International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 10, Issue. 2, October 2023, pp. 2188-2196 **DOI: 10.26540/ijgsr.v10.i2.2023.254**
***Available Online* at www.ijgsr.com**

Research paper

Postural behavior of rhesus monkeys at high altitude (Shimla and low altitude area in Himachal Pradesh

Bhatnagar, P. S.* and Mazumdar, P. C.
Zoological Survey of India, Central Zone Regional Centre, Jabalpur, Madhya Pradesh, India
Zoological Survey of India, 535, M- Block, New Alipore, Kolkata, West Bengal, India
***Corresponding author email: zsiscientist2004@yahoo.com

Received: 17/08/2023
Revised: 24/08/2023
Accepted: 01/09/2023

Abstract The present study attempted to study posture in rhesus monkeys at high altitude and low altitude. Quantitative observations were taken using scan sampling .Various types of postures were observed. Sitting made hands free for object manipulation which was useful in tasks like feeding and grooming. Huddled and bipedal standing were some other postures observed in the present study.

Keywords: Altitudinal gradient, Posture, Adaptation, *Macaca mulatta*

Introduction:

Position of body segments at a given time characterize the posture; maintained posture is an active process which is controlled by diverse sensory and central inputs and these ensure that there is no change of position (Massion, 1984).A simple definition is that posture is the body segments 'configuration at any given time (Thomas, 1940). However, this definition is purely descriptive and does not take into account several functions sub-served by posture. Later on, Genetic model and Hierarchical model of posture have been used to explain posture. Two of the general functions of the posture are- an antigravity role and a role in interfacing the body with its environment such that perception and action can ensure (Massion *et al.,* 2004). Majority of motor acts materialise as posture and movement are coordinated to achieve goal of the task. It is necessary that body be in a bio mechanically stable position during whole of movement whiles the projection of centre of gravity falling between the different points of support (Griller and Waller, 2004).

Altitude may be an important geographical feature in the behavior of animals. Earlier some researchers have studied altitudinal variation in animals. Effect of mature leaf food selection of Japanese Macaques (*Macaca fuscata*) has been studied in two different altitudinal zones of Yakushima (Japan) in the coniferous (1000-1200m) and coastal (0-200m) (Hanya *et al.*, 2007). In China, *Rhinopithecus bieti* is known to shift its altitudinal position (Yang, 2003). In an eurytopic Indian non-human primate *Semnopithecus entellus* (langur) mode of tail carriage has been found to be different at some of the geographic locations

(Roonwal, 1979 a,b and 1981). Gebo (1992) has studied locomotor and postural behaviour in new world monkey species *Alouatta palliata* and *Cebus capucinus.* As there appeared to be a need for investigating postural behavior of rhesus at high and low altitude area, so the present study was carried out with an objective to know posture of rhesus at high and low altitude. Himachal Pradesh is a state with good range of geographical variation. Therefore, at high altitude available rhesus (*Macaca mulatta*) groups at Jaku temple (1952 m), Shimla and at lower altitude (660 m) , Renuka Wildlife Sanctuary were chosen for the present study; it has a temple of Renuka Devi and rhesus are living around the temple.

Methodology:

Study locale -

(i) High Altitude- Shimla- It is located in mid hills of western Himalaya and it rose in the wake of Gurkha wars that ended in 1815-16.It was a small village earlier and later on became summer capital of British India and now is the state capital of Himachal Pradesh. Jaku temple (Latitude 31.115316 degree , longitude 77.163378 degree) is on a hill that towers over Shimla. The temple is at an altitude of 1952 m. Jaku temple is dedicated to Lord Hanuman. It is visited by devotees. One part of the temple complex is called Monkey Kingdom. At the base of the temple there is another temple called Balaknath temple. At Jaku temple, Shimla rhesus were also observed to drink water from taps (by pushing its cap upwards in a vertical plane) and rarely by pressing the tap in a horizontal plane. Besides, they were drinking water from the substratum surface also. Rhesus also snatched (or attempted to snatch) spectacles (and some other objects) from people which people attempted to retrieve by offering eatables to rhesus.

(ii) Low Altitude - Renuka wildlife sanctuary- (altitude 660 m, Latitude 30.610442 degree, longitude 77.452300 degree)-It is in Sirmaur district of Himachal Pradesh. It has a lake (called lake Renuka) named after the temple of Renukaji located in the sanctuary. There are free-living animals such as rhesus, langur, bats, birds as well as those in enclosures such as lions, some of the ungulates and birds. Devotees and tourists come to the sanctuary. At Renuka Wildlife sanctuary , rhesus were observed to drink water mostly from the edge of lake or from substrate surface. Snatching of eatables from people was also observed.

