

Original Article

Morphometric analysis and roosting ecology of bat species *Pteropus Medius* in Mansehra, Khyber Pakhtunkhwa, Pakistan

Análise morfométrica e ecologia de poleiro de espécies de morcegos *Pteropus Medius* em Mansehra, Khyber Pakhtunkhwa, Paquistão

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Abstract

Morphometric measurement and roosting ecology of *Pteropus medius* were aimed to find out in Mansehra district of KP, Pakistan. Total 3149 numbers of bats were found in eight biological spots visited; Baffa Doraha, Darband, Dadar, Jallu, Hazara University, Garhi Habibullah Chatter Plain and Jabori, in total 299 numbers of different species of trees including; *Morus alba*, *Pinus raxburghi*, *Eucalyptus camaldulensis*, *Morus nigra*, *Grevillea robusta*, *Brousonetia papyrifera*, *Platanus orientalis*, *Ailanthus altissima*, *Hevea brasiliensis* and *Populus nigra*. Morphometric features were measured and found vary according to sex of the bats. The average wing span, wing's length from tip of wing to neck, from thumb to tip of wing and the body's length from head and claws were recorded to be 102.98 cm, 49.07cm, 28.7 cm and 22.78 cm respectively in males while 93.67 cm, 44.83cm, 24.78cm and 22.78 cm respectively in female bats. Mean circumference of the body including wings and without wing were measured as 22.78 cm and 17.29 cm in males and that of female were 20.07 cm and 16.9 cm. Average length of thumb 3.64 cm, ear's length 3.1 cm, snout 5.62cm, eye length were 1.07 cm for both sexes and length between the feet in extended position were 16.3 cm. Generally different measurement of males bodies were found to be greater than female such as mean body surface area, mass, volume and pressure were found to be 2691.79 cm², 855.7gm, 1236.4 ml and 295.77 dyne/ cm³ for male and 2576.46 cm², 852.71gm, 1207 ml and 290.2 dyne/ cm³ respectively for female. While weight and density for both males and females bats were same with mean of 8.59 newton and 0.701 g/m³. Findings of current reports can add valued information in literature about bats, which can be used for species identification and conservation.

Keywords: *Pteropus medius*, roosting trees, morphometric analysis, Pakistan.

Resumo

A medição morfométrica e a ecologia de poleiro de *Pteropus medius* foram realizadas no distrito de Mansehra de KP, Paquistão. Foram encontrados 3.149 morcegos em 8 pontos biológicos visitados; Baffa Doraha, Darband, Dadar, Jallu, Universidade Hazara, Garhi Habibullah Chatter Plain e Jabori, no total 299 números de diferentes espécies de árvores, incluindo: *Morus alba*, *Pinus raxburghi*, *Eucalyptus camaldulensis*, *Morus nigra*, *Grevillea robusta*, *Brousonetia papyrifera*, *Platanus orientalis*, *Ailanthus altissima*, *Hevea brasiliensis* e *Populus nigra*. As características morfométricas foram medidas e variam de acordo com o sexo dos morcegos. A envergadura média da asa, o comprimento da asa da ponta da asa ao pescoço, do polegar à ponta da asa e o comprimento do corpo da cabeça e garras foram registrados em 102,98 cm, 49,07 cm, 28,7 cm e 22,78 cm, respectivamente, nos machos. Enquanto 93,67 cm, 44,83 cm, 24,78 cm e 22,78 cm respectivamente, nas fêmeas. As circunferências médias do corpo incluindo asas e sem asas foram medidas de 22,78 cm e 17,29 cm nos machos e as das fêmeas foram 20,07 cm e 16,9 cm. O comprimento médio do polegar 3,64 cm, comprimento da orelha 3,1 cm, focinho 5,62 cm, comprimento dos olhos 1,07 cm para ambos os sexos e comprimento entre os pés em posição estendida foi de 16,3 cm. Geralmente, as medidas diferentes dos corpos masculinos foram maiores que as femininas, como a área de superfície corporal média, massa, volume e pressão foram encontrados em 2691,79 cm², 855,7 gm, 1236,4 ml e 295,77 dines para masculino e 2576,46 cm², 852,71 gm, 1207 ml e 290,2 dines respectivamente para fêmeas. Enquanto o peso e a densidade para machos e fêmeas de morcegos foram os mesmos com média de 8,59 N e 0,701 g/m³. Os achados de relatórios atuais podem agregar informações valiosas na literatura sobre morcegos, que podem ser utilizadas para identificação e conservação de espécies.

Palavras-chave: *Pteropus medius*, árvores empoleiradas, análise morfométrica, Paquistão.

