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## A Suggested Thermoneutral Zone for African Lions (*Panthera leo* Linnaeus, 1758) in the Southwestern Kalahari, Namibia

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**Abstract:** Aspects of the thermoregulatory behaviour of a small pride of African lions (*Panthera leo*) consisting of two adult males, an adult female and two cubs, were investigated at Intu Afrika Kalahari Game Reserve, southeastern Namibia, during winter 2003 and summer 2004. Early morning sunbathing on dune crests was considerably longer during winter when compared to summer, but the cutoff ambient temperature for this behaviour was the same (25°C) for both seasons. Loin exposure, on both empty and full bellies, always occurred between 28 and 34°C. Panting during winter only occurred after bursts of activity on empty bellies. During summer, however, panting was observed while the pride was active and static, being initiated at ambient temperatures of 34°C. It can, therefore, be inferred that the thermoneutral zone for this pride lies between 25 and 33°C.

**Key words:** *Panthera leo*, Kalahari desert, loin exposure, panting, sunbathing, thermoregulation

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### INTRODUCTION

The width of the thermoneutral zone of an animal is an indicator of its level of adaptation to its immediate environment (Schmidt-Nielsen, 1998) since the upper and lower limits indicate the initiation of biothermal defences for purposes of heat balance. Within the zone, however, heat balance is well maintained with little physiological effort and is complemented by behavioural adaptations. The nature and size of the African lion (*Panthera leo* Linnaeus, 1758) places constraints on the measurement of metabolic responses to changing ambient temperature under field conditions. The upper and lower limits of the thermoneutral zone then have to be inferred on the basis of thermoregulatory behaviour and the ambient temperature thresholds at which these behaviours are complemented by observable physiological thermoregulation such as panting (Schmidt-Nielsen, 1998). However, Louw (1983) reports that a larger body size can absorb a greater amount of heat, but the larger size, in turn, reduces the rate of dissipation. This affects the initiation and duration of thermoregulatory behaviour as small ambient temperature changes are buffered, in essence, by the size of the African lion.

In this regard, field observations were conducted on a small pride of African lions (two adult males, an adult female and two cubs) at Intu Afrika Kalahari Game Reserve (24°06.33' S; 017° 56.31' E), southeastern

Namibia, during winter (May-July, 2003) and summer (February and March, 2004). The reserve is situated in the dune sea of the Kalahari consisting of dunes running from northwest to southeast separated by lower-lying dune streets and pans. Activities of the pride were monitored and related with ambient temperature during continuous daytime and nighttime shifts. Sunbathing (direct exposure to maximum sun such as lying exposed on dune crests), loin exposure (the exposure of lions while lying on the side or on the back) and panting (observable rapid oscillation of the floor of the mouth, ears drawn back and head lifted) were used to deduce the thermoneutral zone of the Kalahari pride. Ambient temperature was recorded hourly by using a MCS 120-02 Data Logger with the sensor permanently fixed outside of the research vehicle.

Sunbathing is a common feature of behavioural thermoregulation in both ecto- and endotherms and significantly lowers energy demands (Morse, 1980). The total amount of time the pride spent in the sun during winter (mean 44 h over 30 days) was considerably longer than the time recorded in summer (mean 19 h over 40 days) (Fig. 1). During the former, the lions settled on the crest of the dune every morning at roughly 07:30 and when they were well fed, they moved to shade early, between 09:00 and 10:00. When their bellies were empty they moved into the shade later, between 11:00 and 13:00. During the summer trials, however, the pride spent 54% of the mornings they were observed (n = 40) on the dune

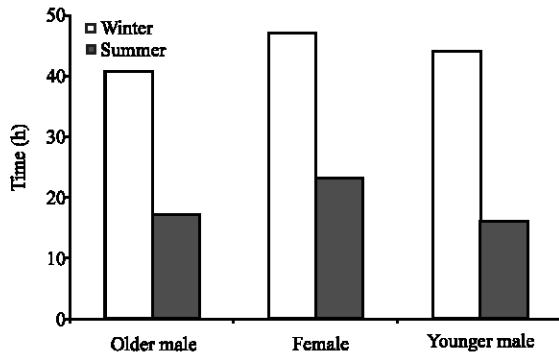


Fig. 1: Seasonal variation in time spent sunbathing on dune crests during the early mornings by African lions in the Kalahari

