Short notes

Field body temperatures of the lizard *Anguis fragilis*

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Although the body temperatures of lizards active in the field have been studied for many years, the majority of such studies have used day-active heliothermic animals, in many cases from the deserts of North America and Australia (Avery, 1982). Such lizards tend to have a high mean activity temperature (in many cases, well over 30°C; Cloudsley-Thompson, 1971) and it is generally assumed that the activity temperature range (Pough and Gans, 1982) is narrow, although precise information on the width of the activity temperature range is commonly lacking (Huey, 1982; Avery, 1982). Such species occupy the specialisation end of a continuum running from strict thermal specialism (species in which the activity temperature range is narrow and body temperature tends not to correlate with ambient temperature) to thermal generalism and thermoconformity (species where body temperature passively tracks ambient temperature and thus if ambient temperature varies widely, the activity temperature range will tend to be wide. Huey and Slatkin (1976) argue that thermal specialists will tend to be found where the costs of precise thermoregulation are low. Thermal generalists and thermoconformers will be found in places, such as aquatic and fossorial habitats and tropical forest, where the costs of precise thermoregulation are high. Our knowledge of the thermal relations of species living in these high cost thermal environments is rather meagre. Although some lizards from such environments are thermoconformers (Hertz, 1981), it is known that others do show some thermoregulatory adjustments (Huey and Webster, 1975; Hertz and Huey, 1981) although body temperature is generally not maintained as high or as precisely as in

many species from low-cost thermal environments (Huey, 1974; Huey and Webster 1976).

This study reports on field body temperatures of the European legless lizard *Anguis fragilis*, a species which is partly fossorial and which is associated with thick vegetation: it is rarely seen in the open (Smith, 1964). Although this species is rarely encountered basking directly in the sun, it frequently raises its body temperature under sun-warmed objects such as sheets of corrugated iron and thin rocks (Arnold and Burton, 1978). Thus, although *A. fragilis* presumably lives in a high cost thermal environment, it is probably not a strict thermoconformer. The selected body temperature range and mean selected temperature (Pough and Gans, 1982) of small numbers of this species in laboratory thermal gradients have been reported (Spellerberg, 1976; Gregory, 1980). However, the relevance of such laboratory studies to body temperatures of animals in the field must be questioned, particularly for a species living in a high cost thermal environment. In such circumstances the cost of thermoregulation in laboratory thermal gradients may well be lower than in the field.

Cloacal temperatures (T_b) of 83 adult *A. fragilis* were recorded with a Schultheis fast-registering mercury thermometer within 20 seconds of capture at a number of sites in southern England and Wales (between latitudes 50°N and 52°N) between April and September. Four *A. fragilis* were found lying in the open while the remaining 79 were located under objects such as sheets of corrugated iron, pieces of thin wood and thin slabs of limestone, all of which are capable of transmitting heat when warmed by the sun. Air temperature 1 m above the ground (T_a) was recorded immediately after each recording of *A. fragilis* body temperature. In addition, the sex of each animal, the time of day at which T_b was measured, and the prevailing climatic conditions were recorded. T_bs obtained between 1000 and 1500 hours on bright sunny days were con-sidered to have been obtained under conditions which were optimal for thermoregula-tion (referred to hereafter as 'optimal conditions'). T_bs obtained before 1000 hours, after 1500 hours, or between 1000 and 1500 hours on days whch were not bright and sunny were considered to have been obtained under conditions which were not optimal for thermoregulation (referred to hereafter as 'suboptimal conditions').

There was no significant effect of month of collection or sex on T_b of *A. fragilis* ($P > 0.05$ in both cases), but there was a highly significant effect of conditions under which T_b was obtained ('optimal' or 'suboptimal': $P < 0.001$). There was no signifi-cant interaction effect (month × sex × 'optimal'/'suboptimal' conditions: $P > 0.05$; 3-way ANOVA). In view of this, T_bs collected at different months and T_bs of males and females were considered together but T_bs collected under 'optimal' and 'subop-timal' conditions were considered separately.