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1. Introduction

Vertebrate diversity is severely affected due to increased anthropogenic activities in aquatic and terrestrial habitats. Ecosystem changes result in changes to the habitats of species (Hassan et al., 2021a, b). The biological diversity of each ecosystem depends on the ecological services delivered (Hassan et al., 2023). Chiropteran are different from all other mammals which have wings, make them able for flight freely, and are second major mammalian order after rodents, and are diverse enough almost 1,232 species of bats are known which contribute to one fourth of 5,487 total mammal and contribute 20% out of total wild animals. Pakistan's ecosystems contain a broad variety of life and wealthy natural habitats (Hassan et al., 2020). In Pakistan bats comprise about one fourth of the known mammalian species which comprise 50 species with 26 genera and 8 families (Roberts, 1997; Simmons, 2005; Simmons, 2010; Schipper et al., 2008; Kunz et al., 2011). In Indian subcontinent 119 bats species have been reported (Bates and Harrison, 1997). Among which the contribution of bats from Pakistan are 56 species (Mahmood-ul-Hassan et al., 2009). Bats were adapted to access to a variety territories, having most climatic zones and earthbound land types, it's feeding on fruit, leaves, nectar, flowers, fish, blood, small mammals, and insects but the majority are feeding on insects (Schnitzler and Kalko, 2001). *Pteropus medius* (Indian flying fox) have accommodated in sub order megachiroptera in the family Pteropodidae which live in colonial form in trees that keep them safe from various dangers (Richmond et al., 1998; Cheke and Dahl, 1981; Rainey and Pierson, 1992). These Indian fruit bat have been reported to be inhabitants of trees such as *Acacia* species, *Ficus*, *Bauhinia*, *Tamarindus indica* and *Casurina Samanea saman* species (Chakravarthy et al., 2009). While in Pakistan these are reported in trees like *Ficus bengalensis* and *Broussonetia papyifers* (Roberts, 1977). The habitat preference depends on factors such as secure from predators, environmental stresses and resource availabilities (Kunz, 1982). They use special unique sense echolocations to locate their niche and preys etc. (Schnitzler et al., 2003). Bats play important role in ecosystem such as regenerations of forest and maintain plants populations' structure and distribution as well as in food chain (Heithaus et al., 1975; Fleming et al., 1998; Estrada et al., 1993).

Humans' activities badly affect biodiversity at all level. Degradation of habitat mostly brought many bat species to the side of extinction. Monitoring of bats for long time is thus necessary to know the negative impact of human on the diversity of bats all over the world (Meyer et al., 2010). Unluckily 8 species of bats have gone through extinction, and among which of bats which feed on fruits are at high risk (Clawson, 2002). As human population increased deforestation occur for agricultural and housing purposes have vanished roosting sites of these bats (Mickleburgh et al., 2002; Fujita and Tuttle, 1991; Mildenstein et al., 2005). In Pakistan less attention has been given to conservation of bats (Butt and Beg, 2001). The correct identification of these species is key step to conserve them. In the world, scientists use many approaches and processes to identify different species of bats.

Now advanced method are advised to differentiate species with same morphological characters on the basis of variations in their phylogeny (Russo et al., 2006), but these equipment are of high price to be purchased in many developing countries. Therefore bat zoologists in most part of the world use classical morphological traits and behaviour of bats to identify them (Nagorsen and Brigham, 1993; Harris, 1974). Among which factors such as skull biometry are also used for identifications (Hill and Smith, 1984; Jacobs et al., 2006). Identifications keys of chiropteran species are one of the authentic ways to recognize them (Daniel, 2009; Srinivasulu et al., 2010). Many reports on bats have been published across the globe such as Hutson et al. (2001); Houston et al. (2004); Russo et al. (2006); Jacobs et al. (2006); Weller et al. (2007); Pereswiet-Soltan (2007); Kelm et al. (2008); Kalka et al. (2008); Williams-Guillen et al. (2008); Whitaker and Karataş (2009); Srinivasulu et al. (2010); Ghazali and Dzeverin (2013); Rummel et al. (2019); Anderson and Ruxton (2020); MacCraken et al. (2021). But, no proper consideration has been offered towards bats and few reports are available on this regards from the northwestern part of Pakistan which is the habitat of many numbers of species of animals. Current study can be value addition to present literature on bats as current site of study have divers species of Bats which need exploration.

2. Material and Method

2.1. Study area

Current study was carried out in Mansehra (34.3313°N, 73.1980°E) district of PK (Pakhtunkhwa), Pakistan. Where Eight ($n=8$) biological spots were visited to check different sites that where could be find communities of bats.

