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Body Temperature In Captive Long-Beaked Echidnas (Zaglossus Bartoni)

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Abstract

The routine occurrence of both short-term (daily) and long-term torpor (hibernation) in short-beaked echidnas, but not platypus, raises questions about the third monotreme genus, New Guinea's *Zaglossus*. We measured body temperatures (T_b) with implanted data loggers over three and a half years in two captive *Zaglossus bartoni* at Taronga Zoo, Sydney. The modal T_b of both long-beaks was 31 °C, similar to non-hibernating short-beaked echidnas, *Tachyglossus aculeatus*, in the wild (30–32 °C) and to platypus (32 °C), suggesting that this is characteristic of normothermic monotremes. T_b cycled daily, usually over 2–4 °C. There were some departures from this pattern to suggest periods of inactivity but nothing to indicate the occurrence of long-term torpor. In contrast, two short-beaked echidnas monitored concurrently in the same pen showed extended periods of low T_b in the cooler months (hibernation) and short periods of torpor at any time of the year, as they do in the wild. Whether torpor or hibernation occurs in *Zaglossus* in the wild or in juveniles remains unknown. However, given that the environment in this study was conducive to hibernation in short-beaks, which do not easily enter torpor in captivity, and their large size, we think that torpor in wild adult *Zaglossus* is unlikely.

Keywords: body temperature; long-beaked echidna; *zaglossus*

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1. Introduction

Long-beaked echidnas, *Zaglossus* spp., comprise one of three extant genera of monotreme mammals. They are the largest of the monotremes, 9–16 kg and are found in New Guinea and some nearby islands. Three species have been described, based on small differences in morphology ([Flannery and Groves, 1998]) with *Zaglossus bartoni*, studied for this paper, found only in the cooler montane areas of Eastern New Guinea. *Zaglossus* spp. have been studied little in either ecological or physiological contexts, however, more is known about the other two monotremes.

The striking heterothermy of short-beaked echidnas, but not platypus, raises questions about the thermal relations of *Zaglossus*. Field studies on the short-beaked echidna (*Tachyglossus aculeatus*) have shown lower and more variable body temperatures (T_b) than those usually associated with mammals ([Augee et al., 1970, Grant, 1983, Grigg et al., 1989 and Grigg et al., 1992a]). T_b in the short-beaked echidna characteristically cycles through 4–6 °C on a daily basis with a modal temperature of 30–32 °C ([Grigg et al., 1992a]) and a skew in the distribution of T_b towards the lower temperatures. T_b cycles are usually correlated with activity, an increase in T_b being associated with the onset of activity. In addition, the short-beaked echidna has been shown to exhibit an array of body temperature patterns consistent with both short- and long-term torpor (also described as hibernation) ([Grigg et al., 1989, Grigg et al., 1992a, Nicol and Andersen, 1996 and Grigg and Beard, 2000]). The mostly aquatic platypus, *Ornithorhyncus anatinus*, also displays a daily cycle in T_b, but smaller than in the short-beak (usually <2 °C) with a mode of 32 °C ([Grigg et al., 1992b]). T_b has not been found to correlate with activity and the platypus has not been found to display any patterns, which could be described as torpor or hibernation.

Data for *Zaglossus* in the literature are sparse; a T_b of approximately 29 °C is quoted in [Dawson, 1973] and a mean T_b of 31.7±0.1 °C was measured by [Dawson et al., 1978] using a rectal probe over an ambient temperature (T_a) range of 15–30 °C during measurements of metabolic rate, probably in *Z. bartoni*. [McNab, 1984] reported good thermoregulation at 31 °C from spot measurements before and after metabolic chamber runs over an ambient temperature range of 20–30 °C but decreasing slightly (no lower than 29 °C) at lower T_a. Both researchers indicated that T_b rises at T_a>30 °C. All these measurements were made in an artificial environment, where T_a was held constant and suggested that *Zaglossus* T_b is likely to be in the 'typical' monotreme range. However, there has been no study of T_b in any species of *Zaglossus*, unrestrained and in a naturalistic T_a regime to determine whether or not they show daily cycles in T_b or enter short- or long-term torpor.

