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Loin Exposure as a Means of Complementing Thermoregulation in Kalahari Lions (*Panthera leo* Linnaeus, 1958)

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Abstract: Fieldwork on the thermoregulatory behavior of a small pride of lions (*Panthera leo*), consisting of three adults and two cubs, was conducted at Intu Afrika Kalahari Game Reserve, Namibia. Continuous daytime and nighttime observations of the pride were performed during winter (May-July 2003) and summer (February-March 2004). Temporal incidences of loin exposure showed a positive relationship with increasing temperature from winter to summer. Full belly loin exposures during both seasons occurred across the ambient temperature range, but empty belly loin exposures were only observed above 17°C. The frequency of loin exposure for both seasons on empty or full bellies rapidly increased from 28°C. The two males demonstrated a similar probability of loin exposure, possibly as a result of their similar shape and sex and the average orientation of loins into an oncoming breeze occurred 51 and 58% during winter and summer, respectively.

Key words: *Panthera leo*, behavioral thermoregulation, loin exposure, Kalahari Desert

INTRODUCTION

Temperature has a profound effect on life. If physiology is fine control of thermoregulatory processes in animals, then behavior is broadband control (Cabanac, 1972). In extreme environments such as the Kalahari Desert where ambient temperature ranges are significant, homeostasis becomes increasingly challenging and once behavioral mechanisms for heat balance fail, biothermal defenses must be initiated. Within the thermoneutral zone, however, heat balance is well maintained without any physiological effort and is complemented by behavioral adaptations which are known to be energetically cost-effective for the animal. Thermoregulatory behavior includes changes in posture, orientation, position and activity and is applied by many animals (Louw, 1993). African lions (*Panthera leo* Linnaeus, 1758) are known to regularly expose their loins and to date, although there has been speculation as to whether this serves a thermoregulatory function (Eloff, 2002), no definitive investigation has been performed. Here we report on detailed field observations on aspects of the behavior of a small pride of African lions with a specific focus on loin exposure as a means of behavioral thermoregulation in terms of both dissipating and absorbing heat across thinly furred areas.

Study area: Fieldwork was conducted in southeastern Namibia at Intu Afrika Kalahari Game Reserve (24° 06.33' S; 017° 56.31' E). The reserve, on the southwestern fringe of the Kalahari Desert, is situated approximately 60 km northeast from Mariental. It is privately-owned and covers an area of 10 000 ha of dune sea. The area forms part of the Arid Savanna Biome with grasses constituting more than 50% of the canopy cover, followed by woody trees or shrubs (Lovegrove, 1993). In the reserve, the principal grass species is Kalahari sour grass (*Schmidtia kalihariensis*) with the dominant tree species being the camelthorn (*Acacia erioloba*) and dominant shrub the black thorn (*A. mellifera*). Unlike other areas of the Kalahari Desert, the reserve has a high density of trees as a result of the strong flow of the Auob River aquifer. The wildlife on the reserve is characteristic of the Kalahari Desert and includes blue wildebeest (*Connochaetus taurinus* Burchell, 1823), Burchell's zebra (*Equus burchelli* Gray, 1824), Cape oryx (*Oryx gazella* Linnaeus, 1758) and springbok (*Antidorcas marsupialis* Zimmermann, 1780). The climate of the area is typical of a semi-desert with capricious and patchy rains and temperature extremes during winter (min -15°C) and summer (max 40°C). During fieldwork daily temperature peaks occurred at 15:00 and nighttime lows between 05:00 and 06:00, just prior to sunrise. Sand temperature fluctuated greatly during a 24 h cycle, reaching maxima of 40°C and 59°C during winter and summer, respectively. The highest ever temperature recorded for Kalahari sand during the summer months is 75°C (Apps and Du Toit, 2000).

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MATERIALS AND METHODS

Research subjects: Field observations were limited to a small pride of lions held under semi-captive conditions in a 500 ha enclosure at Intu Afrika Kalahari Game Reserve. The pride consisted of three adults, two males and a female and two cubs. The latter, sired by the older male, were born in November 2003 and were included in all the trials during summer 2004. The older male was approximately four and the female and younger male 3½ years of age at the start of the winter trials in 2003.