2.2. Data collection

Net and slingshots were used to capture bats samples (*Pteropus medius*) from eight selected sites. All the safety steps were followed and transported to parasitology laboratory, Department of Zoology, Hazara University, Khyber Pakhtunkhwa, Pakistan for further morphometric analysis.

2.3. Morphometric analysis

The bats samples were anaesthetized with the help of chloroform and killed in vacuum chamber. Bats were fitted on white sheets with help of paper pins and the body parts such as width, and length as well as circumference was measured with scale. While body mass were calculated by digital scales. To get volume of each specimen of bats graduated cylinder were used and other parameter such as pressure, weight and density were evaluated through chemical formulae;

Pressure $p = w/A$, where (w) are the weight of bats and (A) area.

Density $D = m/V$, (m) are the mass of bats and (V) is volume

Weight $W = mg$, (m) are mass and g gravitational acceleration

2.4. Roosting site analysis

Different roosting sites and trees species were noted in each biological site and direct roost calculation method were used for *Pteropus medius* colonies calculation (Rodríguez-Herrera et al., 2008).

2.5. Statistical analysis

Descriptive statistics, ANOVA and Pearson correlation were applied to measure mean variances and correlation, previous verification of normal distribution and variance homogeneity (Zar, 1999) by using SPSS 18, and ORIGIN PRO 9.0 for graphing.

3. Results

3.1. Morphometric profile

Morphometric measurement of the current study showed that generally size of different body part of male bats is larger than that of female bats. The average measurements in males bats were recorded to be wing span (102.98 cm), wing's length from tip of wing to neck (49.07cm), from thumb to tip of wing (28.7 cm) and the body's length from head and claws (22.78 cm). While 93.67cm, 44.83cm, 24.78cm and 22.78cm respectively in female bats. Mean circumference of the male body including wings were 22.78 cm and without wing were measured as 17.29 cm. While these measurement in female bats were 20.07 cm and 16.9 cm respectively. In the same way mean body surface area, mass, volume and pressure in male bats were found to be 2691.79 cm², 855.7gm, 1236.4 ml and 295.77 dyne/cm³ respectively.

While these measurement in female bats were measured as body surface area 2576.46 cm², mass 852.71gm, volume 1207 ml and pressure 290.2 dyne/cm³. However some measurements were same in both sexes and found exactly equal in length such as average lengths of thumb 3.64 cm, snout 5.62cm, ear's length 3.1 cm, length between the feet in extended position 16.3cm while eye length were found to be 1.07 cm. Weight and density for both males and females bats were also same with mean of 8.59 newton and 0.701 g/m³ respectively (Tables 1-2).

3.2. Roosting trees

Total 299 roosting trees were counted containing bats colonies at all sites, related to different families including; Proteaceae, Salicaceae, Platanaceae, Myrtaceae, Simaroubaceae, Pinaceae, Euphorbiaceae and Moraceae. The species were; *Platanus orientalis*, *Hevea brasiliensis*, *Pinus raxburghi*, *Populus nigra*, *Ailanthus altissima*, *Morus alba*, *Brousonetia papyrifera*, *Grevillea robusta*, *Morus nigra*, *Eucalyptus camaldulensis*. Different sites had different numbers and different types of trees. Total numbers and types of trees at each biological spot were; **Baffa Doraha** n=73 (*Platanus orientalis* n=6, *Populus nigra* n=47, *Eucalyptus camaldulensis* n=7, *Grevillea robusta* n=13) and in 2nd site **Garhi Habibullah** n=45 (*Pinus raxburghi* n=11, *Populus nigra* n=31, *Ailanthus altissima* n=3). At 3rd site **Darband** the tree numbers and types were n=23 trees (*Grevillea robusta* n=6, *Hevea brasiliensis* n=4, *Pinus raxburghi* n=13). While at 4th site **Chattar plain** counted trees were n=41 trees (*Ailanthus altissima* n=2, *Morus alba* n=6, *Platanus orientalis* n=17, *Morus nigra* n=4, *Brousonetia papyrifera* n=3, *Eucalyptus camaldulensis* n=9).

Table 1. Mean of different morphometric analysis for both sexes.

