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***Research Article** (Open Access)*

DISTRIBUTION AND MORPHOMETRIC OF THE *SCOTOPHILLUS KUHLII* (LEACH, 1821), AT UTTAR PRADESH, INDIA

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ABSTRACT
Family Vespertilionidae commonly known as evening bat and frequently found associated with human habitats. The present study carried out on the distribution and morphometric of the *S. kuhlii* in various districts at Uttar Pradesh, India from Aug 2016 to Dec 2018. It was observed that various habitats occupied by *S. kuhlii* in 23 districts. A total of 970 individuals counted from 216 roosts and 273 bats captured for morphometric analysis and comparison made between males and females. Results revealed that forearm length, wingspan, body moss 5th metacarpal, and 2nd metacarpal and hind arm of female was longer than males showed significantly different. Body, head, ear, maxillary and mandible length showed no significant differences. The present study signifies that body mass of females was higher than males. Roost was highly depleted by local people as they were scared due to a zoonotic disease. Hence, awareness programs should be a plan about bats.

Keywords: *Distribution, Morphological characteristics, Population, Roost depletion. S. kuhlii, Vespertiliniodae*

INTRODUCTION
Vespertilionidae bats are known as evening bats, which alone provides 493 species from 54 genera out of total 1,386 species throughout the world (Burgin *et al.,* 2018). A total of fifteen species of *Scotophilus* found in different parts of the world including seven species distributed throughout sub-Saharan Africa, four across southern and southeastern Asia, three endemic to Madagascar, and one endemic to Reunion Island (Robert *et al.,* 2009). In the Indian subcontinent, only *S. kuhlii* and *S. heathii* were reported, especially *S. kuhlii* found in most states in Indian subcontinent as reported by Bates and Harrison (1997) and also in Western Ghats (Vishakha *et al.,* 2015), Assam (Rahman and Chaudhary, 2017), and Delhi (Dookia and Mishra, 2018). *S. kuhlii* was first reported from the Pilibheet district of Uttar Pradesh by Wroughton (1914). A comparison between geometrically similar animals of different sizes shows that the power required for flying increases faster with increasing body mass (Pennycuick, 1975). Based on the morphological characters, it is medium-sized species with pelage colour of the dorsal region, soft and olive-brown and abdomen light-creamy (Bates and Harrison, 1997; Elangovan and Kumar, 2015; Dookia, 2018). The facial structure is similar to a dog like a mouth (Bates and Harrison, 1997). Ear length is smaller as compared to the head with a half-moon shaped and tragus is separated from the pinna by a clear cut groove (Elangovan and Kumar, 2015; Dookia, 2018). The Average ear length was 10mm to 13.5mm (Bates and Harrison, 1997; Javed, 2014; Elangovan and Kumar, 2015). The average of forearm length ranges from 44 to 49 mm in length (Bates and Harrison, 1997; Elangovan and Kumar, 2015; Rahman and Chaudhary, 2017; Dookia, 2018). Minimum body mass was 16 grams and a maximum of 25g (Zhu *et al.,* 2012; Rahman and Chaudhary, 2017). *S. kuhlii* frequently occupies different types of roost such as natural and man-made structures like monuments, renounce building, crevices, caves, old temples, palm fronds, hollow structure in palm trees and dried leaves on palm trees (Brosset, 1962; Sinha, 1986; Elnagovan and Kumar, 2015). Anthropogenic pressure which gradually changes vegetative land into settlements (Grimm *et al.,* 2008) supports very few species and is having harmful impact on some species (McKinney, 2002).
According to IUCN version 3.1 (IUCN, 2008), *S. kuhlii* is the least concerned among stable species. However, *S. kuhlii* has not been considered in the wildlife protection act 1972 and the convention on

International Trade in Endangered Species of Wild Fauna and Flora appendices (Rahman and Chaudhary, 2017). Therefore, our aim in this study was to assess the distribution of *S. kuhlii* and its morphological characters at Uttar Pradesh.

