Notes on ....

# Measurement of Southern Brown Bandicoot (*Isoodon obesulus*) body temperature using internal and external telemeters

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*Manuscript received January 2007; accepted June 2007*

**Abstract.** Two types of external temperature telemeter were designed and tested for their accuracy in measuring body temperature of southern brown bandicoots. Three attachment sites (groin, armpit and base of tail) and a number of methods of attachment were tested. The most effective was attachment to the base of the tail with surgical tape. Accuracy of external body temperatures was tested against data obtained from a surgically-implanted telemeter. External temperatures measured by telemetry did not accurately reflect core body temperature, but were instead closer to ambient temperature. As such, external telemetry is not recommended for use with animals of this size (~ 1000 g).

**Keywords**: Body temperature telemetry, bandicoot, external telemeter, circadian rhythm.

## Introduction

Measurement of body temperature ($T_b$) is fundamental to studies of mammalian physiology and is of prime importance in assessing the thermal responses of animals which may exhibit heterothermy (Brown & Bernard 1991; Dausmann 2005). The most common method of $T_b$ measurement is via the insertion of a rapidly responding thermocouple or thermistor into the cloaca or rectum. Although accurate if performed correctly, this method requires the study species be captured and handled. Such procedures can be stressful for the study species and therefore may result in elevated $T_b$. Further, the technique does not allow for continual remote measurement of $T_b$ in free-ranging species (Brown & Bernard 1991; Audet & Thomas 1996). To combat this limitation, some researchers use surgically implanted telemeters to remotely monitor $T_b$ (Muchlinski *et al*.; 1998; Refinetti 1999; Geiser & Drury 2003), however, this method also has it drawbacks. The most important is that implantation of telemeters requires the study animals to undergo at least one surgical procedure. This can be stressful and cause infection, both of which can alter thermoregulatory patterns. Surgical implantation also reduces the signal transmission distance of the telemeter (as the signal must pass through the body wall), which is important in studies of highly-mobile species (Audet & Thomas 1996; Barclay *et al*. 1996).

To both measure $T_b$ remotely and avoid surgery related difficulties, external attachment of body temperature telemeters have been used on a number of species of endotherms (Audet & Thomas 1996; Barclay *et al*. 1996; Körtner & Geiser 2000; Körtner *et al*. 2001; Dausmann 2005). In these studies, small telemeters were either glued to the experimental animals, attached using an elastic harness, or as a collar. Individual studies have had mixed results, largely depending on the size of the subject species. External $T_b$ telemetry worked well with small sized animals (~ 20–100 g) where skin temperature ($T_{sk}$) was close to and linearly correlated with $T_b$ (Audet & Thomas 1996; Dausmann 2005). However, in larger animals (380–550 g) the difference between $T_{sk}$ and $T_b$ increased by several degrees (Körtner *et al*. 2001). The only time external $T_b$ telemeters have been used on a mammal greater than 600 g was by Dawson & Bennett (1978), who measured pouch temperature at moderate ambient temperatures ($T_a$) for a single female spectacled hare wallaby (*Lagorchestes conspicillatus*; average mass 2660 g). In this experiment $T_{pouch}$ was approximately 0.4–0.7°C lower than the simultaneously measured rectal temperature.

This study tested the validity of using externally attached temperature telemeters for measurement of $T_b$ for captive southern-brown bandicoots (*Isoodon obesulus*). Data were compared to measurements of $T_b$ obtained using a surgically implanted telemeter.

## Materials and Methods

Two adult male *I. obesulus* were studied at the University of Western Australia. During study, bandicoots were maintained in sheltered outdoor enclosures or controlled temperature rooms (CTR) depending on the experiment and were provided with food and water *ad libitum*.