Postural behaviour of rhesus was recorded at high and low altitude study areas using scan sampling (Altmann, 1974), besides ad libitum sampling. Group count was also taken. Records of atmospheric temperature and Relative Humidity were obtained using digital thermo-hygrometer. Data was standardized and statistical analysis was done using Mann-Whitney U Test (2 tailed) using website www.holah.karoo.net/Mann-Whitney and Zar (2008) was also consulted. The null hypothesis was that there is no significant difference in behavioural pattern /climatic variable under question at high and low altitude. The field study was undertaken during 2007 and 2008 for a total of 113 hours of scan sampling data. Prior to actual commencement of data recording, reconaissance observations were also taken at both high and low altitude.. The behaviour patterns under study were defined as follows -

Bipedal standing – Standing on the two hind limbs ; it helps the individual to see what can not be seen while sitting.

i) **Sit straight -** sitting with back upright and head usually facing straight.

a. (Leg straight)- leg stretched (abducted ;away from body)

b. (Leg folded) - legs held close to each other and close to ventral surface of body(adducted).

ii) **Sit normal** – Sit relaxed with back slightly curved and head usually inclined towards the ventrum.

a. Leg straight – leg stretched (abducted; away from body)
b. Leg folded – legs held close to each other and close to ventral surface of body; adducted.

In sitting posture, forelimbs could be adducted or abducted.

Huddled - two or more individuals sitting in close physical contact with each other (in cold).

Groomer inclined – Groomer is in inclined position.
i) straight- in an upright position
ii) lying
iii) Turned (bend sideways)

Groomee inclined – Groomee is in inclined position.
i) Straight
ii) Lying
iii) Turned

Drinking while sitting - Drinking water in sitting posture

Drinking while standing - Drinking water in standing posture

Feeding with one hand while sitting - feeding with one hand in sitting posture

Feeding with both hands while sitting - feeding with both hands in sitting posture

Feeding with one hand while standing - feeding with one hand in sitting posture

Feeding with both hands while standing - feeding with both hands in sitting posture

Lying - individual lying (body axis parallel to the substratum).

Infant Piggyback Ride- Infant in piggyback ride position on another rhesus monkey. Heads of both the monkeys are facing in the same direction while pelvis of the top monkey is on the lower monkey's hindquarters.

Infant Ventro -Ventral - Ventral side of infant and ventral side of other rhesus individual are facing each other. Some of the postures were mutually exclusive (when one type of posture takes place the other cannot occur simultaneously in the individual) e.g. sitting and lying, sitting and standing ,infant in ventro-ventral position and infant doing piggy ride.

Result:

There was an altitudinal gradient of 1292 m between high and low altitude study areas and the mean temperature difference was of 7.27 degree Centigrade. The study group composition has been shown in Table 1 and 2.

Table 1. The study group composition of rhesus (*Macaca mulatta*) at high altitude (Jaku temple, Shimla)

Name of study group	Adult male	Adult female	Sub-adult male	Sub-adult female	Juvenile	Infant	Total
Kingdom group (at Jaku temple)	1	5	3	3	1	2	15
Jaku temple group	3	16	3	8	5	9	44
Balaknath temple group	2	4	1	3	5	4	19

Table 2. The study group composition of rhesus (*Macaca mulatta*) at low altitude (Renuka Wildlife Sanctuary)

Name of study group	Adult male	Adult female	Sub-adult male	Sub-adult female	Juvenile	Infant	Total
Sanctuary entrance group	3	7	3	5	4	7	29
Ashram group	1	12	1	2	4	7	27
Tourist Rest House group	7	2	4	2	3	1	19

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 10, Issue. 2, October 2023, pp. 2188-2196 **DOI: 10.26540/ijgsr.v10.i2.2023.254**
***Available Online* at www.ijgsr.com**

Discussion:

Theoretically, various segments of body can take a diversity of postures, but each posture should observe laws of equilibrium (Massion,1984). When a change of centre of gravity occurs, varied reflex actions regulate to bring about corrective postural changes under the action of labyrinthine, visual and somesthetic receptors (Dichgans *et al.*, 1972; Lestienne *et al.*, 1977; Nashner, 1977). When static, an adjustment of posture is required to maintain equilibrium. As opposed to rigid objects , the relative position of body segments can change thus, resulting in change in centre of gravity position , which generates disequilibrium and position of other segments should change to make up for this (Massion,1984). In the present study also behavioural patterns involved different postures and body parts e.g. in grooming various parts of postures were taken by different parts of the body (and likewise in other behavioural patterns) and equilibrium was maintained.