Fieldwork: Fieldwork was conducted during winter 2003 and summer 2004, each season consisting of some 416 h of observations, to enable the gathering of data specifically aimed at temperature balance. Continuous daytime and nighttime observations of the animals were made. All field observations of the lions were made from a vehicle while following the animals as closely as was viable. During day shifts, all movement and stationary activities were recorded and timed with the use of a stopwatch. Selection of site in the enclosure, positioning of the animals and selection of sun and shade were always taken into account. The intensity of panting and duration of loin exposure, both activities which indicate thermoregulation, were documented, as well as activity with empty or full bellies. Panting was counted per minute and the ambient temperature for that particular time recorded, while loin exposure was timed while ambient temperature was again taken. Full and empty bellies were taken into account as it is known that an increase in metabolism increases body heat (Schmidt-Nielsen, 1998). For the sake of convenience the day (24 h) was divided into early morning, midday, late afternoon and nighttime periods which correlate well with daily ambient temperature curves. During the winter season, early morning was from 07:00 to 12:00, midday from 12:00 to 16:00, late afternoon from 16:00 to 18:00 and nighttime from 18:00 to 07:00. For summer, the time for early morning was from 06:00 to 11:00, midday from 11:00 to 16:00, late afternoon from 16:00 to 19:00 and nighttime from 19:00 to 06:00.

Ambient temperature and relative humidity were recorded hourly with the use of a MCS 120-02 Data Logger, during both the nighttime and daytime shifts. The sensor was fixed outside the vehicle to allow for full acclimation and immediate and correct readings. The temperature of the sand was measured at hourly intervals by suspending a thermometer from the vehicle and allowing the mercury tip to penetrate the surface of the sand. It was held in that position for 1 min. Sand temperature readings were taken at the site where the vehicle was parked, which was normally close to the pride in the shade. When an opportunity arose for readings in both sun and shade without disturbing the lions, such as the proximity of sunlight or movement of the pride, this was done. The general direction of the wind was recorded. During summer trials, wind speed on the dune crests and in the dune streets was measured with a handhold anemometer.

RESULTS

The number, duration and conditions under which loin exposures took place for each of the adults, including empty or full belly exposure, are presented in Fig. 1. Throughout the winter study period, the older male (Fig. 1A) did not expose his loins on an empty belly except during the midday period when ambient temperature was high (>25°C). Exposure on a full belly, however, occurred throughout the 24 h period, peaking during the night when ambient temperature was at its lowest (<17°C). Throughout the summer trials, no exposures occurred during early morning. Excluding late afternoon when exposure took place only on an empty belly, both midday and nighttime showed exposure on both an empty and full belly, with a peak during midday. The female (Fig. 1B) demonstrated a greater number of loin exposures during both seasons and did so with both an empty and full belly during the 24 h periods, except for nighttime during winter, when she did not expose on an empty belly. A peak was reached during late afternoon in summer, when she exposed most on an empty belly. The remaining peaks are for full belly exposures, mostly during winter, except for midday in summer. The results for the younger male (Fig. 1C) demonstrate a similar curve with a low number of exposures during all the periods in both seasons and a large peak on an empty belly during late afternoon in summer. Again, as with the other adults, no empty belly loin exposures during winter nighttimes were seen.

The frequency of loin exposure of all the adults during both seasons was merged and demonstrated a distinct relationship with ambient temperature. The frequencies were calculated to correct for differences in total observation time at the different ambient temperatures (Fig. 2). The frequencies for winter indicated from 16°C and below, are all exposures on a full belly. The lowest ambient temperature during the winter trials at which loin exposure on an empty belly occurred was 17.6°C. During summer, the frequency of loin exposure increased up to 34°C with a sharp decline above this. There was an area of overlap between summer and winter and the frequencies for summer for 16°C are, as with winter, also indicated for a full belly. As with winter, the

