Skin reflectance and energy input of melanic and non-melanic populations of wall lizard (*Podarcis muralis*)

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Podarcis muralis is a small to medium-sized European lacertid showing a remarkable chromatic polymorphism with a number of more or less darkened micro-insular populations (or subspecies).

Given that dark skin should increase the heating rate in such heliothermic lizards as *P. muralis*, some authors (MERTENS 1963, CARLQUIST 1965, LANZA 1979) have stressed the thermoregulatory significance of darkening in a microinsular environment.

As the Mediterranean rocky islets and rocks are generally poor in food, the higher heating rate of dark specimens would allow them to be active earlier and thus able to forage sooner than the lighter specimens (LANZA 1979). A better feeding regime would increase the fitness, and therefore favour the spread of dark mutants within the population.

The skin reflectance of melanic wall lizards was seen to be 2% higher than that of non-melanic ones in a short wavelength range 0.38-0.80 μ (LANZA et al. 1986, TOSINI et al. 1991).

To further determine the effect of skin darkening on the thermoregulation of *P. muralis* it was decided to measure the skin reflectance and energy input in a wider wavelength range.

Material and methods

Tests were conducted on live adult males belonging to the following subspecies: 3 specimens of *P. muralis brueggemanni* from Florence [Italy; light brown to green dorsal ground colouration with a fine black or dark brown reticulation ("light" animals)], and 3 specimens of *P. m. marcuccii*, from Argentarola Islet [Monte Argentario, Grosseto, Italy; dark brown to blackish dorsal ground colouration with a black reticulation ("dark" animals)].

Diffuse skin reflectance was measured with a spectrum analyser (Guided Wave Mod. 260) equipped with 316SS optical fibers, operating in the range 0.40-2.20 μm, over an area of 0.3 cm^2 which is large enough to include the complete variegated dorsal pattern of the lizards.

Table 1. Energy input (cal cm^{-2} min^{-1}) of *P. m. brueggemanni* and *P. m. marcuccii* respect to the solar irradiance at sea level, under the conditions specified in Fig. 1, in the visible, in the near infrared and in the whole 0.4-2.2μ

Wavelength	0.4-0.8 μ	0.8-2.2 μ	0.4-2.2 μ
Energy available (in cal cm^{-2}min^{-1}	0.80	0.53	1.33
P. m. brueggemanni	0.78	0.51	1.29
P. m. brueggemanni	0.78	0.51	1.29
P. m. brueggemanni	0.77	0.51	1.28
P. m. marcuccii	0.78	0.52	1.30
P. m. marcuccii	0.79	0.52	1.31
P. m. marcuccii	0.78	0.52	1.30

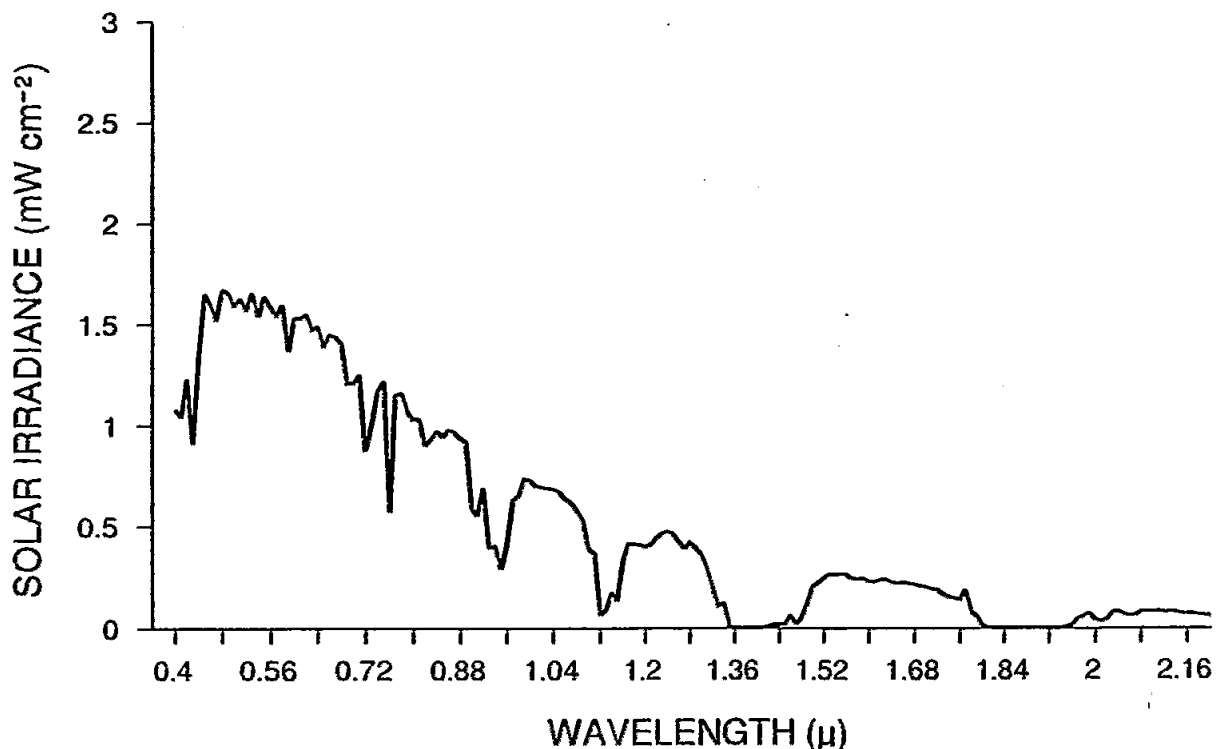Fig. 1. Solar spectral irradiance at sea level calculated following the LOWTRAN 7 AFGL program (KNEIZYS et al. 1988) and assuming, as model, sun at 30° from zenith, clear sky, relative humidity= 76.11% and mean values for the main atmospheric gases and pollutants

