NOTES ON THE DISTRIBUTION AND BEHAVIOUR OF THE NOCTULE BAT (*NYCTALUS NOCTULA*) IN THE NETHERLANDS

by

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Plusieurs colonies de noctules, connues avant la guerre, ont disparu du fait de la destruction de leurs refuges. De nouvelles colonies ont été découvertes. Aux Pays-Bas les noctules gîtent dans des trous d'arbres faits par les pics et agrandis par les insectes. Les boîtes à chauves-souris ne sont guère fréquentées jusqu'ici. Les gîtes varient journellement. Hypothèses sur les facultés de reconnaissance topographique. Étude des modalités de reproduction et des gîtes d'hiver : arbres exclusivement.

INTRODUCTION

Contrary to the other species of Dutch bats which mainly spend the summer in lofts and attics and hibernate in cellars and caves, the noctule is found exclusively in tree cavities — in the Netherlands at least. In central Europe however, it has been reported to hibernate in buildings (Eisentraut, 1936 ; Löhrl, 1936 ; Mislin, 1942 ; Skreb et Dulić, 1955), but also in tree hollows (Ryberg, 1947 ; Hanak c. s., 1962 ; Kepka, 1962).

Owing to its secluded way of life, it is difficult to give a reliable estimate of the noctule's population density in the Netherlands. An inquiry into the presence and numbers of this chiropteran by Van Wijngaarden & Schuilenburg (1958) did not have appreciable results.

As the noctules have a strong social tendency, they are more often found in smaller or larger groups which use to roost alternately in a number of tree cavities in a certain, more or less wooded area and to which we will refer as « colonies » in this paper.

Banded bats have shown to be true to their colony, though incidental « desertion » to other colonies may occur.

In spring and early summer, the females tend to congregate in big parties, usually referred to as « nurseries », « nursing colonies » or « maternities », where the young are born and which may comprise up to 400 individuals in a single tree cavity.

The males at that time are probably living in small communities which are hard to find. In the fall when the young have grown up, the animals scatter in much smaller groups, where the adults of both sexes meet and mating takes place, while the young make up small communities of their own. During hibernation more numerous groups of both sexes are built up again.

When Bels (1952) started his bat banding scheme in 1937, a number of colonies existed in the Netherlands (Haarlem, Bloemendaal, Heemstede, Vijfhuizen, The Hague, Rotterdam and Soestdijk) cf. fig. 1. The hollow trees, which were inhabited by the bats, were cut down during the war or shortly afterwards and the colonies disappeared completely.

Recent colonies

In 1952 bat research was taken over by the authors and they started « colony-hunting » again. Banding was resumed in order to establish the problem of hibernation which was left unsolved by Bels' investigations. Only a small number of colonies could be located, the search for hiding places being hampered by the secretive way of life of these animals : Groenekan-Bilthoven ; Velzerbeek ; Heeswijk ; Ede ; Doorn ; Bunnik ; Naarden ; Beetsterzwaag and Oisterwijk (cf. fig. 1).

The Groenekan-Bilthoven colony was discovered in an oaktree cavity near the village Groenekan. In 1956 noctules were found to roost in a number of tree cavities near the village Bilthoven at about 5 km. from the former site. At first, we considered these bats to belong to another colony, Recoveries of banded bats from Groenekan proved that the two groups made up one large colony, alternately inhabiting one or more of about 15 tree cavities within a radius of approx. 5 km.

From 1952 to 1957, incidental banding took place in this colony at irregular intervals, whenever squeaks from the tree cavity indicated that considerable numbers of bats were present. In 1955 no

