ASPECTS OF TEMPERATURE AND HUMIDITY IN PREFERRED HIBERNATION SITES OF THE NATAL CLINGING BAT *MINIOPTERUS SCHREIBERSI NATALENSIS* (A. SMITH, 1834)

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ABSTRACT

In the Transvaal, *Miniopterus schreibersi natalensis* forms hibernating colonies during May–July on the highveld where the ambient and cave temperatures are lower than in the lowveld. In two highveld caves, mating and hibernating colonies were resident from January to the end of July, but only one cave was occupied for hibernating during the winter. In the cave selected for hibernation humidity was lower, and fluctuated more, than in the other cave. Temperature also fluctuated more, but tended to average lower, than in the unused cave. It appears that low temperature rather than high humidity determined the choice of a hibernating cave.

INTRODUCTION

Bats of temperate biomes select different hibernating conditions and hibernate for varying lengths of time. These differences can be attributed to regional climatic conditions. The most essential condition for hibernation in bats seems to be low ambient temperature (Twente 1955; Rice 1957; Griffin 1958; Tinkle and Patterson 1965), and the importance of high humidity has also been stressed (e.g., Griffin 1958). High relative humidity seems essential to prevent dehydration. However, Tinkle and Patterson (1965) doubt the importance of humidity *per se*, and place greater emphasis on the thermal stability of moist air.

Because the optimum condition (high humidity and low temperature) seldom occurs universally throughout a species' range, it will have to seek out those places most suitable for hibernation. Within a given area (even a specific cave or cavern) preference for a given site varies according to species (Twente 1955). This paper presents data on the importance of temperature and humidity in the selection of caves for hibernation by *Miniopterus schreibersi natalensis* in the Transvaal highveld.

STUDY AREA

Fieldwork was conducted mainly in two adjoining dolomite caves on the Jack Scott Private Nature Reserve, Uitkomst, 56 km west of Pretoria (25°54′S/27°46′E). The caves are known as American Cave and Long One Cave respectively. The two openings of American Cave face south-west and the single opening of Long One Cave faces south-east. Excavation for early Pleistocene fossils has taken place. The caves are relatively dry, containing no significant permanent water. American Cave (Figure 1) consists of two big chambers and one side chamber, while Long One Cave (Figure 2) has only one big chamber and one side chamber. According to Twente's (1955) classification of caves, American Cave can be regarded as a "cavern", and Long One as a "cave".

Maps of the caves were drawn with the aid of compass and tape measure; heights were estimated. The two big chambers of American Cave are about equal in size, although situated on different levels. The front chamber with its two entrances is more or less rectangular with an average height of ± 5 m. The second, deeper chamber opens in the floor in the far right-hand corner of the front chamber. The opening is small and drops steeply so that the floor of this chamber is ± 12 m lower than the floor of the front chamber, with which its roof is continuous. It has a maximum height of ± 14 m. A small side chamber is situated in the floor of the far left corner, and descends sharply to its lowest point, ± 11 m below the floor of the second chamber. In the near left corner is a rather deep diagonal fissure in the wall, tapering towards its far end. The main chamber of Long One Cave (Figure 2) opens outwards to the south-east through a narrow tunnel, ascending with an angle of 45°. This chamber has a maximum height of ± 10 m. In the far left corner is a side chamber, which slopes sharply downwards, its walls converging at the furthest point.

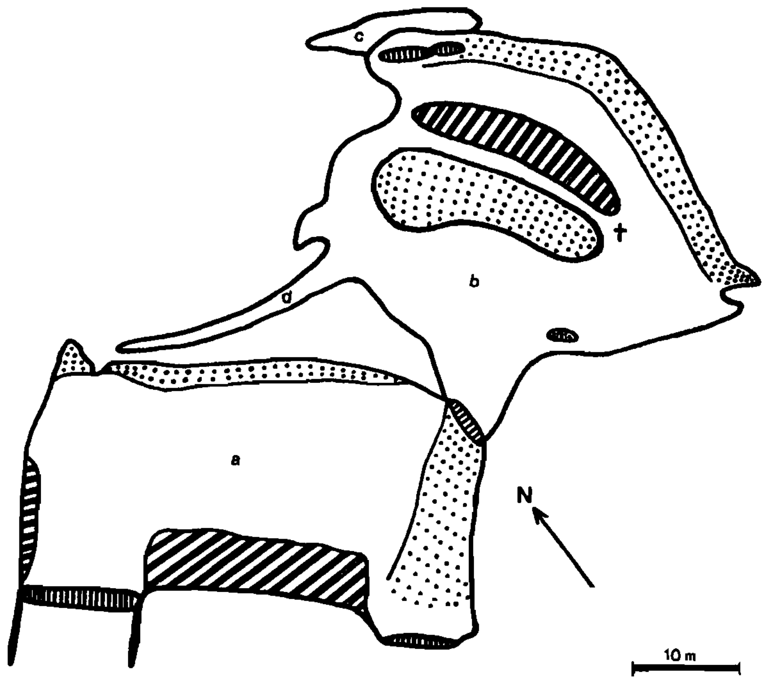

FIGURE 1

Plan of American Cave, showing two big chambers (a) and (b), a side chamber (c), and a diagonal fissure (d). Stippled areas indicate archaeological excavations, double parallel lines rubble heaps and single parallel lines entrances.

