

Detection of ultrasonic calls

From 58 observation points, 51 contacts were obtained, 36 of which led to the discovery of either a flight route or a feeding place (Fig. 1).

There were two flight routes from the nursery. The most used one ($\chi^2 = 164{,}8$; 5 f.d.; $p < 0{,}001$; n = 255 bats during five counting sessions) ran along stone walls and led directly to the nearest woodland (see f 1 on Fig. 1) . The other ran along other stone walls, then hedgerows with trees and led to another wood (see f 2 on Fig. 1). Three other flight routes were found connecting woodlands (see f 3, 4, 5 on Fig.1). They ran along large hedgerows separating grazing meadows. Some tall trees were included in these hedges: *Quercus robur, Fraxinus excelsior, Acer pseudoplatanus* and very old *Crataegus monogyna*. A sixth was located along a leafy woodland path (see f 6 on Fig.1).

Although some foraging was observed along the hedgerows, the feeding grounds were deciduous woodland (*Fraxinus excelsior; Quercus sp., Carpinus betulus, Acer pseudoplatanus, Acer campestre*) with copses (*Crataegus monogyna; Corylus avellana; Cornus mas; Cornus sanguinea*) or mixed clear coniferous woodland (*Pinus nigra; Pinus sylvestris*).

Fig. 1. – Localisation of observation points (**X**), feeding grounds ( ) and flight routes ( ) discovered by ultrasonic call detection. deciduous woodland; coniferous woodland; clear-felling; grazed pasture; cutting pasture; arable land; hedgerows inferior to 2 meters height; hedgerows superior to 2 meters height; scrubs; o o o orchard; trees line; river; **R**: nursery roost; **c**: cave; **f 1 to 6**: flight route 1 to 6. Map based on IGN topographic map (59/6) and completed by our field observations.

Most of the observation points were checked both during the first (May to June) and the second (July to August) part of the study. No obvious change was observed in either the location of the flight routes or the feeding grounds.

Radio tracking experiment

The bat was released five minutes after its capture and flew directly to the next woodland, without apparent difficulty. Having flown for 6 min, it perched for 10 min on an old oak and then returned to the roost till the next night.

During subsequent nights, having left the nursery, the animal flew immediately to a woodland strip in the vicinity where it hunted in deciduous (*Quercus sp., Fraxinus excelsior, Acer pseudoplatanus*) or in mixed coniferous woodland with coppices (*Pinus sp., Quercus sp., Fraxinus excelsior, Corylus avellana, Crataegus monogyna*). Woodland paths were used as flight routes and allowed the animal to move quickly.

Every night, when either leaving the roost or returning to it, the bat was located along the same hedgerow (*Fraxinus excelsior, Corylus avellana, Crataegus monogyna, Quercus sp.*) connecting two woodland areas used as feeding grounds (see double arrow on Fig. 2).

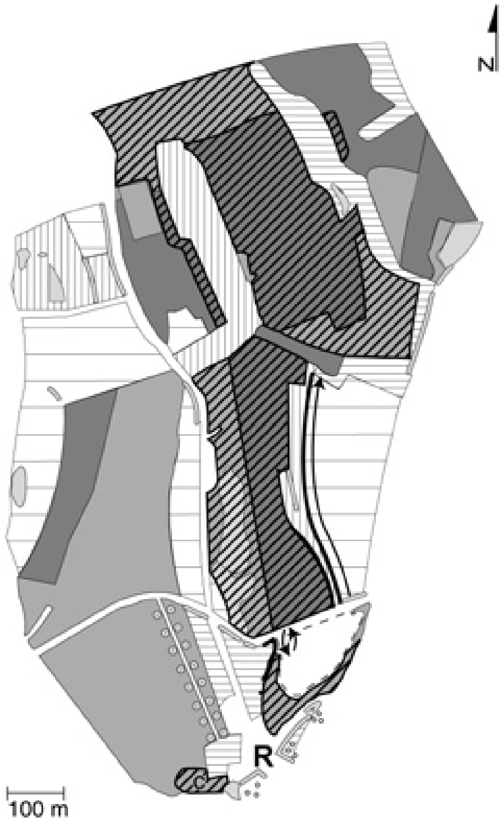

Fig. 2. – Localisation of feeding grounds ( ) and flight routes ( )exploited by the tracked bat. deciduous woodland; coniferous woodland; clear-felling; grazed pasture; cutting pasture; arable land; hedgerows inferior to 2 meters height; hedgerows superior to 2 meters height; scrubs; o o o orchard; trees line; **R**: nursery roost; **c**: cave. Map based on IGN topographic map (59/6) and completed by our field observations.

Fig. 2 illustrates the area covered by this animal and shows its feeding grounds as well as its flight routes. The map is based on a total of 27 hours (1623 min) of observation, the radio contact having been lost during 25 h (1473 min). In fact, contact was lost when the animal went into dense woodland or was too far away from the position of the observer. The maximum observed range was 1.2 km from the roost but it was presumably more.

