Charakterystyka mikroklimatu Jaskini Szachownica oraz jego wpływ na zimujące nietoperze

Characteristics of microclimate of Szachownica cave, and its effect on wintering bats

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Abstract

Underground roosts, both natural (karst and tectonic caves) and artificial (tunnels, mines), provide roosts for many groups of animals, including bats. The characteristic feature is their specific microclimate: relatively constant temperature and high humidity. There are three microclimatic zones in the undergrounds: i) dynamic zone, where the seasonal amplitude is higher than 3.0°C, ii) transition zone where the seasonal amplitude is between 1.0-3.0°C, and iii) static zone, where the seasonal amplitude is less than 1.0°C (Pulina 1960, modified). The range of individual zones depends on the shape of the undergrounds, their depth/ length, the number and size of the openings, and the average annual temperature in the area. In underground objects with dynamic microclimate, the temperature and humidity are heavily dependent on the climatic conditions prevailing outside (Attitude 2000, Perry 2012).

Individual species of bats are characterized by their specific preferences ranging from a wide range of micro-climate parameters for Barbastelle (*Barbastella barbastellus*) and Brown long-eared bat (*Plecotus auritus*), to a narrow temperature and humidity range for Lesser horsehoe bat (*Rhinolophus hipposideros*) (Nagel and Nagel 1991). The increase in daily amplitude results in an increase in the incidence rate, which in turn translates into higher energy expenditure (Ransome 1971). In most cases the thermal characteristics of the underground are most often conducted on the basis of microclimate measurements at the height of 0.5 to 1.5 m above the bottom of the floor (Kwiatkowski and Piasecki 1989). However, this feature does not explain much about the conditions of bats inhabited. The type of equipment used for the measurement is also a problem, for example: the Assmann psychrometer measures the temperature not so much in the vicinity of the bat, but rather in its surroundings. Such varied and often inaccurate methods give results far from reality. It seems that the wintering temperature range of some species is artificially inflated. Szachownica cave is a perfect object for the study of the selectivity of wintering sites by bats.

Materials and methods

Temperature and humidity recorders (DS1923 Thermochron iButton, Maxim Integrated Products, USA) were placed in 8 points in cave (Figure 1). In addition, one recorder was placed outside the cave to characterize the climate. Temperature measures were carried out every 2 hours. Logers are placed in places where occurs wintering of bats: in crevices or recesses of the ceiling. Measurements were carried out during the three winter seasons: 2009/10 (before cave conservation), 2014/15 (start of conservation work) and 2015/16 (after major work). Additionally, in the 2009/10 season temperatures were measured in the vicinity of bats: air and rock temperatures, and the bats themselves (Ri-Thermo N, Riester clinical pyrometer). The following parameters were used to characterize the microclimate of the cave: i) daily amplitude - due to its dependence on external conditions; ii) minimum daily temperature - due to its influence on potential increase of bat awaking and cave freezing.

Results and discussion

The highest daily temperature fluctuations were recorded in the Transition Hall (up to 1.0°C), significantly lower in the Waste Hall (up to 0.4°C), while in the rest did not exceed 0.1°C. The minimum daily temperature was the lowest in the Transition Room (mean -0.5°C in 2009/10, subsequent years> 2.5°C), the remaining measurement points did not show temperatures below 0°C. The strongest influence of the external conditions on the temperature inside the cave was noted in the Transition Hall, much less influenced in the Waste Hall, while the rest of the cave: Crossroads, Parallel Isthmus and Great Hall have microclimates independent of external conditions. In the Mushrooms Parts, a gradual increase in temperature was observed - it is related to the warming of the air from the rock and the lack of air circulation (Fig. 1).

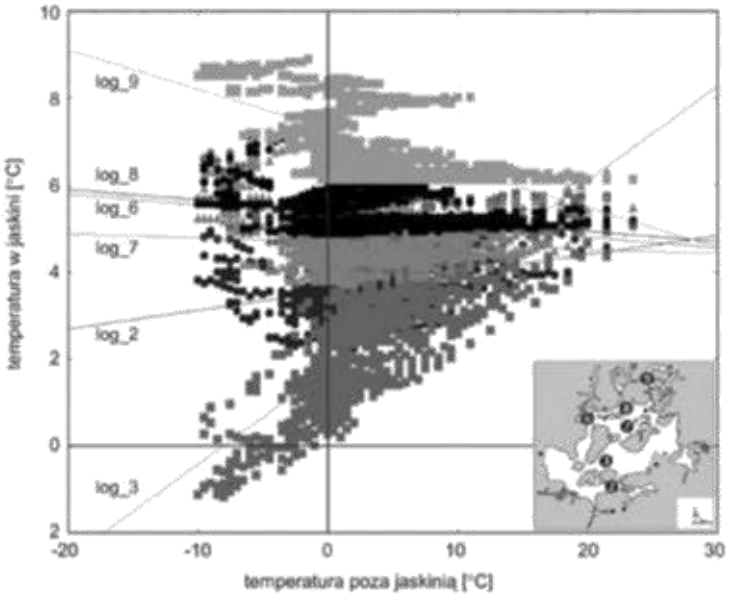

Fig. 1. Temperature dependence inside the cave from outside conditions (winter 2014/15). Log Cabin 2, Transition Hall - Logger 3, Crossroads - Logger 6, Great Hall - Logger 7, Parallel Isthmus - Logger 8, Mushrooms Parts - Logger 9

