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RESEARCH ARTICLE

Roosting Ecology and Distribution of Fulvous Roundleaf Bat *Hipposideros fulvus* Gray 1838, in Thar Desert of Rajasthan, India

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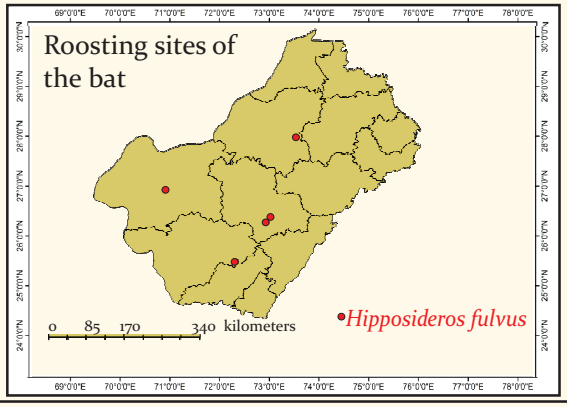
Study Area: Thar Desert, Rajasthan, India
Coordinates: 26°59'04"N; 71°00'06"E



Abstract

Fulvous roundleaf bat *Hipposideros fulvus* belongs to a bicolour group of family Hipposideridae. A detailed study on the ecology and roosting site characteristic was conducted for two years in western Rajasthan and five roosts were identified with breeding records in one site. Earlier, few morphometric measurements below the standard measurements were once described. The shape, size, and length of baculum have also been described. Out of 362 roosting sites scanned in three districts of western Rajasthan, only five sites were occupied by this species. All these five sites were having different microclimatic conditions with round the year high humidity and very low-temperature variation. It is noteworthy that in the case of *H.fulvus* few measurements need to be taken care of while comparing with standards described earlier.

Key words: Subterranean Caves, Microchirpteran, Morphometric measurements

Introduction:

Bats are one of the most successful mammalian order, and probably the most diverse (Altringham, 2011). One of the 26 mammalian orders, the Chiroptera includes 1250 species (Fenton & Simmons, 2014) of bats world over in rather two unequal suborders – Yinpterochiroptera (consisting 186 species of Old World fruit bats in one family) and four family of microbats Rhinophomatidae, Rhinolophidae, Hipposideridae, Crasenoycteridae (Srinivasulu et al,. 2010). Yangochiroptera consists of remaining 931 species belonging to 17 families. Till date, 125 species have been recorded from India (Thong *et al.*, 2018), and as many as 25 species of bats have been reported from Rajasthan (Srinivasulu et al., 2013). A sum of 15 species of bats has been reported so far from the Thar Desert (Senacha & Dookia, 2013; Srinivasulu *et al.,* 2013). In Thar Desert of Rajasthan, microchiropteran bats roost in caves, moist tunnels, dilapidated buildings, historical monuments, step wells, and community wells. It is only due to the harsh environmental conditions like high ambient temperature and low tree densities, they avoid roost like hollow bark, tree and birds' nests. Hipposideros is a large genus found throughout the Old World (Monadjem *et al.*, 2010). About 16 species of hipposiderids belonging to four genera – namely, *Hipposideros* Gray, 1831; *Asellia* Gray, 1838; *Coelops* Blyth, 1848, and *Triaenops* Dobson, 1871 are distributed in South Asia (Srinivasulu *et al.,* 2010). The short muzzle and noseleaf are the characteristic and unique feature which surrounds the nostrils and absence of sella and connecting process are typical identification features of *Hipposideros fulvus* (Hill *et al.*, 1986). The genus *Hipposideros* are small to medium-sized bats (forearm length between 33.0 and 99.00 mm) with a medium-sized tail (20.0 to 64.0 mm); noseleaf with anterior leaf with or without median emargination, an intermediate and a posterior leaf; supplementary leaflets absent or, when present, may range between one and four, and in some species the last supplementary leaflet is much reduced; ears pointed with large antitragus and no tragus; interfemoral membrane broad (Plate- 1), completely enclosing the tail except for the extreme tip mostly, and exceptionally up to 5 mm in some species (Hill *et al.*, 1986). *H.fulvus* is the only species of genus *Hipposideros* present all over Rajasthan. During field survey in three districts, Barmer, Jodhpur and Jaisalmer, it was documented in five different localities belongs to three different places. Roosting sites were away from human habitation, isolated places in the hilly region. Except one long man-made tunnels all others were deep moist caves. A detailed and thorough study was conducted to understand the relationship between microclimatic parameters and the population of *H.fulvus*.

