



The use of day roosts and foraging grounds by Natterer's bats (*Myotis nattereri* Kuhl, 1818) from a colony in southern Germany

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Natterer's bat (*Myotis nattereri* Kuhl, 1818) occurs from SW-Europe and N-Africa through W-Asia (HORACEK and HANAK 1983). Little is known about its ecology, though fecal analysis indicates that prey is caught close to or from vegetation (GREGOR and BAUEROVA 1987; SHIEL et al. 1991; BECK 1991, 1995; TAAKE 1992; SWIFT 1997). In behavioral experiments Natterer's bat is capable of detecting arthropods close to vegetation by echolocation, using signals of broad band-width (SIEMERS and SCHNITZLER unpubl. data).

In the course of a field study on echolocation and foraging behavior, we fitted three *M. nattereri* with radiotransmitters in order to locate their hunting areas. Here we present data on activity pattern, home range, and hunting area. Additionally, data on use and types of day roosts are given.

The study was conducted in the vicinity of Mössingen, Baden-Württemberg, Germany on the foothills of the Swabian Alb (48°23'N, 9°01'E) from May through August 1996 (radiotracking between July 24th and August 15th). The study area is situated between 470 and 700 m above sea level and is characterized by fruit tree orchards, beech-dominated deciduous forests, and monocultures of spruce (*Picea abies*). Villages and roads lie interspersed.

A colony of *M. nattereri*, comprising 50–60 animals distributed over several day roosts, was studied. Three adult non-lactating females (animal A1 through A3) were fitted with crystal-pulsed transmitters (BD-2A and BD-2B supplied by Holohil Systems Ltd., Ontario, Canada) weighing 0.6–0.7 g (6–7 % of the animals' body weight). The bats were tracked using FT 290-receivers (Andreas Wagner Telemetrieanlagen, Cologne, Germany) connected with 5-element Yagi antennae. Whenever we had radio contact, bearings were taken at 5 min intervals. With two observers at hand, two bearings were taken at the same time from different locations and an animal's position was determined by triangulation using the computer-program Tracker (Camponotus AB, Solna, Sweden). Home ranges and core hunting areas were determined from fixes obtained by triangulation. The home range was defined as the smallest convex polygon comprising all fixes of an animal. The core convex polygon comprising 50 % of the fixes was considered as the core hunting area. Additionally, with only one observer at hand, we monitored the temporal use of the core hunting areas. We obtained telemetric data for animal A1 from 8 nights, for A2 from 6 nights, and for A3 from 3 nights. Radio contact was maintained for about 70 % of the time spent monitoring A1 and for approximately 80 % and 55 % for A2 and A3, respectively.

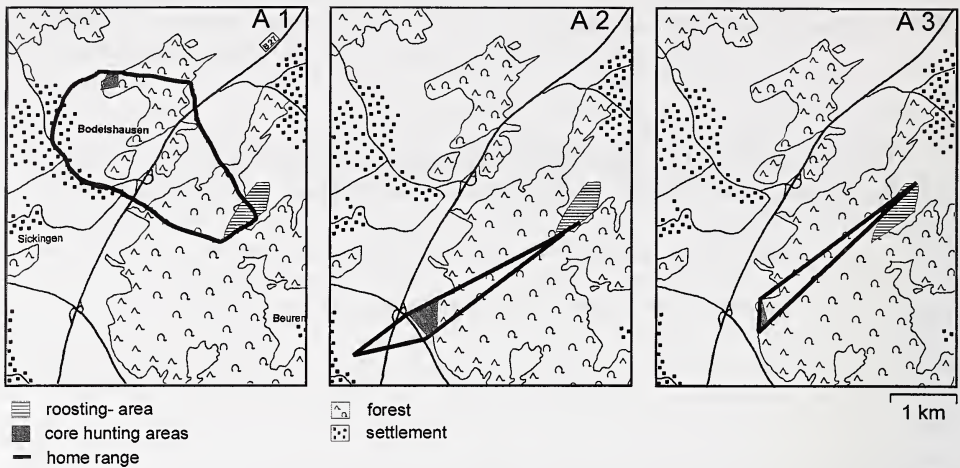


Fig. 1. Home ranges (minimum convex polygon containing all radio fixes) and core hunting areas (core convex polygon containing 50 % of fixes) of three adult female *Myotis nattereri* (A1, A2, A3). The roosting area encompasses 13 artificial and natural roosts used by the colony under study.

