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Possible thermoregulatory behaviour in *Giraffa camelopardalis*

V. Kuntzsch and J. A. J. Nel

Department of Zoology, University of Stellenbosch, Stellenbosch, South Africa

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Giraffe, *Giraffa camelopardalis,* are widespread in dry woodlands and savannas in Africa (Smithers 1983) even where ambient temperatures exceed 40 °C during summer. Their independence of free water (Dagg and Foster 1976) thus indicate physiological and behavioural adaptations to reduce water loss.

Although Brownlee (1963) considered the giraffe's shape the most efficient for distribution of the large body weight in a hot climate, to give a large surface area for the dissipation of heat, Innis (1958) and Dagg (1970) found no definite thermoregulatory behaviour in wild (eastern Transvaal, South Africa) and captive (Taronga Zoo, Sydney, Australia) giraffe. However, observations of free-ranging giraffe in the Etosha National Park, Namibia (18° 35′ to 19° 33′ S, 14° 24′ to 17° 08′ E), suggested the contrary.

During July 1987 (winter) the body orientation of stationary giraffe in relation to the sun was noted, by scanning at five minute intervals at waterholes. In December 1988 (summer, the rainy season) fewer giraffe visited waterholes and the body orientation of each individual encountered when driving along roads through woodland and on the fringe of the Etosha Pan were recorded. On all occasions during both seasons ambient temperature and wind speed was also noted. Four main categories of body orientation were used: 1. lateral (long axis of giraffe at right angles to the sun); 2. anterior (facing the sun directly); 3. posterior (facing away from the sun); 4. shadow. Categories 2. and 3. were grouped as "longitudinal".

Some 660 observations on ca. 290 giraffe (including possible resightings of the same individuals) were obtained, most at temperatures similar to the mean prevailing summer (35 °C) and winter (16 °C) temperatures. Wind seemed to have little effect on giraffe, apart from on drinking behaviour. The orientation of giraffe was therefore best observed at low windspeeds (< 5 m.s^{-1}) in winter. As giraffe away from waterholes were observed in summer, windspeed did not influence observations.

At temperatures below 20 °C, only 5 % of the observed giraffe selected shadow, 35 % faced the sun with their longitudinal axis and 60 % were standing parallel to the sun's rays (Fig. 1). This pattern was reversed at high T_a (> 30 °C), where most giraffe (91 %) preferred shadow or faced the sun longitudinally, therefore reducing the body surface area exposed to the sun.

The percentage of giraffe standing at right angles to the sun decreased from 60 % to 9 % over the temperature range $<$ 20 °C–37 °C, with the reserve true for the percentage of giraffe facing the sun longitudinally, or selecting shadow. At $T_a > 34$ °C relatively more giraffe preferred shadow.

A significant deviation from the expected frequency of orientation (i.e. equal number of animals in all directions) was found using the Chi-Square Goodness-of-Fit Test. In the temperature range 25–30 °C, however, no significant difference occurred (Chi-square = 4.88, $p > 0.05$, df = 3, n = 150), possibly indicating this as the thermoneutral zone of giraffe.

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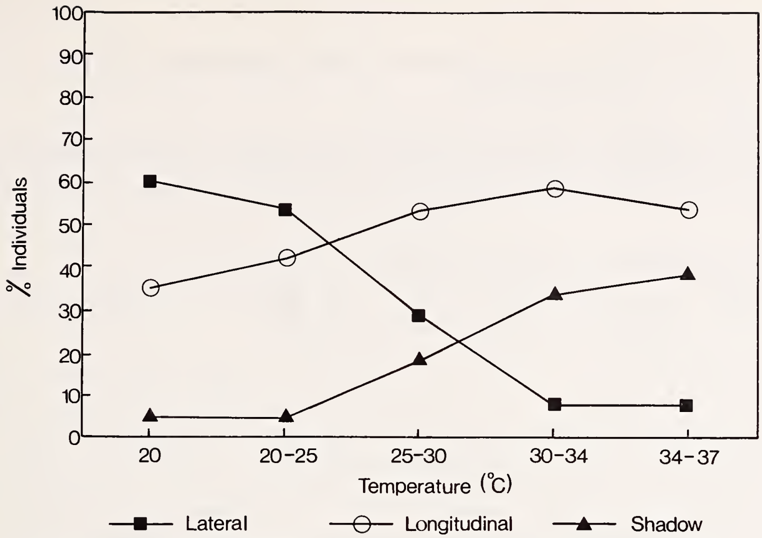

Fig. 1. Body orientation of giraffe relative to the sun over different temperature ranges

Significant differences in body orientation between the sexes and age groups were observed at $T_a > 30\,°C$ (Chi-square = 14.77 for "lateral", 271.99 for "longitudinal" and 128.84 for "shadow"; $p < 0.001$; df = 2). More than 80 % of the adult males faced the sun longitudinally, but only 60 % of the adult females and less than 20 % of the calves. Approximately 70 % of the calves selected shadow in this temperature range, against the 32 % and 13 % of the female and male giraffe respectively.

Physiological adaptations enabling giraffe to tolerate heat and arid conditions include a mechanism for cooling the exhaled air by the mucosa in the nasal passages (Langman et al. 1979), and a carotid rete mirabile which might have a thermoregulatory function as in other artiodactyls (Taylor and Lyman 1972; Mitchell et al. 1980).

Anatomical adaptations include large size and mass, thick skin (Dagg and Foster 1976), long neck and legs, and short body ovoid in cross section. Our data indicate that giraffe also make use of behavioural thermoregulation (Fig. 1). At lower ambient temperatures giraffe tend to position themselves so as to absorb heat over the largest possible body surface, while minimizing heat uptake at high T_a by positioning themselves with their longitudinal axis towards the sun, or seeking shadow.

Size also influences thermoregulatory behaviour. Adult males and females and calves all react in a similar way to high T_a. The taller and heavier males, however, are able to effectively make use of different orientations towards the sun, while the females and especially the calves select shadow. This substantiates Brownlee's (1963) theory of the effective distribution of body mass as well as the theory of a big body, in conjunction with a labile body temperature, acting as a "heat sink".

Giraffe would thus appear to be physiologically and anatomically well adapted to hot arid conditions. This, in conjunction with thermoregulatory behaviour would explain their success in exploiting open woodland and savanna habitats in Africa.

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Authors' address: Volker Kuntzsch and J. A. J. Nel, Department of Zoology, University of Stellenbosch, Stellenbosch 7600, South Africa