
Body temperatures of the Common toad, *Bufo bufo*, in the Vendee, France

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ABSTRACT — Field body temperatures of nocturnally active Common toads (*Bufo bufo*) ranged from 11.7–18.9°C and from 27.8–34.2°C when in daytime retreats or abroad. The lowest body temperatures of individual toads were recorded during March and November. Body temperatures had good associations with air and substrate temperatures during nocturnal activity but were significantly lower than air temperatures in open areas during the day.

IT is well known that temperature influences the behaviour and metabolism of ectotherms and therefore field body temperatures are critical for physiological processes and for survivorship (Hutchison & Dupre, 1992). Thermal studies have largely concerned reptiles; less attention has been paid to the amphibia which often undergo sustained activity in the field, for instance during migratory behaviour (e.g. Oldham, 1967; Szatecsny & Schabetsberger, 2005) or in conflicts over territory or mates (e.g. Wiewandt, 1969). The field body temperatures of nocturnally active anurans are of interest as they may define the thermal niche of a species and determine when and where a species is active. Except for temperatures recorded during migratory movements there appears to be little information on body temperatures of the common European toad, *Bufo bufo* (eg Wisniewski *et al.*, 1981; Reading & Clark, 1995). A recent major review (Beebee & Griffiths, 2000) records a decline in activity below 5–6°C (Slater *et al.*, 1985) but it appears there is no information on temperatures throughout the active year. In this paper, we present such information on the annual activity body temperatures of *B. bufo* in France.

METHODS AND MATERIALS

Information was gathered during 2003 and 2004 in the Vendee region of France. Most data ($n = 143$) were recorded when searching fields and gardens at night, apparently whilst they were foraging in

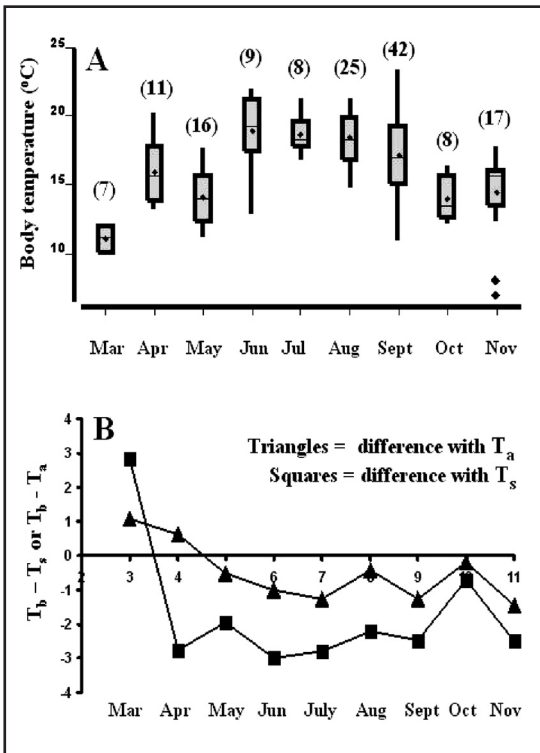
terrestrial home ranges or engaged in post breeding wandering. Some individuals were found during the day ($n = 15$) but as far as we could ascertain, no animals were involved in breeding migration. Body temperature (T_b) was measured using a Digitron infra-red pyrometer and here defined as the skin surface temperature taken at less than 5 cm from the skin surface. Skin surface temperature may only differ by small amounts from cloacal temperature in anurans ($mean = 0.46^\circ\text{C}$) but handling the animals may result in considerably raised body temperature (Fouquette, 1980). Thus, no animals were handled during sampling. The default error on the detector is 0.01°C . The emissivity was set at 0.95, an estimated value for the dry skin of toads that we assumed is close to the value for reptiles (emissivity of reptiles = 0.95 (Tracy, 1982)). Hence, there may be a small degree of error in the readings. Simultaneously to body temperatures, air temperatures (T_a) were recorded 10–15 cm above the surface where the toad was located and substrate temperatures (T_s) by directing the Pyrometer at the substrate surface. Humidity was recorded with a L'atelier humidity meter.

RESULTS

Nocturnal body temperatures. Active toads were observed between March and November. Figure 1 A shows monthly body temperatures of animals active after dark. Mean nocturnal T_b ranged from 11.7–18.9°C with the highest means recorded in

June, July and August (*means* of 18.9, 18.7 and 18.4°C respectively). Body temperatures were significantly higher than T_a or T_s only during March (two sample *t*-tests: versus T_s , $t = 8.2$, $p < 0.0001$, $d.f. = 8$; versus T_a , $t = 2.8$, $p = 0.02$, $d.f. = 10$). In general, mean monthly T_b ($15.8 \pm 2.6^\circ\text{C}$) was lower than mean monthly T_a ($16.1 \pm 3.3^\circ\text{C}$) and mean monthly T_s ($17.4 \pm 4.3^\circ\text{C}$) but the differences were not significant (two sample *t*-tests $p > 0.05$). A plot of the differences can be seen in Fig 1B. Coefficients of determination (r^2) have