Two types of single-stage FM external $T_b$ telemeters were custom made for this study (Titley Electronics, Ballina, Australia and Sirtrack Wildlife Tracking Equipment, Havelock North, New Zealand). Both were < 20 mm x 15 mm x 10 mm in size and weighed < 3 g. Both had internal loop antennae and transmission longevity of ~ 3 months. Prior to use, both telemeters were calibrated by placing them in a water bath at various temperatures (measured by a reference mercury thermometer) and recording their pulse rate. The temperature of the water bath was increased in intervals of 2°C every thirty minutes between 10 and 45°C. Exponential equations relating telemeter frequency and temperature were calculated. Telemeters were initially used to test attachment sites (groin, armpit and base of the tail) and methods (including surgical tape and glue) on one bandicoot (mass 1035 g). These particular attachment sites were chosen as it was thought that $T_{sk}$ at these sites would be closer to core $T_b$. Then, one telemeter was coated in purified beeswax and surgically implanted into another study animal (mass 1160 g). For implantation, the bandicoot was anaesthetised with 4% (induction) and 1% (maintenance) halothane. The abdomen was incised and the telemeter inserted into the peritoneum. The incision was stitched and the animal left in a CTR at 28°C for 2 weeks to recover. Another telemeter was attached to the base of the tail of the same animal using surgical tape for comparison between external and internal telemetry data. This bandicoot was placed in a CTR on a 12 hour light:dark cycle. The room was set to 10°C (night) / 20°C (day) for one week (Cycle 1) then 20°C (night) / 30°C (day) for one week (Cycle 2) to test the influence of $T_a$. After this time, the bandicoot was returned to its sheltered, outdoor enclosure and $T_b$ was measured again for approximately 2 weeks. These data are shown in Figure 1.

Telemetry data were recorded using an AR8000 radio receiver, CU8232 interface, antenna and personal computer running AR8000 Temperature Telemeter Logging Companion (© 1997 Stig O'Tracey Spiney Norman Systems). Raw data were exported to MS Excel for conversion and analysis.

## Results

Attachment of external telemeters proved to be difficult at all sites, with the base of the tail proving the best in terms of attachment duration, lowest discomfort for the experimental animals, and greatest signal strength. Attachment in the groin or armpit using surgical tape inhibited the normal movement of the bandicoots and individuals were easily able to reach these sites to remove the telemeter (reducing attachment time to less than 24 hours). Telemeters stayed attached to the tail for 5 to 14 days.

A distinct daily pattern in $T_b$ was observed for *I. obesulus* based on the data from the surgically implanted telemeter (Fig. 1). Under Cycle 1, the average core $T_b$ measured was 36.8±0.1°C (max 39.7°C, min 32.6°C, n = 4547). Both the highest and lowest $T_b$s generally occurred in the early hours of the morning (Fig. 1). During the inactive phase (0600 to 1800 hrs), $T_b$ was more stable than during the night (1800 to 0600hrs – active phase); however, there was no difference in average $T_b$ between day (37.8 ± 0.1°C) and night (37.3 ± 0.1°C) throughout the controlled temperature study. Under Cycle 2, average $T_b$ was 36.0 ± 0.2°C (n = 2502). Base of the tail external telemetry data appeared to simply mirror $T_a$ throughout both trials. Under Cycle 1, average $T_{sk}$ was 17.8 ± 0.1°C (max 25.8°C, min 13.6°C, n = 2041). The inactive phase $T_{sk}$ (19.3 ± 0.1°C) was marginally higher than the active phase $T_{sk}$ (16.5 ± 0.1°C). Inactive phase $T_{sk}$ (19.3°C) was virtually identical to $T_a$ during that time. Under Cycle 2, average $T_{sk}$ was 26.8 ± 0.1°C. Once again, the inactive phase $T_{sk}$ (26.5 ± 0.2°C) was only marginally higher than the active phase $T_{sk}$ (24.3 ± 0.2°C).

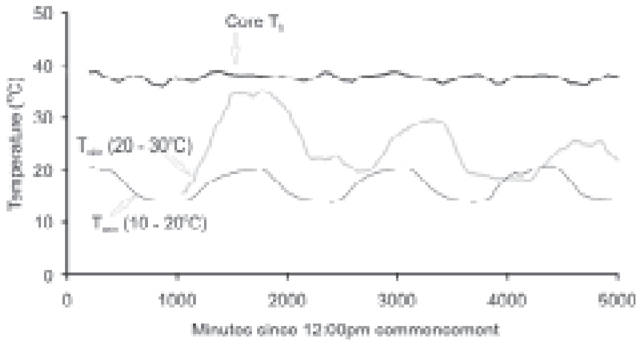


**Figure 1.** Body temperatures of a single male southern brown bandicoot. Black line = core $T_b$ measured by a surgically implanted telemeter for a bandicoot under ambient conditions; dark grey line = external telemetry data under a 10–20°C temperature cycle; light grey line = external telemetry data under a 20–30°C cycle.