+ Marks the location of a thermograph and hygrograph.

MATERIAL AND METHODS

On each visit to the two caves the general activity level of the bats was checked to see whether they were torpid or active, and their numbers estimated.

Thermographs and hygrographs, with one-week clockwork cycles, were provided by the climatological branch of the Weather Bureau in Pretoria, and recorded temperature and humidity in both caves throughout 1968; two instruments (one thermograph and hygrograph) were placed on a table, 36 cm × 86 cm and 76 cm high approximately centrally in each cave. In American Cave the table was placed in the second chamber (Figure 1), while in Long One Cave it was placed in the main chamber (Figure 2). The accuracy of each instrument was checked weekly with an aspiration psychrometer.

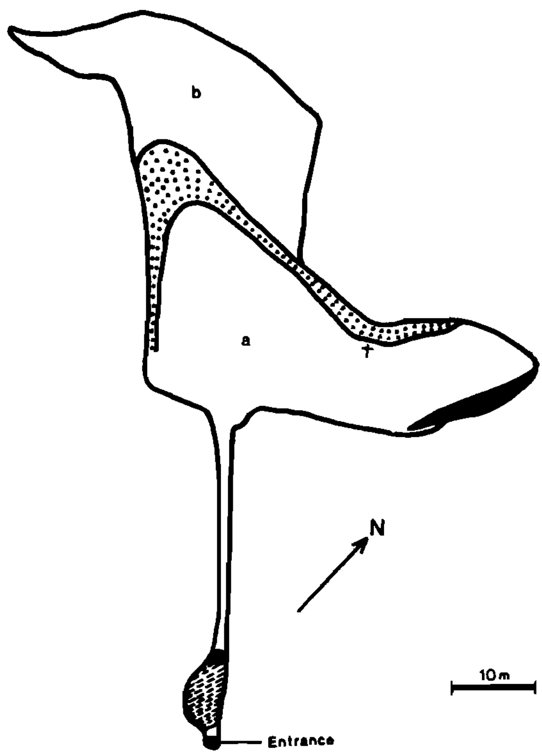

FIGURE 2

Plan of Long One Cave, showing the main chamber (a) and side chamber (b) in the far left corner. The stippled strip indicates a trench running along the left and far walls of the main chamber. The dark patch along the right side of the main chamber indicates a steep crevice running upwards. The interrupted parallel lines at the entrance indicate a ± 7 m open excavation.

+ Marks the location of a thermograph and a hygrograph.

Minimum and maximum daily, weekly and monthly temperature and humidity were read directly from the thermograph and hygrograph record sheets. Mean temperature and humidity for any particular day were derived by calculating the mean readings for 12 successive two-hour periods from midnight to midnight of that day. These means were in turn used to calculate mean weekly and monthly temperature and humidity. Ambient external temperatures were obtained from Pelindaba, the nearest weather station to the caves (Weather Reports; in press). Ambient external humidity was taken to be the same as that at the Pretoria weather station, the closest station providing sufficient data on humidity (Weather Reports; in press).

RESULTS

GENERAL

The two caves are occupied mainly by two bats: *M.s. natalensis* and lesser numbers of *Rhinolophus clivosus*. During 1968 the maximum number of *R. clivosus* was estimated at 150–200 individuals, while the maximum number of *M.s. natalensis* during the same period was 6 000 individuals.

The caves are occupied by *M.s. natalensis* mainly from March to July when mating and hibernating colonies are formed. At the end of July these colonies break up and migrate to different caves in the northern Transvaal bushveld, where maternity colonies are formed during the months October to February. During March and April there seemed to be no special preference by *M.s. natalensis* for either of the two caves, since they were occupied by more or less equal numbers (to be discussed in detail elsewhere). Movements between the two caves, as shown by marked bats, were common. However, *M.s. natalensis* was never found in the front chamber of American Cave. This chamber is always dimly illuminated in daytime, and *M.s. natalensis* only forms colonies or clusters well outside the twilight zone (to be discussed elsewhere). *R. clivosus* stayed mainly in American Cave during March and April and showed no preference for either of the two chambers. Just before hibernation all bats of both species moved to Long One Cave where they stayed throughout the hibernating period (May–July). During this time American Cave appeared to be abandoned (only five individuals of both species were counted in American Cave during the winter of 1968). After hibernation the *M.s. natalensis* colony broke up, and migration to the northern Transvaal bushveld took place. The *R. clivosus* colony stayed until mid-September and then also left for places as yet unknown.

Hibernation in Long One Cave is not a continuous period of torpidity, but is characterized by various types of activity such as intra-cavernous movements and even emigrations and immigrations (to be discussed elsewhere).