The colony under study roosted in bird nest boxes and artificial bat roosts, hung in the freestanding trees of an orchard belt. Between 3 and 30 individuals occupied a single roost at a time. By radio-telemetry we found a day roost in a hollow branch of a beech-tree (*Fagus sylvatica*) at 7 m height on the slope of a forested hill. During a hot period, animal A1 roosted therein for two consecutive days, on the second of which seven Natterer's bats were counted leaving the roost. We discovered a total of 13 day roosts within a minimum convex polygon of 24.3 ha; about 90 % of it being orchards and 10 % hilly mixed forest (Fig. 1). As established by inspection of roost sites, the colony changed roosts at least 12 times in 11 weeks (May 1st to July 23rd). On one occasion, we discovered about 20 Natterer's bats in an artificial bat roost together with a hornet queen (*Vespa crabro*) on its newly built nest.

The first bats emerged from a roost 31.6 ± 9.6 min (mean \pm standard deviation, $n = 24$) after local sunset and the last ones returned to the roost 39.6 ± 9.9 min ($n = 19$) before local sunrise, as monitored visually. Time between sunset and emergence and return and sunrise, respectively, remained fairly constant from May through August; thus the animals' active period was more than 1.5 h shorter in mid-summer than in spring and fall (Fig. 2).

The home ranges, determined from radio fixes, measured 523 ha in A1, 123 ha in A2, and 80 ha in A3 (Fig. 1). The home range of A2 would have extended to approx. 580 ha if we had included one night (7./8. August) during which we followed A2 without being able to triangulate. Core hunting areas within those home ranges covered 2.8 ha for A1 and 18.6 ha for A2. Due to a lack of sufficient fixes for A3, we could not determine the size but only the rough position of the bat's core hunting area (Fig. 1). The bats' presence in their core hunting area could be confirmed on each of 9 nights of inspection with only one observer at hand. Out of a total of 24 h 15 min of tracking-time between 22:45 pm and 4:48 am across those 9 nights, individuals were present on average 56.6 % of the time in their core hunting area (A1: 86.2 %, A2: 46.8 %, A3: 51.2 %).

Centers of the core hunting areas were located at a distance of 3.1 ± 0.3 km ($n = 3$) from the roosting area. The animals were found up to a distance of 3.7 ± 0.7 km ($n = 3$) from the roosting area. With the exception of the immediate surroundings of the roosting area, the home range of A1 did not overlap with those of A2 and A3, whereas all fixes

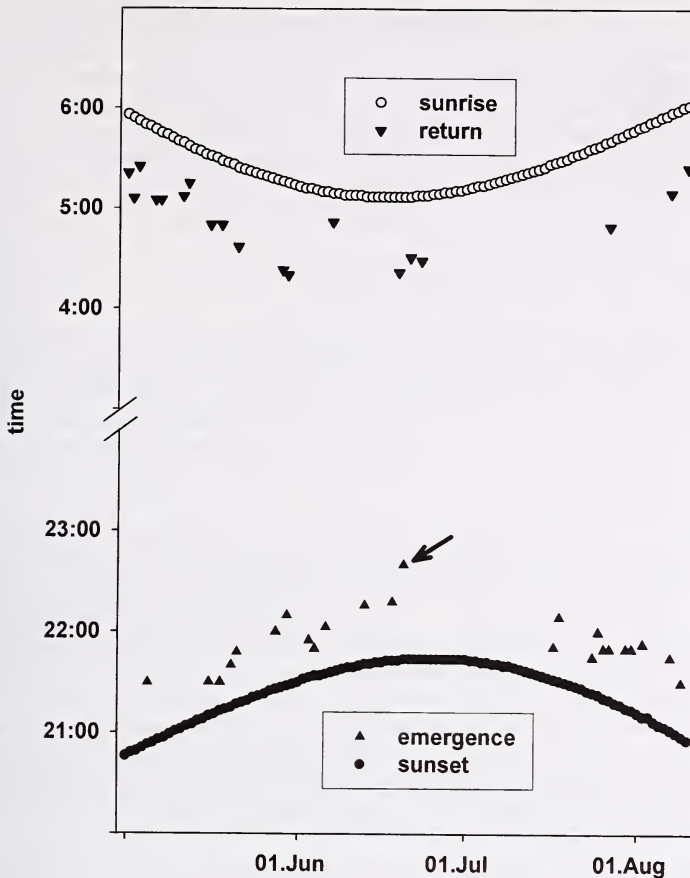


Fig. 2. Emergence of first ($n = 24$) and return of last ($n = 19$) *Myotis nattereri* in comparison with local sunset and sunrise between May 1st and September 10th 1996. On June 20th, the animals delayed emergence about 25 min, waiting for a bout of heavy rain to pass (arrow). Note break in time axis.

obtained for A3 lay within the home range of A2 (Fig. 1). In 3 nights we recorded the simultaneous presence of A1 and A2 in the same area. The core hunting areas of A1 and A2 were 3.9 km apart; those of A2 and A3 were adjacent.

