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Research paper

Behavioural thermoregulation in langur Monkeys in Puri District, Odisha

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Abstract: Behavioural thermoregulation study was made on a unimale bisexual langur group of 21 individuals excluding infants at Veerpratappur, Puri district, Odisha using scan sampling method for over 80 hours during 2007; besides, ad libitum observations were also taken. Prior to this, reconnaissance observations were taken on the group. Data analysis of Regression coefficient by F test showed that there is no significant difference in rates of each behaviour pattern at different time periods of the day. While t-test used between two relevant behaviour patterns showed that certain behaviour patterns are used more than others at a particular time period. The rates of behaviour patterns with respect to the Sun did not differ significantly as langurs made use of shade significantly more than being in the Sun. The shade helps them to adopt diversity of postures with respect to the Sun at different time periods of the day thus helping them to regulate their exposure to solar radiation.

Introduction:

There have been very little studies on thermal behavioural biology of primates even though temperature is an important ecological constraint (Hill *et al.*, 2004). (Stelzner, 1988) has also mentioned that in comparison to other ecological factors, temperature and thermoregulation in primate behaviour ecology has received relatively little attention. Earlier some of the detailed studies on wild primates (Baboons, Papio spp.) behavioural thermoregulation include that of (Stelzner and Hausfater, 1986) (Stelzner,1988), (Brain and Mitchell,1999), (Pochron, 2000), (Hill, 1999). Barret *et al.* 2004) have studied cave use in Chacma baboons (*Papio hamadryas ursinus*), while (Dasilva, 1993) has studied effect of climate and diet on postural changes and behavioural thermoregulation in

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Colobus polykomos. However, to the extent known, there appears to have been no quantitative studies on Indian non-human primates, so the work was undertaken on langur (*Semnopithecus entellus*) to make an attempt to know whether some of its behaviour patterns change as a function of its thermal environment in question . The following dual hypothesis were formulated: (i) There is no change in behaviour patterns under study without change in thermal environment in question at different time periods of the day.(ii) Some of the behaviour patterns under study are used more than others.

Study Area:

Puri is a religious place with temple of Lord Jagannath which attracts huge number of devotees every year. The city of Puri is on the sea coast. The study site Veerpratapur is about 11 Km from Puri on Puri-Bhubaneshwar highway. Its geographical coordinates taken through Garmin GPS were 19. 53 N, 85 .48 E. The people have main occupation as agriculture. They grow paddy, vegetables and other crops. There are two schools in the village and temples are also present. There are quite a few water bodies in the area which are used by local people for various purposes such as irrigation, drinking water, washing and bathing. The predominant trees in the area are that of coconut. The study area has a village with people living in cemented houses and huts, where langurs are known to occur since time immemorial.

Materials and Methods:

Langur (*Semnopithecus entellus*) is predominantly folivorous. It lives in social groups, which are of three types – all male, multimale and unimale The selected study group was of unimale type i.e. it had one alpha male as its leader, several females and their infants. Besides, atmospheric temperature and relative humidity were measured with digital thermohygrometer. To take into account the combined effect of temperature and relative humidity, the temperature – humidity index or heat index was used. The heat index gives a predicted temperature under standard conditions equal to that for a given combination of temperature and humidity, and is calculated from the formula given below-

$$T9hi) = -8.784694756 + 1.61139411 (T) + 2.338548839 (RH) - 0.14611605 (T). (RH) - 0.0.12308093 (T)^2 - 0.016424827 (RH)^2 + 0.002211731667 (T)^2. (RH) + 0.00072546 (T). (RH)^2 - 0.000003582 (T)^2. (RH)^2$$

Where T(hi) is the heat index in degree C and RH is the relative humidity expressed as a percentage. The heat index is specially designed to assess the impact of humidity on air temperature when air temperatures are already high and the formula is not valid for temperatures below about 23.89 degree C (Hill *et al.*,2004).

Reconnaissance observations were taken in 2006. In the subsequent year in 2007, quantitative data were taken using scan sampling method which has been used in the present paper. Besides ad libitum observations were also recorded (Altmann, 1974). After standardization of scan samples, linear regression was used using Heat Index and a particular behaviour pattern. To know the effect of climate variable under consideration separately, regression was applied using temperature and relative humidity data as well. F-test was applied to evaluate for significance of regression. The t-test was also applied between relevant

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combination of two behavioural patterns to see if they differ significantly at a given heat index. Statistical methods were used following (Zar, 2005). Interpolated OLR (Outgoing Long wave Radiation) data was taken as daily average during the study period in 2007 from website www.cdc.noaa.goc/data/gridded/data.interp_OLR.html

It is available as 2.5 degree latitude x 2.5 degree latitude global grid. Wind data was taken from Indian Meteorological Department (IMD), Pune for Puri (Odisha) for the study period in 2007 (monthly average). Wind speed was 15 Kmph in south-westerly (210 degree) direction at 08.30 hrs. This wind data can be used for a radial distance of 25 Km from Puri.