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Materials and methods:

Study area: the Great Indian Desert or the Thar Desert extends over about 0.32 million km² forming approximately 10% of the total geographic area of India. More than 60% of the desert lies in the State of Rajasthan, followed by 20% in Gujarat (Krishnan, 1977). The present study was conducted in three arid most districts of this region, namely, Jodhpur, Jaisalmer, and Barmer, and these districts consist of a large area of the arid or semi-arid zone, situated in the western part of Rajasthan and cover a large area of Thar Desert of Rajasthan. Climatically, Rajasthan is a typical hot desert where summer and winter both seasons are very harsh. The temperature in winter is very low and dips up to 0°C. In summer, the temperature escalates and rises up to 49°C. The annual average rainfall is very low between 150-300 mm. The large area of Rajasthan comes in a semi-arid region due to this; high temperature and low humidity are basic characteristics of this landscape.

Roosting sites:

Cave and roosting site feature: total five roosting sites of *Hipposideros* were located in the study area, among them, three were natural caves and two were manmade long tunnels or flood drainage channels but these too were deep, dark and had high moisture contents. Among these five sites, Daijar cave (Jodhpur) was having many chambers with complex natural tunnel system that ends inside small chambers and it made a complex web of small tunnels inside this cave. These caves have two wide openings and both are parallel to each other. Complete darkness, constant humidity, and temperature make the tunnel a convenient and habitable habitat for bats. Kundal cave (Barmer district) is surrounded by medium hill range. This cave has two opening, one is top of the cave with a narrow opening and another is parallel to the ground (front side). It has a mega single chamber structure along with a deep crevice, which makes it more habitable for bats. Lunavaas cave (Jodhpur) is situated at top of a hillock at about 200-300 feet height from the base of the hill. This cave has only one opening and opened in a medium chamber of 12-15 feet height and it was connected to a small chamber through a tunnel. Mandore tunnel (Jodhpur) is manmade and situated in Mandore garden of Jodhpur city; this tunnel has two openings, one in front and another backside of the tunnel. This is the biggest roosting site of bats among all other roosts. The tunnel has a mega chamber of almost 15-20 feet height and continues from one end to another end. It is s unique site and many species of bats were roosting here with Hipposideros fulvus. Gajroopsagar tunnel site (Jaisalmer) is also a man-made tunnel connecting two water bodies and remain inaccessible for more than 5-6 months due to a high level of water inside the tunnel. *H.fulvus* occupies only two very narrow, deep chambers in the side walls of the tunnel. Because of the very narrow opening and water inundation, it was not possible to take regular microclimatic data from this site.