The dorsal energy input (E_i) was calculated normalising, respect to the solar irradiance at sea level (Fig. 1), and integrating the reflectance spectra recorded for each specimen (further details in BACCI et al., 1992).
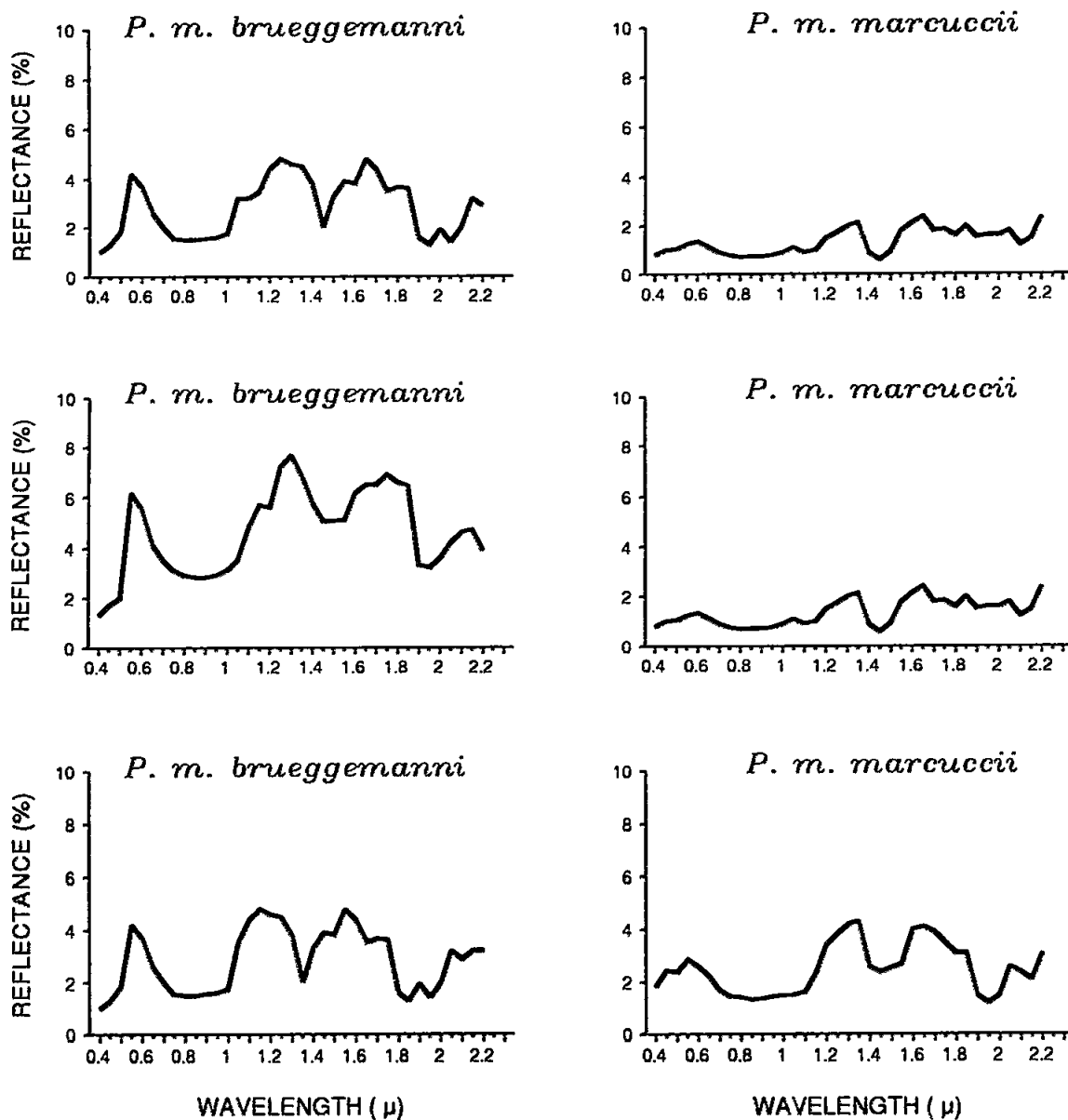

Fig. 2. Skin reflectance in live specimens of *P. m. brueggemanni* and *P. m. marcuccii* in the wavelength range 0.4-2.2 μ

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Results

The obtained spectra (Fig. 2) show the skin reflectance of *P. m. marcuccii* (range: 0.5-4.5%) to be lower than that of *P. m. brueggemanni* (range: 0.7-7.9%). Each group presents a characteristic scan with slight individual differences.