## Discussion

Most previously trialled methods of attachment of external telemeters were deemed inappropriate in this study as (i) bandicoots are large enough for the thermal gradient between $T_{core}$ and $T_{sk}$ to become an issue if the telemeter was attached at any site except the most insulated, (ii) I wanted to be able to remove and reattach the telemeters easily and (iii) male (pouchless) animals were used. The resources to custom manufacture specialised telemeter attachment devices were not available, so surgical tape was used as the method of attachment. This was because it is cheap, simple to use, is easily removable and will fall off on its own after a while (important in the field). The 'armpit', groin and base of the tail were used, with the base of the tail proving the best in terms of ease of attachment / removal, strength of signal, reduced bandicoot discomfort and duration of attachment. The fact that base of the tail external telemetry data appeared to simply mirror $T_a$ throughout both trials suggests that the gradient between $T_{sk}$ and $T_b$ for a mammal of this size (ie over ~ 1000 g) is too great and that external body temperature telemetry is not viable for species of this size.

Average $T_b$ measured using internal telemetry was marginally higher than previously reported $T_b$s of resting bandicoots at 30°C (33.7 ± 0.2 to 36.1± 0.1°C; Hulbert & Dawson 1974; Withers 1992, Larcombe & Withers 2006) and the resting $T_b$ of *I. obesulus* at 30°C (35.0 ± 0.1°C; Larcombe 2002). The slightly higher $T_b$ measured here was expected, as the bandicoots were not resting when $T_b$ was measured, but instead continued their normal activity. Increased activity results in an increase in $T_b$ (Brown & Dawson 1977). The mean $T_b$ of the closely related northern brown bandicoot (*Isoodon macrourus*) under $T_a$s of 12–22°C was 36.2°C (range 34.2 to 38.6°C), which is almost exactly the same as the 36.8°C measured in this study under Cycle 1 (Gemmell *et al.* 1997). Similarly, the maximum (38.6°C) and minimum (34.2°C) $T_b$ measured for *I. macrourus* are close to those measured in this study (39.7°C and 32.6°C, respectively). This shows that *I. obesulus*, like *I. macrourus* has a relatively labile $T_b$, with the $T_b$ of both varying by ~ 5°C daily.

The differences in $T_b$s measured in the active and inactive phases of the bandicoots natural circadian cycle can be explained by two factors. Firstly, a more stable inactive phase $T_b$ may be because the animals were intermittently moving during the night/active phase. During the inactive phase, $T_b$ would be expected to be fairly stable as the animals activity levels were relatively constant (ie while they slept) however, this constancy would be lost during the active phase as the animals would have varying levels activity depending on what they are doing. Conversely, the slightly higher inactive phase $T_b$ can be explained by the fact that the $T_a$ when the bandicoots were inactive was up to 10°C higher than the active phase $T_a$.

*I. obesulus* displays a slight nychthermal variation in $T_b$. Hulbert & Dawson (1974) found no pronounced cycle in the body temperatures of five bilbies (*Macrotis lagotis*), however $T_b$ was slightly higher at the beginning and end of the night and that the greatest variation in $T_b$ was during the active phase. Brown & Dawson (1977) found that three species of kangaroo displayed a nychthermal variation in $T_b$ of 1.6–3.1°C, and, generally, rectal temperature was highest in the late afternoon (end of the inactive phase) and lowest in and early morning. The chuditch (*Dasyurus geoffroii*) also had a higher and less variable $T_b$ during the active phase (Arnold 1976). Conversely, Gemmell *et al*. (1997) noted a distinct daily pattern in $T_b$ for several species of marsupial with $T_b$ being higher during the active phase.

The results of this study indicate external temperature telemetry does not provide an accurate measure of $T_b$ in the southern brown bandicoot, and as such it is not recommended for use with animals of this size (~ 1000 g). Further study on a larger sample size is needed to assess whether *I. obesulus*, and marsupials in general, actually exhibit circadian variation in $T_b$ and, if so, what this variation is.

***Acknowledgements**:* This project was funded by an APA Grant. Bandicoots were caught and held under license from CALM. This research was conducted with the approval of the UWA Animal Experimentation Ethics Committee. Thanks to Sasha Voss and Philip Withers for comments on the manuscript and Shane Maloney for the loan of the telemetry equipment and help with implantation surgery.

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