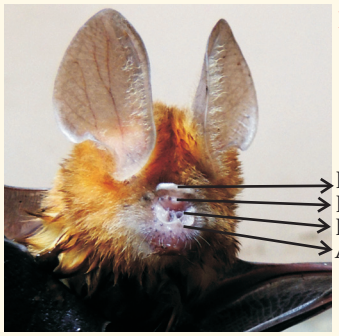

Plate-1: Facial description of *Hipposideros fulvus*

Microclimatic data collection and morphometric analysis: this survey was done from January 2016 to January 2018 in the study area with total 362 roosting sites in Thar Desert of Rajasthan, including five roosting sites of *Hipposideros fulvus*. Information on microclimate data of roosts like temperature, humidity and light intensity inside the bats' roosts were collected using thermo-hygrometer for temperature and humidity and lux meter for light intensity. Morphometric analysis: few bats were captured from roost with help of hoop net and mist net. Hand (Hoop) nets or scoop nets with adjustable-length handles are particularly more convenient for capturing bats in caves, mines, buildings, trees, cervices, cavities and in foliage (Kunz & Kurta 1988). All morphometric data were recorded by Mitutoyo™ digital Vernier caliper for the further taxonomical study of bats. Only two voucher specimens were prepared for further examination includes craniodental, baculum and head body length measurements. One male voucher specimen was further processed for measuring length and shape of baculum, through the standard protocol (Topal, 1975) and photographed by Olympus SZX10 microscope.

Results :

Morphometric analysis: during field survey, total 45 individuals was captured for morphometric measurement and analysis from 5 roosting sites of the study area along with two voucher specimens (one male and one female) for the study of craniodental and baculum (Plate.- 2,3). Among 45 individual, 35 male and 10 females are measured during the survey (Table-1).

Baculum morphology: it was 1.5 mm in length and 0.17 mm in breadth was rod-like and slightly curved in the middle. The proximal end was broad with distal tip narrower and rounded.

Roosting ecology: out of 300 and above roosting sites, only 5 sites were occupied by *Hipposideros fulvus*. While looking at the broad habitat, the microclimate of roost and cave morphology, it was found that the inner microclimatic conditions were very similar to each other and rest all roosting sites were altogether different. Broadly all these 5 roosting sites were situated in deep, moist and dark corners of the natural cave or man-made tunnels (Table-2.). Bats

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always prefer to roost in high humid chambers. To understand the relationship between the temperature, humidity and number of bats in roosting sites, Spearmann's rank correlation test was performed. Daijar cave, Mandore tunnel and Kundal cave shows significant negative correlation between temperature and number of bats (Table-3), when surrounding ambient temperature changes (low/high) bat population increases inside the cave, as the inside temperature remains between 22-34°C. Whereas Lunavas cave roost does not show any such correlation between these two parameters. On the other hand, Mandore tunnel roost shows positive correlation ($p<0.05$, $R<0.227$) between bat population and humidity, means the number of bats gradually increase with the humidity. Other three roosting sites did not show any correlation between the bat population and humidity. The observations on temperature, humidity and number of bats in roosting sites were observed for two years and it was calculated that suitable temperature for bats lies between 22°C to 34°C (Fig.-1) and humidity ranged between 65% to 80% (Fig.-2). The peculiar microclimatic temperature and humidity is the major controlling factor for bats, especially *H.fulvus* in western Rajasthan as the outer temperature and humidity show considerable fluctuation throughout the year.

Table 1: External and cranio-dental measurement (mm) of *H.fulvus* from the study area (n=45)

External Measurements	Bats & Harrison (1997)	Present study
HB	40-50	36.69-44.96*
T	24-35	24.84-25.84
HF	6-9.8	7.43-8.99
FA	38.4-44	35.99-42.57
E	19-26	17.77-20.43*
5MT	28.7-33.1	30.56-32.21
4MT	28.3-33.9	31.32-33.22
3MT	27.3-31.2	29.64-30.96
1PH3MT	16.1-18.9	17.01-17.86
2PH3MT	16.2-19.5	15.79-19.42*
1PH4MT	10-12	9.94-10.99*
2PH4MT	8.2-11.2	8.61-9.19
TIB	16.5-20.7	17.84-19.32
Cranio-dental measurements (Present study n=2)		
CCL	15-16.4	15.48-15.62
M	11.1-12	11.6-11.9
C-M3	6.4-7.5	7.3-7.5
ZB	8.6-9.6	8.2-8.9
BB	7.5-9.4	8.5-8.8
PC	22-28	23.2-26.4
M3-M3	5.8-6.8	6.1-6.3
C1-C1	3.6-4.4	3.7-3.9
GTL	17.2-18.6	17.6-17.9
Baculum	-	0.15

External measurement: HB- head & body length; T- tail; HF- foot; TIB- length of tibia; FA- forearm; WSP- wing span; 3MT-3rd metacarpal; 4MT-4th metacarpal; 5MT- 5th metacarpal; 1PH3MT- 1st phalanx of 3rd metacarpal; 2PH3MT-2nd phalanx of 3rd meta-carpal; 1PH4MT- length of 1st phalanx of 4th metacarpal; EAR- Ear

Plate-2: Lateral & Dorsal view of Baculum of *H. fulvus*.