Long-beaked echidnas are reported to be increasingly rare and endangered due to habitat destruction and hunting pressure ([IUCN, 2002]) so an investigation of the similarities or differences between them and their short-beaked relatives could allow some of the better-known features of short-beak ecology to be applied to *Zaglossus* conservation management. Although a field study would be preferable, as a first step we carried out this study on two individuals, probably *Z. bartoni* at Taronga Zoo, Sydney, Australia, the only specimens in captivity outside Papua New Guinea. One or both of them may have been used in the metabolic studies referred to above.

2. Methods

The body temperatures of two long-beaked echidnas, considered to be *Z. bartoni* in the light of the revision of the genus by [Flannery and Groves, 1998] a male and a female (estimated ages 30 years and 36 years, respectively, at beginning of study), were monitored continuously from April 1999 to November 2002, except for a 6-week period March–April 2001. They were implanted with temperature loggers ('Tidbit', Onset corp.) coated with a biologically inert mixture of 'Elvax' and paraffin wax and inserted through a mid-ventral laparotomy as described by [Beard and Grigg, 2001]. The wax served to reduce the risk of reaction by the animals to the implant and also to waterproof the loggers to avoid the slow incursion of moisture into the epoxy, which can result in gradual decay of the calibration and, ultimately, failure ([Grigg and Beard, 2001]). Loggers resided in the animals for 2 years, logging every half hour and were replaced half way through the study with loggers recording every 48 min for another 19 months. In addition, during the first period, wax-coated temperature-sensitive radio transmitters (Sirtrack Ltd, New Zealand) were implanted simultaneously to allow location of animals within the exhibit, validate logger data and allow real-time observation of T_b. Average body mass of both long-beaked echidnas was 10 kg throughout the study.

For comparison, two female *Tachyglossus aculeatus* (average body masses 3.5–4 kg throughout monitoring period) were implanted at the same time. Data from short-beaks were obtained from April 1999 to April 2001 and April 1999 to October 2001, respectively. Unfortunately, they both died from unrelated causes before the study was completed and were not able to be replaced due to Zoo exhibition considerations.

The surgical procedures were carried out by veterinary staff at Taronga Zoo, under ethical clearances from both the Zoo and The University of Queensland. Husbandry practices followed those developed and applied over many years by Zoo staff. The animals were all housed together in a naturalistic outdoor pen measuring approximately 8×8 m with earth floor and provision for extensive tunnelling. They were fed daily an artificial diet based on minced meat, olive oil, eggs and bran. Notes were taken by keepers of any significant events involving the study animals. Video footage was taken on a regular but part-time basis, as part of an ongoing program monitoring *Zaglossus* behaviour. Ambient temperature was recorded by another logger hanging in the shade, in the pen. Additionally, comprehensive meteorological data were available from the nearby weather recording station at Observatory Hill in Sydney 3.7 km away and at similar elevation.

3. Results

Neither of the long-beaked echidnas showed any sign of prolonged, deep torpor. In contrast, the short-beaked echidnas in this study exhibited T_b patterns indicative of deep torpor or hibernation in three out of the five-echidna years for which we have data. Fig. 1 shows T_b data from the female long-beak compared with that from one of the short-beaks.

