Myotis	Vol. 40	47 - 54	Bonn, December 2002

Radio-tracking a Lesser horseshoe bat (*Rhinolophus hipposideros*) in Bavaria: an experiment to locate roosts and foraging sites

Jennifer Holzhaider, Eva Kriner, Bernd-Ulrich Rudolph & Andreas Zahn

Abstract. A radio-tracking experiment with *Rhinolophus hipposideros* in southern Bavaria revealed a new roost of a colony and a first insight into the foraging areas of this species in the Alps. The radio-tracked female mainly foraged in mountainous forests using 7 different foraging areas in three nights. They were located at an average distance of 2.4 km (max. 3.6) from the roost.
Key words. *Rhinolophus hipposideros*, foraging habitats, foraging behaviour.

Introduction

The population of *Rhinolophus hipposideros*, which was a common bat species in Bavaria in the mid of the 20th century, decreased dramatically between 1960 and 1990 (Rudolph 1990, Zahn & Schlapp 1997). Only one nursery colony was known from Herreninsel, an island on lake Chiemsee (Upper Bavaria), and evidence of another nursery colony was obtained from nettings of females and fledgling young at a cave near Kochel in the Bavarian Alps (Holzhaider 1998). The colony of these animals was found in June 2000 in a nearby church 7 km away. At the same time the netting of a lactating female at a cave entrance in the foothills of the Alps near Aschau, 10 km south of lake Chiemsee, indicated the existence of a third nursery colony.

Observations at this cave showed that *Rhinolophus hipposideros* used it as a day and a night roost regularly. The first individuals arrived at the cave shortly after sunset, indicating a nursery colony nearby. However, since the colony roost was not found by the control of potentially suitable buildings, the nature conservation authority of Upper Bavaria gave its permission to radio-track a female in order to find the nursery. As time and manpower were limited, the bat was tracked in the field during 4 nights only. However, the results show that the method is a useful tool for quickly locating roosts giving some initiate ideas about foraging habitats.

Study area and methods

On August 22nd 2000 a lactating female arriving at the cave entrance at 9:00 pm was captured in a mist net. A 0.4 g transmitter (Titley-Electronics, Australia) was glued between its shoulders using skin bond cement. The lifespan of the small battery was only about 10 days. The radio-tracking

equipment included two 5-element Yagi antennae and two Yupiteru MVT-7100 radio-receivers. The bat (weight 5.4g) was released at 11:00 pm and tracked by two teams of two persons each. The animal's position was located by cross bearings every 2-10 minutes and the bearings were synchronized using walkie-talkies . "Homing in" on the animal was tried, mainly in order to come as close as possible to the bat when it was resting. Observations lasted from dusk to dawn. The activity of the female was monitored during three nights (August 24/25th, 25/26th and 30/31st 2000). Only these nights were evaluated because in the first night, the foraging time obviously was shortened (return to the roost at 2 o'clock), probably because handling and fixing the transmitter had influenced the behaviour of the bat. A fluctuation in intensity and a change of direction of the received signal indicated a flying bat. The bat was assumed to be stationary when the signal was stable. The cross bearings were mapped on topographic maps (1:25.000) in order to show flight paths and foraging areas. A minimum convex polygon (Anderson 1982, Harris et al. 1990) was used to estimate the size of the foraging areas.

To evaluate the availability of potential foraging habitats we determined human land use patterns in a circle of 3.2 km around the colony. The results of the radio-tracking showed that the main foraging activity took place within this area. We calculated the percentage area of forests, settlements and grassland/fields from the topographic map and estimated the percentages of coniferous forests and mixed deciduous-coniferous forests present. Agricultural used areas covered about 30 % of the area, settlements (including roads, gardens and orchards) about 10 percent. The rest of the area (60 %) was covered by forests whereby the percentage of coniferous stands (*Picea abies* > 50 %) was estimated to be about 20 % of the circle of 3.2 km and the percentage area of deciduous or mixed forests (mainly *Fagus sylvatica* and *Picea abies*; in much lower numbers *Larix europaea, Acer pseudo-platanus*, *Abies alba* and *Fraxinus excelsior*) was estimated to be 40 %. In the open areas linear landscape elements such as hedges, tree lines and riparian vegetation were common in the surroundings of the settlements. North of Aschau large open areas (fields and meadows) exist in the valley of the river Prien. In the foraging areas the average diameter of tree trunks at breast height (dbh), the average distance between trees and the percentage area of ground covered by herbs or shrubs were estimated.