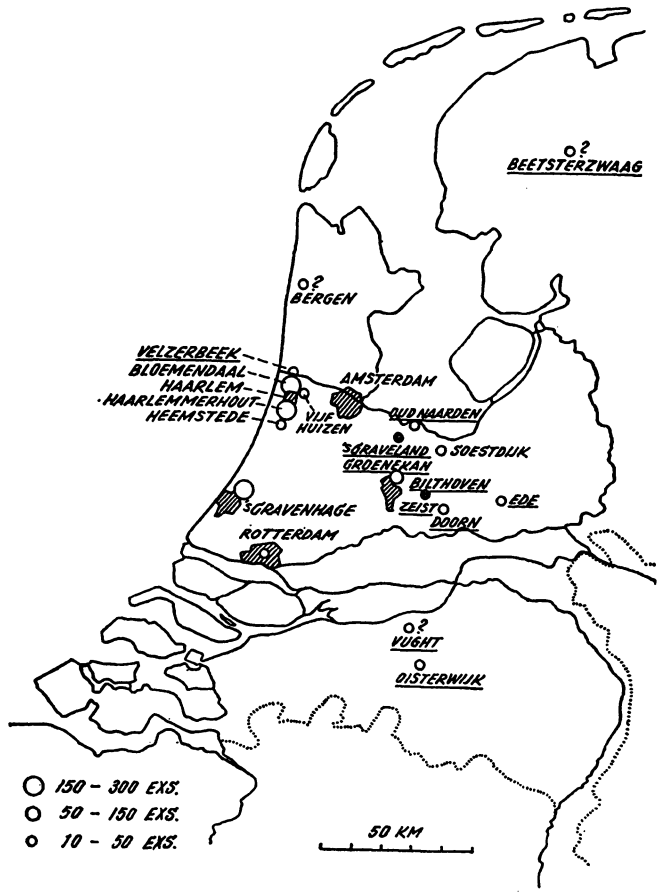

Fig. 1. — Distribution of the noctule in the Netherlands.
Name of locality not underlined : Colony has disappeared since 1946.
Name of locality underlined : Colony has been discovered since 1952.
(•) 's Graveland and Zeist : Hibernating colony.
? : Size of colony not known.

banding took place as the colony was not checked at all. As banding practice disturbed the normal behaviour of the noctules (in neither case did the bats return to the original roost for a consi-

derable period of time after our banding activities), we stopped banding in 1958 and started counting the animals when they left their hiding place at dusk. In this way, the bats were not disturbed and the normal processes of breeding and raising offspring could be studied. This was done in three years in succession, after which banding was resumed (in 1961) by another method : the bats were collected only once after the young had begun to fly.

The numbers of bats found in or leaving the tree cavities in the Groenekan-Bilthoven area do vary considerably.

In 1953 a small colony (23 exs) was reported to us from Velserbeek, in the vicinity of Haarlem. This may be the remainders of big colonies which Bels (1952) studied in this region from 1937 to 1946.

A hollow beech was cut down near Heeswijk Castle in 1956 and 16 Noctules were sent to Utrecht where they were banded and released.

Near Ede, on the Kernhem Estate, we discovered a fairly numerous colony in the fall of 1958. The bats were hiding in 14 trees alternately (6 oak, 7 beech and 1 maple).

In the same year another colony was found, inhabiting a double walled chimney of a small country hotel in the woods near the village Doorn. No observations were made then, but next year 36 bats were seen leaving the chimney wall by a narrow fissure where mortar had fallen out between two bricks. Unfortunately, next year the chimney was rebuilt and the bats disappeared.

A third colony was discovered in 1958 in a tree cavity on the estate « Oud-Amelisweerd » near Bunnik. Eight noctules were caught and banded.

A naturalist showed us a colony of bats in the woods near Naarden-Huizen in 1961, where we collected 14 noctules from 2 trees. Next year, however 31 exs were observed, leaving another tree in the neighbourhood.

In the same year (1961) a small colony of 7 animals was reported to us in the vicinity of Oisterwijk. Four of them were pregnant females. One of them had been banded previously in the Groenekan-Bilthoven colony at a distance of 60 km.

Selection of hiding places

The noctules are roosting mainly in tree cavities originally made by woodpeckers, though cavities, developed from decay which starts near the junction of a limb and the main tree trunk are also likely to be used. In our opinion, however, the former are preferred.

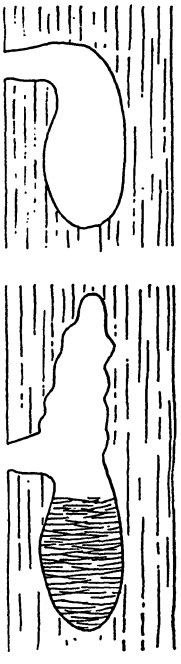

Fig. 2. — Top : Nesting hole made by a woodpecker. Bottom : Enlargement of the hole by decay and wood destroying insects.