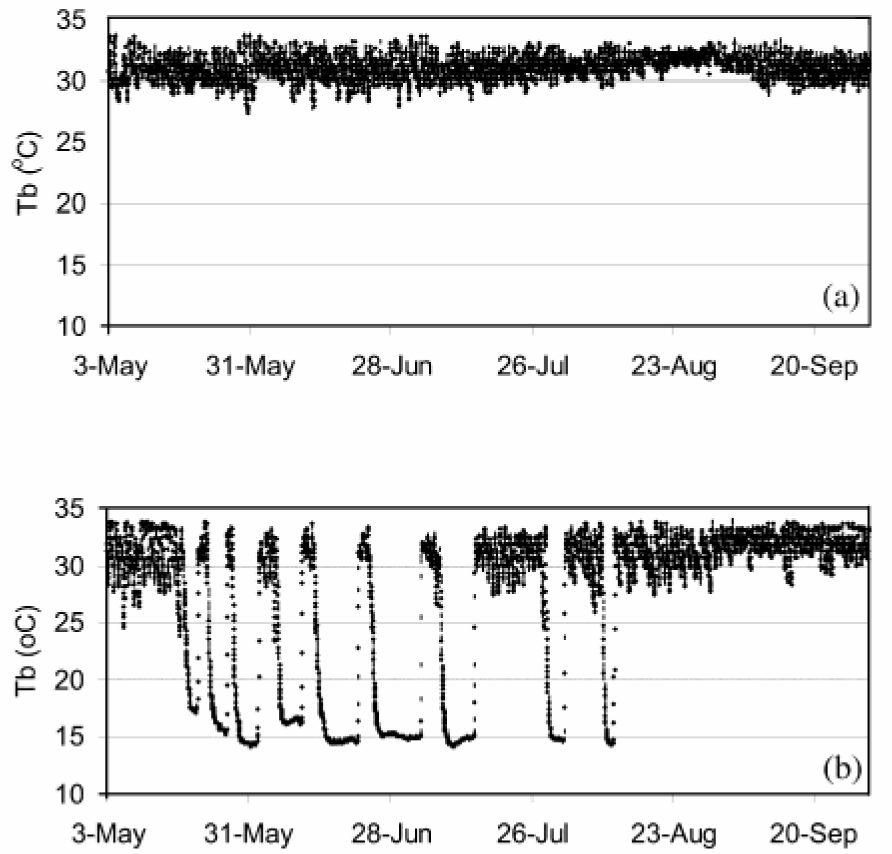

Fig. 1. Comparison of T_b pattern for (a) *Zaglossus* female and (b) *Tachyglossus* female during 5 months of 2001.

Both *Z. bartoni* mostly showed an asymmetrical daily cycle in body temperature (Fig. 2) similar to that seen in short-beaks. The most common period between consecutive T_b minima was 24–27 h and the modal amplitude was 2–4 °C. Daily T_b minima occurred around dusk (more tightly correlated in the male than the female) coinciding with the onset of nightly activity as confirmed by video. Daily T_b maxima were usually observed just before the cessation of nightly activity, when the animals were last seen on video (usually between midnight and 04.00 h).

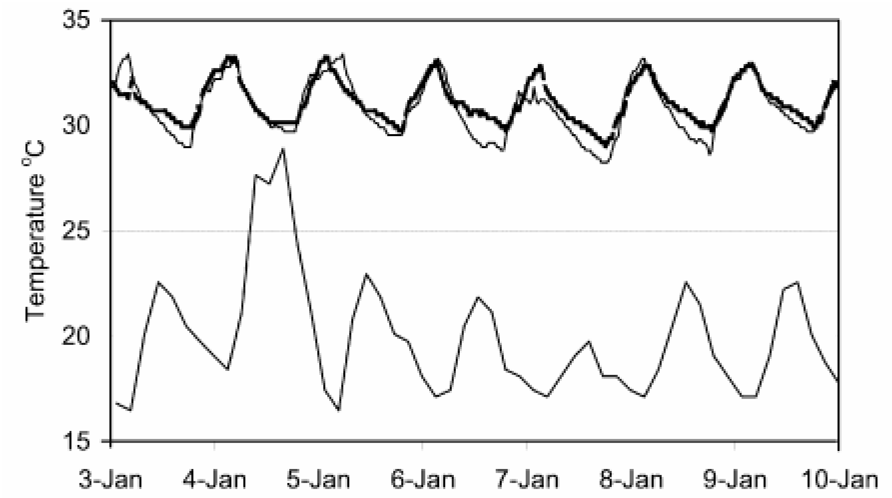

Fig. 2. Typical daily T_b pattern in the male (heavier dotted line) and female (lighter solid line) *Zaglossus* in January 2000. The lower trace is shaded air temperature recorded in the animals' pen.

The distribution of body temperatures recorded for both long-beaks and short-beaks over the whole study is shown in Fig. 3 along with a previously published distribution from platypus ([Grigg et al., 1992b]). The long-beaked echidnas showed a broadly similar distribution of T_b to their short-beaked cousins, but less skewed towards lower temperatures. Both types of echidna appear to be more heterothermic than platypus.