The skin of both groups is more reflective in the near infrared (0.8-2.2 μ) than in the visible (0.4-0.8 μ) part of the spectrum.

E_i is slightly higher in *P. m. marcuccii* ($\bar{x}$= 1.30 cal cm^{-2} min^{-1}, S.D.= 0.0057) than in *P. m. brueggemanni* ($\bar{x}$=1.29 cal cm^{-1}min^{-1}; S.D.=0.0057). Both groups absorb more energy in the visible than in the near infrared (Table. 1) range, due to the fact that solar irradiance is higher in the visible (59.3% of the total energy available according to model used) than in the near infrared (39.3%).

A simplified version of NORRIS' (1967) and SPELLERBERG's (1976) models was employed to estimate how much this slight difference in E_i influenced the heating rate of the lizards. This calculation was carried out on two hypothetical lizards with the same weight (8 g) and dorsal surface (16.32 cm) but with the mean E_i tested in *P. m. brueggemanni* and in *P. m. marcuccii*, respectively.

The dorsal energy gain (E_g) was calculated as follows:

$$(E_i - E_r + S_a)S_e = E_g$$

E_i= Energy input per cm^2 in the 0.4-2.2 μ range,

E_g= Lizard emissivity to longwave radiation at 25°C, assuming the lizard to be a grey body radiator on its entire surface (8.26 × 10^{-11} T^4, T= Kelvin degrees),

S_a= Re-radiation from the sky (a grey body) is at the rate of 0.56 cal cm^{-2}min^{-1} assuming an air temperature of 30°C (GATES 1962),

S_e= Effective dorsal surface available for energy exchange= total dorsal surface − 11% (BARTLETT & GATES 1967).

The dorsal energy gain for the two lizards is:

P. m. brueggemanni   *P. m. marcuccii*
17.41 cal cm^{-2}min^{-1} 17.55 cal cm^{-2}min^{-1}

The density of these lizards is approximately 1.1 g cc^{-1} and, as reptilian tissue heats 18% faster than the same volume of water (BARTHOLOMEW & TUCKER 1963), the rate of heating for the two lizards is:

2.82°C min^{-1} 2.84°C min^{-1}

which corresponds to a difference of 0.02°C min^{-1} in the hypothetical heating rate.

Discussion

Our reflectance spectra show that *P. m. brueggemanni* and *P. m. marcuccii* specimens differ in their absorbance of solar radiation, but not as much as could be expected on the basis of a simple visual comparison. The slight difference is consistent with the different overall chromatic pattern of the two phenotypes. In fact, "light" and "dark" specimens of *Podarcis* differ mainly in having respectively a

lesser and a larger amount of epidermal melanophores, while a thick continuous dermal stratum of hidden melanin-bearing cells occurs in both forms (MERTENS 1934, EISENTRAUT 1950).

Our mean reflectance values are about 4% higher than those reported in the same wavelength range and in the same species by literature (HUCTHINSQN & LARIMER 1960, LANZA et al. 1986, TOSINI et al. 1991). Such a difference could be due to the different systems of measurement.

However, this discrepancy regards only the absolute reflectance values while the difference in skin reflectance between the two lizards subspecies is almost the same (1.4% in this paper, 2% in LANZA et al. 1986).

The differences in E_i of the two phenotypes seem to be valid as: 1) the range of solar irradiance experimented corresponds roughly to 98.6% of solar energy at sea level; 2) the pigments absorb wavelengths shorter than 2.5 μ (GIBSON & FALLS 1979); and 3) in lizards with labile colouration colour change typically alters reflectivity in the 0.32-1.15 μ spectral range (NORRIS & PORTER 1969).

Can the slight difference (0.01 cal cm^{-2} min^{-1}) in E_i account for an overall heating which is significant from a functional point of view?

The hypothetical heating rates calculated for "light" and "dark" lizards demonstrate the negligible influence that such a small difference in E_i exerts on the warming of lizards (0.02°C min $^{-1}$). Such small ectotherms as *P. muralis* probably warm up so rapidly that slight changes in E_i do not cause appreciable differences in the rate of heating (STEVENSON, 1985).

Similar results were obtained in *P. muralis, P. sicula, P. tiliguerta* (LANZA et al. 1986, TOSINI et al. 1991) and in *P. dugesii* (CRIPS et al. 1979).

Therefore the adaptative value of microinsular melanism does not seem to reside in a thermoregulatory wantage, as hypothesized with different nuances by MERTENS (1934, 1963), CARLQUIST (1965) and LANZA (1979).

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