The woodpeckers (probably *Picus viridis* and *Dendrocopus major,* although no certain data are available, as the cavities only get inhabited by bats a long time after the original residents have left), when cutting a nesting site in a tree trunk, always do so in a downward direction (cf. fig. 2, top). After this cavity has been left by the bird, it is usually first occupied by another hole-nesting bird species e. g. starlings (*Sturnus vulgaris*) or tits (*Parus* spec.). Gradually the hole fills up with nesting debris, but it is extended upward by decay and the activity of wood-destroying beetles (cf. fig. 2, bottom). When this has happened, the cavity is then suitable for the noctules, as they prefer to climb upward and hang from the wall, while birds are more likely to move downward to build their nest. The nestbuilding in the meantime has filled up the tree cavity and it has become more or less unfit for birds. Nevertheless bats are often disturbed by starlings, as in trees with a large interior space, these birds may build a nest on a level well above the entrance hole (van Heerdt & Sluiter, 1958).

Unfortunately, when a tree has become fit as a bat roost, it will usually be cut down, having lost its value from the foresters' point of view. In order to overcome the shortage of suitable roosts for the noctules, bat boxes have been installed in certain woods (Issel & Issel, 1955). According to these authors, however, they are often first occupied three years after they have been fitted to the trees (also Krzanowski, 1959).

Thus far, about 300 bat boxes have been placed in the Nether-

lands since 1959, but as far as we know no colony of the noctule has been established in any of them.

Behaviour in the summer quarters

Behaviour of the noctules has been studied during the last 10 years in the Groenekan-Bilthoven summer quarters. In 1958-1960 this study was intensified and no banding took place in order to not disturb the normal course of events (cf. p. 466).

Instead we began a regular inspection of the summer roosts, visiting the trees in which the bats resided, at least once a week. In order to facilitate our notetaking, each single tree has been registered. After a preliminary check during the afternoon when we were guided by the shrill squeaks of the bats, counting took place as the bats left their roost at dusk. This method provides no difficulties as the noctule starts its flight about 20 min. after sunset and there is still enough light to allow reliable counts to be made.

It has been stated by Ryberg (1947, p. 75), Bels (1952, p. 40) and Löhrl (1955, p. 104), that summer quarters even if they have not been disturbed, often change from one tree to another, doing so without any obvious reasons. These activities make investigations tedious, as much time must be spent in relocating the new roost. In the Groenekan-Bilthoven colony, however, the major part of the noctules' roosts became known to us, although a small number has not been located.

A number of trees which were regularly inhabited at the beginning of our observations period went out of use in the course of time, while other trees which were not visited at first became frequently used later on.

The time of emergence from the tree cavity usually is at 20-30 minutes after sunset. A heavy overcast may advance the moment of departure, but when the weather is fine and clear, the time of emergence may be later. Cold, rainy weather also tends to delay the evening flight.

The piercing squeaks which are emitted by the colony throughout the day at irregular intervals, tend to become more frequent about an hour before sunset and often ring continuously just

before the bats emerge (Bels, 1952). On hot afternoons also a fair amount of noise may be made by the animals.

To start the evening flight, one or two « scouts » leave the tree cavity and after 5-10 minutes the main body flies out, usually within 10-20 minutes. After the young have been born, this behaviour is liable to be changed to a certain extent :

The bats no longer leave the roost in a continuous stream, but in small bursts of 3-6 individuals. Thus, it often takes an hour or more before the main body has left the tree, while a small number of « baby-sitters » may stay behind inside the cavity. Later on, when the young have begun to fly, the picture becomes still more complicated, because they make short practising flights around the tree. Countings of the numbers of emerging bats at this moment become difficult and unreliable.

Another feature is the ever changing number of bats leaving their hiding places to hunt for food. This may be attributed to two causes : 1) Only part of the inhabitants of a roost leave the hollow tree on any one evening (cf. Burton, 1958, who stated this fact for *Eptesicus*). The weather conditions and the success of insect hunting on the previous night may possibly supply an explanation for this feature. 2) A number of bat roosts believed to be used by this particular colony, is still unknown to us and the missing bats may hide in these places.

The location of roosts

Location of a suitable hiding place is far easier for other mammals and birds that can see a cavity entrance from a certain distance, than it is for bats which merely are « listening in the dark » for the faint echoes of their ultrasonic pulses of sound. Without doubt, light waves allow for a more detailed information about the surroundings than even the most refined ultrasonic orientation sounds, such as used by all bats which engage in echolocation.

