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Photoperiod affects thermoregulatory set point temperatures in the wall lizard *Podarcis muralis*

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The development of a thermographic technique for non-invasively measuring the temperatures of small lizards (Jones and Avery, 1989) has made it possible to determine values for both upper and lower set point temperatures (Firth and Turner, 1982) in unrestrained animals which can move freely around an arena which simulates the natural environment (Tosini and Avery, 1993). Studies of European wall lizards (*Podarcis muralis*) in a standardised arena, using a 60 W tungsten bulb as radiant heat source, have shown that set point temperatures can be affected by a number of intrinsic (e.g. Tosini and Avery, 1993, 1994a) and external (e.g. Tosini and Avery, 1994b; Tosini et al., 1995) factors. The physiological mechanisms underpinning the control of set point temperatures in reptilian behavioural thermoregulation are complex (Firth and Turner, 1982). The hormone melatonin, which is secreted from the pineal, the parietal eye and the retinae of the lateral eyes in *Iguana iguana* (Tosini and Menaker, 1995), is involved in these processes (Saarela and Reiter, 1994). Melatonin secretion in most vertebrates is inhibited by light (as in *Lacerta viridis*, Rismiller and Heldmaier, 1987), and so is affected by photoperiod. Changes in photoperiod might therefore be expected to influence thermoregulation and body temperatures, and has been shown to do so in a number of reptiles (Ballinger et al., 1969; Graham and Hutchinson, 1979; Rismiller and Heldmaier, 1988). The purpose of the present experiment was to determine whether changes in photoperiod affect upper and lower set point temperatures in thermoregulating *P. muralis*.

Six adult lizards (three males and three females), captured near Florence (Italy), were used. They were maintained in the laboratory, and experiments were performed with sin-

Table 1. Overall mean and median values for T_{start} and T_{move} (C) for *P. muralis* held under different photoperiods. *indicates values which differ significantly (oneway ANOVA with T-method tests, $P < 0.05$) from the others in a column.

Photoperiod	n	T_{start}			T_{move}		
		mean	SD	median	mean	SD	median
4L : 20D	60	32.98*	0.67	33.01	37.98*	0.50	38.05
8L : 16D	60	33.95	0.47	34.00	38.87	0.61	38.85
12L : 12D	60	34.06	0.64	34.10	39.18*	0.49	39.20

gle lizards in standardised arenas, under conditions described by Tosini and Avery (1993) but with the arena maintained in a lightproof room. After one week of acclimatization to the experimental arena, with a photoperiod of 8L : 16D maintained using the tungsten bulb, values for upper and lower set point temperatures (i.e. the temperatures at which basking was initiated and at which the lizard ceased basking) were determined using infra-red thermography (Tosini and Avery, 1993) for ten consecutive basks on one day. Durations of basks and intervening periods of foraging, and overall heating rates during each bask, were also measured. The photoperiod was then changed to 4L : 20D, and after one week of acclimatization, values for thermoregulatory variables for another ten basks were recorded. The entire procedure was then repeated after a change to a photoperiod of 12L : 12D. All measurements took place during the middle period of the photophase (corresponding to 10:00-12:00 h in real time) with a room temperature between 20.5 and 22°C. Since no significant differences in values for any thermoregulatory variables were found in individuals subjected to the same L : D cycles (one-way ANOVA, $F_{5,54} = 0.56$-1.76 and Kruskal-Wallis tests, $P > 0.1$ in all cases), the results for individuals have been combined.

Mean values for the lower and upper set points T_{start} and T_{move} were significantly lower in the shortest photoperiod than in the other two (one way ANOVA, $F_{2,177} = 65.1$ and 138.0, T-method tests; Kruskal-Wallis tests, $H_2 = 82.9$ and 109.4; $P > 0.05$; table 1). None of the remaining variables (T_{move}-T_{start}, bask duration, forage duration, heating rate) varied significantly between photoperiods (one-way ANOVA, $F_{2,167} = 1.34$-2.16 and Kruskal-Wallis tests, $P > 0.1$ in all cases); mean values for 8L : 12D were 4.89 K, 1.51 min, 4.03 min and 3.84 $\mathrm{K\,min^{-1}}$, respectively.

Previous studies have shown that photoperiods with long photophases can increase selected body temperatures in the lizards *Lacerta viridis* (Rismiller and Heldmaier, 1988) and *Sceloporus undulatus* (Ballinger et al., 1969) and in some turtles (Graham and Hutchison, 1979). Other lizard species (*Crotaphytus collaris, Anolis carolinensis*) are unaffected (Licht, 1968; Sievert and Hutchison, 1991). Less attention has been focussed on the effects of very short photoperiods. *Anolis carolinensis* show no response to short photoperiods (Licht, 1968); *Sceloporus undulatus* showed no response to a photoperiod of 6L : 18D in May, but mean body temperatures decreased under the same photoperiod in July. The response of *Podarcis muralis* is consistent with this result.

The results presented here demonstrate that photoperiod is one of the external factors which can alter set point temperatures in *Podarcis muralis*. The light source included infra-red radiation, and so the period available for thermoregulation also varied; this factor can have an effect on growth rates (Avery, 1984). It should be noted that 4L : 20D is a far shorter photoperiod than lizards of this species would ever experience in nature. The mechanisms by which the duration of photothermal radiation affect set point temperatures remain unknown.

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