Figure 1. Graphs of monthly body temperatures in *B. bufo*. Fig. 1A shows box plots of monthly means and distributions of body temperatures. The boxes represent the interquartile ranges, the means are shown as diamonds and the medians as horizontal bars. Vertical lines either side of the interquartile ranges represent the general ranges but the large diamonds for November (Fig1A) represent outliers - data that are between 1.5–3 times from the interquartile range. Numbers in parenthesis indicate sample sizes. Fig 1B shows the monthly differences between mean body temperatures and mean air or substrate temperatures.



been calculated to estimate the variation in body temperature that can be explained either by variation in air or substrate temperatures. The results suggest association of body temperature with both environmental temperatures (substrate $r^2 = 70.8\%$, air $r^2 = 70.6\%$) but not with humidity recorded at the time of capture (*mean humidity* = $80.3 \pm 9.9\%$, $r^2 = 0.3\%$). Nor were mean monthly body temperatures associated with the mean number of sightings per month (*mean sightings* = 15.8 ± 11.4 , *range* = 7 – 42, $r^2 = 6.9\%$) or the mean monthly humidity levels (*mean of the monthly means* = $80.9 \pm 5.2\%$, $r^2 = 3.3\%$).

Diurnal body temperatures. Fifteen individuals were found during daylight hours in what appeared to be either sentinel activity ($n = 4$; see Fig 2 for an example) or in hide areas. Body temperatures ranged from 27.8–34.2°C (*mean* = $30.2 \pm 2.2^\circ\text{C}$) and were significantly lower than mean substrate temperatures in the open (*mean* = $41.3 \pm 2.3^\circ\text{C}$, $t = 11.1$, $p < 0.0001$, $d.f. = 25$), significantly higher than shaded substrate temperatures (*mean* = $28.4 \pm 2.7^\circ\text{C}$, $t = 2.03$, $p = 0.05$, $d.f. = 26$) but not significantly different from shaded air temperatures (*mean* = $28.8 \pm 2.5^\circ\text{C}$, $t = 1.6$, $p = 0.11$, $d.f. = 28$).

DISCUSSION

The toads measured in this study were active over broadly a similar period of time as those studied elsewhere (e.g. Wisniewski *et al.*, 1981; Slater, *et al.*, 1985 and review in Beebee & Griffiths, 2000) and over a wide range of body temperatures. The lowest nocturnal body temperatures were found during November but March temperatures were also low and just above ambient temperatures of 2–4°C when activity apparently ceases in other areas (Wisniewski *et al.*, 1981). It may be that the higher than environment temperatures in March were achieved by the toads seeking out higher microhabitat temperatures and although the differences were small may be significant for an individual toad. Research on UK populations has suggested that the temperatures required for activity may be population specific (e.g. Frazer, 1966; Wisniewski *et al.*, 1981). Although we

found no statistical association between toad activity or T_b with humidity, it is likely that humidity is important for activity at certain times of the year. For example, although temperature may be the critical factor for long distance migration in the UK (R.A. Griffiths, pers. comm.) current work in the Vendee suggests there is the possibility, based on road mortality counts, that such movement in late October and November may in part be rainfall dependent.

The Vendee area is well known for hot, very dry summers with daytime humidity dropping to around 20% increasing to 80–90% in the hours after dusk; daytime retreats when found, were under sheets of plastic, canvas and cardboard. These were locations where temperatures and humidity were high and presumably enhance digestion efficiency and reduce dehydration. Daytime activity abroad may concern sit-and wait predation (Fig. 2) but could also be examples of mosaic basking (R. Avery, pers. comm.). However, it is unknown whether diurnal activity is common but difficult to detect, or simply infrequent. The high body temperatures recorded for diurnal activity are in good agreement with those found in other day active anurans (Carey, 1978) and, perhaps surprisingly, comparable with those in deserts (eg *Bufo mauritanicus* and *Rana perezi*; Meek, 1983) which are close to the lethal temperatures for toads of around 38°C (Brattstrom, 1979; Hutchinson & Dupre, 1992). Evaporative cooling should enable basking anurans to maintain relatively low body temperatures as evaporative losses increase at higher air temperatures stabilising body temperature (Shoemaker, *et al.*, 1987; Buttemer & Thomas, 2003). Indeed, certain anurans are active abroad even when the environment may be too hot for reptiles (Meek, 1983). Laboratory studies on



Figure 2. Diurnal sentinel behaviour/ mosaic basking in *B. bufo*. This individual was found in June 2004 when air temperatures were above 30°C.

bufonids have shown a strong correlation of field selected body temperatures with physiological performance (e.g. Putnam & Bennett, 1981) indicating the importance of body temperature for activity.

Nocturnal activity may partly involve the avoidance of predators. Ten captured snakes in the area – (nine *Natrix natrix* and one *N. maura*) regurgitated Common toads suggesting they are major predators in the Vendee as they are elsewhere (Reading & Davies, 1996; Arnold & Ovenden, 2002). Both snakes are common, diurnally active and widely foraging and hence, for toads, minimising diurnal activity may be adaptive in that it reduces predator encounter frequency, although it may be that the snakes search toad daytime retreats. Interestingly, if this small sample of snake feeding behaviour is representative, it could indicate that the more diurnally abundant green frogs (*Rana esculenta/lessonea* complex) are largely ignored because they bask extensively, have high body temperature and hence presumably have greater agility and speed compared to *B. bufo*.

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