The core hunting area of A1 comprised mixed deciduous forest, a monoculture of coniferous forest (*P. abies*), an area that had been deforested by a storm and recently replanted with oak (*Quercus* spp.) and margins of pasture; hence, an area rich in edge structures. The hunting areas of A2 and A3 were situated at the edge of a coniferous forest (*P. abies*) and included a fresh clearing and orchards with trees planted at distances between 10 and 30 m apart.

We conclude that animals were continuously on the wing, as signal direction kept changing most of the time. On one occasion only, it remained constant for 75 min while it was raining heavily, and the animal presumably hung in a sheltered place within a coniferous forest.

We first detected the animals in the core hunting area 84.3 ± 25.8 min ($n = 9$) after they had left the roost in the evening. When the bats were heading back from the hunting areas to the roosts in the morning they covered the distance with 5.7 ± 0.2 km/h

(mean \pm sd, $n = 3$). From photographs under stroboscopic illumination, the flight speed of *M. nattereri* was determined to be 15.5 ± 3.2 km/h ($n = 10$). Thus the animals could have reached their roosting areas nearly three times faster than they actually did. We conclude that the animals were hunting on their way to and from the core hunting area.

Our findings confirm that the activity period of *M. nattereri* depends on sunset and sunrise, and thus on light intensity, as well as on weather conditions (see ENGLÄNDER and LAUFENS 1968; LAUFENS 1973; SWIFT 1997).

We found that Natterer's bats used individual core hunting areas at least during the study period; i.e. they showed site-fidelity. The existence of core hunting areas visited night after night is also reported for other European bat species, e.g. *Myotis myotis* (AUDET 1990), *Myotis emarginatus* (KRULL et al. 1991), and *Myotis daubentonii* (ARNOLD pers. comm.). By fidelity to individual, exclusive hunting grounds the bats could avoid intraspecific competition for resources (e.g. VON HELVERSEN 1989). From our data we cannot answer the question as to what degree core hunting areas overlap, but the simultaneous presence of A2 and A3 in the same area might indicate that some overlap occurs. Another advantage of small and hence well known core hunting areas could be that the bats establish a detailed cognitive map, improving orientation in space and the repeated use of rewarding feeding sites.

Concerning the habitat type used by *M. nattereri*, it is striking that coniferous forest was present in all of the three determined core hunting areas, whereas the study area is dominated by mixed deciduous forest. Extensive orchards were present in two of the core hunting areas. All core hunting areas were rich in horizontal and vertical edges. The hypothesis that *M. nattereri* hunts close to edges of vegetation is supported indirectly by fecal analysis (GREGOR and BAUEROVA 1987; SHIEL et al. 1991; BECK 1991, 1995; TAAKE 1992; SWIFT 1997), predictions from wing morphometry (NORBERG 1981) as well as behavioral experiments on detection ability (SIEMERS and SCHNITZLER unpubl. data) and directly by visual observation in the field (ARLETTAZ 1996; SWIFT 1997; SIEMERS and SCHNITZLER unpubl. data). The data presented here do not conflict with this view of *M. nattereri*'s foraging ecology, but the spatial resolution of telemetry is too coarse for explicit confirmation.

In our study we found a distance between roosting area and core hunting areas of about 3 km for *M. nattereri*. *Myotis blythii*, *M. daubentonii*, and *M. myotis* travel about 4 km, 6–8 km, about 9 km and even up to 25 km between roosting and core hunting areas, respectively (AUDET 1990; ARLETTAZ 1995; ARNOLD pers. comm.). From these considerable distances it may be concluded that intraspecific competition forces individuals to hunt at some distance from roosts (VON HELVERSEN 1989), or that core hunting and roosting areas are chosen according to different criteria. Hunting grounds should yield abundant and accessible prey, while roosting areas should provide roosts protecting the bats from predators, providing a favorable micro-climate (LEWIS 1995) and enough space for conspecifics, especially in nursing colonies. The roosting area of the colony under study is characterized by a high density of bird nest boxes and artificial bat roosts, most of which are well exposed to the sun in spring, when the crowns of the free-standing fruit trees are still leafless. We presume that the abundance of possible roosts and their warm temperature compared to hollow trees in the middle of a forest make the roosting area favorable. The localization of one day roost within a forest neighboring the orchard during a hot period had led us to speculate whether the bats might choose roosts in the cooler forest during hot summer days. The Natterer's bats changed roosts often and are, according to LEWIS (1995), to be categorized as low roost-fidelity species. As the bats changed frequently from one roost to another in the immediate vicinity, climatic differences are unlikely to play a major role and we consider the avoidance of parasites to be an important factor for those changes (e.g., LAUFENS 1973; LEWIS 1995).

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