Results

Location of the nursery roost

When the bat was released at 11:00 pm it rested close to the cave for 15 minutes (probably on a tree). It was then located several times in the forested slopes north of the cave (see fig.1), crossed the valley near Aschau at an unknown place and was located again in the forest of the eastern slopes before it moved into the village of Aschau. At 2 o`clock it was found in an old building at a distance of 2,3 km from the cave. We had contact with the bat during 90% of the time between 11:00 pm and 2:00.

The next morning an inspection of the building, an old power station (altitude 630 m above sea level), showed 13-14 adult and juvenile *Rhinolophus hipposideros* roosting in the attic, proving that the main colony roost had been found. In the attics of two other old houses (distance to the nursery roost 30 m and 400 m) we observed 3-4 and 1 other individuals. Taken together with the four bats seen emerging from the cave in the evening of the same day (23th of August), the population consisted of 20 *R. hipposideros* at least. In 2001 up to 40 adult bats in total were counted simultaneously in the three buildings and the cave.

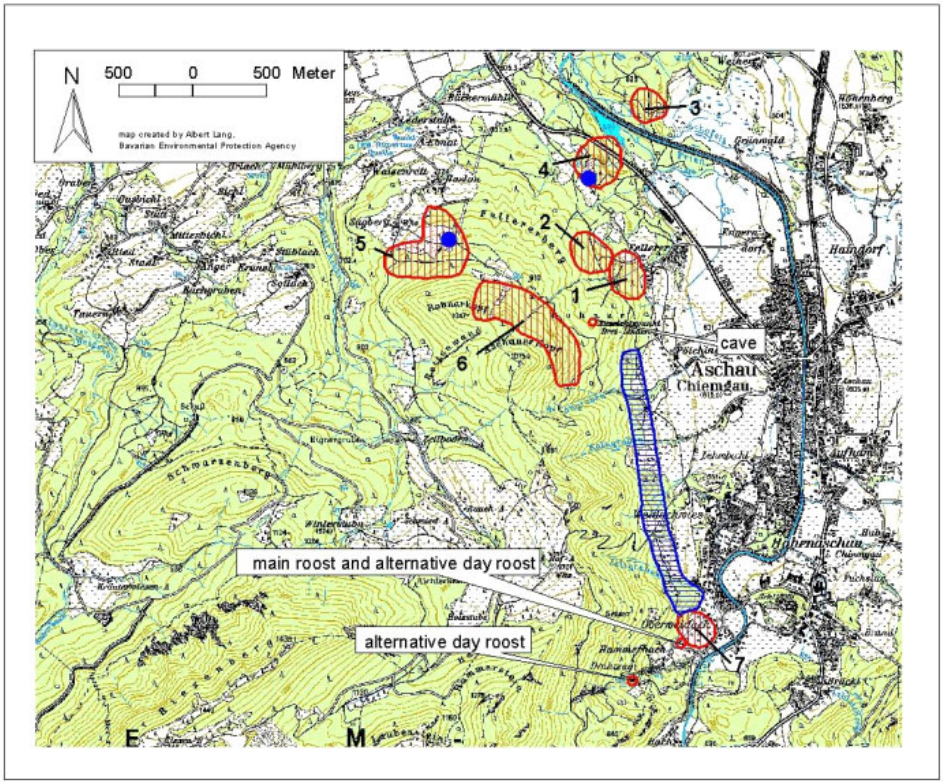

Fig. 1. Study area: blue marked area: flight path; red marked areas: foraging areas, blue dots : night roosts (tree, house); red dots : colony roost (house) and alternative roosts (house, cave). © Topographischen Karte 1:50 000, Nr. L 8338; authorisation for printing (Nr. 1722/02) obtained from „Bayerisches Landesvermessungsamt München".