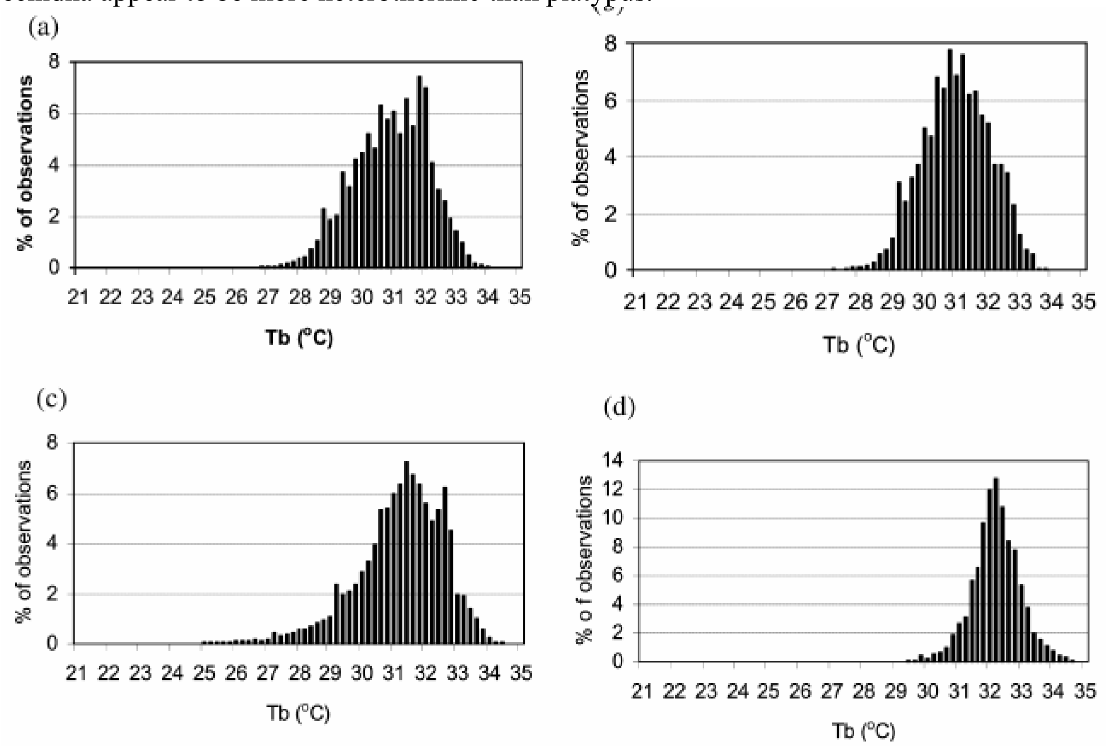

Fig. 3. Frequency histograms showing distribution of T_b in (a) the male *Zaglossus*, (b) the female *Zaglossus*, (c) the two female *Tachyglossus* in this study, and (d) platypus (from [Grigg et al., 1992b]).

The minimum T_b registered for the male *Zaglossus* was 24.2 °C (occurring in January 2001) and for the female, 26.5 °C (in November 2000 and September 1999). However, in general, body temperatures of both *Zaglossus* were above 29 °C. Minima below 29 °C was not necessarily associated with 'days off' (see below). Interestingly, the occasions on which lower than usual T_b for both male and female *Zaglossus* were associated with significant rainfall. For example, the male's lowest recorded T_b occurred on a day registering 129 mm rainfall in 12 h. The female also recorded a low T_b (27.9 °C) during this time, as did one short-beak.

Maximum T_b recorded for both *Zaglossus* was 34.2 °C, in January 2002 for the male and in October 2001 for the female, but T_b usually did not exceed 33 °C. Any excursions above this were mostly brief, with T_b brought back down very quickly, in contrast to excursions below the usual minima, which were often more prolonged. The T_b of the short-beaks was generally more labile, with maxima more often exceeding 33 °C (even up to 35 °C) and minima often drifting below 27 °C.

