REMARKS ON THE THERMOPREFERENDUM OF PALEARCTIC BATS IN THEIR NATURAL HABITATS

by

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This contribution comprises two remarks of ecological rather than physiological character. Contrary to Herter (1952), Herreid (1967), and Harmata (1969), I did not examine the temperature preference, or thermopreferendum, of bats under experimental conditions but concluded on it only on grounds of temperatures registered in various natural habitats of the bats. Thus, my observations pertain to the thermopreferendum of the resting bats, either inactive or active metabolically.

My first remark concerns the temperatures preferred in winter. Hibernating bats are known to differ as to their requirements for ambient temperatures in their winter quarters, as pointed out, e.g., by Dulić (1958) and by many other authors.

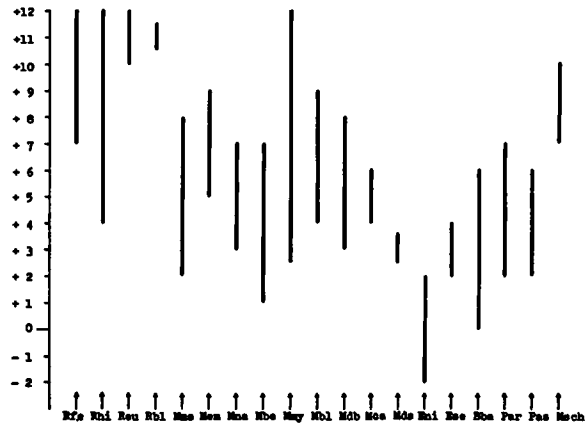

Fig. 1. Temperatures recorded in the underground hibernating quarters of certain bat species (data from Czechoslovakia and Bulgaria). Abbreviations: Rfe - *Rhinolophus ferrumequinum*, Rhi - *R. hipposideros*, Reu - *R. euryale*, Rbl - *R. blasii*, Mms - *Myotis mystacinus*, Mem - *M. emarginatus*, Mna - *M. nattereri*, Mbe - *M. bechsteini*, Mmy - *M. myotis*, Mbl - *M. blythi*, Mdb - *M. daubentoni*, Mca - *M. capaccinii*, Mds - *M. dasycneme*, Eni - *Eptesicus nilssoni*, Ese - *E. serotinus*, Bba - *B. barbastellus*, Par - *Plecotus auritus*, Pas - *P. austriacus*, Msch - *Miniopterus schreibersi*.

This phenomenon can be illustrated by fig. 1, showing temperature amplitudes as recorded in close vicinity of hibernating individuals of various species of bats in Czechoslovakia and Bulgaria (the data have been collected during November to March but mostly during February).

Quite accidentally, I was able to observe the effects of a change of temperature in a hibernating quarter irregularly visited (but always in January or February) within a span of twelve years. The cave in question, called "Erichova", is situated on the bottom of the 138 mm deep Macocha abyss in the Moravian Karst. The cave communicates with the bottom of the abyss by a large entrance, and with an extensive system of stalagmite caves, accessible to the public by a smaller corridor. Normally, this communication is closed by a wooden wall. I examined only the front part of the Erichova Cave, some 50 m deep, with ambient temperature normally varying between 1° and 4°C in winter. The back part of the cave, situated some 10 m higher and slanting towards the surface, is consequently substantially warmer than the front part. The neighbouring large caves are also warmer, with ambient temperature 8° to 9°C, throughout the year. As indicated in table I, *Barbastella barbastellus* is the most frequent hibernating species in the Erichova Cave. Table I indicates the numbers of individuals collected; the actual abundance was much higher, being estimated at more than 1000 hibernating individuals in 1963. In February 1966, *B. barbastellus* was not found in this locality, nor were bats of the genera *Plecotus* and *Eptesicus*. On the other hand, the number of *Myotis myotis* increased conspicuously and, also, there were some individuals of *Rhinolophus hipposideros* which otherwise frequently hibernate in the adjacent warm caves. It appeared that the wooden wall separating the front part of the Erichova Cave from the extensive adjacent caves had been bro-

Year	1959	1963	1965	1966	1968	1969	1970
Temperature / Species	1,5			6	1,5(6)	3(7)	4(8)
B.barbastellus	197	147	77		36	42	38
P.auritus							1
P.austriacus		1	1				
E.serotinus		2	1				1
M.nattereri			1				1
M.myotis	6	3	7	14	3	24	32
M.blythi	1		2		1	1	
R.hipposideros				2			

Table I. Catches of bats in the front part of Erichova Cave (January—February). Temperature recorded in one and the same place near the original shelter of *Barbastella barbastellus;* in parentheses, temperatures in the communication with the warmer, stalagmite cave (near the wooden wall). Solid arrow indicates breakdown of the wall in November 1965; dashed arrow indicates restoration of the wall in April 1966.

ken down in November 1965, due to which fact the ambient temperature in the cave under study increased by some 3°C. The wall was restored in April 1966. In subsequent winter seasons, *B. barbastellus* reappeared in the locality but in smaller numbers. Large numbers of *M. myotis* were noticed even during the last two winter seasons but there were no *R. hipposideros* any more. Since the hibernating quarter under study did not undergo any other apparent changes than the above-mentioned change of ambient temperature, I am inclined to believe that the changes in its bat population are a direct consequence of the temperature changes. This unintentional experiment, somewhat resembling the stove experiment described by Punt & Parma (1964), tends to confirm that the differential preference for certain ambient temperature among different bat species during hibernation is a reality. Hence, the temperature preference in full hibernation is not a phenomenon merely accompanying other ecological characteristics, such as the preference for a particular macrobiotope, size and shape of shelters, site during hibernation, etc.