In the present study, by standing bipedally, monkeys increased their range of sight and grasped objects. From an evolutionary viewpoint, bipedalism in primates originated in monkeys, reaching its zenith in human beings. Due to erect posture , man has benefits such as sight, sound, smell, touch and sophisticated manipulation as well as voice and speech. Erect posture gives man advantage as to sight, sound, smell, touch, and delicate manipulation, voice and speech, which is evident by the greater complexity and quantity of his brain structure (Scanes-Spicer, 1910). However, Monkey's bipedalism is different from that of humans (Nakatsukara *et al.*, 1995). Seth *et al*. (2001) have mentioned that groomer and groomee were active participants in grooming with each individual assuming specific posture, adjusting its activities to the postures of its partner. In the present study, a wide variety of postures were used in grooming as shown in Table 3 .It is known that grooming serves to strengthen the social bond. In contrast to Ventro-ventral position , there is piggy ride position also that is taken by infants of the older age-class in rhesus which enables them a greater visualization. Dunbar and Badam (1998) also found that infant-1 monkeys continually cling to their mother's ventral surface with strong hands and foot grasps. Independent motor coordination develops in infant-2 period. Higher rate of venro-ventral contact in infants at higher altitude (Table 3 and 4) indicate that this serves in providing warmth due to comparatively colder atmospheric temperature there. Similar results have also been observed in other studies; in baboons in captivity during the first 8 weeks of infants , ventro-ventral contact with mothers was found to be significantly negatively related to temperature (Brent *et al.*, 2003) and in Japanese macaque (*Macaca fuscata*) infants in captivity in an Italy zoo, lower temperatures were associated with more attempts by the infants to keep contact with their mothers (Schino and Troisi, 1998).

Posture can be explained with the help of two models - genetic model and hierarchical model. The first one of these, Genetic model of posture (its foundation rests on genetically pre-wired mechanism for finishing postural tasks) says that posture supports the body against gravity, preserve balance, orient the body with respect to the gravity and also adapt the body's segments to the on-going movement. It holds good for many basic postural controls, its limitations include the fact that it can not account for issues related to flexibility of postural reactions and anticipatory postural adjustments, of which the latter ones are concerned with coordination between posture and movement. On the other hand, the hierarchical model of posture takes into consideration experience and learning and gives finely tuned adaptations of postural functions to the movement needs of day to day life. According to this model two types of Central NS processing are required for controlling posture. One of the higher order achieves an internal representation of body posture (the so called 'body schema'). Parallel to this, a lower order control effects kinematics and force (kinetics) which are needed for executing postural functions as an essential aspect of the task. It is to be noted that this model does not exclude genetic model as it makes use of several genetically pre-wired circuits for completing postural tasks (Massion *et al*., 2004). During the course of phylogenetic development, animals acquired a diversity of innate actions so that they could adapt to the different conditions of environment. The hierarchical model explains the outcome of present study as primates make use of learning and experience. In recent times, distinction between innate and learned behaviour is fast disappearing as behaviour patterns that are innate form part of learned behaviour.

Table 3. Results of scan sampling at high altitude and low altitude (rate /minute /individual for behavioural patterns and average for Temperature and Relative Humidity as average)

Behavioural pattern/ Atmospheric parameter	High altitude	Low altitude
Sit normal with leg folded and far	0.0029	0.6671
Sit normal with leg folded and close	1.3522	0.2771
Sit normal leg straight	0.1523	0.2655
Sit straight and leg(s) Stretched	0.0592	0.0051
Bipedal standing	0.0139	0.0010
Relative Humidity (RH) %	58.45	45.08
Temperature (degree C)	22.84	30.11
Infant Ventro-ventral	0.3872	0.2318
Infant Piggy Ride	0.0333	0.0312
Huddled	0.0145	0.1114
Groomer inclined	0.1465	0.1636
Groomer straight	0.0063	0.0028
Groomer lying	0.0002	0.0055
Self Grooming	0.0017	0.0048
Groomer turned	0.0026	0.0027
Groomee inclined	0.0467	0.0441
Groomee straight	0.0069	0.0029
Groomee standing	0.0022	0.0001
Self Grooming	0.0128	0.0003
Groomee lying	0.0727	0.0757
Groomee turned	0.0186	0.0557
Drinking (sitting + inclined)	0.0706	0.0473
Feeding sitting (one hand+ both hands)	0.3748	0.2503
Feeding standing (one hand+ both hands)	0.0007	0.0073
Lying	0.0654	0.1511