Data collected in 2000 from both *Zaglossus* were examined in closer detail. No trend was found in amplitude of daily cycles through the year and no influence of time of year on daily maximum or minimum T_b. Nor was there any correlation between daily minimum T_a and daily minimum T_b. However, the long-beaks did show some departures from the 'normal' pattern. Infrequently (less than half a dozen times per year), T_b dropped continuously for more than 24 h (Fig. 4a,b) resulting in a pattern reminiscent of the 'days off' described for *Tachyglossus* by [Grigg et al., 1992a]. The resulting minimum T_b was not necessarily lower than that for a normal daily cycle (Fig. 4b), nor was the lowest minimum T_b always associated with a 'day off'. These 'days off' were scattered throughout the year and never extended beyond 60 h. The lack of a daily peak in body temperature was taken to indicate lack of activity (as has been shown in short-beaks) and this was confirmed in a number of cases by the video record and by direct observation. There were more examples of this pattern in the male than in the female *Zaglossus*.

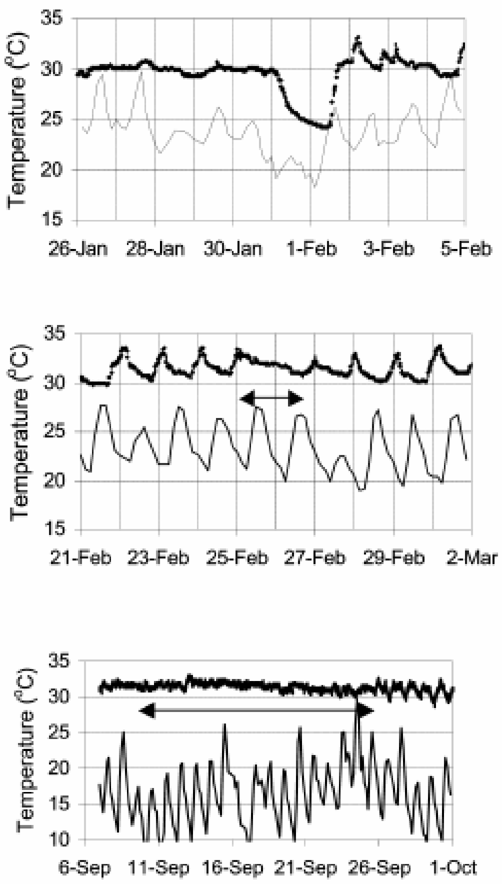

Fig. 4. Examples of departures from the typical T_b pattern. (a) Male *Zaglossus* in 2001 (known to be inactive until February 2) showing both patterns we have associated with lack of above-ground activity: reduced amplitude of daily swings in T_b, January 26–30 and 'day-off' January 31–February 1.

Heavy rain occurred on January 31. (b) Female *Zaglossus* in 2000 showing 'day- off' pattern (→). Note that minimum T_b reached did not drop below other daily minima. (c) Female Zaglossus in 2002 showing period of relative thermostability (→) during which she was not sighted above ground. Lower traces in each panel are ambient temperatures measured at Bureau of Meteorology station 3.7 km away. Ticmarks=midnight.

In contrast, other departures from the 'normal' pattern occurred when the amplitude of daily swings in body temperature was very much reduced, sometimes to <0.5 °C (Fig. 4c). This could occur at any time of year and from instances when this coincided with observations by keepers and on video this pattern of greater thermostability was also correlated with inactivity—or at least when the animal was not visible above ground. Indeed, qualitatively, there was a positive correlation between the degree of activity (as judged by time observed active on video) and the amplitude of the daily T_b cycle. Also, during these periods the time of the daily minimum was irregular and did not coincide, as at other times with dusk. This lack of entrainment of daily T_b rise with time of day further supports the assumption that this T_b pattern relates to lack of normal above ground activity. The pattern of reduced daily heterothermy was more often observed in the female than in the male and she tended to maintain a T_b higher than 31 °C with some excursions to higher than normal maxima during these times.

The T_b patterns indicating lack of above-ground activity did not occur coincidentally in the male and female *Zaglossus*.