Results:

Group composition of the study group has been shown in Table 1 while details of thermal environment considered in the present study (temperature, Relative Humidity and Heat index at different time intervals) are presented in Table 2. Behavioural patterns in relation to time interval, rates, ANOVA values are shown in Table 2–7.

Table 1. Group composition of study langur group (*Semnopithecus entellus*)

Adult male	Adult female	Sub-adult female	Juvenile	Infant I	Infant II	Total
1	9	3	4	3	1	31

Table 2. Temperature, Relative Humidity and Heat Index at different time intervals of the day

Time intervals	7.30-10.30 AM	10.30-12 noon	12noon-04.22 PM
Temperature degree C	33.08	35.13	35.01
Relative Humidity (RH)	72.11	59.73	60.80
Heat Index (Thi)	44.66333755	45.30706007	45.46719921

Table 3. Overall rates of different behavioural patterns

Behavioural patterns	7.30 to 10.30 AM	10.30 AM to 12.00 noon	12.00 noon- 04.22 PM
NND>0(NND= nearest neighbour distance)	0.71	0.70	0.83
In shade	0.79	0.77	0.91
In Sun	0.03	0.04	1.74
Huddled	0.0029	0	0
Normal sitting posture	0.80	0.73	0.91
Lying	0.02	0.01	0.03
Sitting facing Sun	0.14	0.16	0.14
Sitting back to Sun	0.29	0.2	0.23
Sitting sideways to Sun	0.32	0.41	0.51
Stretched out	0.02	0.002	0.0009
Locomotion	0.09	0.06	0.06
Feeding	0.09	0.11	0.14

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Drinking	0	0.0008	0.002

Table 4. Linear regression and ANOVA to test significance of regression coefficient in relation to heat index at different time intervals

Behaviour pattern	**R Sq**	**F value**	**Significant/non-significant**
NND>0	0.3602	0.563063	F<0.05(1)3,1 ns
In shade	0.3007	0.4301	F<0.05(1)3,1 ns
In Sun	0.4327	0.7630	F<0.05(1)3,1 ns
Huddled	0.9645	27.2377	F<0.05(1)3,1ns
Normal sit posture	0.0971	0.1075	F<0.05(1)3,1ns
Lying	0.0354	0.0367	F<0.05(1)3,1ns
Facing Sun	0.1076	0.1206	F<0.05(1)3,1ns
Back to Sun	0.7507	3.0112	F<0.05(1)3,1ns
Side to Sun	0.8728	6.86	F<0.05(1)3,1ns
Stretched out	0.9810	51.8413	F<0.05(1)3,1ns
Locomotion	0.9645	27.2377	F<0.05(1)3,1ns
Feeding	0.8113	4.3020	F<0.05(1)3,1ns
Drinking	0.8113	4.3020	F<0.05(1)3,1ns

df regression=3, regression =1, F 0.05(1)3,1=216

Table 5. Linear regression and ANOVA to test significance of regression coefficient applied to see how each behavioural pattern under study regress in relation to temperature at different time intervals

Behaviour pattern	**R Sq**	**F value**	**P value**	**Significant/non-significant**
NND>0	0.1532	0.181008	F<0.05(1)3,1	ns
In shade	0.1105	0.1243	F<0.05(1)3,1	ns
Huddled	0.9972	366.67	F<0.05(1)3,1	s
Normal sit posture	0.0056	0.0057	F<0.05(1)3,1	ns
Lying	0.0027	0.0027	F<0.05(1)3,1	ns
Facing Sun	0.2964	0.4212	F<0.05(1)3,1	ns
Back to Sun	0.9229	11.9763	F<0.05(1)3,1	ns
Side to Sun	0.6754	2.0810	F<0.05(1)3,1	ns
Stretched out	0.9893	92.7125	F<0.05(1)3,1	ns
Locomotion	0.9972	366.6759	F<0.05(1)3,1	s
Feeding	0.5940	1.4636	F<0.05(1)3,1	ns
Drinking	0.5940	1.4636	F<0.05(1)3,1	ns

df regression=3, regression =1, F 0.05(1)3,1=216

Table 6. Linear regression and ANOVA to test significance of regression coefficient applied to see how each behavioural pattern under study regress in relation to Relative Humidity at different time intervals.