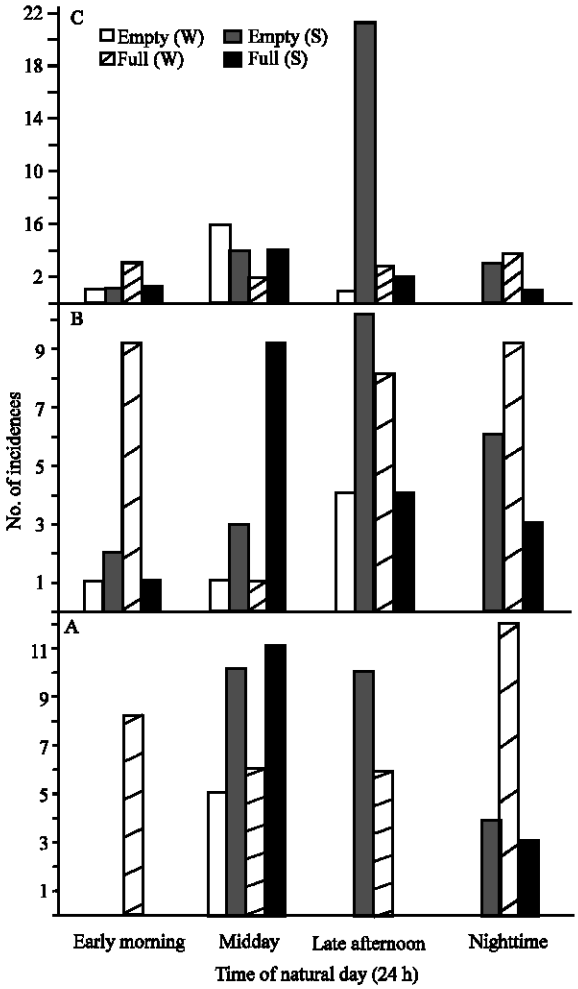

Fig. 1: Seasonal and temporal incidences of loin exposure with empty (E) or full (F) bellies by adult African lions during a day (24 h). A, older male; B, female; C, younger male; S, summer; W, winter

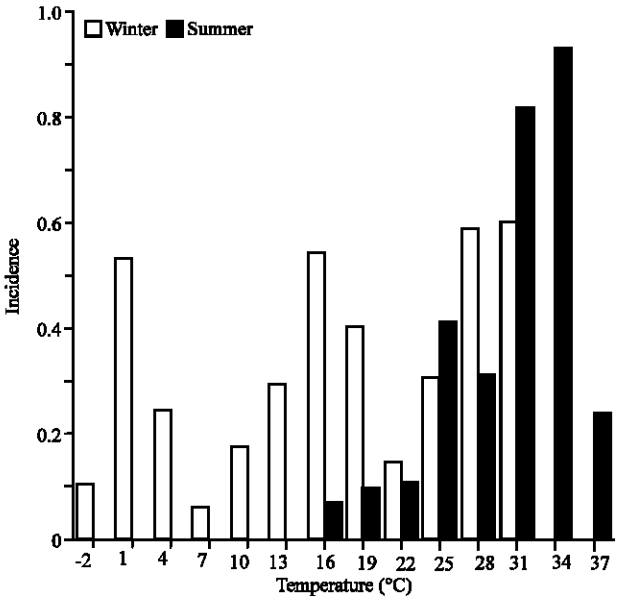

Fig. 2: Seasonal incidence of loin exposure by adult African lions at the range of temperatures observed during the period of study in the Kalahari

Table 1: Seasonal variation in minimum and maximum ambient temperature (°C) at which loin exposure by African lions was observed during the period of study in the Kalahari.

	Winter		Summer	
Individuals	Minimum	Maximum	Minimum	Maximum
Older male	1.2	31.4	19.6	38.5
Female	-1.7	31.6	17.7	37.7
Younger male	5.2	28.5	17.7	37.7

pride did not expose loins on an empty belly at ambient temperatures below 17.7°C, a difference of 0.1°C from winter.

A large variation in the range of temperatures at which individual pride members exposed their loins on either an empty or full belly during both the seasons was observed. Table 1 indicates the ranges for both winter and summer. The lowest ambient temperature observed for loin exposure was for the female at -1.7°C during winter and the highest was 38.5°C for the older male during summer.

The probability of loin exposure at an ambient temperature greater than 25°C during winter and 30°C during summer was calculated for the three adults. The formula used was P (E) = m/s (Kemp, 1998), where m is the number of observed loin exposures at the said temperature and s the total number of loin exposures for the animal concerned. The results for the winter study period are 0.16 for the older male, 0.15 for the younger male and 0.09 for the female. The summer results are 0.24 for the older male, 0.23 for the younger male and 0.18 for the female.

DISCUSSION

Loin exposure in the African lion is a common sight. Seasoned travelers to game parks in Africa have all seen the sight of lions, "spread out like honey", with their hind legs in the air, loins and bellies exposed. The loin and belly has a large surface area and has sparse insulation.

