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Husbandry of captive bearded dragons (*Pogona vitticeps*); does handling influence thermoregulation?

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ABSTRACT. - The behaviour and body temperatures of the bearded dragon (*Pogona vitticeps*) were recorded during periods with handling and non-handling intervals. Differences in perching and hiding were observed after the animals were handled but basking and locomotory activity remained almost constant. The observed differences in behaviour appeared to have no influence on either set point or variance in body temperatures.

INTRODUCTION

The thermal dependence of reptilian physiology and the behavioural mechanisms employed to achieve target body temperatures are now well understood (Huey, 1982). Changes in the body temperature of ectotherms have been shown to influence, among others, growth rates, reproduction and general health. Therefore in respect to husbandry, it is important that reptiles should be given the opportunity to display natural behaviour and attain appropriate body temperature levels through the provision of housing that resembles as closely as possible a species natural habitat (Avery, 1985). However there are other husbandry factors to consider, stress for instance, which in reptiles may disrupt behaviour and induce sub optimal body temperatures (Arena & Warwick, 1995). The discovery of elevated body temperatures in the teiid lizard *Callopistes maculatus* in response to being handled - defined as emotional fever (Cabanac & Gosselin, 1993), gave rise to a series of questions regarding lizard biology, not the least being, what are the long term implications of persistent handling and how widespread are handling effects on the body temperatures of different species? This paper gives details of a study of thermoregulatory behaviour in the Australian bearded dragon (*Pogona vitticeps*). The aim was to determine whether handling would disrupt behaviour patterns to the extent that thermal set points and thermoregulatory precision would be affected. The work was part of a second year Higher National Diploma research project undertaken by K.C., M.H. & T.W under the supervision of R.M. at Huddersfield Technical College.

METHOD

All work was carried out at the Herpetological Unit at Huddersfield Technical College between September 2001 and June 2002. Observations were made usually once per week between 1300hrs and 1520hrs on lizards from two enclosures of 2.1 x 1.1m and 0.5 x 1.2m in ground measurement. Both enclosures had perching, basking and hiding areas available. The enclosures were glass covered units and hence the lizards were subject to natural light at all times although UV lamps and infrared heaters were also installed. The latter produced thermal gradients from around 15 – 55°C. A non-invasive Omega OS204 Digital Thermometer was used to record skin surface temperature of each dragon which corresponds fairly closely to core body temperature in lizards (Meek, 1999). Four types of behaviour were identified 1) *Basking*, positioned under a heat lamp, 2) *Perching,* positioned remotely from a heat source in an elevated location either on a rock or branch, 3) *Locomotory activity,* which is self explanatory and 4) *Hiding*, inside a hide box or down a tunnel. The results of this study are based on a total of 1170 behaviour records and 1170 body temperature measurements.

The lizards (n = 9) were all adults, captive bred at the college, and aged between 2 and 3 years. They were exposed to both people passing and actually entering (walk-in) their enclosures on a daily basis. Each cage had only one resident male, although as many as 6 females could be present in a cage but only 3 lizards were identified and used from each cage at any given time (1 male and 2 females). No physical interactions were observed during the study between individuals other than mating.

Procedures. The behaviour of three animals was observed for one hour during which time the lizards body temperatures and behaviour were recorded every five minutes. All animals were then removed from the enclosure and held and manipulated for a period of twenty minutes before being returned to the cage. They were observed for a further hour, recording temperatures and behaviour as before. Independently on other weeks a control was set up where the procedure was repeated except the animals were left in their enclosures for the twenty minute interval without being handled or measured in any way. Both groups of lizards were employed as control and manipulated treatments.

RESULTS

Behaviour. Table 1 shows the pooled behaviour of the bearded dragons during the one hour periods before and after the handling and non-handling intervals. Differences in behaviour between observational conditions were apparent. Basking intensity was 67% for the 1 hour before and 69% for the 1 hour after the 20 minute non-handling interval; this compared to 29% of basking before and 31% basking after the handling interval. However we considered the general differences between the handling and non-handling sessions less important than the relative changes in behaviour (the differences between A and B compared to the differences between C and D). Examined from this perspective it would appear that there were no shifts in basking duration after handling or non-handling (2% increase in both instances) and only a 1% decrease after handling and 1% increase without handling in locomotory activity (all $p > 0.05$ using a percentage comparison test with the h-distribution at $d.f.$ = 234 for non handling and $d.f.$ = 351 for handling). Perching increased from 31 to 38% after the lizards were handled but decreased by 5% - from 16 to 11% during non-handling sessions but neither of these behaviour shifts were found to be significant (handling ($d.f.$ = 351) and non-handling ($d.f.$ = 234) both gave $h = 0.147$, $p > 0.05$). The only significant shift in behaviour was the 8% decrease in hiding after being handled ($h = 0.194$, $d.f.$ = 351, $p < 0.05$); this increased non-significantly by 2% after the 20-minute non-handling period.