MATERIALS AND METHODS

Study area

The field survey was carried out at various places of different districts (Fig. 1) from August 2015 to December 2018 in Uttar Pradesh (U.P.). UP is located in the northern part of India and the 4th largest area wise state in the India. The state boundary is surrounded by Rajasthan, Haryana and Delhi, Uttrakhand, Bihar, Jharkhand, Chhattisgarh, Madhya Pradesh, and the country of Nepal. The roost survey was conducted at various places such as monuments (Historical place, protected by Archeological Survey of India), old Temples, abandoned buildings (renounce building by a human), and old trees. This survey was conducted at once during the entire study. The roosting site was identified based on the guano dropping beneath the roost and pungent odor coming out from the roost. Roost ID was given for farther observation. Besides, roost depletion was confirmed by the questionnaire method i.e. fears of zoonotic disease, bush-meat, and medicine. The GPS coordination of the roosting site was taken by compass mobile application. The individuals were counted by visual observation during the emergence of a small colony and video recording (TV-Out Digital Video Recorder) was used for the big colony (more than hundreds of individuals in single roost). The bats were captured during emergence time by mist net (Avi net, Dryden, USA). The nets were erected at exit points of roosts and bank of the pond. The Morphological characters such as body mass, head and body length, length of forearms and hind arms, body width, length and width of the ear, tragus width, length and width of stratum, second, third, fourth and fifth metacarpals, maxillary and mandible length, wingspan, thumb, tail length have been measured by using digital vernier caliper (Mitutoyo, 500-181,0003472, Japan). Simultaneously, the status of sex such as male or female and a juvenile were identified based on the phalangeal joint. The weight of the bat has been taken by spring balance. Bats released immediately after taking measurements at the site of capture. Morphological characters of male and female *S. kuhlii* were compared using the Kruskal Wallis H test, (SPSS, version 20) because data was nonparametric. The map was made by ArcGIS software.

Figure 1: Map of study area (Uttar Pradesh).

The colony locations (roost sites) were marked as solid circles with the help of GPS.

RESULTS

A total of 970 individuals of *S. kuhlii* were counted from 216 roosts during the study period from various places of the districts. The maximum 62 roosts, (39.69%) were observed in residency in which population size was having 105 bats found in Lucknow district, while there were occasionally two roosts found on palm trees (*Livistona*) with 258 individuals. A sum population of bats in monument and palm tree was 363. While only one individual was captured in village Ajgara, district in Varanasi (Table 1). Detail information about the distribution of roosting sites of *S. kuhlii* given table (Table 1).

Table 1: Distribution, types of roosting habitats with GPS location and population of *S. kuhlii* in different habitats with geographical districts in Uttar Pradesh

Roosting site	GPS Coordination	No. of population	Type of roosting habitat
Allahabad[#]		**7.4 ± 5.27**	
Shantipuram	25°31'45.66"N 81°51'13.87"E	5	Abandoned building
Basupur	25°21'26.39"N 82°13'15.51"E	14	Abandoned building
Ahopur	25° 9'24.79"N 82°12'9.46"E	12	Abandoned building
Bahadurpur	25°25'54.83"N 82° 0'23.94"E	2	Abandoned building
Soraon	25°36'25.26"N 81°50'59.12"E	4	Abandoned building
Faizabad[#]		**12.5 ± 3.53**	
Newghat	26°48'38.99"N 82°12'19.29"E	15	Tree cavity
Kachahari	26°48'38.99"N 82°12'19.29"E	10	Abandoned building
Azamgarh[#]		**13.5 ± 2.12**	
Bilariya ganj	26°12'1.51"N 83°13'43.39"E	15	Abandoned building
Tofa pur	26° 9'18.67"N 83°11'20.45"E	12	Abandoned building
Ambedkar nagar[#]		**8.5 ± 3.00**	
Tanda	26°32'35.75"N 82°39'52.37"E	6	Abandoned building
Railway station Tanda	26°32'36.83"N 82°38'43.71"E	10	Tree cavity

Akbarpur bus station	26°26'2.99"N 82°32'27.47"E	12	Tree cavity
Railway station Akbarpur	26°25'45.18"N 82°32'24.21"E	6	Abandoned building
Barabanki[#]		**8.5 ± 2.12**	
Chauka ghat	25°19'59.23"N 82°59'29.48"E	10	Abandoned building
Dariya bad	26°53'18.72"N 81°33'24.84"E	7	Abandoned building
Basti[#]		**13.25 ± 3.59**	
Gandhi nagar	26°47'47.11"N 82°43'55.53"E	11	Abandoned building
Jhakarkatti	26°47'40.95"N 82°43'45.32"E	10	Abandoned building
Rudhauli	26°48'59.88"N 82°45'5.65"E	14	Abandoned building
Patkhauli	27° 3'16.37"N 82°36'42.75"E	18	Abandoned building
Bahraich[#]		**11.00 ± 0.00**	
Jarwal road	27° 7'9.57"N 81°32'5.11"E	11	Abandoned building
Ghazipur[#]		**6.5 ± 4.041**	
Zangi pur	25°39'14.58"N 83°33'27.53"E	12	Abandoned building
Phullanpur	25°35'19.49"N 83°33'49.11"E	4	Abandoned building
Lanka	25°33'55.47"N 83°33'8.35"E	3	Abandoned building
Bhitari	25°34'0.71"N 83°17'21.83"E	7	Abandoned building
Gonda[#]		**6.00 ± 0.00**	
Ityathok	27°17'23.62"N 82° 1'37.53"E	6	Abandoned building
Gorakhpur[#]		**6.00 ± 0.00**	
Maniram	26°50'56.94"N 83°20'19.90"E	6	Abandoned building
Jhansi[#]		**4.00 ± 00**	
Fort	25°27'28.44"N 78°34'32.25"E	4	Abandoned building