Therefore, we have to presume in these chiropterans a keen knowledge of environmental topography involving a highly specialized memory which is indicated by Griffin and Rawson in their study of an *Eptesicus fuscus* (Griffin, 1958, p. 163 ssq.). The young bats, in the course of their adolescence, probably learn the tradi-

tional hiding places of their nursing community by following the adults around and by exploratory flights of their own.

The strong social tendency in bats makes it possible for a large number of individuals to live in the restricted number of bat roosts offered by any particular territory.

Although a fairly large number of tree cavities may be found even in the well tended Dutch woods, generally only a few seem to suit the demands of the noctules, which are, as a matter of fact, difficult to understand from a human point of view.

The frequent changing of roosts of the nursing colonies may add to the chances of survival of the species.

The considerations mentioned above may explain, why tree cavities which have become unused in the course of time, are not likely to be reoccupied, simply because the knowledge of their existence has been lost to the members of the colony. Reasoning along this line, establishing of new roosts seems difficult and explains the poor success of bat boxes.

It is possible that new roost locations are started by solitary males or by small male colonies who in turn may attract females in the mating season and thus the location becomes known to them as a suitable place for a maternity. The solitary males would have a kind of pioneering function. Although these considerations are speculative, it is a matter of fact that, of the 28 bat boxes which we are supervising, the only two which were inhabited by noctules last year, were occupied by solitary males.

Behaviour during the fall

The noctules' mating season starts early in September and continues throughout the winter months. In September and October, however, sexual activity is highest.

Small mating groups are then established by males and females which usually consist of one or more males and a number of females (Bels, 1952).

As a rule, the mating groups are not established in the same tree as the summer roosts, though exceptions have been noted. During the same period, the juveniles make up small groups of their own.

WINTER ROOSTS AND MIGRATION

Bels (1952) experienced some difficulty in understanding the behaviour of Dutch noctules during the hibernation period.

In one instance, 15 bats were recovered from southern locations, mostly from Belgium, but 3 were recaptured much further south, in the vicinity of Paris ; in contrast to the preceding recoveries, 3 hibernating groups were found in trees near Haarlem : 22-XII-1936 (24 ♂♂, 10 ♀♀) ; 29-XII-1937 (same tree, 3 ♂♂, 2 ♀♀) ; 1-I-1939 (12 ♂♂, 9 ♀♀).

Checking the correspondence on the Belgian recoveries, it appeared that in only two cases hibernation quarters were recorded : Kruisbeke, 25-XI-1939 (25 ind. in one tree) and Antwerp, 16-III-1944 (approx. 100 ind. in one tree). The other data all concerned solitary dead or dying individuals, probably stray animals which were affected by exposition, weakness or otherwise.

Central- and East European noctules seem to exhibit a different behaviour. In four places, noctules were found hibernating in holes and fissures in the walls of buildings. Löhrl (1936) records a hibernating group in a hole near the roof of the « Alte Akademie » in Munich (Germany). Meise (1959) banded about 900 noctules, hibernating in a loft in a church in the centre of Dresden (Germany), from 1926 until 1939 (cf. also Eisentraut, 1936 ; Roer, 1960). Mislin (1942) published an account on noctules (250 ind.), hibernating inside the « Bishop's Court » near the Basle Cathedral (Switzerland), in a fissure at the height of about 5 metres. Skreb & Djulié (1955) observed a winter roost of about 500 noctules in the storage place for rolled shutters in the Microbiological Institute at Zagreb (Yougoslavia) which is situated near a forest. Noctules were, however, never reported from caves or other subterranean hiding places.

In the Netherlands, there are no known cases of noctules, hibernating in buildings. This difference in behaviour may be explained by the severe winters prevailing in more continental regions.

The banding activities of Bels and Meise show a remarkable difference : Bels banded noctules in their summer quarters, but he got more often isolated recoveries of dead or dying animals, only two cases concerned real hibernating groups. Meise (1959), however, banded exclusively noctules in their hibernating quarters

and received recoveries during the summer. Only in one case out of 8 the bat had been found with a number of other bats in a tree cavity.

These facts, combined with the small number of recoveries makes the assumption of a true migration of the noctule speculative, though we recognize the possibility of a migratory behaviour in the central European populations.

Though Bels banded only during the summer and Meise during the winter, their recoveries show a certain conformity : they both suggest a migration route from summer to winter quarters and vice-versa. A critical consideration of the results, however, reveals that the population of the summer-resp. winter quarters has rather been scattered about the surrounding area. To our opinion, the recovered bats have been scared by the banding proces and must be considered as straglers and not as regular migrants.