TEMPERATURE AND HUMIDITY

The Uitkomst area

Ambient external temperatures for 1968 were highest in January and December (Figure 3) with mean monthly temperatures of 23,3°C and 23,1°C respectively. The coldest months were June (8,7°C) and July (11,5°C). There was a steady drop in the mean monthly temperature from

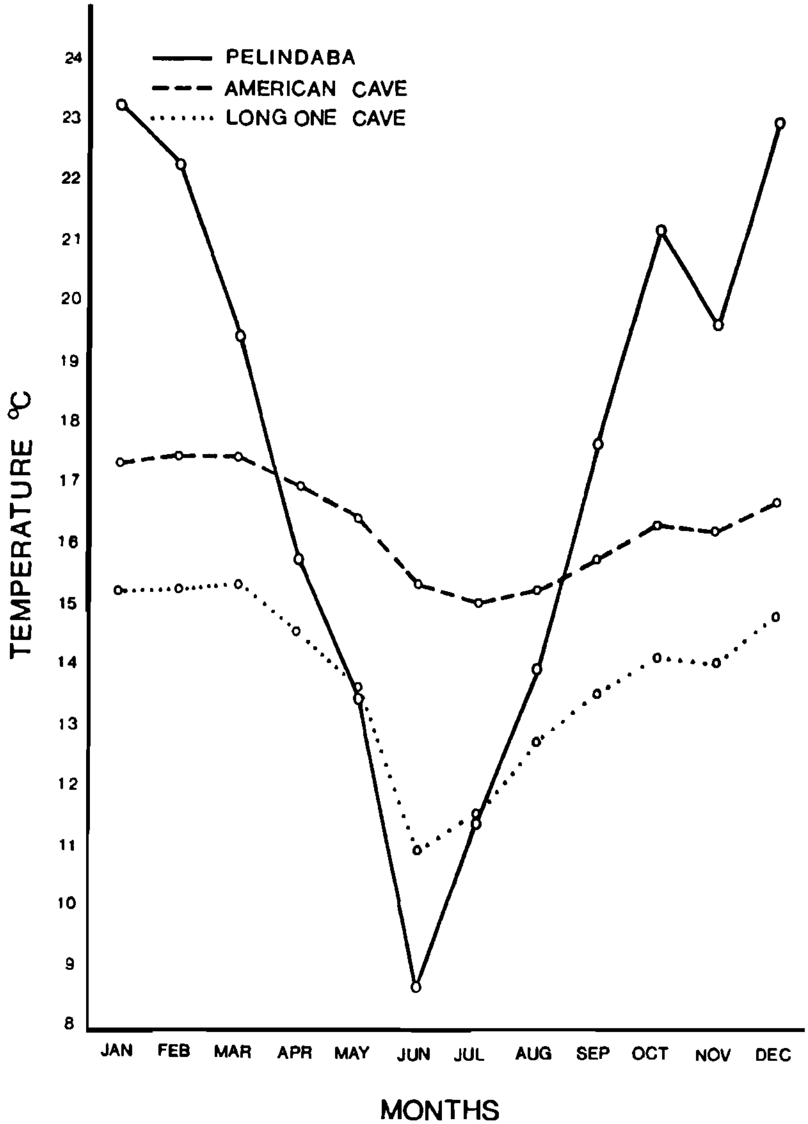

FIGURE 3

Mean monthly temperatures in Long One Cave, American Cave and at Pelindaba during 1968 (Pelindaba temperatures from unpublished Weather Bureau data).