Kanpur		**5.00 ± 0.00**	
Beethur	26°36'20.65"N 80°16'11.16"E	5	Abandoned building
Lucknow[#]		**5.12 ± 1.96**	
Residency	26°51'38.29"N 80°55'36.43"E	258**, 105*	Monuments, Plam tree
Jugganr	26°52'25.80"N 81° 4'51.55"E	3	Abandoned building
Mohanlalganj	26°45'59.80"N 80°56'41.87"E	4	Abandoned building
Nigohan	26°33'44.45"N 81° 1'47.71"E	3	Abandoned building
Goshaiganj	26°34'11.60"N 82°22'55.30"E	6	Abandoned building
Bani	26°39'20.17"N 80°47'51.48"E	7	Abandoned building
Utratia birdge	26°46'15.53"N 80°55'47.30"E	7	Abandoned building
Char bagh loco wherhouse	26°49'58.03"N 80°55'23.72"E	8	Monuments
Bada Imambada	26°52'8.17"N 80°54'45.70"E	7	Abandoned building
Chhota Imambada	26°52'17.83"N 80°54'31.31"E	3	Monuments
Aminabad	26°50'46.53"N 80°55'34.78"E	4	Abandoned building
Narhee	26°50'48.02"N 80°57'9.24"E	7	Monuments
Badshah Nagar	26°52'9.54"N 80°57'39.53"E	6	Abandoned building
Transport Nagar	26°46'42.70"N 80°53'30.27"E	3	Abandoned building
Alam Nagar	26°50'21.90"N 80°51'45.67"E	7	Abandoned building
Pushpendra Marg	26°46'16.78"N 80°55'54.51"E	2	Abandoned building
Kallipushcim	26°44'40.47"N 80°56'21.81"E	5	Abandoned building
Mau[#]		**5 ± 0.00**	
Bus stop	25°56'11.02"N	5	Tree cavity

	83°34'4.39"E		
Maharaj Ganj#		**9.00 ± 0.00**	
Veer Bahadur Nagar	27° 8'40.60"N	9	Abandoned building
	83°33'43.83"E		
Santkabir nagar#		**12.5 ± 3.53**	
Fort Qazi khailil Urrahman	26°47'41.16"N	15	Monuments
	83° 4'31.87"E		
KhaIilabad	26°46'34.86"N	10	Monuments
	83° 2'2.97"E		
Siddharth nagar#		**8.72 ± 7.77**	
Jaipur	27°24'51.71"N	30	Abandoned building
	83° 1'4.96"E		
Bansi city	28°54'3.32"N	8	Abandoned building
	77°18'13.40"E		
Mahala village	27°26'14.93"N	11	Abandoned building
	83° 2'19.76"E		
Basantpur	27°24'51.71"N	2	Abandoned building
	83° 1'4.96"E		
Babhani	27°24'51.71"N	4	Tree cavity
	83° 1'4.96"E		
Dumariya ganj	27°12'5.35"N	5	Abandoned building
	82°39'13.78"E		
Chilhiya	27°21'57.62"N	2	Abandoned building
	83° 0'43.08"E		
Navgarh	27°17'56.64"N	8	Abandoned building
	83° 5'34.02"E		
Shohrat garh	27°24'9.11"N	12	Tree cavity
	82°57'34.88"E		
Itwa	27°19'53.70"N	8	Abandoned building
	82°41'49.42"E		
Chandanpur	27°24'7.74"N	6	Abandoned building
	83° 2'0.43"E		
Shravashtee#		**3.5 ± 0.70**	
Jaitvan	27°58'31.65"	3	Abandoned building
	81°36'2.76"E		
Hussain jat villege	27°30'46.88"N	4	Monuments
	82° 2'19.21"E		
Sitapur#		**5.75 ± 1.70**	
Mehmoodabad	27°17'48.17"N	8	Abandoned building
	81° 7'30.44"E		