4. Discussion

Long-beaked echidnas, short-beaked echidnas and platypus together provide a general picture of monotremes as heterothermic mammals with modal T_b in the low 30 s, lower than that of most Metatheria and Eutheria. The daily T_b swings in the long-beaks were less than those seen in short-beaks and more akin to the platypus pattern. The narrower range in *Zaglossus* may be due to the thermal inertia of a larger animal. As far as can be ascertained from this study, adult *Z. bartoni* do not appear to employ the long-term or deep torpor seen in *Tachyglossus sp*. Of all *Zaglossus*, *Z. bartoni* would be the species most likely to show any kind of torpor, living as it does in the cooler areas of New Guinea. Although the long-beaks in this study were captive, conditions were conducive enough to encourage the short-beaks living in the same enclosure to hibernate, despite being notoriously unwilling to do so in captivity. We think it unlikely, therefore, that adult *Zaglossus* will be found to hibernate in the wild, especially considering their large body size compared to other known hibernators and the energy implications of rewarming. It is possible, however, that juveniles may be more like short-beaks it their T_b profile owing to their smaller size.

Although departures from the daily cyclic pattern were observed in the long-beaks, this seldom resulted in lower than normal T_b and, therefore, probably do not constitute torpor but merely, literally, a 'day off' where a rise in T_b was not experienced due to their inactivity.

The periods of reduced heterothermy are interesting. Most were at relatively high T_b; perhaps indicating some activity underground, particularly as some of the highest and most prolonged high T_b was recorded during these times. Short-beaked females are known to exhibit periods of high and stable T_b when underground in late gestation, incubation or early nursing ([Beard and Grigg, 1992 and Beard and Grigg, 2000]). Although this long-beaked female has not bred, by analogy with short-beaks she may have been exhibiting T_b patterns associated with reproduction during at least some of these periods. Indeed, if higher and more stable T_b could be shown to correlate with some facet of reproduction, this could be useful in attempts at captive breeding. The fact that the male showed this stable pattern much less often (and tended to have a lower T_b when he did) perhaps supports this possibility.

In common with *Tachyglossus*, ambient temperature *per se* seems not to affect T_b of the long-beaks. This concurs with the studies by [Dawson et al., 1978 and McNab, 1984] in which T_b measured in equilibrium with a constant T_a varied little over a T_a range up to 30 °C.

As with short-beaks, the daily T_b cycle seems to be correlated closely with activity ([Grigg et al., 1992a]), which seems to play a major part in elevation of body temperature. This could be a potential problem, assuming an upper lethal temperature similar to *Tachyglosssus* (approx. 36 °C) and larger body size. However, unlike *Tachyglosssus*, *Zaglossus* do possess sweat glands, can apparently greatly increase their conductance at T_b>20 °C and have a very low metabolic rate ([Dawson et al., 1978 and Dawson et al., 1979]). Also, the *Zaglossus* in this study, unlike *Tachyglossus,* appear to be almost exclusively nocturnal which would tend to reduce the risk of overheating with exercise.

The only climatic variable, which showed any correlation with T_b was rainfall, perhaps surprisingly, because *Zaglossus* inhabit areas of routinely high rainfall. However, this was not a particularly tight correlation and possible reasons for it along with other departures from normal rhythmic T_b patterns will have to wait for a field study. We are mindful that early work on captive *Tachyglossus* provided some quite misleading information later found not to be applicable in the wild. We hope this study may provide a springboard from which to launch a fuller investigation of *Zaglossus*' thermal capabilities in the wild.

Acknowledgements

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References

Augee et al., 1970. M.L. Augee, E.H.M. Ealey and H. Spencer, Biotelemetric studies of temperature regulation and torpor in the echidna, *Tachyglossus aculeatus*. *J. Mammal.* **51** (1970), pp. 561–570.

Beard and Grigg, 1992. L.A. Beard and G.C. Grigg, Reproduction by echidnas in a cold climate. In: M.L. Augee, Editor, *Platypus and Echidnas*, The Royal Zoological Society of NSW, Sydney, Australia (1992), pp. 93–100.

