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Automatic registration of bat activity through the year at Mønsted Limestone Mine, Denmark

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Abstract

Bat activity was recorded automatically the year round with a double light barrier at the exit of the mine. The method yields quantitative data without interference on the natural behaviour of the bats. Four periods are defined: 1) Hibernation period (November–late March), with very low activity. 2) Departure period (late March–mid May), with a marked peak in April, and a second small period of departure in the first half of May, representing the departure of *Myotis brandtii.* 3) Summer activity period (mid May–mid June), when a large number of *M. daubentoni* males use the mine as some sort of transitional roost. 4) Arrival period (late July–November), consisting of two periods with a gradual transition: End of July through August with a balance between in- and outflights, and September–November with a net flux into the mine indicating the start of hibernation. The species could not be separated, but this was a minor drawback as the gross number and behaviour of the different species was known in outline, studied by other methods. 80–90% are *M. daubentoni.*

Introduction

Mønsted Limestone Mine in Jutland, Denmark, is used for hibernation by 4,000–6,000 bats. Five species are found: *Myotis daubentoni* 3,500–5,000 (Baagøe et al. 1988), *M. dasycneme* 500–1,000 (Nielsen et al. 1995), *M. brandtii* 100–200 (Degn 1989), *M. nattereri* 50–100, and a few individuals of *Plecotus auritus.*

This makes Mønsted Limestone Mine one of the largest and most important hibernation sites in Northern Europe, and detailed knowledge of how and when the bats use the mine is important for conservation and management purposes. The aim of the present study was to present a year round picture of the bat activity.

Traditional counts of hibernating bats always include the risk that bats are disturbed (Stebbings 1988). Besides, in Mønsted Limestone Mine counts are impossible because most of the bats hide away (Baagøe et al. 1988). Catches at the entrance definitely cause great disturbance. Therefore the use of automatic registration is a good solution and has been used in a number of studies (Thomas and Laval 1988). One drawback is that species identification is not possible. But in the present study this was considered a minor problem because our main goal was to get an overall impression of the activity, and because the species composition and the gross number of each species was already known.

Materials and methods

Mønsted Limestone Mine consists of several kilometers of galleries of varying dimensions. The only permanent entrance to the mine for bats is through a hole in a wooden gate (for details see Baagøe et al. 1988).

Bat movements through the hole (25×28 cm) in the gate were recorded. The recording system covered the flight route so that a passing bat interrupted two arrays of infra-red beams 25 cm apart. Each array consisted of 8 infra-red light emittors (diodes) and 8 receivers (phototransistors). The light was chopped with a frequency of 1 kHz to minimize influence of ambient light-levels. A pass was recorded when the two arrays were interrupted within a minimum and maximum time calculated to fit the distance between the arrays and the flight speed of the bats.

The system was set up on 13. December 1977, and registration ended on 5. July 1982. Reliable data were sampled for 900 nights, which is 55% of the time. Non-function periods were due to unstable mains supply, light beams blocked by insect pupae, condensed water on the emittors, and break-down of electronic components.

For the first three years data were recorded on waxed paper on a Miniscript-Z event recorder. The last two years data were also stored on tape. A Memodyne data logging system stored date, time, and number of out- and inflights for 20-minute periods.

Visual counts of passing bats revealed that some bats were not recorded automatically. The data can only be regarded as a relative index of activity. The most important sources of error are: 1. Bats with a longer (or shorter?) passing-time than the time-constant are not recorded. 2. One bat circling outside and another one circling inside breaking the beams within the time-constant could cause a false recording. 3. Condensed water on the emittors dispersed the light, and the reliability decreased.

Results

Although 5 species use the mine, *M. daubentoni* make up 80–90% of the hibernating population. The data therefore largely represent the activity of this species, except when otherwise stated. Catches (e. g. BAAGØE et al. 1988; DEGN 1989) and observations at different times through the year confirm this.

Because of technical problems continuous recordings from one particular year could not be produced. So the activity throughout the year is composed of representative periods from different years, when the apparatus was in full function (Fig. 1). The following presentation is divided according to the bats' activity pattern.

Activity through the year

In winter the activity through the exit is very low until mid February. After that time it increases a little, but even in the first part of March there is no net outflux from the mine.