Table 4. Results of comparison of high and low altitude values using Mann-Whitney U Test

Behavioural pattern/atmospheric parameter	U values	U value used	U values from table at 5 % level	S(significant)/ns(not significant)
Sit normal with leg folded and far	0, 70	0	14	s
Sit normal with leg folded and close	64, 6	6	14	s
Sit normal leg straight	19.5, 50.5	19.5	14	ns
Sit straight and leg(s) Stretched	45, 25	25	14	ns
Bipedal standing	42.5, 27.5	27.5	14	Ns
Relative Humidity(RH)	51, 19	19	14	Ns
Temperature	0, 70	0	14	s
Ventro-ventral	64, 6	6	14	s
Piggy Ride	29, 41	29	14	Ns
Huddled	37.5, 32.5	32.5	14	Ns
Groomer inclined	30.5,3 9.5	30.5	14	Ns
Groomer straight	40,2 0	20	14	Ns
Groomer lying	22, 48	22	14	Ns
Self Grooming	25, 45	25	14	Ns
Groomer turned	26, 44	26	14	Ns
Groomer inclined	37, 33	33	14	Ns
Groomer straight	46, 24	24	14	Ns
Groomer standing	38, 32	32	14	Ns
Self Grooming	50, 20	20	14	Ns
Groomer lying	33.5, 36.5	33.5	14	Ns
Groomer turned	14, 56	14	14	Ns
Drinking sitting (sitting + inclined)	29, 41	29	14	Ns
Feeding sitting (one hand+ both hands)	34.5, 34.5	34.5	14	Ns
Feeding standing (one hand+ both hands)	22, 48	22	14	Ns
Lying	7, 63	7	14	s

Sitting in case of primates makes hands free for other tasks such as object manipulation. This is one of the feature which sets the primates apart from many other quadrupeds making use of pronograde posture (walking or resting with the body horizontal, denoting the posture of quadrupeds, www.biology-online.org/dictionary). In a study on Formosan monkeys, it was observed that monkeys can take the orthograde (sitting) posture for 84% of the day. This has a very important evolutionary meaning; orthograde posture is an adaptive behavior derived from arboreal life. It shows that a basic physical condition for bipedalism has already been prepared in the forest life (Kawai and Mito, 1973). In an interesting study on positional behavior in five sympatric old world monkeys at Kibale forest in Uganda, it was found that they utilize five similar type of positional behavior but in varying frequencies and situations. Colobines preferred to sit (about 90% of all postures) while cercopithecines stand more frequently (Gebo and Chapman, 2005).

In the present study, there was a significant difference between keeping leg far and close in sit normal position at the two altitude gradients. At the high altitude, the rate for close was more as it helps in conserving energy in lower temperature as it helps to reduce heat loss in a comparatively colder conditions as the ventral side gets covered due to legs being held close. ; the temperature at high and low altitudes was as shown in Table 3 with the two mean differing by 7.27 degree C for an altitude difference of 1292 m and the temperature difference was found to be significant (Table 4). Rate of lying was comparatively more at low altitude and the difference was statistically significant .Lying was more at low altitude as one possible reason could be that while lying a greater surface area of body is exposed to the environment for thermal exchange. Other results were not statistically significant (Table 4).