Beard and Grigg, 2000. L.A. Beard and G.C. Grigg, Reproduction in the short-beaked echidna, *Tachyglossus aculeatus*: field observations at an elevated site in South-East Queensland. *Proc. Linn. Soc. NSW* **122** (2000), pp. 89–99.

Beard and Grigg, 2001. Beard, L.A., Grigg, G.C., 2001. Radiotelemetry of echidnas and platypus. In: Eiler, J.H., Alcorn, D.J., Neuman, M.R. (Eds.), Proceedings of 15th International Symposium on Biotelemetry. Juneau, Alaska, USA. International Society on Biotelemetry, Wageningen, The Netherlands, pp. 493–500

Dawson, 1973. T.J. Dawson, Primitive mammals. In: G.C. Whittow, Editor, *Comparative Physiology of Thermoregulation* **3**, Academic press, New York and London (1973), pp. 1–46.

Dawson et al., 1978. T.J. Dawson, D. Fanning and T.J. Bergin, Metabolism and temperature regulation in the New Guinea monotreme *Zaglossus* bruijnii. In: M.L. Augee, Editor, *Monotreme Biology, The Australian Zoologist* **20(1)**, The Royal Zoological Society of NSW, Sydney, Australia (1978), pp. 99–103.

Dawson et al., 1979. T.J. Dawson, T.R. Grant and D. Fanning, Standard metabolism of monotremes and the evolution of endothermy. *Aust. J. Zool.* **27** (1979), pp. 511–515.

Flannery and Groves, 1998. T.F. Flannery and C.P. Groves, A revision of the genus *Zaglossus* (*Monotremata*, *Tachyglossidae*), with description of new species and subspecies. *Mammalia 1* **62** 3 (1998), pp. 367–396.

Grant, 1983. T.R. Grant, Body temperatures of free-ranging platypuses (*Monotremata*), with observations on their use of burrows. *Aust. J. Zool.* **31** (1983), pp. 117–122.

Grigg et al., 1992a. G.C. Grigg, M.L. Augee and L.A. Beard, Thermal relations of free-living echidnas during activity and in hibernation in a cold climate. In: M.L. Augee, Editor, *Platypus and Echidnas*, The Royal Zoological Society of NSW, Sydney, Australia (1992a), pp. 160–173.

Grigg et al., 1989. G.C. Grigg, L.A. Beard and M.L. Augee, Hibernation in a monotreme, the echidna *Tachyglossus aculeatus*. *Comp. Biochem. Physiol. A* **92** (1989), pp. 609–612.

Grigg and Beard, 2000. Grigg, G.C., Beard, L.A., 2000. Hibernation by echidnas in mild climates: hints about the evolution of endothermy? In: Heldmaier, G., Klingenspor, M. (Eds.), Life in the Cold. Eleventh International Hibernation Symposium. Springer-Verlag, Berlin, pp. 5–20

Grigg and Beard, 2001. Grigg, G.C., Beard, L.A., 2001. Application of radiotelemetry to studies of the physiological ecology of vertebrates. In: Eiler, J.H., Alcorn, D.J., Neuman, M.R. (Eds.), Proceedings of 15th International Symposium on Biotelemetry. Juneau, Alaska USA. International Society on Biotelemetry. Wageningen, The Netherlands, pp. 535–551

Grigg et al., 1992b. G.C. Grigg, L.A. Beard, T.R. Grant and M.L. Augee, Body temperature and diurnal activity patterns in the platypus, *Ornithorhynchus anatinus*, during winter. *Aust. J. Zool.* **40** (1992b), pp. 135–142.

IUCN, 2002. IUCN 2002, 2002 IUCN Red list of threatened species

McNab, 1984. B.K. McNab, Physiological convergence amongst ant-eating and termite-eating mammals. *J. Zool. Lond.* **203** (1984), pp. 485–510.

Nicol and Andersen, 1996. Nicol, S., Andersen, N.A., 1996. Hibernation in the echidna: not an adaptation to cold? In: Geiser, F., Hulbert, A.J., Nicol, S.C. (Eds.), Adaptations to the Cold: Tenth International Hibernation Symposium. University of New England Press, Armidale, Australia, pp. 7–12.