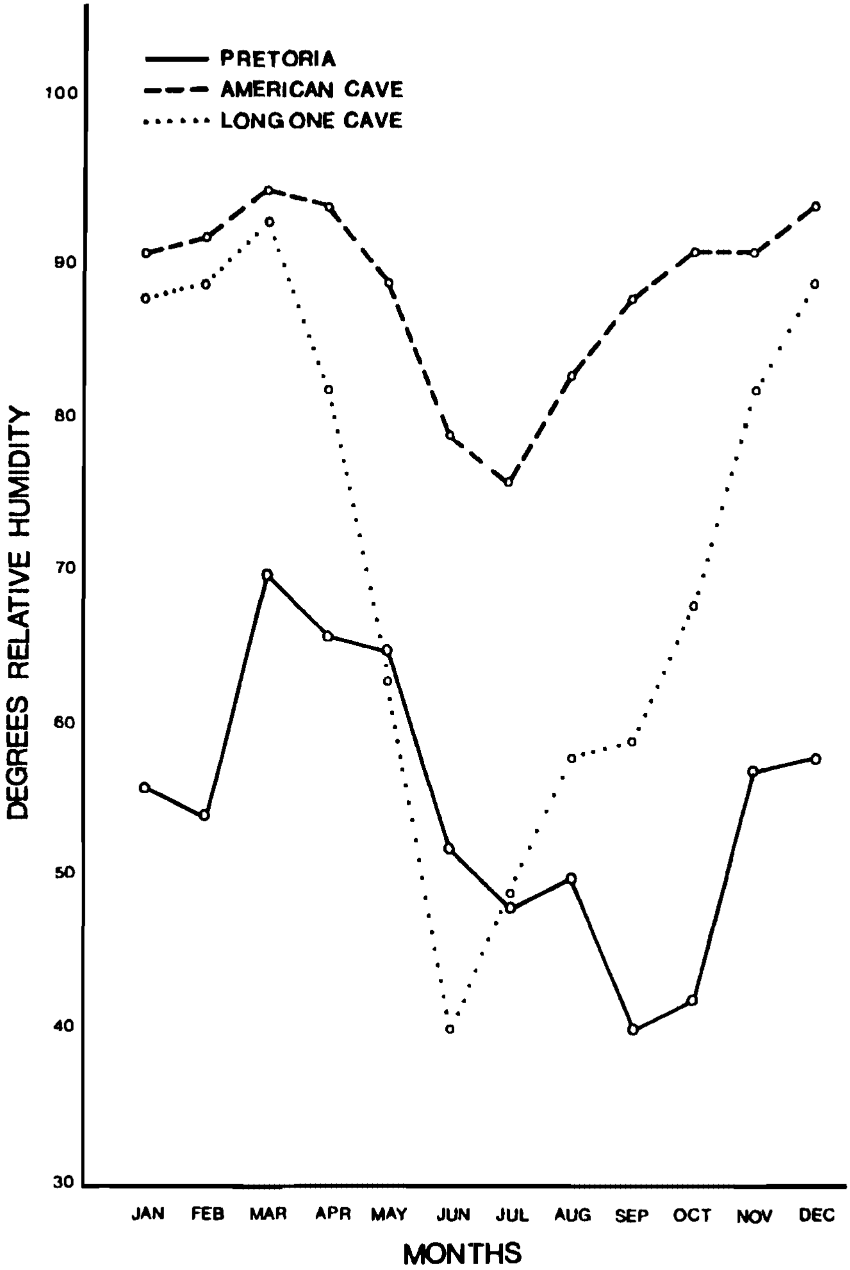

FIGURE 4

Mean monthly humidities in Long One Cave, American Cave and at Pretoria during 1968 (Pretoria humidity from unpublished Weather Burea data).

January (23,3°C) to June (8,7°C). This was followed by a sharp increase in temperature to 21,3°C during October. During November the temperature again dropped to a mean of 19,7°C and then steadily increased to 23,1°C during December. The absolute maximum temperature recorded was 34,5°C on 5 January and the lowest temperatures recorded were —0,9°C on 5 June and 0,0°C on 2 July.

Ambient external humidity fluctuated considerably from month to month (Figure 4). The highest mean monthly humidity recorded was 70% (March), and the lowest 40% (September). From January (56%) to February (54%) there was a slight decrease in humidity followed by a sharp increase to 70% during March. This was followed by an irregular decrease to a minimum of 40% during September. From September onwards the humidity again increased irregularly to 58% during December.

American Cave

There were only sight differences between weekly maximum and minimum temperatures (Figure 5). Temperature fluctuated little throughout the year. From January until the end of March mean weekly temperatures were fairly constant, varying between 17,4°C and 17,6°C. From the end of March mean weekly temperatures declined steadily from 17,6°C to a minimum of 14,9°C at the end of June, followed by a more or less steady increase to 16,8°C during December, with a drop from 16,7°C to 16,0°C in November. The greatest difference between maximum and minimum temperatures in one week (1°C), was between 15,2°C and 16,2°C during the last week of September. During the rest of the year the difference was never as much as 1°C from one week to the next. The highest mean daily temperature was 17,7°C (3 March), the lowest 14,8°C (24–26 June).

The humidity in American Cave was fairly stable, showing only small differences between weekly maximum and minimum values (Figure 6). From January until the end of May the mean weekly humidity fluctuated between 89% and 95%. From the end of May there was a steady decline in humidity to a minimum of 74% at the beginning of July. This was followed by a steady increase to a maximum of 95% in December. The greatest difference between weekly maximum and minimum humidities was 14%, during the third week of August, when the humidity varied between 78% and 92%. The highest mean daily humidity was 97% (21 January) and the lowest was 72% (6 July).

Long One Cave

Long One Cave was characterized by marked fluctuations in temperature, and considerable differences were found between weekly maximum and minimum values (Figure 7). From January to the end of March weekly mean temperatures fluctuated little, between 15,0°C and 15,5°C. From the end of March there was a sharp decline in temperature, from a weekly mean of 15,5°C to 10,8°C at the end of June. This was followed by a more or less steady increase to a weekly mean of 14,9°C in December, with one severe drop from 14,7°C to 13,1°C in November. The greatest difference between the weekly maximum and minimum temperatures was 3,3°C, between 9,4°C and 12,7°C, at the beginning of June. The highest mean daily temperature recorded during 1968 was 15,6°C (11 January and middle March). The lowest mean daily temperature for the same period was 10,4°C (13, 14 and 29 June). Long One Cave also showed considerable