Occurrence of exposure with empty and full bellies during the four periods of the day show definite peaks during the midday and late afternoon period, demonstrating a positive relationship with increasing ambient temperature. During the cooler times of the day, specifically early morning during winter and nighttime during both seasons, exposure was high when the belly

was full. The highest peaks for early morning during winter, while the lions were sunbathing, are only for full bellies. During summer, ambient temperature climbed quickly in this time period and exposure was low or absent. The results across the board for both seasons at the different temperatures show that from 28°C, after the lions had moved to the shade, the frequency of exposure rapidly increased to 34°C. Above this temperature, panting was employed and loins were not exposed. Metabolic heat increases when digestion takes place. Lions are obligate carnivores and consume large amounts of raw protein, skin and fats in one feeding. In experiments done with domestic dogs, "oxygen consumption rose after a meal to a maximum of about twice the resting rate, returning to a normal level after 24 to 72 h" (Brafield and Llewellyn, 1982). The specific heat of combustion for fats is twice that of carbohydrates with protein in between these values. Further to this, experiments performed on the domestic dog revealed that heat production was greater on days when meat was fed than when the diet was of fat or sugar.

During the winter and summer study periods, the minimum temperature for loin exposure on an empty belly differed by 0.1°C. This indicates that below this temperature (17°C), metabolic heat on a full belly was such that loins could be comfortably exposed for heat dissipation and further supports the assertion that loin exposure is related to thermoregulation. Another contributing factor to this assertion is the percentage of perpendicular or parallel orientation towards the breeze or the sun during loin exposure. During the winter study period, the older male oriented his loin exposure 55% of the total, the female 46% and the younger male 52%. The subsequent summer trials showed orientation in the older male at 65%, the female at 51% and the younger male at 57%. The cubs oriented their loins 44% of the nine total exposures. The increase in oriented loins to the breeze during the hotter summer trials shows that the African lion uses wind to cool the surface area exposed. It is not a form of evaporative cooling since no sweat glands are present in this area.

The close relation of the probability results for loin exposure in the two males also supports the assertion that loin exposure is related to thermoregulatory behavior. The two males were similarly overweight and, therefore, have similar rotund shapes and surface areas. Therefore, their sex, shape and excess weight cause the probability that thermoregulatory mechanisms will be employed at similar times, indicated by the probability calculations. The results for the female, on the other hand, are very different from that of the two males.

Further, on four occasions, once during the winter trial and three times during the subsequent summer trial, the lions were observed to raise a leg and rest it either on another animal or against a tree. This was always observed during late afternoon when temperatures were high and mostly when a breeze was present. The increase of surface area and corresponding changes in posture are of the most obvious behavioral mechanisms used for thermoregulation.

Potentially, other explanations may also play a role in loin exposure of African lions. For instance, domestic cats, when ill, do not lie on their backs (van Ee, 2004) and therefore, the exposure of loins in the African lion may simply be as a result of confidence and a relaxed attitude. Looking at the winter trial data, the younger male, under duress from the older male, exposed his loins a total of 15 times during daytime as opposed to the 25 times for the older male. During the subsequent summer trials, when the younger male turned adult and began to defend himself from dominance, he exposed his loins a total of 36 times versus the 30 times of the older male. During nights, exposure of loins may indicate high levels of confidence since the most vulnerable area is exposed in the dark. The older male did so 11 times during winter and the younger male only four times. The summer results show seven nighttime exposures for the older male and two for the younger, again supporting the assertion of total confidence. Another factor which may be taken into consideration is the large amounts consumed during feeding. Lying on the back may simply be more comfortable than lying on the side or the belly. The range of temperatures at which loins were exposed supports the above. The exposure of the loins may also assist in the cooling of the scrotum in the males, necessary for fecundity.

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REFERENCES

Apps, P. and R. Du Toit, 2000. Creatures of Habit. Struik Publishers, Cape Town.

Brafield, A.E. and M.J. Llewellyn, 1982. Animal Energetics. Blackie and Sons, London.

Cabanac, M., 1972. Thermoregulatory Behavior. In: Essays on Temperature Regulation. Bligh, J. and R. Moore (Eds.) North Holland Publishing Co., Amsterdam. J. Bligh., pp: 19-36.

Eloff, F., 2002. Jagters van die Duine. Sunbird Publishing, Cape Town.

Kemp, C.J., 1998. Biometry 124. University of the Free State, Bloemfontein.

Louw, G., 1993. Physiological Animal Ecology. Longman Group, Essex.

Lovegrove, B., 1993. The Living Deserts of Southern Africa. Fernwood Press, Vlaeberg.

Schmidt-Nielsen, K., 1998. Animal Physiology: Adaptation and Environment. Cambridge University Press, Cambridge.