Table 1. Behaviour of *Pogona vitticeps* during the study period. The results show the different levels of behaviour expressed as percentages of total behaviour within each one hourly sampling period before and after handling and non-handling intervals. Percentage values have been rounded to the nearest integer and the results are based on pooled samples for each observational period. Sample sizes are for non-handling observations (A and B) n = 234 for each sampling hour and for handling (C and D) n = 351 for each sampling hour.

	Basking	Perching	Hiding	Locomotory activity
A) Before non-handling	67	16	1	16
B) After non –handling	69	11	3	17
C) Before handling	29	31	26	14
D) After handling	31	38	18	13

Body temperatures. Table 2 shows the statistics relating to pooled body temperature measurements; Fig. 1 shows histograms of the overall body temperature distributions before and after the handling or non-handling intervals in more detail. The data were examined for relative shifts in the patterns of body temperatures that could be identified as due to handling influences, which is again between A and B compared to differences between C and D in either Table 2 or Fig 1. This is 1) adjustments in set point temperatures, here determined as the arithmetic mean body temperatures and 2) changes in thermoregulatory precision, defined as the variances in body temperatures around the means. As can be seen from Table 2 the changes in mean body temperatures were minor either from before to after handling (0.1°C) or between before to after non-handling (0.2°C). The differences were tested using ANOVA which showed that they were not significant; non-handling, $F_{(1,466)} = 0.4$, $p > 0.05$; handling, $F_{(1,700)} = 0.87$, $p > 0.05$.

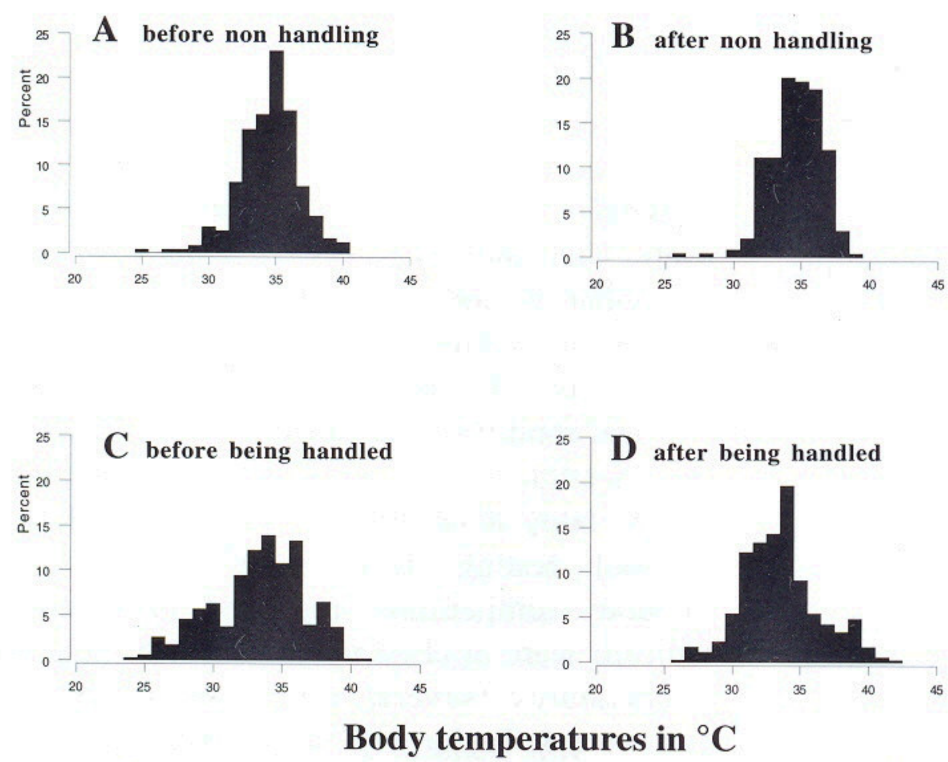

Figure 1. Frequency distributions of *P. vitticeps* body temperature before (A) and after (B) the non-handling interval and before (C) and after (D) the handling interval. The data are shown as percent frequencies of the total number of observations within each hourly period. Sample sizes are given in Table 2.