Factors (Length and width)	N	Descriptive Statistics			
		Minimum	Maximum	Mean (cm)	Std. Deviation
(Male bats)					
Body circumference with wings	5	19.60	26.70	22.78	2.92524
Body circumference w/o wings	5	15.60	19.20	17.29	1.43944
Wing span	5	80.00	126.00	102.98	17.01023
Wings from neck to tip of wings	5	38.00	61.00	49.07	8.44855
Thumb to tip of wing	5	23.00	38.00	28.70	5.35724
Body length from head and claws	5	19.01	25.56	22.78	7.43512
(Female bats)					
Body circumference with wings	5	17.10	24.40	20.07	4.3285
Body circumference w/o wings	5	12.40	18.70	16.9	2.7231
Wing span	5	85.10	124.07	93.67	19.2875
Wings from neck to tip of wings	5	33.09	66.00	44.78	7.4783
Thumb to tip of wing	5	26.00	39.00	22.78	6.7611
Body length from head and claws	5	14.85	20.21	17.29	4.7111
(Male and female)					
Thumb	5	2.41	5.31	3.64	0.89443
Ear	5	3.00	3.60	3.12	0.26833
Snout	5	3.00	6.60	5.62	1.37586
Length Between the feet	5	12.10	24.00	16.3	3.76829
Eye length	5	1.00	1.50	1.07	0.22361

N: Number of samples of bats measured.

And at 5th site **Dadar** n=34 trees (*Grevillea robusta* n=7, *Eucalyptus camaldulensis* n=12, *Pinus raxburghii* n=15). 6th site **Jabori** n=33 (*Pinus raxburghii* n=16, *Populus nigra* n=11, *Morus alba* n=6). And 7th **Jallu** numbers of trees were n=30 (*Hevea brasiliensis* n=21, *Melia azedarac* n=9). While at 8th biological site **Hazara University** trees counts were n=20 (*Eucalyptus camaldulensis* n=13, *Pinus raxburghii* n=7)(Table 3).

3.3. Bats colonies

Mean count of bat colonies were counted to be 118.22 ± 73.50 with maximum count at Baffa Doraha with mean 277 ± 94.08 and minimum count of 58 ± 52.52 at Chattar plain. Over all descending pattern of means of bats colonies were Baffa Doraha (277 ± 94.08) > Ghari Habibullah (171 ± 86.94) > Dadar (117.33 ± 71.39) > Darband

Table 2. Mean of mass, weight and other parameter of both male and female bats.

Descriptive Statistics					
Parameter	N	Minimum	Maximum	Mean	Std. Deviation
(M) Mass	5	803.00	920.00	855.723 gm	43.25853
Weight	5	7.87	9.07	8.59 N	0.48940
Volume	5	1223.00	1250.00	1236.40 ml	10.18823
Surface area	5	2648.70	2723.80	2691.79 cm ³	28.92634
Pressure	5	281.99	310.88	295.77 dyne/cm ³	11.25107
Density	5	0.76	0.81	0.701 g/m ³	0.26453
(F) Mass	5	800.00	918.00	852.71 gm	42.3128
Weight	5	6.87	9.27	8.59 N	0.57611
Volume	5	1153.00	1240.00	1207 ml	13.3813
Surface area	5	2438.10	2671.50	2576.46 cm ³	29.3411
Pressure	5	278.23	308.72	290.2 dyne/cm ³	12.6912
Density	5	.67	.74	0.701 g/m ³	0.02669

N: Number of samples of bats measured.

Table 3. Number and types of different roosting trees at each site.

Sites	Scientific name	Number of trees
Baffa Doraha	<i>Grevillea robusta</i>	13
	<i>Populus nigra</i>	47
	<i>Platanus orientalis</i>	6
	<i>Eucalyptus camaldulensis</i>	7
Garhi Habibullah	<i>Ailanthus altissima</i>	3
	<i>Pinus raxburghii</i>	11
	<i>Populus nigra</i>	31
Darband	<i>Grevillea robusta</i>	6
	<i>Pinus raxburghii</i>	13
	<i>Hevea brasiliensis</i>	4
Chattar plain	<i>Platanus orientalis</i>	17
	<i>Morus alba</i>	6
	<i>Morus nigra</i>	4
	<i>Brousonetia papyrifera</i>	3
	<i>Eucalyptus camaldulensis</i>	9
Dadar	<i>Ailanthus altissima</i>	2
	<i>Pinus raxburghii</i>	15
	<i>Grevillea robusta</i>	7
Jabori	<i>Eucalyptus camaldulensis</i>	12
	<i>Morus alba</i>	6
	<i>Pinus raxburghii</i>	16
Jallu	<i>Populus nigra</i>	11
	<i>Melia azedarach</i>	9
Hazara university	<i>Hevea brasiliensis</i>	21
	<i>Pinus raxburghii</i>	7
	<i>Eucalyptus camaldulensis</i>	13

(94.67±38.3)>Jabori(88.33±62.17)>Jallu(75±39.59)>Hazara University(64.5±38.89)>Chattar plain(58±52.52)(Figure 1).