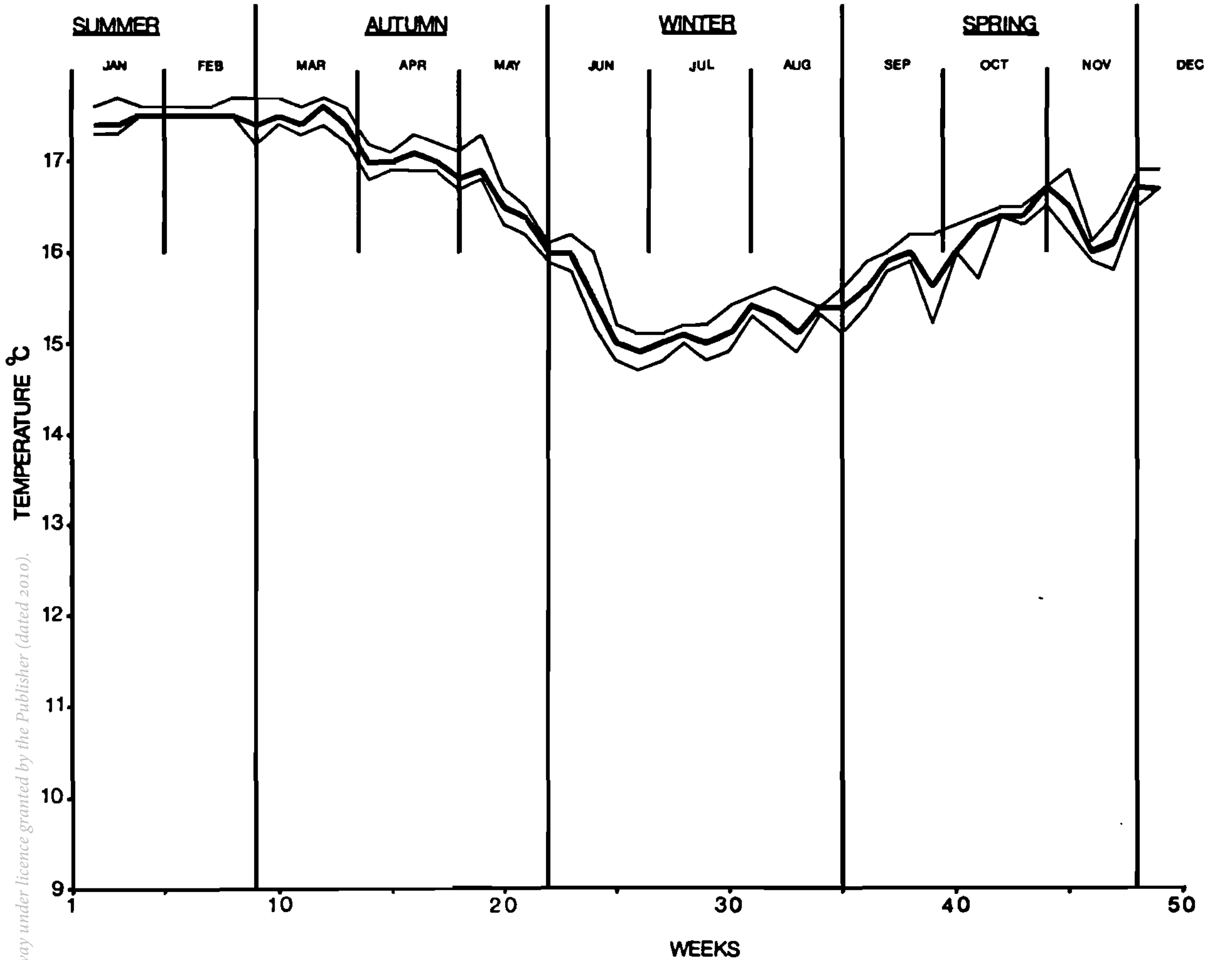

FIGURE 5

Weekly maximum, minimum and mean temperatures in American Cave during 1968.