The variances in lizard body temperatures were greater before the 20-minute intervals whether handled $s^2 = 10.9$ versus $s^2 = 7.9$ or not handled, $s^2 = 4.79$ versus $s^2 = 3.53$. A Levene`s test set at the 95% interval was unable to reject a null hypotheses of equal variances in the corresponding data sets; variances did not change significantly either after the lizards were handled or in the absence of handling. The Levene`s value for not handled variances (A versus B) was 0.74, $p = 0.89$, and when the lizards were handled (C versus D) 0.87, $p = 0.74$. Therefore no significant changes in either set point temperatures or degree of thermoregulatory precision could be found in the body temperature data.

Table 2. Body temperatures (°C) of *Pogona vitticeps* before and after non-handling and handling intervals. The *p* values are based on comparison of means of pooled data sets (ANOVA) between A and B and between C and D. Mean body temperatures are given with one standard deviation along with minimum and maximum body temperatures recorded. The number of observations (*n*) during each observation period is also given.

	Mean	± Std. Dev.	Min.	Max.	*n*	*p*
A) Before non handling	34.4	2.2	24.7	39.8	234	
B) After non handling	34.5	1.9	25.5	38.7	234	0.52 (*n.s.*)
C) Before handling	33.3	3.3	23.9	41.0	351	
D) After handling	33.5	2.8	26.0	41.7	351	0.35 (*n.s.*)

DISCUSSION

The results of this study were unable to show conclusive evidence that handling influenced *P. vitticeps* body temperature levels despite the mainly minor behavioural differences. The results were not unexpectedly different from Cabanac & Gosselin`s (1993) study on handling effects in *C. maculatus* since the reaction of a reptile to being handled may be dependent on its natural escape behaviour. Consider flight as the method of escape, here increases in body temperature and the subsequent Q_{10} effects would be beneficial increasing, critically, muscular energy. This is indeed the method employed by many of the smaller teiid lizards (including *C. maculatus*) that are often quick moving highly mobile animals. In contrast, passive defence as seen in certain glass lizards (e.g. Hailey & Theophilidis, 1987), death shamming (Carpenter & Ferguson, 1977) and the cryptic behaviour frequently observed in agamids (e.g. Hennig, 1979) including *P. vitticeps*, require that the animal remains immobile. Increases in body temperatures and metabolic rates in response to predators may not be adaptive in this escape tactic since movement would render them conspicuous. The perching recorded in captive *P. vitticeps* appears to be analogous to the crypsis observed under natural conditions.

A second and perhaps just as obvious possibility is that, as captive bred animals, the lizards had become habituated to the presence of humans. Habituation has been observed in other lizards e.g. *Lacerta*, *Amphibolurus*, *Uta* (Greenberg, 2001) and *Anolis* (Sugarman, 1990). A good example is in *Anolis carolinensis* where the defensive immobility response diminishes with increasing exposure to human observers (McNight, 1978) and may vary with environmental conditions (Hennig, 1979). Bearded dragons may also be in this category, since they are comparably easy to maintain in captivity in the sense that they are `placid` i.e. subjectively they appear to tolerate disturbance and low levels of stress and this could result in a lack of effects on behavioural thermoregulation. It is also possible of course that the dragons were affected by handling but not in the ways measured here. The problem of measuring stress or other physiological disturbances in reptiles is that the only direct way is through measuring hormone levels, but the act of removing a blood sample may in itself be a stressful experience (Avery, 1999). In this respect the lizards could even have been influenced in some way by measurement, irrespective of the use of non-invasive infrared detectors to record body temperatures, although it might then be expected that if they were sensitive to this degree, they would react in some significant way to handling.

Behaviour alone may not necessarily provide a useful indication of stress in reptiles. In lizards behaviour is not always homogenous and may adjust to subtle background environmental conditions, differences between individuals, physical condition and, on occasion in *P. vitticeps,* the selection of temporary semi-dormant periods to low body temperatures - possibly a form of metabolic resting? However, the ranges and means of body temperature recorded in captive *P. vitticeps* were in close agreement with field body temperatures (several references reviewed in Heatwole & Taylor, 1987) indicating no evidence for any ` low temperature preference` in captive reptiles suggested by Warwick (1990). The present approach was based on the assumption that if a handled lizard is stressed, normal behaviour will be abandoned to the extent that this will influence thermoregulatory precision or shifts in thermal set points; there was no evidence for this in the present study. Future studies could provide useful information in this area of interest by investigating shifts in respiration rates (Avery, 1999) and comparative growth rates between handled and non-handled animals.

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