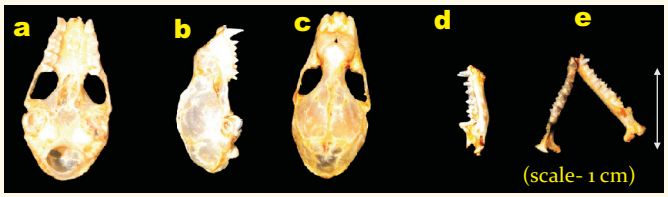

Plate-3:. Ventral (a), Lateral (b), Dorsal (c) view of skull and lateral (d) and dorsal (e) view of lower mandible (jaw)

Cranial and dental measurement: GTL- Greatest length of skull; CBL- Condylo-Basal length; CCL- Condylo-canine length; ZB- Zygomatic breadth; BB- Breadth of brain case; IC- Interorbital construction; PC- Post orbital construction; M- Mandible length; RW- Rostral width; C-Mn- Maxillary tooth row; C-Mn- Mandibular tooth row; Mn-Mn- Posterior palatal width; C1-C1- Anterior palatal width (Bates & Harrison, 1997).
*Slight variation in the lower range from Bates & Harrison (1997).

Table-3: Spearman's rank correlation to understand relationship between temperature and humidity with number of bats (n=72)

S.No.	Variables	p value	CC.	Sig. L
1	**Roosting site: Daijar Cave**			
	Temperature, No. of Bats	0.001	-0.381	0.01
	Humidity, No. of Bats	0.339	-0.114	
2	**Roosting site: Mandore Tunnel**			
	Temperature, No. of Bats	.000	0.409	0.01
	Humidity, No. of bats	.050	0.227	0.01
3	**Roosting site: Lunavas cave**			
	Temperature, No. of Bats	.057	-0.225	-
	Humidity, No. of bats	.052	-0.230	-
4	**Roosting site: Kundal Cave**			
	Temperature, No. of bats	0.036	-0.247	0.05
	Humidity, No. of Bats	.326	-0.117	-

CC.- Coefficient Coorelation; Sig. L- Significant level

These roosts were also occupied by other sympatric bats such as R*hinopoma hardwickii* which was most common in all sites, but always occupied a different chamber of the cave or tunnel. *Rhinopoma microphyllum* was it's sympatric in Jodhpur district only. T*aphozous perfortus* and *T.nudeventris* were found sharing roost in Mandore tunnel. These sympatric species of bats broadly share the roost, but inside the roosting caves, their choices vary. *Hipposideros fulvus* in this arid region required some specific place for survival, and they preferred deep caves with small tunnel structure which have high humidity, complete darkness, and low temperature.

Discussions:

The first survey on bat diversity in the desert region of Rajasthan was conducted by Prakash (1963). But a proper

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Table-2:. Features of roosting sites of *H.fulvus* in Western Rajasthan.