From mid March the activity starts increasing, and the number of departures greatly exceeds the number of arrivals per night. Departure is intensive from the end of March

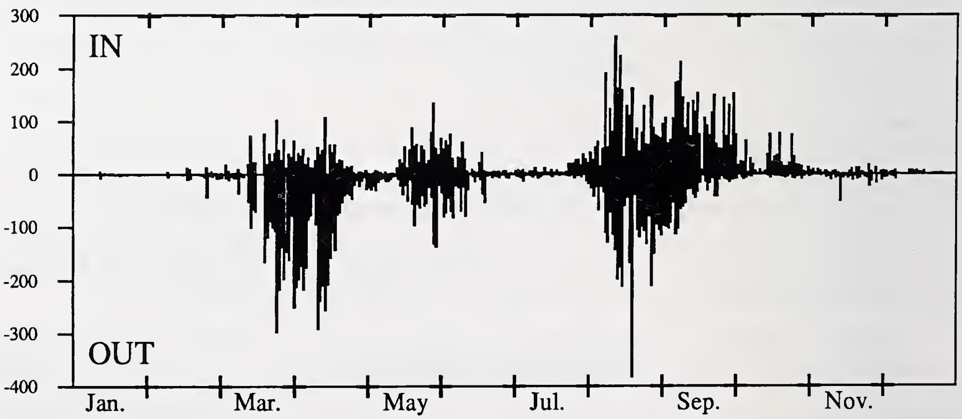

Fig. 1. Bat activity at Mønsted Limestone Mine through the year. Columns above the x-axis indicate number of inflights per night, and below the axis outflights are indicated. This also applies to figures 2–5.

towards the end of April without a sharply defined maximum, but with great variations from night to night. During the last 1–2 weeks of April the activity decreases rapidly.

In the first half of May a second period of departure is found, but involves only a small number of bats.

The departure comes to an end around the middle of May. After this time no bats were expected to use the mine, but a new activity period of about 5 weeks begins after the middle of May. The number of registrations in both directions is about equal calculated over the whole period, indicating no net in- or outflux.

During the first three weeks of July the activity is low, but starts rising around the turn of the month. The number of registrations increases until the middle of August, when a rather high level of activity in both directions is reached and maintained until about 1. September.

From then the net flux of bats into the mine is increasing, and the number of outflights per night begins to decline steadily until near zero about 1. October. The number of inflights remains high during the whole of September, and many hundred bats arrive also in October. In November and the first part of December the number of inflights becomes very small.

Activity in separate nights

In order to get a detailed description of bat activity during different periods of the year, the activity through separate nights was analysed.

An example of the activity during one night in the departure period in spring is shown in figure 2. The departure starts about 1 hour after sunset and comes to a maximum 1.5–3 hours after sunset. Already at midnight the activity is again very low and remains so for the rest of the night.

In early summer (mid May to mid June) a maximum outflight is often recorded during the night after a night with a maximum inflight. The coefficient of correlation between the number of bats arriving one night and the number leaving on the next night is high ($r = 0.91$). Figure 3 shows an example of the activity pattern during two successive nights, preceeded and succeeded by a night with very low activity. The first night (31. May) about

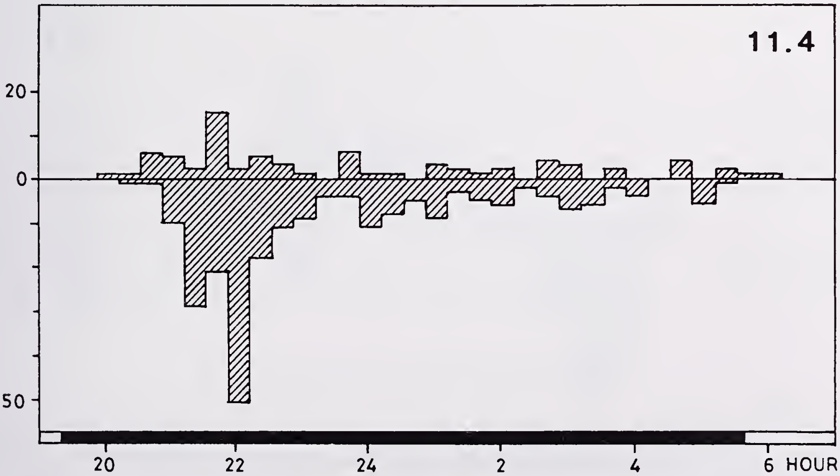

Fig. 2. Bat activity during a night in the departure period (April 11.). The period from sunset to sunrise is indicated by a black bar on the time scale. This also applies to figures 3–5.

90 bats arrive the mine around 01–02 h. The bats do not leave again the same morning but stay in the mine the following day. The next night they fly out before midnight, and bats return later in the same night.