Behaviour pattern	R Sq	F value	P value	Significant/ non-significant
NND>0	0.1350	0.1561	F<0.05(1)3,1	ns
In shade	0.0948	0.1047	F<0.05(1)3,1	ns
In Sun	0.1896	0.2340	F<0.05(1)3,1	ns
Huddled	0.9939	163.396	F<0.05(1)3,1	ns
Normal sit posture	0.0024	0.0024	F<0.05(1)3,1	ns
Lying	0.0060	0.0061	F<0.05(1)3,1	ns
Facing Sun	0.3203	0.4714	F<0.05(1)3,1	ns
Back to Sun	0.9361	14.6681	F<0.05(1)3,1	ns
Side to Sun	0.6509	1.8649	F<0.05(1)3,1	ns
Stretched out	0.9833	59.0730	F<0.05(1)3,1	ns
Locomotion	0.9939	163.39	F<0.05(1)3,1	ns
Feeding	0.5685	1.3177	F<0.05(1)3,1	ns
Drinking	0.5685	1.3177	F<0.05(1)3,1	ns

df regression=3, regression =1, F 0.05(1)3,1=216

Table 7. Result of t-test applied to different behavioural patterns in combination

S. No.	Behavior pattern	Time interval 7.30-10.30 AM(df=18, t0.05(1), 18=1.734)	Time interval 10.30 AM-12.00 Noon (df=17,t0.05 (1),17=1.740)	Time interval 12.00-04.22 PM(df=15,t 0.05(1)15=1.753	Significant/ non-significant
1	**NND>0 Vs Huddle***	10.78|t|>0.05(1),18	12.82|t|>0.05(1),17	10.93|t|>0.05(1)15	s
2	**In shade Vs IN sun**	10.74 |t|>0.05(1),18	12.73 |t|>0.05(1),17	11.18 |t|>0.05(1)15	S
3	**Normal Vs posture Vs Lying**	11.82 |t|>0.05(1),18	9.80 |t|>0.05(1),17	12.74 |t|>0.05(1)15	S
4	**Facing Sun Vs Back to Sun**	-3.31 |t|>0.05(1),18	-1.63 |t|>0.05(1),17	-2.74 |t|>0.05(1)15	Ns
5	**Back to Sun Vs Side to Sun**	-0.38 |t|>0.05(1),18	-5.70 |t|>0.05(1),17	-3.60 |t|>0.05(1)15	Ns
6	**Facing Sun Vs side to Sun**	-2.76 |t|>0.05(1),18	-5.54 |t|>0.05(1),17	-4.06 |t|>0.05(1)15	ns

*low rate in scan sampling

These tables evidently indicate how each behavioural pattern under study regress in relation to various parameters at different time interval whereas outcome of t-test to know if two appropriate combinations of behavioural patterns differ significantly is given in Table 7.
The analysis of regression coefficient(Beta) using F –test supports null hypothesis (H0 : Beta= 0) i.e. there is no dependence of behaviour patterns under study on heat index at different time intervals of the day as shown in Table 4 for the behaviour patterns under study when heat index is taken into consideration. However, when regressed with respect to temperature, the result for huddled and locomotion were significant F 0.05(1)3,1=366.67 and F=0.05(1)3,1=366.6759 respectively (Table 5). However, results were not significant when behaviour pattern were regressed with respect to Relative Humidity (Table 6).
Analysis by t-test showed that there is no statistically significant difference between the behavioural patterns with respect to the Sun (facing sun, back to sun and side to sun). When analysed in different combinations. However, there is statistically significant difference between being in shade in being in the Sun (Table 7). Average rate of behaviour patterns considered in the present study has been shown with average rate of Interpolated OLR for the study period in Table 8.