The obtained results show a divergence from the previous division of the cave thermal zones proposed by Polonius (2001) and Głazka et al. (1978). However, standardized measurements do not,, take into account microsites occupied by bats. Interestingly, while temperatures are below 0°C (dynamic zone) in the Transition Hall, in the Waste Hall and Crossroads - also referred to as dynamic zones, both fluctuations and minimum temperatures can be assigned to transitional or even static zones. Of the most prevalent bat species, the greatest tolerances for temperature fluctuations have Barbastelle (*B. bar-bastellus)*, and if the temperatures in the Transition Hall were negative, the bats themselves wintered at positive temperature (Figure 2c). On the other hand, Brown long-eared bat (*P. auritus)* - considered as a species with similar thermal preferences to Barbastelle, always chose places with temperature > 2.0°C (Figure 2b). Higher winter temperatures were chosen by Natterer's bat(*M. nattereri)*, Daubenton's bat (*M. daubentonii*) and Grater mouse-eared bat (*M. myotis)* (Fig. 2a): 4.0°C to 6.5°C. Interestingly, the temperature of the bat's body is more dependent on the temperature of the rock than the ambient air temperature and their difference is between 1 and 2°C.

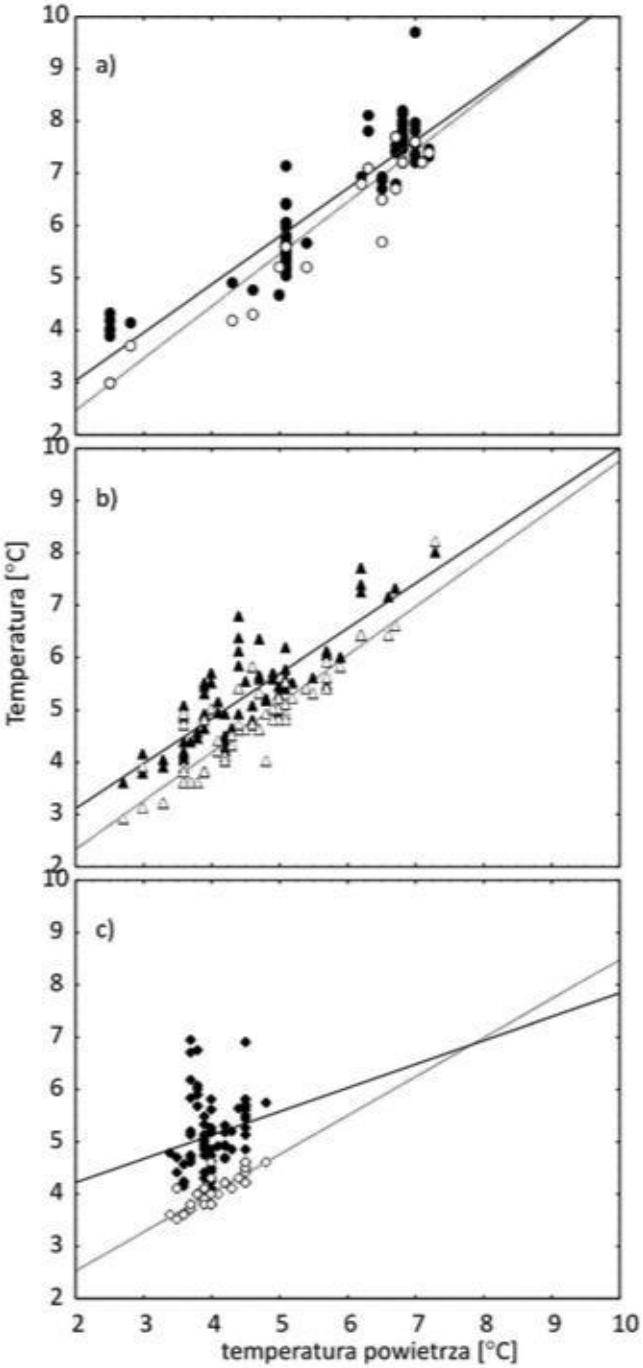

Fig. 2. The dependence of rock temperature (white points) and bat body temperature (black points) at the Grater mouse-eared bat, Brown long-eared bat and Barbastelle, on ambient temperature (winter 2009/10).