The activity during a representative night in the beginning of the arrival period is shown in figure 4. Most bats leave the mine before 22 h. After midnight arrivals predomi-

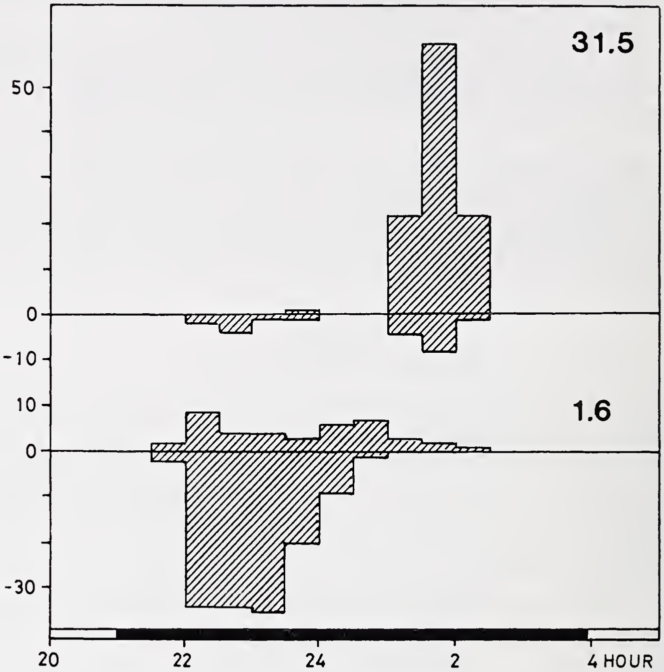

Fig. 3. Bat activity on two successive summer nights, May 31. and June 1.

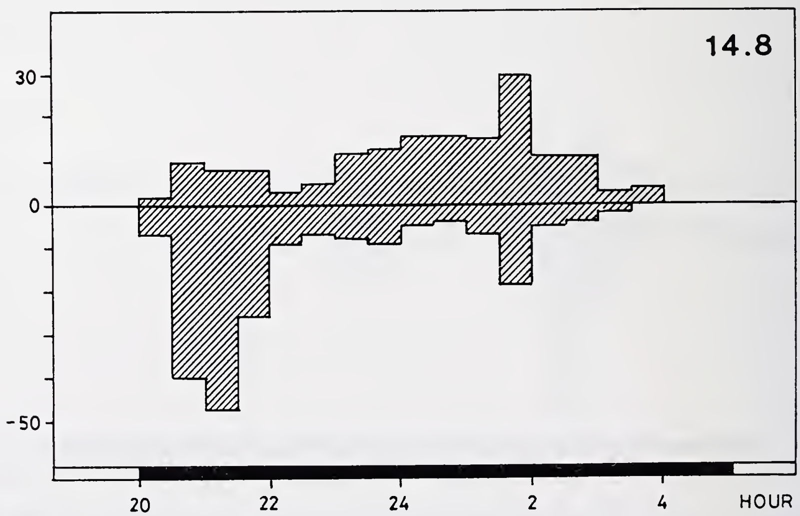

Fig. 4. Bat activity during a night in the first part of the arrival period (August 14.).

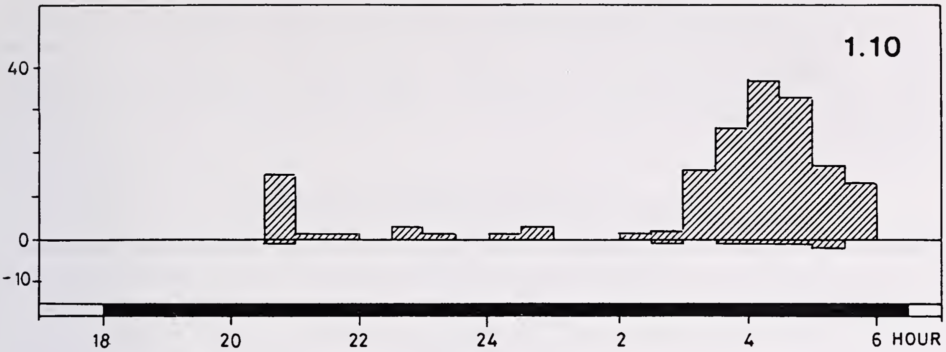

Fig. 5. Bat activity during a night in the last part of the arrival period (October 1.).

nate. In the last half of August the activity pattern is more unstable. The number of outflights sometimes exceeds the number of inflights. Still a considerable number of bats depart from the mine before midnight in most nights.

An example of the activity during a typical night of the last part of the arrival period is shown in figure 5. Nearly all the activity is directed into the mine and takes place 03–06 h. Activity ends shortly before sunrise.

Discussion

The method described above has disadvantages, mostly connected to technical problems. But it yields quantitative data and – at least in theory – it works automatically all year round and is less time consuming than other methods. Another major advantage is that bat workers do not interfere with the normal behaviour of the bats.

The species cannot be separated. But in the present study this was a minor problem because knowledge about the behaviour and gross numbers of the five species had been accumulated previously. By combining this information the characteristic periods of bat activity throughout the year can be defined and described.