My second remark pertains to the thermopreferendum of summer nursing colonies, currently termed the "Wochenstuben". It is well-known that the Wochenstuben of such bat species as the Horseshoe Bats and the members of the genera *Myotis, Plecotus,* and *Eptesicus,* situated in the lofts of buildings, at least in Europe, show extremely high values of ambient temperature in relation to the climate of the respective region. Thus, the ambient temperature in the Wochenstuben occupied by *Rhinolophus hipposideros* which I examined (Gaisler, 1963) was 12° to 42°C; in the Wochenstuben of *M. emarginatus,* I found ambient temperatures of 15° to 36°C. Much the same data are also available for *M. myotis* (e.g., Kolb, 1950). Through occasional measurements, I determined temperatures of 30° to 35°C in the Wochenstuben of *Myotis mystacinus* and *M. nattereri.* Such high temperatures do not occur in the original summer shelters, i.e. in caves, at least not in the case of the first three species mentioned. Thus, for instance, in the Drienovecká Cave in eastern Slovakia, being the largest known original summer shelter of the non-tree-dwelling bats in Czechoslovakia, the places of the Wochenstuben of *M. schreibersi, M. myotis, R. euryale* and *R. ferrumequinum* show ambient temperatures of 9° to 13°C.

As a matter of interest, I noted the ambient temperature in the Wochenstuben of bats in two regions at the southern limit of the Palearctic Region which I could — likewise incidentally — visit. Considering that such data from the warmer regions of the world are hardly available in literature, an account of some of my observations might be useful.

In the Wochenstube of *Myotis longipes* and *Miniopterus schreibersi,* situated in a low gallery near the Royal Palace in Jalalabad, Afghanistan, the ambient temperature is around 25°C. In Egypt, I measured the ambient temperatures in the Wochenstuben and obtained the following data: *Rhinopoma hardwickei* (3 Wochenstuben), 22.8°—27.5°; *Taphozous nudiventris* (2 W.), 24.5°—35.0°; *T. perforatus* (1 W.), 32.0°; *Nycteris thebaica* (1 W.), 26.5°; *Asellia tridens* (4 W.), 27.0°—32.0°; and *Rousettus aegyptiacus* (1 W.), 26.0°C. At the same time, I also measured the outdoor temperatures which were regularly higher both in sunlit places (30.0°—45.5°C) and in the shade (28.0°—37.0°C).

Although the above data were collected during April and May only, I doubt that the ambient temperatures in the shelters of these bat species would ever reach relatively extreme values. All places are protected from direct solar irradiation. Hence, they may be presumed to show temperatures substantially lower than the daily maxima even during the hottest season of the year. Much the same observations have been made in other

warm regions, above all, in southern Europe. On the contrary, the Wochenstuben in the lofts of buildings, as known in western and central Europe, show higher temperatures than outdoors during much of the summer. Hence, we have here a paradoxical situation that most of the Wochenstuben of originally cave-inhabiting bats are at present situated in relatively cooler shelters in the south than in the north.

There arise several theoretical questions, two of which I would like to mention. The first one concerns the hypothetical original shelters of bats before the arrival of man. Are the differences observed between individual species in temperature preference in their hibernating quarters correlated with the differences in ambient temperatures in the original summer shelters of their Wochenstuben? Without entering into a comprehensive discussion, it is my opinion that they are not. One example for all: such bats as *Eptesicus nilssoni* or *Barbastella barbastellus,* showing preference for cooler hibernating quarters, must have inhabited much warmer tree shelters during the warm season of the year than *Rhinolophus hipposideros* or *Miniopterus schreibersi,* showing marked preference for warmer hibernating quarters, whereas they inhabited relatively cool caves during the summer. In addition it should be noted that, for instance, in the Carpathian region, all these four species still occur in summer shelters that can be considered original in ecological respect.

The second question concerns bats inhabiting buildings in the temperate zone. Does the selection of the site of their Wochenstuben in the buildings correspond to the original thermopreferendum or is it rather a manifestation of temperature tolerance or even a secondary adaptation to ambient temperature? The answer to this question is not as simple as it would appear at first sight. Herreid (1967, and other papers) seem to be one of those stressing high temperature tolerance rather than preference in active bats. Menaker (1969) speaks about the heat acclimation of summer bats. According to Harmata (1969), "the endurance of bats to high temperatures is sometimes significant". As for lofts, it should be considered that in the warm season, the lofts are not only the warmest parts of the buildings but, at the same time, they offer the safest shelters to the bats of all the aerial parts of the buildings. Furthermore, one must bear in mind that other elements of microclimate (above all, humidity) may influence the habitat selection of Wochenstuben — similarly as supposed in the hibernating bats by, e.g., Daan & Wichers (1968). Nevertheless, it seems logical — and also, it is in agreement with the experimental results obtained by Harmata (1969) — that the preference for certain sites in the lofts is, to a great extent, the manifestation of a high thermopreferendum of metabolically active (homoiotherm) bats. Besides, it is probable that buildings as the sites of the Wochenstuben are of greater ecological importance for those species which originally inhabited underground spaces during summer. Apart from the thermopreferendum itself, also the presence of buildings may be one of the factors limiting the distribution of these bat species in our latitudes. If so, then man had done much more in favour of certain bats than he does now to their detriment by using insecticides and destroying their hunting grounds.

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