The range of T_b recorded for *A. fragilis* under 'optimal' conditions (N = 69) varied from 14.5°C to 28°C (fig. 1); mean T_b was 22.6°C, with a standard deviation (SD) of 3.1°C. The regression equation relating T_b to T_a was as follows:

$$T_b = 25.9 - 0.216 \, T_a \quad (r = 0.212, \ df = 68, \ P = 0.081)$$
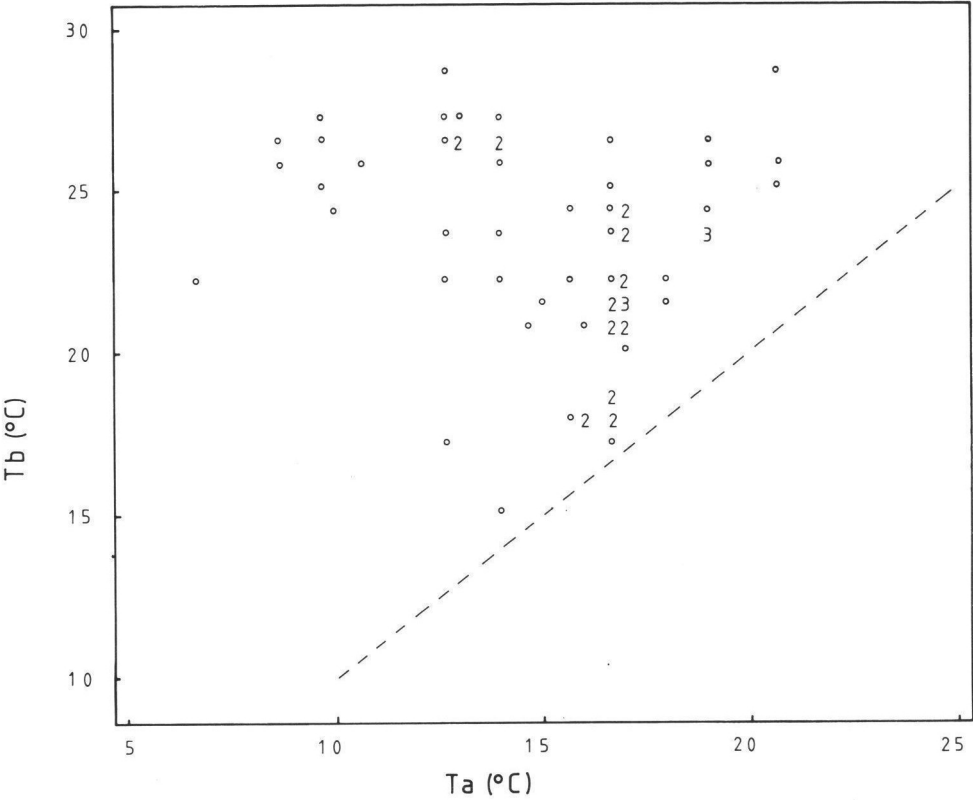
Figure 1. The relationship between *Anguis fragilis* cloacal temperature (T_b) and air temperature (T_a) under optimal conditions. Numbers in the body of the Figure indicate number of observations if more than one. The broken line is where $T_b = T_a$.

Thus there was not significant correlation between T_b and T_a, but in all cases T_b was higher than T_a.

The range of T_b for *A. fragilis* recorded under 'suboptimal' conditions (N = 14) varied from 10°C to 17°C (fig. 2); mean T_b was 13.5°C and SD = 2.4°C. Under these conditions, the regression equation relating T_b to T_a was as follows:

$$T_b = 6.0 + 0.629 \, T_a \quad (r = 0.688, \, df = 13, \, P = 0.007)$$

In this case, there was a significant correlation between T_b and T_a, and in two cases T_b was lower than T_a.