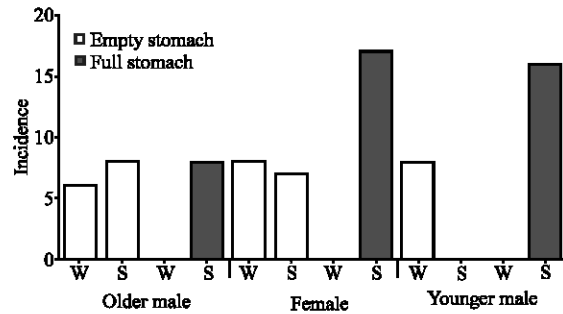


Fig. 3: Seasonal incidence of panting at an empty or full belly by the small pride of African lions during daylight hours. S, summer; W, winter

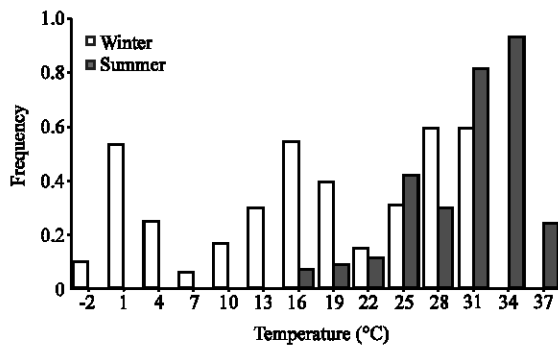


Fig. 2: Seasonal frequency of loin exposure by adult African lions at the range of temperatures observed during the period of study in the Kalahari

crests and on these occasions they moved into the shade between 07:00 and 09:00. During both seasons, sunbathing ended when the median ambient temperatures reached approximately 25°C. At this ambient temperature, the pride moved into the shade.

Loin exposure in the African lion may be related to a behavioural mechanism employed for thermoregulation (Smith and Kok, 2006). During winter loin exposure on a full belly increased as temperature increased, while empty belly exposures occurred only during midday when ambient temperature was relatively high - approximately 28°C. Throughout the summer trials, however, loin exposure on an empty belly was prevalent throughout the daylight hours, with a distinct increase in full belly exposure as ambient temperature increased. Results across the board for both seasons show that from an ambient temperature of 28°C, the frequency of exposure on both empty and full bellies increased up to 34°C (Fig. 2).

Panting was recorded when the rapid oscillation of the tongue was seen coupled with shallow breathing, an upright posture, ears pulled back and eyes squinted. Panting of the pride in the Kalahari was closely observed and seasonally compared. During winter there was an observable increase in panting during midday, while during late afternoon the occurrence of panting was either similar or greater to those observed during early mornings. No panting was observed during nighttime, nor did panting occur on a full belly during winter. All the panting observed during these trials was after bursts of activity induced by vehicles and potential prey seen outside the enclosure. During summer, however, panting behaviour was observed while the animals were static and resting in the shade. Panting at a full belly occurred more often than on an empty belly (Fig. 3). The lowest ambient temperature at which panting was observed on an empty belly was 31.6°C and on a full belly, 28.4°C. The mean ambient temperature for panting during this season was 34°C, this temperature relating only to data logger measurements.

When heat load can no longer be decreased by behavioural and circulatory mechanisms, heat balance can only be maintained by evaporative cooling. Evaporation is the only element in the heat balance equation which always represents heat loss. There are two principal pathways for evaporative cooling: panting and sweating (Schmidt-Nielsen, 1998). Animals that do not possess a large number of sweat glands, such as the family Felidae, generally employ panting as a means of evaporative cooling although saliva spreading is also a common behavioral mechanism for thermoregulation (Cabanac, 1972). Hull (1973) also reports on its use by animals to cool down. During the summer trials, both the female and younger male were observed to lick their own chests for between 3 and 6 sec on 12 occasions. The particular lion,

when licking the chest, always lay upright, exposing it. The use of saliva to assist in evaporation and subsequent cooling down would be effective in reducing surface temperature. Average temperature when panting was employed during summer was at 34°C and above. Taking into account the results of the sunbathing where the pride moved into the shade at an average temperature of 25°C and the inception of panting at 34°C, it appears as though, in the case of the pride in the Kalahari, the thermoneutral zone can be set between 25 and 33°C, the same as for humans (Louw, 1993). Motivation for this is the fact that the thermoneutral zone is the temperature range where the animal can rely on cardiovascular changes and behavioural adjustments to maintain thermal balance. Outside of this zone, physiological adaptations must be employed to either conserve or dissipate body heat. If sunbathing is required under 25°C and panting is initiated above 33°C, the thermoneutral zone may very well lie in this region. Laboratory tests that measure metabolic rates and oxygen consumption are not practical in the case of African lions unless hand-reared and, as a result, the thermoneutral zone remains to be tested.

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