Flight path and distances of foraging areas

During all three nights the bat used the same flight path from its roost to the foraging areas situated further north. The flight path was located on the western slope of the valley (fig. 1), but it was not possible to decide whether it flew within the forest or along the forest edge. Whilst moving along the flight path the female did not stop. The foraging areas were located at distances of 0.1, 1.9, 2.4, 2.6, 2.9, 3.3 and 3.6 km from the nursery roost (mean distance 2.4 km).

Foraging areas and night roosts

The female used seven foraging areas in three nights. Their size ranged from 3.6 to 18.2 ha (mean 8.4 ha) and they where located at altitudes between 600 and 1000 m above sea level. Six of them were mainly covered with mixed forests in which either *Fagus sylvatica* or *Picea abies* prevailed (fig. 2b).

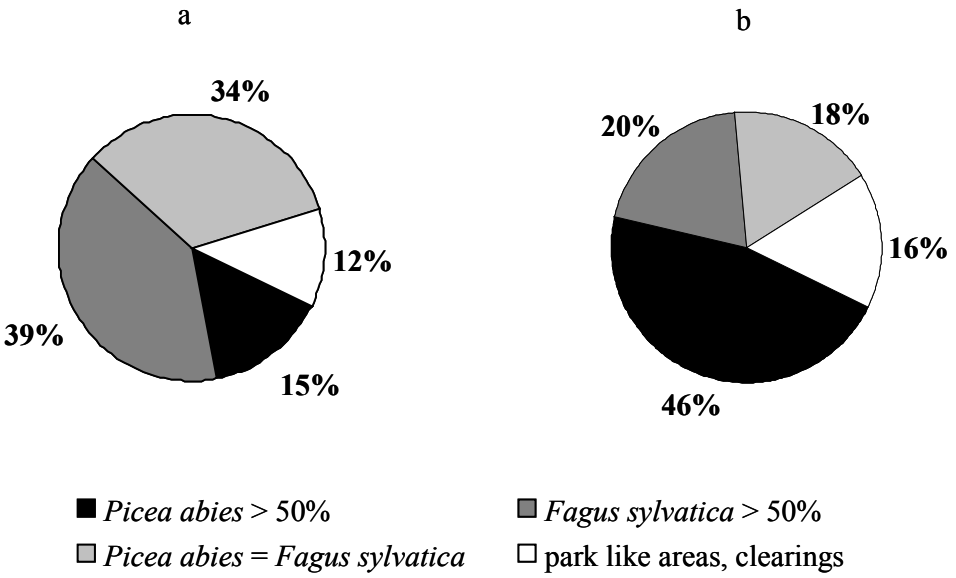

Fig. 2. Use of foraging habitats (a) and land use patterns of the foraging habitats (b). In 2a the percentage of the total foraging time spend in different habitats (forests of different tree compositions and open areas) is given. 2b shows the human land use patterns of the foraging areas (% of the total foraging area used by the bat).

The seventh area was located close to the colony roost in a park-like garden with old solitary *Fagus sylvatica* trees (dbh at least 100 cm). Five of the hunting grounds represented medium aged or mature forests with mean dbh of 35 cm (min: 25, max: 40) and an average distance between trees of 5 m (2 -10 m). Only one area consisted of young trees (dbh: 10-20 cm.). At four areas the ground was densely covered with herbs, young trees and shrubs (mean height 0,2-1,8 m) and in one case patches of bushes and small trees (up to 3 m high) existed additionally. In all areas there were wide spaces of at least 3 m between the ground cover or the open forest floor and the lowest branches of the trees. The two most intensively used areas included a small fen (area 4, fig. 3a) and parts of a pasture (area 5, fig. 3b), both with several groups of trees. The bat was located several times in and close to these habitats but we could not determine the time it foraged outside of the forest with certainty because of their small size. However, the percentage of the foraging time spent in these open habitats and in the park-like area 7 did not exceed 12 %. The most time was spend in habitats were *Fagus sylvatica* was the dominating tree species (fig. 2a).

Two night roosts were located: One roost was probably in a large, dense spruce tree (*Picea abies*), the other under the roof of a house.