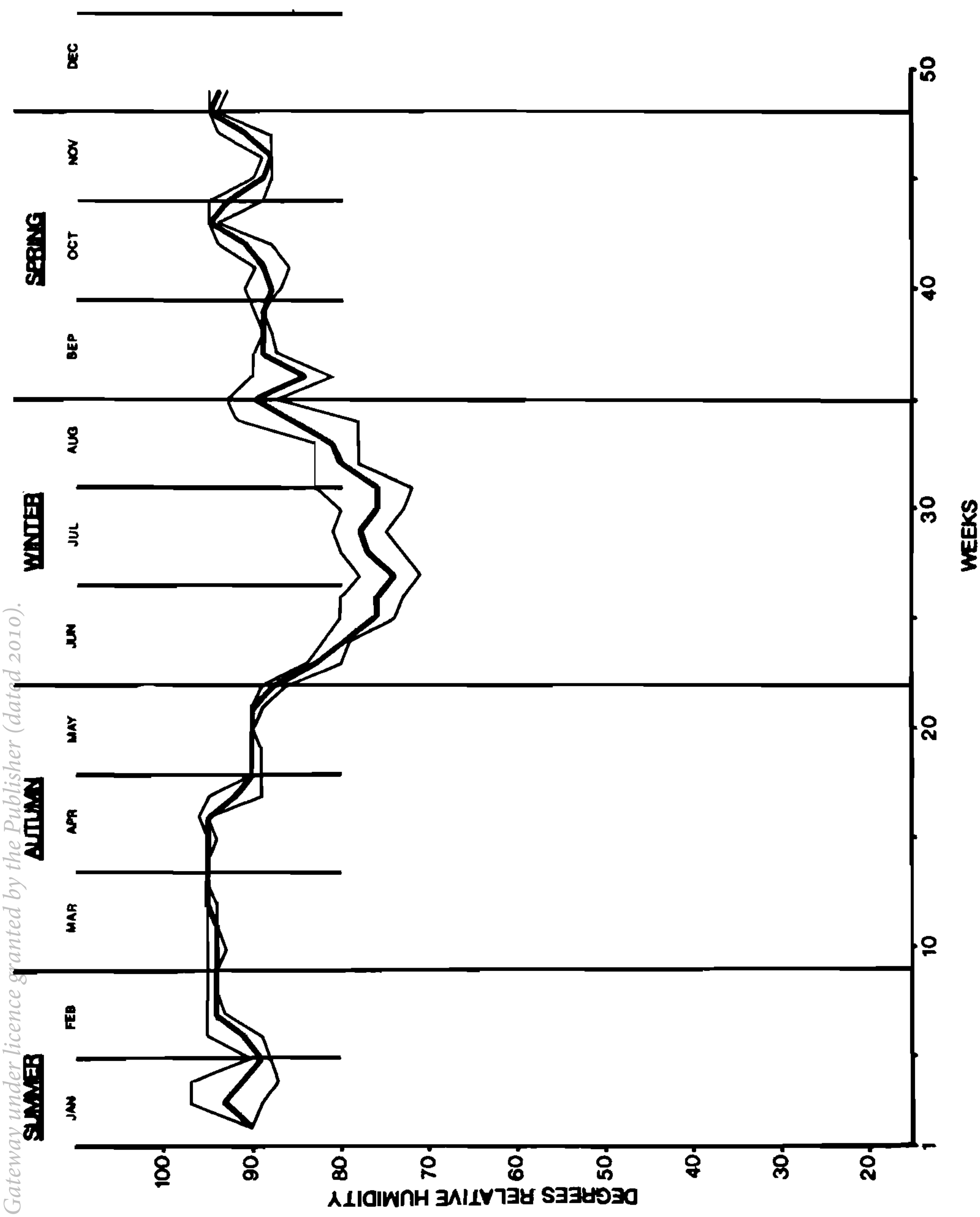

FIGURE 6

Weekly maximum, minimum and mean humidities in American Cave during 1968.

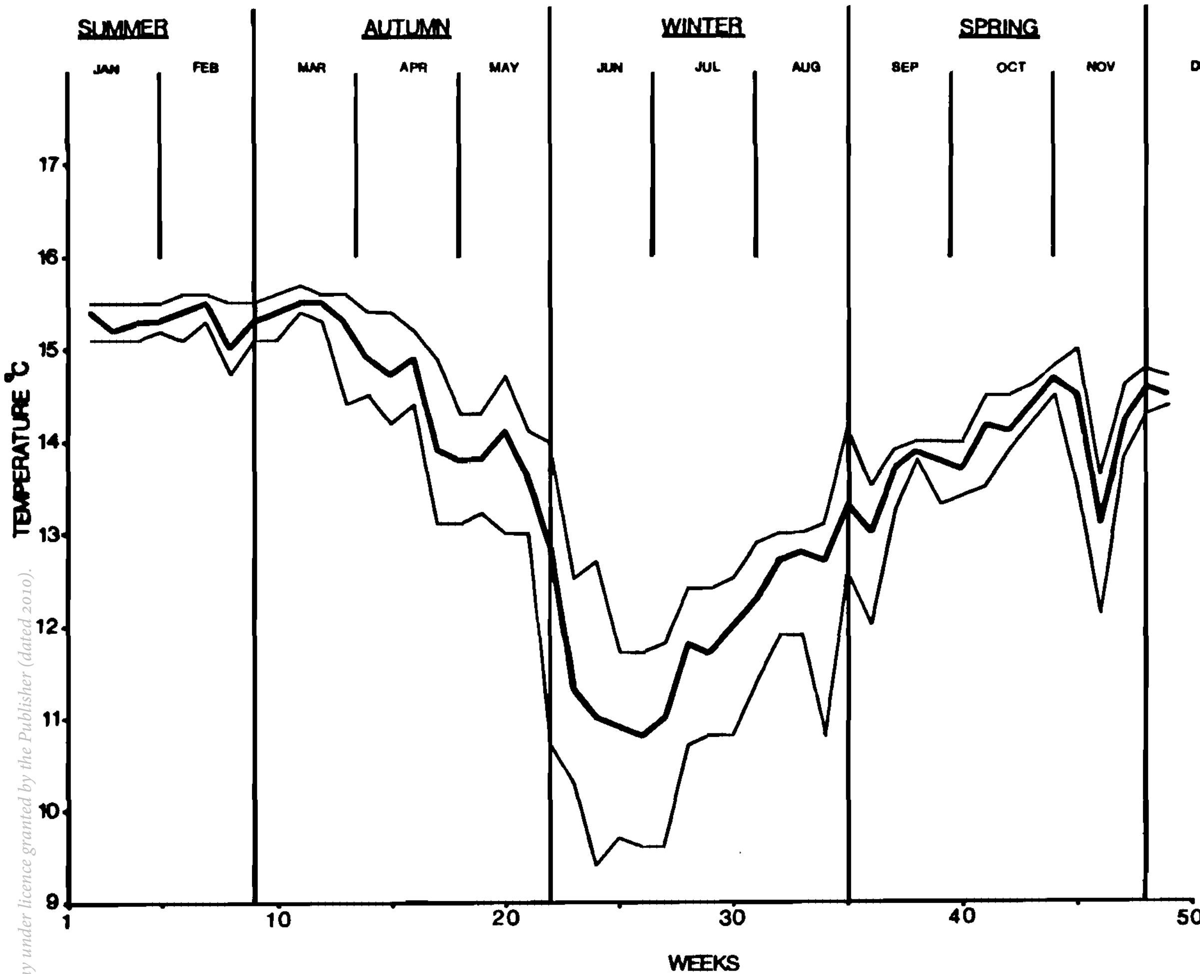

FIGURE 7

Weekly maximum, minimum and mean temperatures in Long One Cave during 1968.