A continued banding practise may give a better insight into these migration and hibernation problems : only when a number of bats that has been banded in a certain winter (or summer) roost, has been recovered in a summer (or winter) quarter for a number of years, a true migration may be spoken of.

The noctules summer quarters in the big forests of continental Europe will be hard to find. This may be the explanation of the remarkable contrast that summer roosts have been found mainly in the Netherlands, whereas winter quarters are more often known from continental regions : the small woods in the Netherlands may be searched more easily, as shrill squeaks give away the roost even at day time. During hibernation, however, no sound betrayes the bat's presence and their winter quarters only become known when the tree is felled. In continental regions, situation is reversed : it is hard to locate the summer quarters in the extensive forests, but winter roosts in buildings are more readily found.

During our research period which started in 1952, we found two hibernating quarters of the noctule. In 1962, a naturalist reported that a partly decayed giant beech on the country estate « Schapenburg » near's-Gravenland (cf. fig. 1) was blown over by a gale. According to a forester about 100 noctules were found inside the tree cavity. They were left lying on the grass, but had disappeared the next day. A closer investigation after a fortnight revealed, amid a decayed mass of wood, 14 noctules, 12 of which were dead

and 2 which were still alive (!). One of the dead animals wore a ring which had been applied by us in the Naarden colony in the fall of 1961 (cf. p. 466).

During the long and severe winter of 1963 a hollow beech was cut down near the village Zeist (cf. fig. 1). In the cavity which had the size of about 30 × 70 cm., a dense cluster of 152 hibernating noctules was found (85 ♂♂, 64 ♀♀, 2 escaped, one killed). Two of them proved to be banded, one in the Groenekan-Bilthoven area (cf. p. 466) the other near Bunnik (cf. p. 466). The bats were partly kept in the laboratory garden, partly used for temperature observations. In spring they were banded and released.

In December 1963 two noctules, banded in the Groenekan-Bilthoven area, were recovered, one in a fissure in a wall of the Chateau of Fontainebleau with 20 unbanded specimens (500 km), the other in a tree cavity near St.-Martin-du-Bois, a village 30 km NE of Bordeaux (800 km).

After all, the noctule's hibernation problem has not been solved. Like Bels (1952), we have found on the one hand hibernating groups of bats in tree hollows in the Netherlands, on the other, banded bats have been recovered hibernating far away in France !

Characteristics of the hibernating quarters

It may be stated that bats, hibernating in tree cavities or in clefts and fissures on the outside of buildings are at a certain disadvantage to those species which spend the cold season in caves and caverns, where the temperature as a rule does not drop below freezing point and where they are thus protected against the risks of a spell of severe cold.

According to Mislin (1942), the critical body temperature (measured externally) which a noctule can stand, is about —4 to —5°C. This author regularly studied a hibernating colony in the Basle Cathedral (cf. p. 471) and noted that the body temperature of the bats rose, when outside temperature dropped below —4 to —5°C. Thus, outside temperatures as low as —17°C could be resisted without evident harm.

In order to investigate the insulating effect of a hollow tree, a series of preliminary observations were carried out with part of the trunk of a hollow oak which was fitted with 3 thermometers,

placed in holes drilled through the wood — the sensing elements of the instruments protruded into the tree cavity (Sluiter & van Heerdt, 1961). As could be expected, the insulating capacity proved to be poor, but the results showed changes of the outside temperature to be buffered to a certain extent. The temperature extremes were less divergent inside the tree cavity as compared with those outside, the oscillations being more or less subdued (cf. fig. 3 & 4).