Table 8. Average Rates for study period for behaviour pattern in the study and Interpolated OLR for the study period(23 March 2007 to 01 April 2007)

Behaviour pattern	Average rate of study period	OLR(W/m sq) average for study period
NND>0	2.24	294.97
In shade	2.47	294.97
In Sun	1.81	294.97
Huddled	.0029	294.97
Normal sit posture	2.44	294.97
Lying	0.06	294.97
Facing Sun	0.44	294.97
Back to Sun	0.72	294.97
Side to Sun	1.24	294.97
Stretched out	0.0229	294.97
Locomotion	0.21	294.97
Feeding	0.34	294.97
Drinking	0.0028	294.97

Discussion:
Langurs are a eurytopic species. Different parts of their zoogeographic distribution have different climates. In the present study, as the place was near Odisha sea coast, humidity has been taken in to consideration along with the temperature. In study on baboons on Africa, temperature, solar radiation intensity humidity and wind speed have all been identified as important factors responsible for thermoregulatory responses (Stelzner and Hausfater, 1986); (Stelzner, 1988); (Brain and Mitchell, 1999) and (Pochron, 2000). However, previous

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studies have focussed on each of these climatic factors in isolation and did not make attempt to evaluate their combined impact on the thermal environment. (Hill *et al.* 2004) have mentioned that simple temperature indices which have often been developed in relation to human thermal physiology represent useful proxies of the thermal characteristics of baboon's perceived environment and represent a useful tool in studies of primate thermal biology. In the present study, relative humidity was one of the important factors, which has been taken in to consideration along with temperature. (Hill *et al.,* 2004) have also stressed that in forest environments, where solar radiation intensity is reduced, humidity and heat index are likely to be of greater significance.

In case of arboreal or forest dwelling species, substantial vegetation cover is likely to reduce the importance of solar radiation, although it has been shown to be important in determining the location of resting places in Howler monkeys (Bicca-Marques and Calegaro-Marques,1988). In the present study too, relevant combination so behaviour patterns with respect to sun do not show significant difference between being in sun and being in shade (Table 7) as shade helps the langurs to adopt diversity of behaviour patterns with respect to the Sun.

Humidity is likely to be of greater significance to high thermal loads in these environments. Humidity was a significant constraint on allo grooming activity for the baboons and was also responsible for patterns of sun avoidance by the baboons in the cool, lush season at Ruaha National Park in Tanzania (Pochron, 2000). Regression analysis has shown (Table 4) that there is no significant change in different behavioural patterns at different time intervals of the day with thermal indices. However, t-test has shown that there is significant difference between two or more types of behavioural patterns (Table 7). (Hill *et al.,* 2004) have taken into consideration wind (their study was carried out in Africa which have Savanna type of open habitat and therefore wind plays an important role).In their studies (Hill *et al.,* 2004) feeding time has been shown to be a negative coefficient of one of the measures of Perceived Environmental Temperature with the probability of feeding declining as Perceived Environmental Temperature increase while resting time was found to be a positive function of Perceived Environmental Temperature which is in accordance with other studies where high environmental temperatures forced baboons into more sedentary activities.

Outcome of the present study shown in Table 4 support null hypothesis 1 as there is no change in behavioural patterns at different time of the day as heat index is more or less same (Table 2) and significant difference shown by huddled and locomotion in relation to temperature alone may be due to their low rates in scan sampling . The observation that there is significant difference between being in shade and in the Sun and rates for positions with respect to Sun (serial number 4,5,6 in Table 7) do not differ significantly, lends support to second hypothesis.

The perceived temperature by the langurs may be different from the environmental temperature presented here. Due to their well developed layer of fur, most primates are more highly insulated than humans, and as a result their convective heat exchange will be less affected by variations in the air temperature and wind speed (Hill *et al.*,2004) and their conductive heat losses to the ground may also be less marked(Stelzner,1988). The indices currently available are, therefore, not directly applicable to non-human primates. However, while they may not precisely reflect a primate's thermal environment, they may provide a useful assessment of the relative thermal impact for a given set of climatic conditions (Hill *et al.*, 2004). Data presented by (Ames and Insley, 1975) for cattle and sheep has shown that the human wind chill index is not valid for animals with natural coverings, particularly at wind velocities greater than 40 Kmph.

A full insight of primate thermoregulation will be feasible only when the biophysical models of the thermal characteristics of the species in question and their environment have been developed (Stelzner,1988). However, it is unlikely that such models will be applicable in all the situations. The output given by thermal indices used by (Hill *et al.*, 2004) need to be considered with a degree of caution but they should nevertheless permit us to face the questions on the constraints imposed on the thermal environment in a far more informed fashion than has been possible as yet (Hill *et al.*,2004).

Climate warming is probably a much bigger threat than either habitat destruction or hybridization, with climate change disproportionately causing extinction of the parts of species ranges that contain the greatest species diversity (Thomas, 2006). For endothermic animal species (i.e. birds and mammals), ambient temperatures affect the energy spent to maintain homeostasis (constant body temperature). As the globe warms, animals will probably shift their ranges and densities. Species will be able to move into areas that are warmed, and withdraw from areas that become too warm. Species within a community will show differential movement (Graham and Grimm,1990); (Overpack *et al.*, 1992). It is also known that as OLR increases, biodiversity decreases (Bass *et al.*, 1998).