Fig. 3a. Foraging habitat No. 4.

Fig. 3b. Foraging habitat No. 5.

Time budget
The bat left its roost in the attic at dusk and stayed outside until dawn (tab.1). During the night it spent several hours resting. In these periods foraging activity in a flycatcher-like style could not be excluded but the constancy of the signal and the location of the night roost do not support this assumption. In a rainy night (30.8.) the bat rested longer than in a dry night (24.8.) but was definitely also foraging during heavy rain. In the third night we did not record the signal for 70 minutes while the bat was probably foraging. This may have led to an overestimation of the resting period in relation to the foraging time.

Table 1. Foraging activity and number of foraging areas.

day	time spent out of the roost	flight activity (% of the time spend out of the roost)	number of foraging areas	comments
24.8.	536 min	70,8	7	
25.8.	417 min (observation gap excluded)	51,8	5	During a 70 min. observation gap the bat was probably also away from the roost
30.8.	536 min	58,7	2	rain

In two nights the bat frequently moved between foraging sites while in the third, rainy night activity was recorded only in the two areas around the night roosts. In some cases the foraging areas were visited several times during the same night. On 24th August for example, the bat came to area 4 three times for a total of 129 minutes, resting 48 % of this time.

Discussion

Location of the nursery roost
The location of the nursery roost within the first night of radio-tracking shows that in spite of the small range of the transmitter (max. 2 km , normally 300-500 m), the method is a useful tool for finding the roosts of this bat species. The same method was already used successfully some years ago by Hammer & Matt (1996) to locate the only colony of the Greater Horseshoe Bat (*Rhinolophus ferrum-equinum*) in Germany. Knowledge of colony sites is essential for the protection of attic dwelling bats. *Rhinolophus hipposideros,* for example, needs special requirements such as wide openings to fly through, which easily could be altered or closed during renovation of buildings (Weiner & Zahn 2000). In our case the detection of the colony site occurred just in time to preserve the roost since the renovation of the abandoned building will start soon.

Foraging areas
In spite of the small sample size, our results show that forests are probably a key foraging habitat in Bavaria which is also supported by results from the island Herreninsel (Kayikcioglu, in prep). Forests cover only 60 % of the surroundings of the roost but

about 90% of the foraging time was spent in this habitat type. Hedges, tree lines and streams which occurred near the foraging sites were never used. Recent studies conducted in Belgium (Motte & Libois 2002) and Switzerland (Bontadina at al., in prep.) support the assumption that forests are the main feeding grounds of *Rhinolophus hipposideros*.

The female foraged in all available forest types (semi-natural mountainous beech-spruce-fir- forests and more 'artificial' spruce dominated forests) except for dense riparian forest, which is a rare vegetation type in the area but does exist close to foraging areas 3 and 4.

However, the larger part of the foraging time was spent in forests with high proportions of deciduous trees (fig. 2).

Except in one area, the distance between the trees was rather large and in dense stands nearby no activity was recorded. In the one case of a comparatively dense stand of spruce, the bat may have foraged mainly in small forest gaps along a small stream. Motte & Libois (2002) assume that the density of the taller trees must be low enough to allow the development of an unterstorey of shrub and small coppice.

Some authors assume that linear landscape elements such as hedgerows and other structured features are of great importance for *R. hipposideros* (Biedermann 1997, Lutz & Mühletaler 1997). However, these habitat types may be used in less forested landscapes for orientation where the bats have to cross open fields in order to move between foraging sites (Motte & Libois 2002, Schofield 1996). In our study area the forest cover allows the bat to avoid open areas most of the time.

Our sample is too small to allow detailed conclusions in respect of foraging distances. The main foraging activity of the studied female took place within 3-4 km around the roost. Observations at the third Bavarian colony in the Alps near Kochel in 2000 showed that the distance to a regularly visited night roost in a cave can be as much as 7 km (Holzhaider 1998, Kriner & Holzhaider unpubl.), indicating the possible activity radius at night.