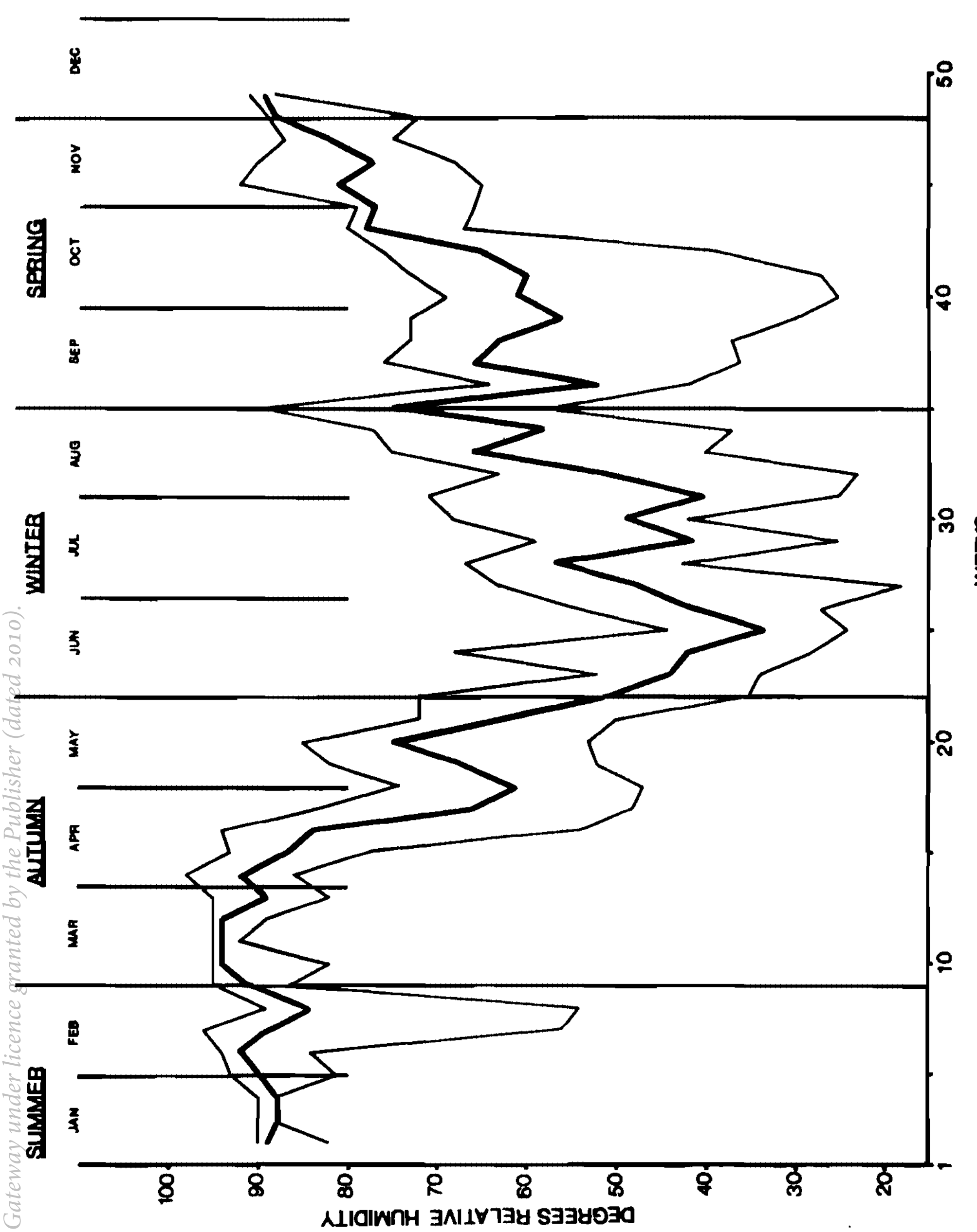

FIGURE 8

Weekly maximum, minimum and mean humidities in Long One Cave during 1968.

fluctuation in humidity, particularly in weekly maximum and minimum values (Figure 8). From January until the end of March, the weekly mean varied between 84% and 94%. From the end of March there was a sharp decline to a mean of 61% at the beginning of May. A sharp increase in humidity to a mean of 75% occurred during mid-May, followed immediately by another sharp decline, to reach the lowest mean value recorded, 33%, at the end of June. From the end of June humidity increased, while fluctuating enormously, until a weekly mean of 89% was reached during December.

The most marked difference between the weekly maximum and minimum humidities was 46%, during the last week of July, when the humidity varied between 25% and 71%. The highest and lowest mean daily humidities for 1968 were 97% (on 2 April) and 27% (on 5 July).

Differences between American Cave and Long One Cave

During 1968 the typical daytime maximum and nightly minimum temperatures of the surrounding area were not reflected in the caves, where temperatures seemed to be much more constant (Figure 3). Similarly, humidity in the two caves proved to be much higher, and much more constant, than that of the surroundings (Figure 4). However, the two caves differed somewhat from each other in both temperature and humidity.

The difference in temperature between the two caves (Figure 3) was always more than 1,5°C, and during the hibernating period (May–July) more than 4°C. American Cave showed fewer marked fluctuations between weekly maximum and minimum temperatures than did Long One Cave (Figures 5 and 7). During the hibernating period the highest and lowest weekly mean temperatures in American Cave were 16,9°C (6–12 May) and 14,9°C (24–30 June) while in Long One Cave they were 14,1°C (13–19 May) and 10,8°C (24–30 June) (Figures 5 and 7).