It is interesting to note that there is evidence of cave use by non-human primates for thermoregulation. As proposed by (McGrew *et al.*, 2003) there are four possible non-exclusive reasons for cave use by non-human primates: security, access to nutrients via geophagy, access to and improved thermoregulation. Barrett *et al.* (2004) have demonstrated that in Baboons (*Papio hamadryas*) cave usage is determined at least in part, by above ground temperatures. Therefore, conservation measures may be useful for behavioural thermoregulation as well.

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References:

Hill, R. A., Weingrill, T., Barrett, L and Henzi, S. P. (2004) Indices of environmental temperatures for primates in open habitats. Primates. 45, 7-13.

Stelzner, J. K. (1988) Thermal effects on movement patterns of yellow baboons. Primates. 29, 81-105.

Stelzner, J. K. and Hausfater, G. (1986) Posture, microclimate and

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thermoregulation in yellow baboons. Primates. 27, 449-463.
Brain, C and Mitchell, D. (1999) Body temperature changes in free-ranging baboons (*Papio hamadryas ursinus*) in the Namib desert, Namibia. Int. J. Primatol. 20, 585-598
Pochron, S. T. (2000) Sun avoidance in the yellow baboons(*Papio cynocephalus cynocephalus*) of Ruaha National park, Tanzania. Variations with season,behaviour and weather. Int. J. Biometeorol. 44, 141-147.
Hill, R. A. (1999) Ecological and demographic determinants of time budgets in baboons : Implications of cross-populational models of baboon socioecology. PhD thesis.,University of Liverpool, UK.
Barrett, L., Gaynor, D., Rendall, D., Mitchell, D. and Henzi, S. P. (2004) Habitual cave use and thermoregulation in chacma baboons (*Papio hamadryas ursinus*). J. Hum. Evol. 46, 215-222.
Dasilva, G. L. (1993) Postural changes and behavioural thermoregulation in *Colobus polykomos* – the effect of climate and diet. Afr. J. Ecol. 31(3), 226-241.
Altmann,J.1974. Observational study of behaviour: sampling methods. Behaviour 49, 227-267. (Stelzner and Hausfater, 1986; Stelzner, 1988; Brain and Mitchell, 1999 and Pochron, 2000). However, previous studies have focussed on each of these climatic factors in isolation and did not make attempt to evaluate their combined impact on the thermal environment. Hill *et al. (*2004).
Ames, D. R. and Insley, L. W. (1975) Wind –chill effect for cattle and sheep. J. Anim. Sci. 40, 161-165.
Bass, B., Hansell, R and Choi, J. (1998) Towards a simpler indicator of biodiversity. Environ Monit Assess. 49, 337-347.
Bicca-Marques, J. C., Calegaro-Marques, C. (1998) Behavioural thermoregulation in a sexually dichromatic Neotropical primate, the black and gold howling monkey (*Alouatta caraya*). Am. J. Phys. Anthropol. 106, 533 – 546.
Graham, R. W. and Grimm, E. C. (1990) Effects of global climate change on the patterns of terrestrial biological communities. TREE 5, 289-292.
Hill, R. A. (2003) In primate seasonality : implications for human evolution.(ed. Brockman, D., Van Schaik, C. P.). Cambridge University press, Cambridge.
Mather, J. R. (1974) Climatology : fundamentals and applications. McGraw-Hill, New York.
McGrew, W. C., McKee, J. K., Tutin, C. E. G. (2003) Primates in caves: two new reports of *Papio* spp. J. Hum. Evol. 44, 521-526.
Overpack, J. T., Webb, R. S. and Webb, T. III. (1992) Mapping eastern vegetation change over the past 18,000 years: No analogs and the future. Geology. 20,1071-1074.
Roonwal, S. M. and Mohnot, S. M. (1977) Primate sof south-east Asia : ecology, socio-biology and behaviour. Massachusetts: Harvard University Press.
Thomas, C. D. (2006) Recent evolutionary effects of climate change. In: Climate change and biodiversity. Ed by T.E. Lovejoy and Lee Hannah. Pp. 75-78. Published by TERI Press, New Delhi.
Zar, J. H. (2008) Biostatistical analysis. 4th eds. 1-359. Published by Dorling Kindersley (India) Pvt. Ltd.