S. No.	Broad habitat (upto 100 mt radius)	Roosting type	Total depth/length of roosting site	Associated bat species
1.	**Location: Mandore tunnel, Jodhpur.** Humidity-72.9% (n=72)		Temperature- 29.5°C (n=72)	
	Underground rainwater drain, situated in urban garden	Old man-made drain, mix roost of 4 species of bats	130 m long, 3-5 chambered rain water drain with high ceiling and small opening at both side	*Rhinopoma microphyllum, R.hardwickii, Taphozous perforatus, T. nudeventris.*
2.	**Location: Daijar Cave, Jodhpur.** Humidity-77.2% (n=72)		Temperature- 26.3°C (n=72)	
	Subterranean cave at the base of long hill range, xerophytic scrub vegetation with agriculture fields in front of the cave	Natural cave, near an old temple with little widening by temple authorities	Multichambered and narrow inaccessible gullies, >300 ft long and 12 ft deep from surface, medium sized two opening	*Rhinopoma microphyllum, R.hardwickii,*
3.	**Location: Lunawas Cave, Jodhpur** Humidity-69.8% (n=72)		Temperature- 28.6°C (n=72)	
	Natural cave, on a small hillock, 150 ft above the surface, xerophytic scrub vegetation	Natural cave, narrow with deep bifurcated at the end.	>100 ft deep, inaccessible gullies in the end, only one opening	*Rhinopoma hardwickii*
4.	**Location: Kundal cave, Barmer** Humidity-72.5% (n=72)		Temperature- 25°C (n=72)	
	Natural cave, on a range of hillocks, xerophytic scrub vegetation	Natural cave, wide opening a big chambers in the centre with deep gullies at the end.	>80 ft deep, inaccessible gullies in the end	*Rhinopoma hardwickii*
5.	**Location: Gajroop Sagar, Jaisalmer** Humidity-74.2% (n=72)		Temperature- 24.5°C (n=72)	
	Man-made closed drainage channel connecting watershed through a hillock on top. Scrub xerophytic vegetation in the surrounding with a perennial water body	Man-made cave, 7 ft high, 5 ft wide with 200 ft long drainage channel at ground level with wide opening at both sides.	>200 ft long with small gaps in sides and small chambers in the centre with deep, very narrow inaccessible gullies.	*Rhinopoma hardwickii*

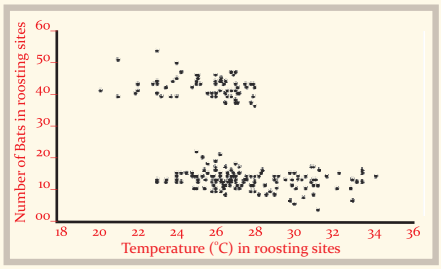

Figure-2: Relationship between Number of Bats and Temperature (*Spearman's rank correlation test)

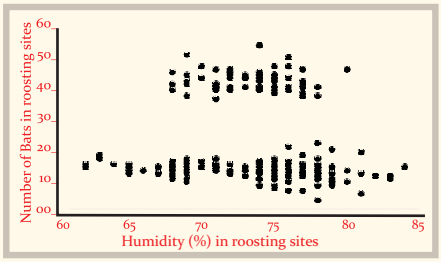

Figure-3: Relationship between Number of Bats and Humidity. (*Spearman's rank correlation test)

systematic species based inventory and survey was done by Sinha (1976, 1979, 1980) and *H.fulvus* was first reported from Mandore tunnel locality (Jodhpur), a Desert region. Further, various researchers surveyed for bats in western Rajasthan (Gaur, 1981; Purohit & Senacha, 2002; Senacha, 2003), but none of them reported *H.fulvus* again and it was declared locally extinct from Thar Desert (Senacha, 2003; Purohit & Gaur, 2005). After a gap of around 37 years, it was reported by Dookia *et al.* (2017) and later a detailed systematic survey planned for exploration in the Thar Desert. The current study was conducted at five *H.fulvus* roosts where one of these roosting sites was also found to be a breeding site. The desert region of Rajasthan witnessed a huge ecological change over the last 6-7 decades (Sharma & Mehra, 2009), a mammoth irrigation project with a huge network of distributaries and perennial availability of water increased humidity as well as and rainfall has also increased. This has changed the desert ecosystem in many ways (Prakash, 1998). *H.fulvus* is a species largely dependent on undisturbed roosting sites, high humidity and consistent temperature in the roost. According to Bates & Harrison (1997), the maximum length of external measurement varies from 40-50 mm in HB, 19-26mm in E, 10-12 mm in 1PH4MT and 16.2-19.5 mm in 2PH3MT, minimum to maximum range of measurement. During present study, external measurement shows some significant differences in morphometric data, Head to Body length (HB) was from 36.69-44.96, Ear length (E) was 17.77-20.43 mm, 4th meta-carpal of 1st Phalanges (1PH4MT) 9.94-10.99 mm and 3rd Meta-carpal of 2nd Phalanges (2PH3MT) was found between 15.79-19.42 mm, which is lower than the one given by Bates & Harrison (1997). The length of baculum was 1.5 mm, similar length was also reported by Sinha (1976). During the study, a total of 362 roosting sites in three districts was found where. only five roosting sites of *H.fulvus* was noted. Interestingly, no noseleaf bats were found in any old building, well and other possible roost sites. This may be a unique feature of *Hipposideros* bats as it