Laharpur	27°42'36.32"N 80°54'5.06"E	6	Abandoned building
KhaIrabad	27°31'42.35"N 80°44'56.98"E	5	Abandoned building
Biswan	27°29'37.53"N 80°59'47.33"E	4	Abandoned building
Sultanpur[#]		**5.75 ± 3.09**	
Kurebhar	26°24'46.18"N 82° 7'17.43"E	10	Monuments
Lambhua	26° 8'24.98"N 82°13'37.52"E	4	Tree cavity
Dostpur	26°16'19.92"N 82°28'21.24"E	3	Tree cavity
Mayang	26°25'22.14"N 82° 1'52.24"E	6	Tree cavity
Unnao[#]		**9.33 ± 7.76**	
Kalukheda	26°33'17.86"N 80°54'28.74"E	7	Abandoned building
Ashoha	26°35'5.60"N 80°50'1.06"E	18	Abandoned building
Banthra	26°31'49.77"N 80°29'42.73"E	3	Abandoned building
Varanasi[#]		**4.6 ± 5.36**	
Kasi Vidyapith	25°19'14.95"N 82°59'23.29"E	14	Abandoned building
Ram Nagar	25°16'35.26"N 83° 2'0.43"E	2	Abandoned building
Pindra	25°29'11.32"N 82°49'40.96"E	4	Abandoned building
Dhaunkal ganj	25°20'14.92"E 82°57'10.24"E	2	Tree cavity
Ajagara	25°16'9.71"N 82°59'32.96"E	1	Abandoned building
Balrampur[#]		**10.5 ± 3.53**	
Pachperwa	27°31'5.43"N 82°38'46.11"E	13	Abandoned building
Ganeshpur	27°36'23.22"N 82° 1'42.52"E	8	Abandoned building

*** indicate Tree population,* monument population and did not include in average, # indicate district with Mean± SD of population of S. kuhlii and # District*

A total of 273 individuals were measured out of 970 bats including 125 males and 147 females. There were found a statistically significant difference in morphometric analysis of male and female of *S. kuhlii*, such as Body mass of females (24.93 ± 2.86g) was significantly higher compared to males (22.39 ± 1.78mm) (H = 52.287, P < 0.05); The forearm length of females (49.03 ± 2.30mm) was longer than males (47.66 ± 1.56mm) and showed significant difference (H=18.53, P < 0.05), followed by an average of 5th metacarpal (43.69 ± 3.14mm) and (45.26 ± 7.59mm) of male and female respectively, which showed statistically significant difference (H = 14.038, P < 0.05), and average 2nd metacarpal of male (45.65 ± 8.60mm) and female (47.34 ± 7.08mm) also showed statistically significant difference (H = 7.089, P < 0.05). The average wingspan (315.07 ± 8.39mm) and (316.11 ± 7.51mm) of male and female respectively, showed statistically significant difference (H = 14.65, P < 0.05) (Table.2). Apart from, morphological characters few characters including body, head, ear, tragus, thumb, Maxillary, and Mandible, of length were not statistically different between males and females of *S. kuhlii* (Table 2).

Table 2: Morphometric analysis of 273 *Scotophilus kuhlii* bats including male (n=125) and female (n=148). Mean ± SD is shown and compressions significant value (kruskal wallis H test, P < 0.05) of male and female.

Parameter(mm)	Male	Female	Statistical value	
			H	P
Body mass (g)	22.39 ± 1.78	24.93 ± 2.86	52.827	**0.001**
Body length	49.94 ± 7.32	50.71 ± 7.29	2.936	0.087
Head length	12.48±2.78	12.78 ± 3.07	0.237	0.627
Tail length	45.33 ± 2.83	45.63 ± 2.89	0.233	0.629
Ear length	11.29 ± 1.33	11.1 ± 1.42	0.653	0.419
Tragus	5.93 ± 0.82	6.13 ± 0.79	2.625	0.105
Forearm	48.02 ± 4.39	49.04 ± 2.80	18.532	**0.001**
5th Metacarpal	43.69 ± 3.14	45.26 ± 7.59	14.038	**0.001**
First phalanx	11.71 ± 5.09	11.03 ± 1.96	0.119	0.73
Second phalanx	9.72 ± 1.87	9.82 ± 2.00	0.192	0.661
4th Metacarpal	46.82 ± 2.26	47.13 ± 2.06	2.705	0.1
First phalanx	15.24 ± 1.95	15.578 ± 1.48	0.445	0.505
Second phalanx	10.96 ± 1.42	11.11 ± 1.59	1.009	0.315
3rd Metacarpal	47.94 ± 2.05	47.84 ± 5.85	3.784	0.052
First phalanx	12.19±1.75	12.39 ± 2.01	0.222	0.638
Second phalanx	11.22±1.36	11.25 ± 1.83	0.733	0.392