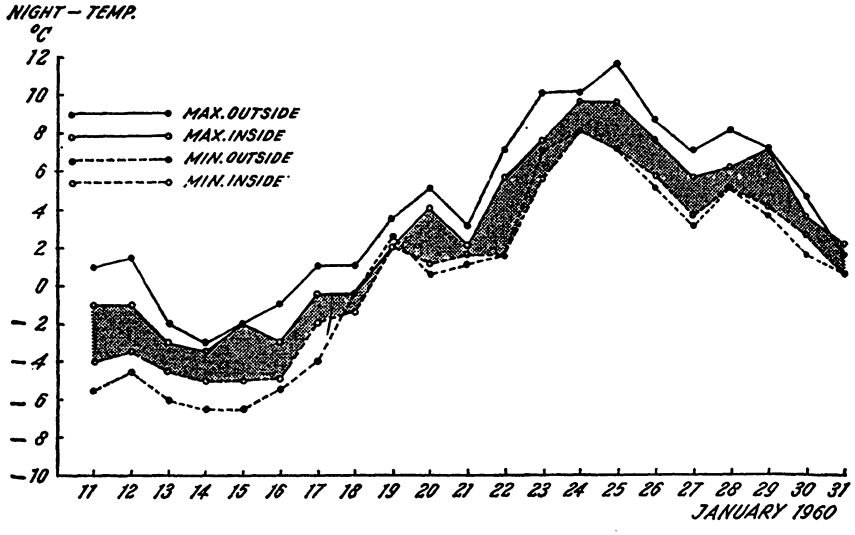

Fig. 3. — Maximal and minimal temperatures measured in and outside a tree cavity in January 1960.

These characteristics of the tree cavity may have a protecting value for the noctule. Though the results of the Mislin's observations, which have been confirmed in experiments of our own (not published) show that noctules do not require special features concerning the insulating properties of the winter roost. We suppose that they may prefer a big tree, with a small cavity and a thick wall (cf. p. 472) to a tree with a big hole and a thin wall. Nevertheless, these bats require more hardiness against low temperature than those species which hibernate in caves and cellars. It is evident, however, that below-zero temperatures, especially of long duration may have a detrimental influence on the hibernating noctules. Casualities during spells of severe cold have been reported by Ryberg (1947), Meise (1951), and Löhrl (1961).

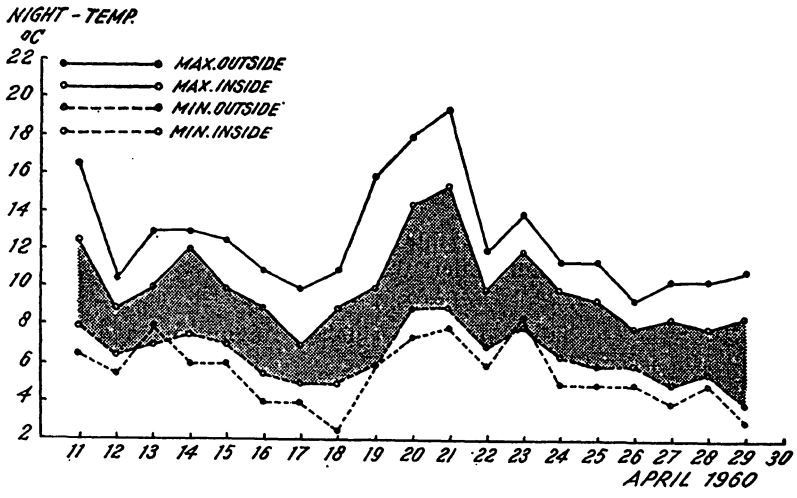

Fig. 4. — Maximal and minimal temperatures measured in and outside a tree cavity in April 1960.

SUMMARY

Several colonies of the noctule, reported before the war, disappeared, because their hiding places were destroyed.

New colonies were recently discovered at Groenekan-Bilthoven, Velserbeek, Heeswijk, Ede, Doorn, Naarden, and Oisterwijk.

In the Netherlands, noctules have always been found roosting in trees, in holes, made by woodpeckers. The type of cavity preferred by the noctule, comes into being after a number of years when decay and wood destroying insects have enlarged the cavity upward. The success of bat boxes has been poor to date.

Banding activities were suspended, but regular counts of emerging bats were made instead, to study the behaviour of an undisturbed nursery. The results show that noctules frequently change trees, even when left alone and that the number of emerging bats may vary considerably from day to day.

Location of suitable roosts is supposed to be more tedious for bats than for other mammals or birds. A specialized memory for topographic details must be assumed. The young are supposed to follow the adults to the traditional hiding places of their nursing community.

In the fall, males and females form small mating groups which consist of one or more males with a changing number of females. These groups are usually not established in the trees which serve as nurseries.

In the Netherlands, winter roosts have thus far been found only in trees, in contrast to more continental regions, where fairly large hibernating groups have been found in buildings. This may be explained by the cold winters prevailing in those regions.

A directional migration must be dismissed until further notice, owing to the absence of reliable data.

The insulating capacity of a tree trunk with a fairly large cavity proved to be poor.

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