Consequences for conservation

Since mature forests in the surroundings of the roosts are important foraging habitats of *Rhinolophus hipposideros* and since these bats seem to avoid flights over large open areas (McAney & Fairley 1988, Biedermann 1994, Schofield 1996) some conclusions for the conservation of this species can be drawn:

- conservation efforts should be concentrated within a circuit of 4-7 km around the colony roosts
- within this area linear landscape elements that connect potential foraging areas have to be protected
- planting of hedges and tree lines could enable the bats to find isolated forest patches or other foraging habitats
- within the forest around the colonies, clearings should be small and patchy
- during reforestation large, deciduous tree species should be favoured and coniferous plantations (e.g. spruce) avoided.

Acknowledgements

We are particularly grateful to Dr. Les Williams who kindly read the manuscript.

References

Anderson, D.J. (1982): The home range: a new nonparametric estimation technique - Ecology 63:103-112.

Biedermann, M. (1994): Schutzmaßnahmen an einem Wochenstubenquartier der Kleinen Hufeisennase, (*Rhinolophus hipposideros* BECHSTEIN, 1800), in Thüringen. - Naturschutzreport 7(2), 392-394.

Biedermann, M. (1997): Das Artenhilfsprogramm Kleine Hufeisennase in Thüringen. - Arbeitskreis Fledermäuse Sachsen-Anhalt e.V.: Tagungsband "Zur Situation der Hufeisennasen in Europa", 27-32.

Hammer, M. & F. Matt (1996): Artenschutzkonzept für die Große Hufeisennase (*Rhinolophus ferrumequinum*, SCHREBER 1774) in Bayern.- Gutachten im Auftrag des Bayerischen Landesamtes für Umweltschutz, unveröff.

Holzhaider, J. (1998): Untersuchungen zur Fledermausfauna in den bayerischen Alpen. – Diplomarbeit Universität München.

Harris, S., Cresswell, W.J., Forde, P.G., Trewelle, W.J., Wollard, T. & S. Wray (1990): Home-range analysis using radio-tracking data: a review of problems and techniques as applied to the study of mammals - Mamm. Rev. 20: 97-123.

Lutz, M. & E. Mühletaler (1997): Schutzkonzept für die Kleine Hufeisennase *Rhinolophus hipposideros* in den östlichen Zentralalpen (Lugnez/Valsertal, Graubünden, Schweiz). - Tagungsband "Zur Situation der Hufeisennasen in Europa", 89-94.

McAney C.M. & J.S. Fairley (1988): Activity patterns of the lesser horseshoe bat *Rhinolophus hipposideros* at summer roosts - Journal of Zoology, London, 216: 325-338.

Motte, G & R. Libois: Conservation of the lesser horseshoe bat (*Rhinolophus hipposideros* Bechstein, 1800) in Belgium. A case study of feeding habitat requirements - Belg. J. Zool., 132 (1): 49-54.

Rudolph, B.-U. (1990): Frühere Bestandsdichte und heutige Bestandssituation der Kleinen Hufeisennase (*Rhinolophus hipposideros*) in Nordbayern.- Myotis 28: 101-108.

Schofield, H.W. (1996): The ecology and conservation biology of *Rhinolophus hipposideros*, the lesser horseshoe bat. - Ph.D. Thesis, University of Aberdeen

Weiner, P. & A. Zahn (2000): Roosting ecology, population development, emergence behaviour and diet of a colony of *R. hipposideros* (Chiroptera: Rhinolophidae) in Bavaria - 231-242. In: B.W. Woloszyn (Ed). Proceedings of the VIIIth EBRS Vol.1, Approaches to Biogeography and Ecology of Bats.

Zahn, A. & G. Schlapp (1997): Bestandsentwicklung und aktuelle Situation der Kleinen Hufeisennase (*Rhinolophus hipposideros*) in Bayern. - Tagungsband "Zur Situation der Hufeisennasen in Europa", 177-181.

Jennifer Holzhaider*, Eva Kriner*, Bernd-Ulrich Rudolph** und Andreas Zahn*

* Department Biologie II der Universität München, Luisenstr. 14, D-80333 München

**Bayerisches Landesamt für Umweltschutz, Bürgermeister-Ulrich-Straße 160, D-86179 Augsburg