During the hibernating period the highest and lowest weekly mean temperatures in American Cave were 16,9°C (6–12 May) and 14,9°C (24–30 June) while in Long One Cave they were 14,1°C (13–19 May) and 10,8°C (24–30 June) (Figures 5 and 7).

The smallest difference in humidity between the two caves (Figure 4) was ± 2% (March) and the largest ± 39% (June), the latter during the hibernating period of *M.s. natalensis*. Also during the hibernating period the highest weekly mean humidity recorded in American Cave was 90% (1–26 May) and the lowest 74% (1–7 July). In Long One Cave, for the same period, it was 75% (13–19 May) and 33% (17–23 June) respectively (Figures 6 and 8).

DISCUSSION AND CONCLUSIONS

Hibernation and migration are the characteristic ways in which northern temperate Microchiroptera avoid severe winter climates (Dwyer 1964). In the Transvaal it is not known whether populations of *M.s. natalensis* migrate to warmer winter areas where there are sufficient insects for food. The only migration observed takes place between the cooler highveld and the warmer lowveld where hibernating and maternity colonies are formed respectively. Most of the wintering sites are unknown, but assuming that bats prefer cool temperatures for hibernation, it seems logical that most of these caves will be found on the highveld where winter temperatures are lower than on the lowveld.

According to Twente (1955), caves tend to maintain a constant temperature throughout the year. Cavern temperatures, on the other hand, are variable, because the two openings allow for air circulation and thus for fluctuations in microclimate, caused primarily by the Venturi effect. Wind blowing over one of the entrances sucks air out of the cavern causing air to rush into the other entrance.

Although American Cave should be regarded as a cavern because it has two openings, there was no typical cavern pattern of climatic fluctuation. Temperature in the second chamber (where temperature and humidity were recorded), was constant throughout the year, and did not fluctuate very much in comparison with that in Long One Cave (Figures 3, 5 and 7). This may be explained in one or more ways. First, the second chamber has a single entrance leading at floor level from the eastern corner of the front chamber, where it is likely to be little affected by air circulation in the front chamber. In effect, it is a cave rather than a cavern. Second, the fact that both entrances of the front chamber are along the same (south-western) wall of the front chamber can possibly reduce or, in certain circumstances obviate, the Venturi effect. The front chamber probably serves to buffer the second chamber from fluctuations in temperature, rather than to cause such fluctuations, and therefore helps to stabilize temperatures in this chamber.

Relative humidity in the second chamber presented a parallel picture to that of temperature, being relatively high and very constant (Figure 6). During the winter there was a uniform decrease in both temperature and humidity, but without marked fluctuation between the weekly maxima and minima, as was found in Long One Cave.

In Long One Cave fluctuations in temperature and humidity were not synchronized. There was little vegetation around the entrance during the winter to reduce the force of the wind, which therefore probably had a more direct effect than on the second chamber of American Cave. Although temperature was fairly constant, it was much lower and fluctuated much more than in American Cave. This occurred particularly during the winter when there was a sharp decline in temperature and great fluctuation between the weekly maximum and minimum values (Figure 7). Relative humidity in Long One Cave was much lower, and showed considerable fluctuation, compared with American Cave (Figure 8). Humidity in American Cave might be more favourable for hibernation than that in Long One Cave, being much higher and more constant, and showing fewer fluctuations between the weekly maxima and minima. However, the lower temperatures in Long One Cave, especially during May, June and July, were possibly more favourable for hibernation than those of American Cave. It has been shown elsewhere (Twente 1955; Rice 1957; Griffin 1958; Tinkle and Patterson 1965) that temperature is one of the main factors in inducing and maintaining hibernation.

SUMMARY

Two adjoining caves were found to be occupied by *M.s. natalensis* in more or less equal numbers during the autumn months. However, just before hibernation during the winter months all the bats concentrated in one of the caves where they stayed throughout the hibernating period and the other cave was abandoned.

Both temperature and humidity were relatively much lower and fluctuated much more in the cave used for hibernation. Hibernating *M.s. natalensis* seemed to prefer the cave with the cooler temperatures, although its humidity fluctuated more than might be expected for optimum conditions of hibernation. In the abandoned cave humidity was optimum, but temperatures were

higher. Low temperature could have been one of the deciding factors in influencing the choice of a hibernation site.

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REFERENCES

DWYER, P. D. 1964. Seasonal changes in activity and weight of *Miniopterus schreibersi blepotis* (Chiroptera) in north-eastern New South Wales. *Aust. J. Zool.* 12:52–69.

GRIFFIN, D. R. 1958. *Listening in the dark*. New Haven: Yale University Press.

RICE, D. W. 1957. Life history and ecology of *Myotis austroriparius* in Florida. *J. Mammal.* 38:15–32.

TINKLE, D. W. & PATTERSON, I. G. 1965. A study of hibernating populations of *Myotis velifer* in north-western Texas. *J. Mammal.* 46:612–633.

TWENTE, J. W. 1955. Some aspects of habitat selection and other behaviour of cavern-dwelling bats. *Ecology* 36:706–732.

WEATHER BUREAU. (In Press). *Report on meteorological data of the year 1968.* RT 31/1970. Department of Transport. Pretoria. Republic of South Africa.