Possibly, the most significant feature in learning is to associate independent signals of which a notable example is classical conditioning in which a previously unrelated stimulus is associated with an innate reflex (Hikosaka, 1994). In this case, it appears that rhesus have been conditioned to environmental temperature to adapt their posture. With change in posture, effective body size of an animal also changes (Gates, 1980), therefore it can regulate exchange of heat. In baboons, posture of hunched and closed type, minimized exposure of trunk and limb while open postures maximized exposure (Stelzner and Hausfater, 1986). Therefore, rhesus at high altitude made more use of energy conservation posture by combining sitting relaxed posture with legs close while those at low altitude had a higher rate of lying to help in energy conservation. Environmental factors have important effect on the geographic distributions of animals and air temperature is one of the factors due to its influence on the body temperature of animals (Stuart, 1952; Brattstrom, 1965; Krebs, 1994; Humphries *et al.*, 2002; Somero, 2005). Body temperature often has great impacts on the physiological functions and the behavioural performance of animals (Bennett, 1980; Kaufmann and Bennett, 1989; Angilletta, 2001). Geographic variation results in different thermal resource availability which greatly declines with elevation and latitude (Van Damme *et al.*, 1987). Modification of posture can be one of the ways to alter surface areas exposed to heat sources or sinks (Heath, 1965). Differences in behavior at different altitudes have been found in some other studies as well**.** In an interesting study on Japanese macaques (*Macaca fuscata*) at two different altitudinal zones of Yakushima (Japan) - in the coniferous forests (1000-1200 m) and coastal forests (0-200 m) macaques chose leaves with less condensed tannin in coniferous forest but this was not the case in coastal forest as macaques in the former type of forests suffer from a higher risk of ingesting large amounts of condensed tannins as their feeding time on mature leaves is seven times as long as that in the latter type of forest (Hanya *et al.,* 2007). In China at Jinsichang mountain, *Rhinopithecus bieti* may change its position with respect to altitude for a thermo-regulatory benefit if distribution of food resources permits so (Yang, 2003).

It appears that there are differences and similarities in posture of rhesus at high and low altitude. Future studies on altitudinal variation in posture of rhesus and other primates may enlighten further.

Summary:
The present study attempted to study posture in rhesus at high altitude (Jaku temple, Shimla altitude 1952 m) and low altitude (Renuka Wild Life Sanctuary, altitude 660 m). Quantitative observations were taken using scan sampling .Various types of postures were observed. Results were analyzed using Mann-Whitney U test which showed that sitting relaxed with legs closed was more at high altitude and the difference was statistically significant, while lying was more at low altitude. There was 7.27 degree C temperature difference at the altitudinal gradient under study, it appears that rhesus have been conditioned to environmental temperature to adapt their posture. Sitting made hands free for object manipulation which was useful in tasks like feeding and grooming. Huddled and bipedal standing were some other postures observed in the present study. Therefore, postures serve different functions for rhesus individually and socially (in grooming several types of postures were involved).

Acknowledgements:
We are grateful to The Director, Zoological Survey of India for permission and facilities. Thanks are also due to Forest Department for permission as well as the Jaku temple, Shimla.

References:

Altmann, J. (1974) Observational study of behavior: sampling methods. Behavior 49, 227-267.

Angilletta, M. J. (2001) Thermal and physiological constraints on energy assimilation in a widespread lizard (*Sceloporus undulates*). Ecology 82, 3044-305.

Bennett, A. F. (1980) The thermal dependence of lizard behavior. Anim. Behav. 28, 752-762.

Brattstorm, B. H. (1965) Body temperature of reptiles. Am. Midland Nat.73:376-422.

Brent, L., Koban, T. and Evans, S. (2003) The influence of temperature on the behaviour of captive mother-infant baboons. Behavior. 140(2), 209-224.

Dichgans, J., Held, R., Young, L., Brandt, T. (1972) Moving visual scenes influence the apparent direction of gravity. Science. 178, 1217-1219.

Dunbar, D. C. and Badam, G. L. (1998) Development of posture and locomotion in free-ranging primates. Neurosc. Biobeh. Rev. 22(4), 541-546.

Gates, D. M. (1980) Biophysical Ecology. Springer-Verlag, New York.

Gebo, D. and Chapman, C. A. (2005) Positional behavior in five sympatric old world monkeys. Am. J. Phys. Anthropol. 97(1), 49-76.

Grillner, S. And Wallen, P. (2004) Innate Vs learned movements – a false dichotomy? Progr. Brain. Res. 143, 3-12.

Hanya, G., Noma , N. and Agetsuma, N. (2003) Altitudinal and seasonal variation in the diet of Japanese macaques in Yakushima. Primates. 44, 51-59.

Hanya, G., Kiyono, M., Takafumi, H. Tsujino, R., Agestuma, N. (2007) Mature leaf selection of Japanese macaques : effects of availability and chemical content. J. Zool. 272, 140-147.