Hibernation period (November–late March).

Many *Myotis*-species including *M. daubentoni* wake up spontaneously several times during hibernation (Daan 1973). This was also found in Mønsted Limestone Mine (Degn 1987). However, from the present study we conclude that only very few bats ventured out through the exit in winter. In a Dutch cave (Daan 1970) using photographic recording also found that only a very small part of the bats waking up actually flew out from the cave.

The outflights in early March represent very little outflux as most outflights were followed 1–2 minutes later by an inflight. We interpret this as the same individual flying out, finding the weather unfavourable, and entering again immediately.

Departure period (late March–mid May).

Baagøe et al. (1988) found that captures at the exit gave a more realistic picture of the departure than counts in the mine, which have earlier been used. The present data correspond well with the trap-captures. The conclusion of Baagøe et al. (1988) can therefore be extended to say that the most correct picture of the departure is obtained by measuring the activity at the exit either by capture or by automatic registration.

In the first half of May only few bats are observed in the mine. Nearly all of them are *M. brandtii* (pers. obs.), and we therefore suggest that the flight recordings at this time are mostly caused by this species. It is also known to depart very late from other Danish limestone mines: Daugbjerg (Egsbæk and Jensen 1963), Smidie and Tingbæk (B. Jensen, pers. comm.).

Summer activity period (mid May–mid June).

Until the automatic recording system was set up, activity in the middle of the summer at the hibernaculum was not known. Later it was reported by Degn (1989) that the bats were male *M. daubentoni* arriving after midnight, staying in the mine the next day, and leaving the mine again after sunset. More than thousand bats visited the mine only once during the summer. This shows that these males did not use the mine as a permanent day roost during summer, but as some sort of transitional roost.

Arrival period (late July–November).

We found arrival to start in late July and stop around the end of November. Most other studies on *M. daubentoni* report a shorter period of arrival (Krzanowski 1959; Egsbæk 1962; Roer and Egsbæk 1966; Daan and Wichers 1968; Daan 1973), but these authors counted bats hanging in the hibernacula.

Klawitter (1980) found two periods of immigration of *M. daubentoni* in the Spandauer Citadelle in Berlin. The first lasted from late July to the end of August. The bats gathered in groups and showed great activity also during daytime. The second period lasted from the beginning of September to the end of October, although it could continue into December. In this period the bats rested solitarily and were inactive.

For *M. lucifugus* Fenton (1969) and Thomas et al. (1979) found two similar phases. In the first one ("swarming"), the animals only stayed in the cave for a few hours per night. They were active, but did not mate. During the second phase they were mostly hibernating, yet matings occurred.

Our results confirm that the arrival period can be divided into two parts with a gradual transition from one to the other. In the first part there is a balance between out- and inflights, indicating that the bats did not hibernate. Fenton (1969) suggested several theories for this behaviour involving dispersion, migration, or some kind of prenuptial activity. The second part of the arrival period is clearly the preparation for hibernation. From the start of September the number of outflights per night decreases rapidly, and most bats have arrived before the end of October.

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Zusammenfassung

Ganzjährige automatische Registrierung der Fledermausaktivität in der Mønsted-Kalkgrube, Dänemark.

Das ganze Jahr hindurch wurde die Fledermausaktivität mit Hilfe einer doppelten Lichtschranke am Eingang der Mine automatisch registriert. Diese Methode liefert quantitative Daten ohne das natürliche Verhalten der Fledermäuse zu stören.

Vier Perioden wurden definiert: 1. Eine Winterschlafperiode mit sehr geringer Aktivität von November bis Ende März. 2. Eine Abflugperiode von Ende März bis Mitte Mai mit einem markanten Maximum im April und einer zweiten kurzen Abflugperiode in der ersten Maihälfte, die den Abflug von *Myotis brandti* markiert. 3. Eine Sommeraktivitätsperiode von Mitte Mai bis Mitte Juni; in dieser Zeit benützt eine große Anzahl von Männchen der Art *Myotis daubentoni* die Mine als zeitweiligen Aufenthaltsort. 4. Eine Ankunftsperiode von Ende Juli bis November, in der sich Ein- und Ausflüge in der Zeit von Ende Juli bis August die Waage halten, und in der ab September die Einflüge mehr und mehr überwiegen und den Beginn des Winterschlafes anzeigen.

Die einzelnen Arten konnten nicht unterschieden werden; dies wird aber nur als ein geringer Nachteil angesehen, da die Anzahl und das Verhalten der verschiedenen Arten mit Hilfe anderer Methoden bekannt wurde. 80–90% der Tiere gehören zu der Art *Myotis daubentoni*.

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