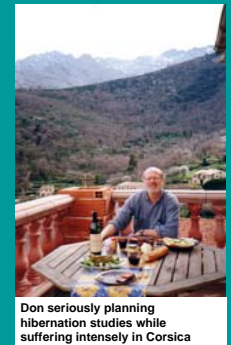




The iBBAT : A Small Datalogger for Recording Body Temperature

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Don seriously planning hibernation studies while suffering intensely in Corsica

Introduction

Bats are among the most thermo-labile of all mammals. Many species and individuals regulate their rate of energy expenditure by adjusting body temperature in response to either the immediate size of their on-board fat reserves or to past or future foraging success. For this reason, monitoring body temperature can tell us much about foraging success and the energetic challenges that individuals face.

This is particularly true for hibernating bats, most of which must survive for up to 8 months on a fixed energy reserve. Hibernating bats may adjust the depth of torpor in response to the size of their fat stores by selecting specific microclimates. They may also adjust the frequency and duration of winter arousals. Torpor parameters are difficult to study by direct observation because hibernating bats are sensitive to human disturbance.

Here, we present a new self-contained datalogger that now allows the measurement of body temperature for bats as small as 10g.

The iBBAT

•The iBBAT is built around the iButton Thermochron technology (Dallas Semiconductors).

•Alpha Mach has developed a rapid and reliable means to extract the thermochron circuit, replace the battery with a lighter model, and repack the assembly in a light waterproof polystyrene case.

•The finished package (model iBBAT) weighs approximately 1.0 g.

•The non-volatile memory can store up to 4096 time-marked temperature samples with $\pm 0.13^\circ\text{C}$ precision or 8192 samples at $\pm 0.5^\circ\text{C}$.

•The circuit is programmable allowing the user to set both the length of the delay before start-up and sampling rate once running.

•The battery will power 500,000 temperature measurements, so the package is reusable over long periods.

•The current price of an iBBAT is CAN\$100, making them cost effective.

User Programmable parameters

Current Date-Time

Delay before wake-up: 1 min to several years

Sampling interval: 5 sec up to 273 hours

Sampling duration: up to 500,000 measurements before battery failure

Memory overwrite (Roll-over): enabled / disabled

Fixed Parameters

Memory Resolution
•8192 entries @ 0.5°C
•4096 entries @ 0.125°C



An iButton thermochron (left) and the circuit once removed for repackaging. Grid is 1 cm.

Field Tests

In October 2004 we placed 13 units on hibernating *Myotis daubentonii* in the Sowia Dolina Mine in southern Poland to test version 1 of the iBBAT. We also placed 28 units on hibernating *M. lucifugus* in an abandoned slate mine near Sherbrooke, Qc to test version 2 of the iBBAT which had a larger-capacity battery.

To attach the iBBAT's to the mid-scapular region, we trimmed the fur and used a non-toxic contact cement. iBBAT's were programmed to record skin temperatures at 21 min intervals in Poland and 28 min intervals in Canada, allowing 121 and 155 days of data collection.

Bats flew well with the iBBAT package and resettled within the mines when released. We recovered 12 of the 13 units from *M. daubentonii* and 17 of the 28 units from *M. lucifugus* in late March 2005.

Although only 1 of 12 units recovered from *M. daubentonii* functioned 13 of 17 units recovered from *M. lucifugus* had registered torpor and arousal cycles over the entire winter. A higher-capacity battery, now used in version 3 of the iBBAT, makes them reliable.



Top: Tomasz Kokurewicz in front of the Sowia Dolina Mine, Poland

Middle: Gate on the Sowia Dolina Mine

Bottom: *M. daubentonii* with iBBAT (version 1)



Top: Entrance to the Windsor Mine near Sherbrooke, Qc in January

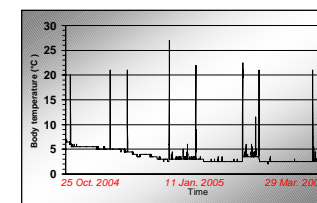
Middle: View from inside the mine in January

Bottom: *M. septentrionalis* with iBBAT (version 2)

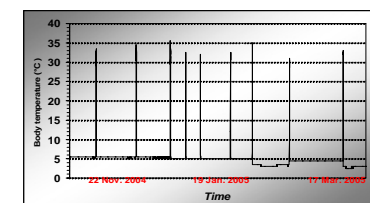
RESULTS

Temperature patterns for hibernating *M. daubentonii* and *M. lucifugus*

Hibernating bats show regular cycles of torpor and arousals that persists throughout winter. Arousals are of short duration (2-3 h) while torpor bouts average 12 d in length. Temporal resolution depends on sampling interval and here was 28 min (Quebec) and 21 min (Poland).



Adult female *M. lucifugus*
Windsor Mine, Québec,



Sub-adult male *M. daubentonii*
Sowia Dolina Mine, Poland

Bats will shift position to seek specific temperature profiles as is shown by this subadult *M. daubentonii* that moved from 5°C to 3.5°C during its second arousal in winter. Note that the iBBAT measures skin temperature relatively accurately and indicates temperatures of $32\text{-}35^\circ\text{C}$ during arousals

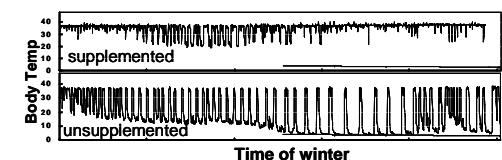
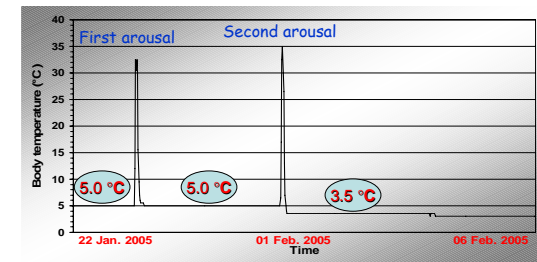


Fig 3: Body temperatures of 2 hibernating chipmunks fitted with datalogger collars allowing the recording of temperatures throughout winter. Note the differences in the depth of torpor of food-supplemented and unsupplemented (control) individuals.

Conclusion

The iBBAT can be used to monitor body temperature over extended periods.

This now allows us to examine the expression of seasonal or daily torpor in bats and a variety of other small mammals as long as they can be recaptured before the units fall off.