Hikosaka, O. (1994) Role of basal ganglia in control of innate movements, learned behaviour and cognition-a hypothesis. In: The Basal Ganglia IV : New ideas and data on structure and function . By Percheron, G.; McKenzie, J.S. and Feger, J. Eds). Pp 589-546. New York : Plenum Press.

Humophries, M. M., Tomas, D. W., Speakman, J. R. (2002) Climate mediated energetic constraints on the distribution of hibernating mammals. Nature. 418, 313-316.

Hung, Shu-Ping; Hsu,Y. And Tu, Ming-Chung. 2006. Thermal balance and altitudinal distribution of two Sphenomorphus lizards in Taiwan. J. Therm. Biol. 31, 378-385.

Kaufmann, J. S., Bennett, A. F. (1989) The effect of temperature and thermal distribution on locomotor performance in *Xantusia vigilis*, the desert night lizard. Physiol. Zool. 62, 1047-1058.

Kawai, M and Mito, U. (1973) Quantitative study of activity patterns and postures of Formosan monkeys by the radiotelemetrical technique. Primates. 14(2-3), 179-194.
Krebs, C.J. 1994. Experimental analysis of distribution and abundance . In : Krebs, C.J. (ED.), Ecology. Addison-Wesley Publishing Co., Oxford, pp. 93-116.
Lestienne, F.; Soechting, J.; Berthoz, A. (1977) Postural readjustments induces by linear motion of visual scenes. Exp Brain Res. 28, 363-384.
Massion, J.; Alexandrov, A.; Frolov, A. (2004) Why and how are posture and movement coordinated . Prog Brain Res . 143, 13-27.
Massion, J. (1984). Postural changes accompanying voluntary movements. Normal and pathological aspects. Human Neurobiol 2, 261-267.
Nakatsukara, M.; Hayama, S. and Preuschoft. (1995) Postcranial skeleton of a macaque trained for bipedal standing and walking and implications for functional adaptation. Folia Primatol. 64(1-2), 1-29.
Nashner, L.M. (1977) Fixed patterns of rapid responses among legs muscles during stance. Exp Brain Res 30, 13-24.
Pirta, R.S. ; Gadgil, M. and Kharshikar, A.V. (1997) Management of the rhesus monkey *Macaca mulatta* and Hanuman langur *Presbytis entellus* in Himachal Pradesh, India. Biol. Conserv. 79(1), 97-106.
Roonwal, M. L. (1979a) Field observations on distribution and tail carriage in the Central Himalayan Langur, *Presbytis entellus schistaceous* (Primates). Proc. Indian Nat. Sci. Acad.(B). 45, 45-55.
Roonwal, M.L. (1979b) Field study of geographic, subspecific and clinal variation in tail carriage in the Hanuman Langur, *Presbytis entellus*(Primates) in South Asia. Zool. Anz. 202, 235-255.
Roonwal, M.L. (1981) New field data on tail carriage in the common South Asian Langur, *Presbytis entellus* (Primates), and its biological and evolutionary significance. Proc. Indian Nat. Sci. Acad. (B). 47, 26-40.
Scanes-Spicer, R. H. (1910) The normal orthograde posture. The Br. Med. J. 1912-1914.
Schino, G. and Troisi, A. (1998) Mother-infant conflict over behavioural theroregulation in Japanese macaques. Behav. Ecol. Sociobiol. 43, 81-86.
Somero, G. N. (2005) Linking biogeography to physiology : evolutionary and acclimatory adjustments of thermal limits. Front. Zool. 2, 1-9.
Stelzner , J. K. and Ausfater, G. (1986) Posture, microclimate and thermoregulation in yellow baboons. Primates. 27(4), 449-463.
Stuart, L. C. (1951) The distributional implications of temperature tolerances and hemoglobin values in the toads *Bufo marinus* (Linnaeus) and *Bufo bocourti* Brocchi. Copeia. 1951, 220-229.
Thomas, A. (1940) Equilibri et Equilibration. Masson, Paris.
Van Damme, R.; Bauwens, D.;Verheyen, R. (1987) Thermoregulatory response to environmental seasonality by the lizard *Lacerta vivipara*. Herpetalogy. 43, 405-415.
Yang, S. (2003) Altitudinal ranging of *Rhinopithecus bieti* at Jinsichang, Lijiang, China. Folia Primatol. 74, 88-91.
Zar, J. H. (2008) Biostatistical Analysis. 4th ed. 1-323. Published by Dorling Kindersley (India) Pvt Ltd., India.