2nd Metacarpal	45.65 ± 8.60	47.34 ± 7.08	7.089	**0.008**
Wing span	315.07 ± 8.39	317.11 ± 7.22	14.65	**0.001**
Thumb length	6.1 ± 0.58	6.09 ± 0.64	0.014	0.905
Maxillary length	11.29 ± 1.28	11.59 ± 1.04	3.663	0.056
Mandible length	10.12 ± 1.34	10.24 ± 1.35	0.005	0.945
Hind arm	17.85 ± 2.43	18.52 ± 2.07	4.927	**0.026**

DISCUSSION

The Asiatic lesser yellow house bat, *Scotophilus kuhlii* was rarely distributed in the study area and chosen different types of roost habitats such as monuments, abandoned buildings, temples, trees cavities, and mud walls. Our result showed similar, of an earlier report by Elangovan and Kumar (2015) that the state Uttar Pradesh has quite a good number of places, ancient temples, historical monuments, and natural forests for providing roosting sites for resting, breeding and protection in adverse conditions. Brosset (1962) and Sinha (1986) reported that *S. kuhlii* roost occurs in different kinds of habitats such as crevices and holes in walls of huts and old buildings, caves, old temples, palm fronds, dried leaves on trees and is found both in urban and rural landscapes. Our result showed that roost of *S. kuhlii* was widely distributed in different types of habitats including monuments, abandoned buildings, and old trees with one individual to a hundred individuals in the single roost. Its pelage colour of the dorsal region was soft and olive-brown and ventrally creamy. The ears of the *S. kuhlii* are small and half-moon shaped compared to the head, it helps in adaptation for retaining heat, because the large surface area will lose heat faster compared to the smaller surface area (Kingston *et al.,* 2010; Rahman and chaudhary, 2017). Our result was similar to previous work reported by Kingston *et al.* (2010). The average forearm length of females is longer compared to the male, may support thermoregulation due to increase length of forearm. This simultaneously increases the wing area, which maintains the heat of the body. Similar studies of Zhu *et al.* (2012) and Goodman *et al.* (2005) showed that forearm of male shorter than female.

Previous studies reports natural selection supports a wing shape which makes it easy for flight in a different situation, which reduced the extra load during the flight (Norberge and Rayner, 1987). Bats hawking high-flying insects have small, pointed wings that give good agility, high flight speeds, and low cost of transport (Norberge and Rayner, 1987). Our result showed that the wingspan longer of females than males. The average wingspan of female of *S. kuhlii* was longer than male recorded by Goodwin (1979). Longer wingspan provides better utilization of resources by maintaining a territory for the un-matured female and young ones (Ralls, 1976). Body mass of females was higher in comparison to the males because body fat content was more compared to males. A similar study found body mass of female *S. kuhlii* higher compared to males recorded by Zhu *et al.* (2012). According to Flux (1967) suggested that females were heavier compared to males according to seasonal variation in the body mass i.e. females more body mass and males have low in spring. Previous studies have shown that ear and hind arm lengths are shorter than females recorded by (Goodman *et al.,* 2005). Our result showed that no differences morphological characters including body, head, tail ear, the length between male and female of *S. kuhlii.* Earlier studies of Elangovan and Kumar (2015) reported that the ears of the species are small and half-moon shaped compared to the head. Loss of roost takes place by several factors such as fire, decay, and anthropogenic activities and deforestation and tree fall (Sedgwick and Knopf, 1992). The depletion of these sites affects fauna and flora which the largest threats to biodiversity globally (Henle *et al.,* 2004; Sala *et al.,* 2000). Our result showed that roost depletion was mostly caused by the zoonotic disease compared to bush-meat and medicine. The zoonotic disease often spread by interfering with an animal

which affects health problems. We observed that *S. kuhlii* distributed throughout the districts in Uttar Pradesh with closed to human-occupied habitats. Based on the morphometric analysis, female *S. kuhlii* body mass was longer than male. During the study period, we found some myths about bats. Some local people used to kill bats for bush-meat, medicines. Some people killed bat and removed his roost, scared by zoonotic diseases such as Rabies, Nipha virus, Corona virus, and bloodsucking. It is also suggested that more and more awareness programs among the communities living adjoining to the roosting sites would be of immense help in conserving the chiropterans in the study area in particular and their entire range in general.

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CONFLICT OF INTEREST
The authors declare no conflicts of interest.

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