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found only in caves of Thar Desert possibly due to consistent microclimatic conditions inside the cave. Variability in weather condition directly impacts the survival and reproductive success in animals (Racey, 1981; Neuhaus *et al*., 1999; Stokes *et al.*, 2001; Burles *et al*., 2009). Due to small body size, insectivorous bats are more vulnerable to any variation in weather conditions as they largely depend on small sized insect prey, which is greatly influenced by weather (Humphrey *et al.,* 1977; Burles *et al.*, 2009).

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References:

Altringham, D.J. (2011): **Bats from Evolution to Conservation**. Second edition. Pub. by: Oxford University Press. p. 324.

Bates P.J.J. & Harrison. D.L. (1997): **Bats of the Indian Subcontinent**. Pub. by: Harrison Zoological Museum Publications. p. 258.

Burles, D.W., Brigham, R.M., Ring, R.A. & Reimchen, T.E. (2009): Influence of weather on two insectivorous bats in a temperate Pacific Northwest rainforest. *Can. J. Zool.,* 87(2): 132-138.

Dookia, S., Singh, G. & Mishra, R. (2017): Re-sighting record of Fulvous Leaf-nosed Bat *Hipposideros fulvus* Gray, 1838 (Mammalia: Chiroptera: Hipposideridae) from Thar Desert, Rajasthan, India. *J. Threatened Taxa,* 9(1): 9764-9767.

Fenton, M.B. & Simmons, N.B. (2014): Bats: A World of Science and Mystery. A Peter N. Névraumont Book. Pub. by: Chicago (Illinois): University of Chicago Press. p. 303 p.

Gaur, B.S. (1981): **Ecology of the Bats of the Indian Desert**. Ph.D. Thesis: Jodhpur University, Jodhpur, India: 1-110.

Hill, J.E., Zubaid, A. & Davidson, G.W.H. (1986): The taxonomy of the leaf-nosed bats of the *Hipposideros bicolor* groups (Chiroptera: Hipposideridae) from southeastern Asia. *Mammalia*, 50(4): 535-540.

Humphrey, S.R., Richter, A.R., & Cope, J.B. (1977): Summer habitat and ecology of the endangered Indiana bat, Myotis sodalis. *J.Mammal,*58(3): 334346. doi:10.2307/1379332.

Krishnan, A. (1977): A climate analysis of the arid zone of India. In: **Desertification and its Control.** Pub. by: Indian Council of Agricultural Research (ICAR), New Delhi, pp. 42-57.

Kunz, T.H. & Kurta, A. (1988): Capture methods and holding devices, pp. 1-29. In: Kunz, T.H (eds) **Ecological and Behavioral Methods for the Study of Bats.** Pub. by: Smithsonian Institution, Washington DCs.

Monadjem, A., Taylor, P.J., Cotterill, F.P.D. & Schoeman, M.C. (2010): **Bats of southern and central Africa: a biogeographic and taxonomic synthesis**. Pub. by: Wits University Press: Johannesburg. p. 596.

