THE COMMON SHEATH-TAIL BAT: A TROPICAL BAT WITH ADAPTATIONS FOR A TEMPERATE LIFE-STYLE

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ABSTRACT

It has been suggested that bats originated in the tropics and have since radiated into the temperate regions. A study of the tropical common sheath-tail bat at the southern end of its range has given some insight into the adaptive changes necessary for the invasion of colder latitudes. The sheath-tail bat does not hibernate but conserves energy over winter by lowering its body temperature in response to a decreased body weight or a reduced ambient temperature. Energy is stored in the form of fat, and large deposits are accumulated in autumn each year. Cold winters impose restraints on reproduction and in females this is highly synchronized to place pregnancy, lactation and growth of the young at an optimum time in the summer months. Because of reduced body temperatures, males are unable to produce sperm in winter and must lay down a store of sperm in the warmer months for use the following spring. Juvenile survival is jeopardized as they have little time to build up fat reserves before being faced with their first winter.

INTRODUCTION

About 20% of all known species of mammals are bats. They are found on many oceanic islands and range from the equator to 55°S in Chile (Koopman, 1967) and 65°N in Iceland (Koopman and Gudmundsson, 1966). The diversity of bat fauna is far richer in the tropics and it has been suggested that bats originated in the tropics and have since radiated into the temperate regions (Hand, 1984).

The further a bat ventures from the equator however, the more difficult life becomes. Clearly bats must adapt to cold winter temperatures, but of greater consequence is the risk of starvation. Most bats are insectivores, and in temperate regions insects virtually disappear in winter. Insectivorous birds cope by either migrating to warmer climes or by using beak specializations to remove dormant insects from rotten wood or from under bark. Clearly the second option is not open to bats. Some bats do migrate, but most bats living in the temperate regions rely on a third option, hibernation. If bats did radiate into the temperate latitudes from the tropics then what adaptations have enabled them to pass through the transition from a purely tropical animal to a hibernating temperate animal?

To gain some insight into the adaptive changes necessary for the invasion of colder regions I have been studying the tropical bat, *Taphozous georgianus*, (the common sheath-tail bat) at the southern end of its range in central Queensland. This bat is an insectivore averaging 30 g in weight found roosting in caves across the northern half of Australia. On the eastern side of the continent it is found as far south as Rockhampton.

METHODS

Field studies were carried out over a four year period from January 1985. The majority of bats were tagged and released and over 2,000 captures and recaptures were recorded. Some bats were maintained in captivity for the long term study of body temperature. This was remotely monitored with a radio-transmitting thermometer glued to the back of each animal. Several male bats were sacrificed for a detailed study of their reproductive physiology.

Figure 1. Body temperature in relation to ambient temperature at a body weight of 25 g (± se).

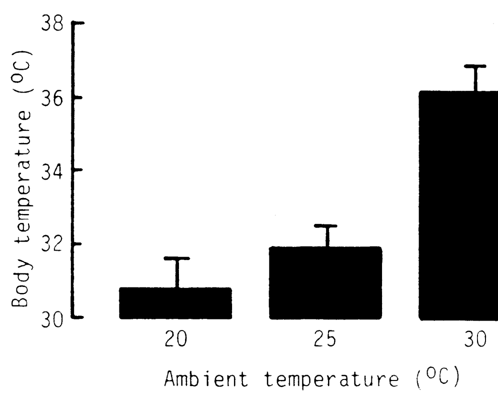
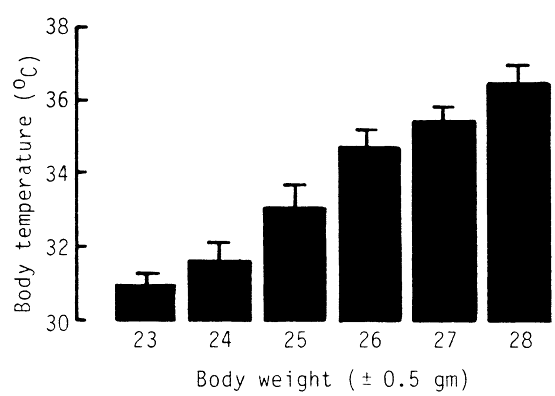


Figure 2. Body temperature in relation to body weight at an ambient temperature of 25°C (± se).



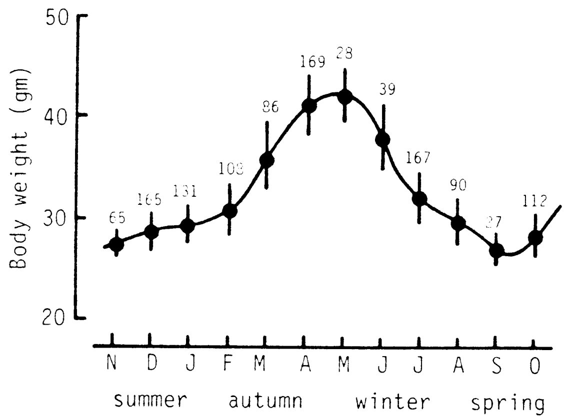


Figure 3. Seasonal change in the body weight of adult bats (± sd)

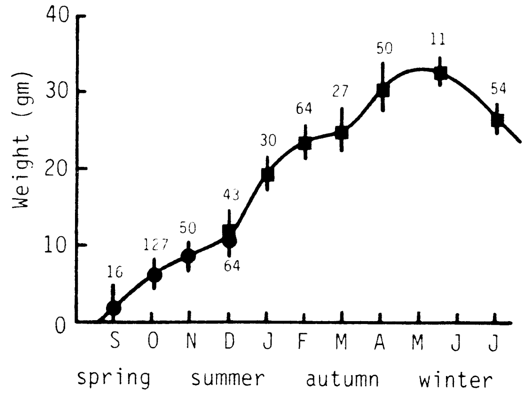


Figure 4. Weight of pregnancies (●) (mean difference between male and female weights) and body weight of juveniles (■) (± sd)

RESULTS AND DISCUSSION

The sheath-tail bat does not hibernate over winter but does lower its body temperature in response to certain conditions. Body temperatures as low as 25°C were recorded and torpor (a depressed body temperature) could be induced in these bats when body weight declined (Figure 1) or ambient temperatures were reduced (Figure 2).