The results (Table 1, 2) confirm that the presence of hunting grounds was strongly associated with pine woodland (*pw*), hedgerows (*h*) and deciduous woodland (*dw*) (χ^2_1 pw = 30.37, p < 0.999; χ^2_1 h= 10.97, p < 0.999; χ^2_1 dw = 6.94, p < 0.95) whereas their absence was associated with arable land (*al*) and spruce woodland (*Picea abies*) (*sw*) (χ^2_1 al = 25.84, p < 0.999; χ^2_1 sw = 19.7, p < 0.999). Hay meadow (*hw*) and grazed pasture (*gp*) did not seem to have any influence (χ^2_1 hw = 0.05, p < 0.999; χ^2_1 gp = 0.02, p < 0.999).

TABLE 1

Cross-table between the presence of foraging areas in the 219 home range cells and some of their habitat characteristics. Results obtained by radiotracking.

Variables		**Number of cells with hunting ground**	**Number of cells without hunting ground**
Pine woodland	with	60	21
	without	49	89
Spruce woodland	with	2	23
	without	107	87
Deciduous woodland	with	62	43
	without	47	67
Grazed pasture	with	18	19
	without	91	91
Hay meadow	with	18	17
	without	91	93
Hedgerows	with	27	9
	without	82	101
Arable land	with	2	28
	without	102	87

TABLE 2

χ^2 values obtained for each variable using table 1.

Variable	χ^2 (*d.f.*= 1)	**Critical value**	***p*** <
Pine woodland	30.37	10.8	0.999
Spruce woodland	19.70	10.8	0.999
Deciduous woodland	6.94	3.84	0.95
Grazed pasture	0.02	10.8	0.999
Hay meadow	0.05	10.8	0.999
Hedgerows	10.97	10.8	0.999
Arable land	25.84	10.8	0.999

DISCUSSION AND CONCLUSION

It is interesting to note that most of our field work has been done with a bat detector. Although ultrasonic pulses of the species were difficult to detect, the particular methodology used is practical for this species and such methodology could be used by most field workers.

Nevertheless, the detection of ultrasonic calls needs to be carefully monitored because a lack of signal reception cannot necessarily be correlated with the absence of bats. Despite this drawback, most areas exploited by *R. hipposideros* in a 500-700 m radius were probably identified, since the observations were made at a large number of points close to one another.

Figs 1 and 2 clearly show that all the feeding grounds of the lesser horseshoe bats were mid-open or closed habitats. Hedgerows and woodlands therefore appear as key-habitats for the feeding of the species.

All these observations are in accordance with the observations made by previous studies. McAney & Fairley (1988) in Ireland rarely detected the ultrasonic foraging pulses of the lesser horseshoe bat over open pasture.

In Switzerland, analysis of excrements and bitten-off food remains indicated that most prey-insects (Lepidoptera, Neuroptera) were caught by bats in abundantly structured hedges, woodland and their outskirts near water (Beck et al., 1989).

In Britain, the use of a bat detector and of an infra red spot lamp by Schofield (1996), confirmed that the lesser horseshoe bat foraged in woodland, hedgerows and tree lines. In England and Wales, this author also used a Geographical Information System to characterise habitat factors and identify the areas in which the lesser horseshoe bat is found. Habitat preferences, as determined by comparisons between availability and utilisation, indicated that the bat selected areas of undulating countryside with hedgerows, tree lines and woodland, in preference to flat open areas that were intensively farmed.

Our observations with a bat detector indicated that in the woods, the horseshoe bat was hunting, swerving between branches and in the foliage of coppice, at 1 to 4 m height. This seems to indicate that the structure of the wooded habitat has more importance for the bat than the specific composition of the different layers. The density of the taller trees (either deciduous or coniferous) must be low enough to allow the development of an understorey of shrub and small coppice.

Moreover, what is striking, is that all places where a contact with a bat was obtained (Fig. 1 and 2) were linked to each other and to the roost by a network of wooded elements: tree lines, wood edges or large hedgerows with tall trees.

Therefore, a network of tall hedgerows can be considered as a key-element in a lesser horseshoe bat home range. This assumption is reinforced considering the fact that no *R. hipposideros* has ever been seen flying at a distance of more than 1 m from a wooded element and that radio tracked individual never crossed open habitats.

The intensity of use of the key-habitats was evidenced within a 500 m radius around the nursery roost with the bat detector. The radio tracking of a single individual revealed that foraging could occur at a distance of at least 1.2 km from the roost. Schofield's study (1996) showed that two *R. hipposideros* out of six marked ones (plastic cyalume light tags) were observed up to 2 km away from their site of capture.

Habitat conservation measures must therefore be taken in a minimum radius of 1-2 km from the roost. They should include a strict protection of tall hedgerows and of all the connecting wooded elements between the roost and the feeding grounds. Moreover, clear-cuttings must be avoided in the nearby woodlands unless some untouched strips are preserved. Coppice management should be maintained and must be regularly cut on small areas so as to make a rotation between stands of different age. Indeed, the importance of this management form has seriously decreased since World War II, because of the decreasing need for small firewood. Finally, a network of wooded elements must be maintained or restored in a wider perimeter to allow easier access to hibernation caves and, for eventual future exchanges with nearby colonies.

One can hope that, in the future, more large-scale European studies using radio tracking and ultrasonic call detection will be undertaken, and will help in the assessment of the foraging habitat requirements and the home range of a given colony.

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