Neuhaus, P., Bennett, R., & Hubbs, A. (1999): Effects of a late snowstorms and rain on survival and reproductive success in Columbian ground squirrels (*Spermophilus columbianus*). *Can. J. Zool.,* 77(6): 879-884.

Prakash, I. (1963): Taxonomic and biological observation on the bats of the Rajasthan desert. *Rec. Indian Mus.*, 59(1,2):149-170.

Prakash, I. (1998): Impact of Indira Gandhi Canal on the desert ecosystem, pp 323-331. In: Eds. Goyal, B., Pathak, P.S. & Saxena, K.G. (eds.), **Ecology Today: An Anthology of Contemporary Ecological Research**. Pub. by: International Scientific Publications, India.

Purohit, A. & Senacha, K.R. (2002): A review of microchiropteran eco-status in Mandore garden, Jodhpur. *J. Nat. Conserv.*, 14(2):251-262.

Racey, P.A. (1981): Environmental factor affecting the length of gestation in mammals, pp. 199-213. In: Gilmore, D. & Cook, B (eds.) **Environmental factors in mammals reproduction**. Pub. by: MacMillan, London.

Senacha, K.R. (2003): Eco-status and demographic changes among the chiropterans of the Thar Desert with special reference to Jodhpur. Ph.D. thesis, Jai Narain Vyas University, Jodhpur, India.

Senacha, K.R. & Dookia, S. (2013): Geoffroy's Trident Leaf-nosed bat, *Asellia tridens* (Geoffroy, E., 1813) from India. *Current Sci.*, 105(1): 21-22.

Sharma, K.K. & Mehra, S.P. (2009): The Thar Desert of Rajasthan (India): Ecology and conservation of desert ecosystem, pp 1-11. In: Sivaperuman, C., Baqri, Q.H., Ramaswamy, G. & Naseema, M.. (eds.) **Faunal Ecology and Conservation of the Great Indian Desert**, Pub. by: Springer-Verlag Berlin Heidelberg..

Sinha, Y.P. (1976): Bacula of Rajasthan bats. *Mammalia,* 40(1):97-104.

Sinha, Y.P. (1979): **Studies on Taxonomy, Distribution, Zoogeography, Osteology and Field Ecology of Bats of Rajasthan, specially the Indian Desert**. Ph.D. thesis, Jodhpur University.

Sinha, Y.P. (1980): The bats of Rajasthan: taxonomy and zoogeography. *Rec. Zool. Sur. India, Misc. Pub.*, 76 (1-4):7-63.

Srinivasulu, C., Srinivasulu, B & Sinha, Y.P. (2013): Chiropteran fauna of Rajasthan: taxonomy, distribution and status, pp. 505-548. In: Sharma, B.K., Kulshrestha, S. & Rahmani, A.S. (eds.). **Faunal Heritage of Rajasthan, India: General Background and Ecology of Vertebrates**. Pub. by: Springer Science+Business Media New York., USA.

Srinivasulu, C., Racey, P.A. & Mistry, S. (2010): A key to the bats (Mammalia: Chiroptera) of South Asia. *J. Threatened Taxa,* 2(7): 1001-1076.

Stokes, M.K., Slade, N.A., & Blair, S.M. (2001): Influences of weather and moonlight on activity pattern of small mammals: a biogeographical perspective. *Can. J. Zool.,* 79(6):966-972

Thong, V.D., Mao, X., Csorba, G., Bates, P, Ruedi, M., Viet, N.V., Loi, D.N., Nha, P.V., Chachula, O., Tuan, T.A., Truong, N.S., Fukui, D., Tu, V.T. & Saikia, U.(2018): First Records of *Myotis altarium* (Chiroptera: Vespertilionidae) from India and Vietnam. *Mammal Stud.,* 43(1):1-7.

Topal, G. (1975): Bacula of some Old World Leaf nosed bats (Rhinolophidae and Hipposideridae, Chiroptera: Mammalia). *Vertebrata Hungarica,* 15: 21-45.