When environmental temperatures are reduced, the maintenance of a high body temperature is energetically expensive. Such an expense can be ill afforded by a bat in winter when food resources are scarce. The ability to lower body temperatures is a valuable adaptation and it is evident that the sheath-tail bat switches into this energy saving mode whenever challenged with reduced environmental temperatures or a declining body weight as a result of food shortage. Some physiologist have suggested that this failure to rigidly maintain a high body temperature is a primitive characteristic, but I can not agree with this view and see the ability to lower body temperature as an advanced feature which has been a crucial adaptation for the invasion of the temperate zones by tropical bats.

Conserving energy is fine, but it is of no value if you don't have the energy to conserve in the first place. It became apparent from the field studies that bats were laying down large fat stores for use over winter. Figure 3 shows the annual body-weight changes in a population of sheath-tail bats. The mean weight of adult bats increases in summer and autumn to a peak of 42 gm in April. Fat reserves are used over winter and the body weight of bats declines by an average of 40% to reach 25 gm in September. Without these fat reserves the sheath-tail bat would not make it through the winter.

Personal survival is one thing, but what really counts is survival of the species. Bats must reproduce, but a number of reproductive constraints are placed on the sheath-tail bat by the difficult winter months. Pregnancy and lactation are energetically expensive for female bats and the rapid growth of young bats also requires a high plane of nutrition. As a consequence, reproduction in females is highly synchronized to place pregnancy, lactation and growth of the young at an optimum time in relation to the summer flush of insects (Figure 4). Mating occurs in September and the females give birth in December. The young bats grow rapidly, reaching adult dimensions within a few months and a peak in body weight by May.

So the females have got their act together, but their reproductive timing makes it difficult for the males. Under normal circumstances, for males to impregnate females in the spring they would be required to produce sperm during winter. Spermatogenesis is not energetically demanding, but the difficulty faced by the male sheath-tail bat is the excessive lowering of testicular temperatures as a result of low body temperatures during the winter. Although the testes of most mammals are maintained at temperatures below the body temperature, enzyme systems within the testes have narrow temperature ranges in which they work most efficiently and the action of the dartos and cremaster muscles to draw the testes of scrotal mammals closer to the body in cold weather is well known. Males have no problem producing sperm in the warmer months, but when winter comes the males lower their body temperature to conserve energy and as a consequence sperm production in the testes collapses. By the time spring rolls around and the females are demanding service, the testes of the males are completely empty. So what the males have to do is lay down a store of sperm in the cauda epididymidis during the warmer months and keep this in readiness through the winter for use the following spring.

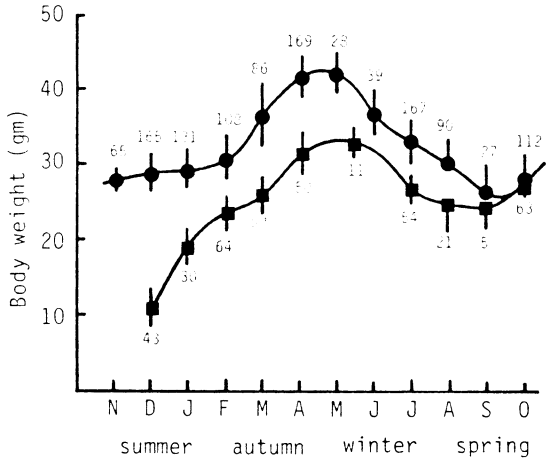


Figure 5. Seasonal changes in the body weight of adults (●) and the body weight of juveniles (■) (± sd).

So in summary, a complex interplay of physiological adaptations is enabling the sheath-tail bat to survive and reproduce at the southern frontier of its range and penetrate further into the temperate latitudes. The 3 key mechanisms involved are :-

1. The reduction of body temperature to conserve energy.

2. The deposition of fat as an energy reserve.

3. The storage of sperm to permit an asynchrony of male and female cycles and allow each to be optimally timed in relation to environmental conditions.

So why hasn't the sheath-tail bat got any further south than Rockhampton? Obviously they're not doing the job well enough yet and if they want to get any further south they are going to have to hibernate completely. Perhaps the biggest problem faced by the species is the survival of the juveniles who have little time to build up fat reserves before being faced with their first winter. While adult bats attain an average weight of 42 gm in autumn, juvenile bats reach an average of only 33 gm before entering their first winter (Figure 5) and they must conserve energy very efficiently if they are to survive to see a second summer.

REFERENCES

HAND, S. (1984) Bat beginnings and biogeography: a southern perspective. In: **Vertebrate Zoogeography and Evolution in Australasia (Animals in Space and Time)**. M. Archer and G. Clayton (Eds.). Herspian Press, Carlisle, W.A. pp. 853-904.

KOOPMAN, K.F. (1967) The southern most bats. **J. Mammal.** 48: 487-488.

KOOPMAN, K.F. and Gudmundsson, F. (1966) Bats in Iceland. **Amer. Mus. Novitates** 2262: 1-6.

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