It is easy to observe thermoregulatory behaviour in day-active heliothermic lizards at times when they are active, but this is far more difficult in secretive species. Thus, a major difficulty in interpreting T_b data from lizards such as *A. fragilis* is in determining whether the individual is exhibiting any thermoregulatory adjustments. In other words, it may be difficult to decide whether the species is a thermoregulator or a thermoconformer. The problem is compounded by the recent demonstration that in
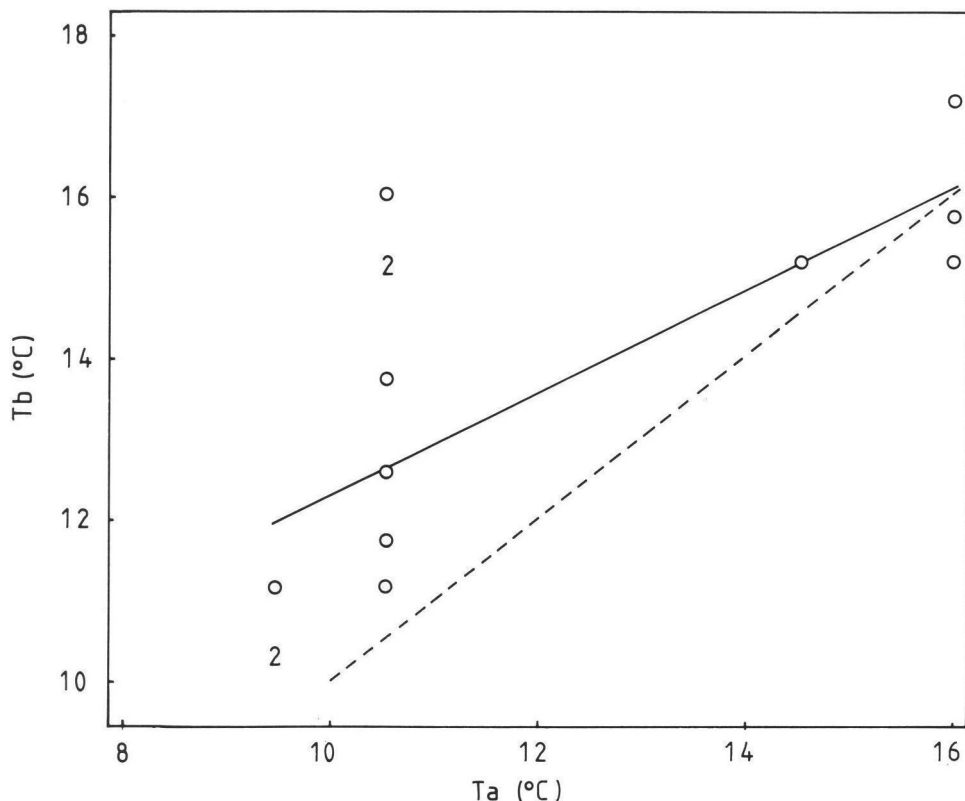
Figure 2. The relationship between *Anguis fragilis* cloacal temperature (T_b) and air temperature (T_a) under suboptimal conditions. Numbers in the body of the Figure indicate number of observations if more than one. The solid line is the best fit of the regression of T_b on T_a. The broken line is where $T_b = T_a$.

the snake *Thamnophis elegans* there is selection of particular T_b ranges not only when the animal is active but also at night and at other times when it is inactive (Huey et al., 1989).

This study demonstrates considerable differences between T_bs of *A. fragilis* obtained under 'optimal' conditions and those obtained under 'suboptimal' conditions. I suggest that under 'suboptimal' conditions, *A. fragilis* was either not thermoregulating at all or not thermoregulating with maximum efficiency because conditions were not suitable; but that under 'optimal' conditions *A. fragilis* showed some degree of thermoregulation. Although the only measure of environmental temperature recorded was T_a, temperatures in soil and vegetation not far below the surface are generally less than T_a (Porter et al., 1973), and thus if *A. fragilis* were a strict thermoconformer, one would expect T_b to be below T_a in some instances, as is the case under 'suboptimal' conditions. The fact that there was a correlation between T_a and T_b under 'suboptimal' conditions but not under 'optimal' conditions provides further evidence that *A. fragilis* was thermoregulating under the latter conditions.

Even although *A. fragilis* appears to show some degree of thermoregulation under 'optimal' conditions, it is plainly a species with a wide activity temperature range (at least 14.5°C to 28°C) and a low mean activity temperature (22.6°C); as already mentioned, for most lizards the activity temperature range tends to be above 30°C. However, the activity temperature range reported here and the mean activity temperature are very similar to values obtained for the selected body temperature range and mean selected temperature for *A. fragilis* in laboratory thermal gradients (Spellerberg, 1976; Gregory, 1980). For *A. fragilis*, the thermal relations of the animal in a laboratory thermal gradient are consistent with its thermal relations in the field, although this is not true for all reptiles (Patterson, unpublished observations).

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