3.4. Statistical results

There were no statistically significant difference among mean of bats colonies at all biological site as the result of one way anova showed that $P > 0.05$ ($P=0.833$). From this result we may predict that bats have no sites preference according to current data. However these bats colonies were dependent on trees numbers and were strong positive correlated with numbers of trees present at each site ($r = 0.930$, $p = 0.000$). Which means that numbers of trees have direct impacts on bats colonies. In other words high numbers of trees in biological spots would have high numbers of colonies according to correlation result of current study. Furthermore the result of correspondence analysis showed that bats prefer to roost on *Populus nigra* as maximum colonies were found on tree species *Populus nigra* (Tables 4-5).

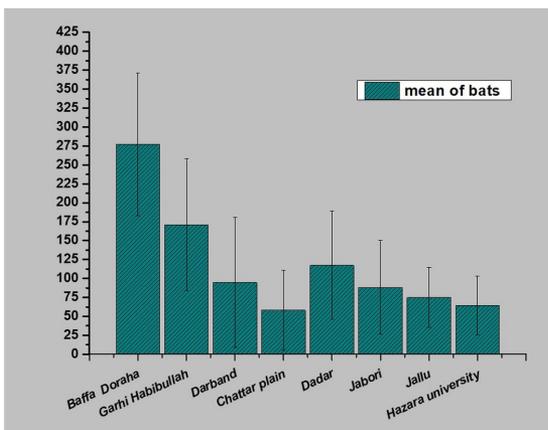


Figure 1. Mean of bats at different biological site.

4. Discussion

Identification of bats specimen and different biometrical features were measured through externally morphological analysis (Jacobs et al., 2006; Hill and Smith, 1985). The average wing span of male bats were found to be 102.98 cm and 93.67 cm in female in current study as compared to previously published reports such as Simmons (2005) where the wingspan was 884±18.17 mm of the killed *P. medius*. Wing span have been reported in range of 112.58 ±1.90 cm (Khan et al., 2021). Thumbs have been reported for adhering to trees as similar opinion was assumed by (Bennett, 1993). Furthermore, other measurements of the current study such as length of snout 5.62 cm, ear were 3.1 cm, length amid the feet 16.3 cm in stretched position and length of eye were 1.07 cm. The possible reason behind the difference among current morphometric measurements with other published reports may be due to body size, age and sex of the bats. As many published reports have showed, generally male bat of species *P. medius* are larger in size as compared to female bats (Khan et al., 2021; Marimuthu et al., 1998; Thatcher, 2004). However, Surface areas of bats in present study were 295.77 cm² for both sexes. Many reports have been showed that Surface areas of bats may be varied according to sex, as body surface areas were reported by Kumar et al. (2016) to be 2691.79 cm² male and that 2576.46 cm² for female. In current study average mass of bats were 869.6 gm, weight 8.59 newton and density 0.701 g/m³ in both sexes. Which were in similarity range with other published reports such as published study of Khan et al. (2021) have reported the mass of male bats 855.7 gm and average mass of female bats 852.71 gm, Similarly Roberts (1997) reported body mass of bat 600 to 1600 gm and reported that females were usually smaller than males. On the other side Rahman et al. (2015) have reported larger value of average mass of bats 1121.9±38.9 gm.

Table 4. Non-significant differences among the means of bats at each site.

ANOVA					
Colony					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	144596.154	7	20656.593	.486	.833
Within Groups	765618.500	18	42534.361		
Total	910214.654	25			

Sig represented, significance. F: factors, deviation. df: degree of freedom.

Table 5. Correlation between numbers of trees and bat colonies at all sites.

Correlation		
	Number of Trees	Colony
Pearson Correlation	1	.930**
Sig. (2-tailed)		.000
N	26	26

**Its mean significance difference from other. Sig represented, significance. N: Number of samples of bats measured.

This difference with current report may be due to variances among different factors of bats for instance age, sex and habitat of different biological spot. In addition present study showed that the numbers of trees in biological spots have direct positive impacts on bats colonies as these roosting trees are shelters and keep them safe from predators and environmental stress. Same reports have been reported by different researchers such as Rainey and Pierson (1992), Richmond et al. (1998).

5. Conclusion

Current study showed that different biological spot sites have different counts of bats colonies which were dependent on trees numbers at each site. Furthermore as their measurement have showed the male bats were larger in size than female. Studies like this should be conducted to accurately identify each and every species of bats and campaign, seminars and program should be arranged regarding bats to conserve them.

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