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Original Article

Distribution records of fruit bats *Cynopterus sphinx* and *Rousettus leschenaultii* from Khyber Pakhtunkhwa, Pakistan

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Abstract
During present survey, extending from June 2010 through May 2012 the greater short-nosed fruit bat *Cynopterus sphinx* (n = 1) and the fulvous fruit bat *Rousettus leschenaultia* (n = 22) were captured from Malakand division in Khyber Pakhtunkhwa (KPK). The morphological and cranial features of the captured specimens were compared with available literature. Baculum morphometry is one of the key features in identification of bat species and was applied for species confirmation of *R. leschenaultii*. *R. leschenaultia* has been already reported while *C. sphinx* being reported for the first time from the study area. *Pteropus giganteus* is another new record from the region.
Key words: Cranial measurements, *C. sphinx*, morphometry, *R. leschenaultii*, Sindh

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INTRODUCTION

Genus *Cynopterus* (Cuvier, 1824) is represented by seven species (Simmons, 2005) while two of them, the *C. sphinx* and *C. brachyotis* are reported from the Indian subcontinent (Bates and Harrison, 1997). *C. sphinx* is common in India and Sri Lanka. However, in Pakistan the species has been reported from Malir, Karachi in Sindh province (Roberts, 1977).

The genus *Rousettus* (Gray, 1821) includes medium-sized fruit bats that are distributed from sub-Saharan Africa, Arabia and Madagascar to the Indian subcontinent and Southeast Asia (Bates and Harrison, 1997). This genus is represented by 10 species and two of them are reported from the Indian subcontinent which include the fulvous fruit bat *R. leschenaultia* (Desmarest, 1820), *R. l. leschenaultia* (Desmarest, 1820) and the Egyptian fruit bat *R. aegyptiacus* (Geoffroy, 1810) *R. a. arabicus* (Anderson and de Winton, 1902), (Bates and Harrison, 1997; Talmale and Pradhan, 2009). Both of them are seasonally migratory and colonize Himalayan valleys in summer in the fruit growing districts up to 1200 m (4000 ft.) elevation (Roberts, 1997). *R. leschenaultii* is a highly gregarious species and colonies vaulted roves, natural rock caves and open wells. It has been recorded near Muzaffarabad in the Jhelum valley of Azad Kashmir, Malakand, the Vale of Peshawar, Sialkot, Lahore and Karachi (Mirza, 1967; Walton, 1974; Roberts, 1977).

A colony numbering several thousand in a rock cave at 1060 m elevation in the Malakand was discovered by Mirza (1967). *R. leschenaultia* bat is comparatively larger than its congener with a forearm length of 80.6 mm (75 - 86 mm). Distribution ranges of mammals of Pakistan have changed over the past 50 years but there is no worthwhile study to document such changes except Taber *et al*. (1967),

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Roberts (1977, 1997) and Beg and Khan (1984).*C. sphinx* and *R. leschenaultia* are included in Appendix II in IUCN SSC Action Plan (1992)-Not Threatened, Lower Risk-IUCN 2003 and is Least Concerned-CAMP 2003; CAMP 2002; IUCN 2008 (Walker and Molur, 2003; Mickleburgh *et al*. 1992; Mahmood-ul-Hassan *et al*. 2009). Present study was conducted in Malakand division, Khyber Pakhtunkhwa to record distribution status of *C. sphinx* and *R. leschenaultia* in the study area.

MATERIALS AND METHODS

Study area

Landscape of Malakand is diverse including plain and hilly areas. It lies on the northern side of the province, Khyber Pakhtunkhwa (KPK) province of Pakistan (Fig. 1). Among the crops, wheat is cultivated on larger scales. Average minimum and maximum temperatures are recorded as17 ºC and 30 ºC, respectively. The wild fauna includes the collared pika (*Ochotona rufescens*), markhor (*Capra falconeri*), the stone marten (*Martes foina*), migratory hamster (*Cricetulus migratorius*), the Persian jird (*Meriones persicus*), the forest dormouse (*Dryomys nitedula*) and the mouse-like hamster (*Calomyscus bailwardi*).

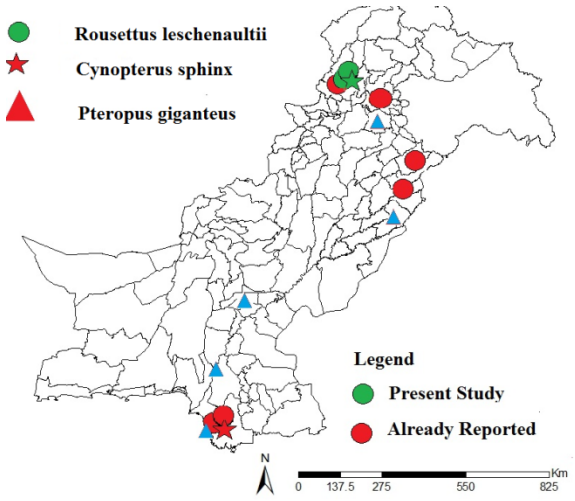

Figure 1 Distribution map of *P. giganteus, R. leschenaultia* and *C. sphinx*.

The soil of Malakand is irrigated by the Swat river and is bounded by elevated mountains having reasonable quantities of minerals and vast deposits of china clay and chromite iron.

Data collection

Bats were collected over a duration of two years (2010- 2012) in Malakand division and adjacent areas. All the mountainous caves were thoroughly searched. The exact location of bat roost was searched and determined using a global positioning system device (Garmin etrax H GPS). The bats were captured through mist and hand nets and every specimen was weighed using Pesola balance 10050, Swiss made up to 0.1 g accuracy. The bats were euthanized and an identification number was assigned to each specimen and transferred to the laboratory for analysis. Measurements of the external body parameters of the captured specimens were recorded following Bates and Harrison (1997). The craniodental measurements were taken following Bates *et al.* (2005) and Javid *et al.* (2011) while the bacula were prepared following Bates *et al.* (2005) and measured following Lidicker and Yang (1986).

RESULTS AND DISCUSSION

A single specimen of *Cynopterus sphinx* was collected from “Kashmir Smasta” and its morphological features were compared with Bates and Harrison (1997), Matveev (2005), Senacha*et al*. (2006) and Aziz (2007).

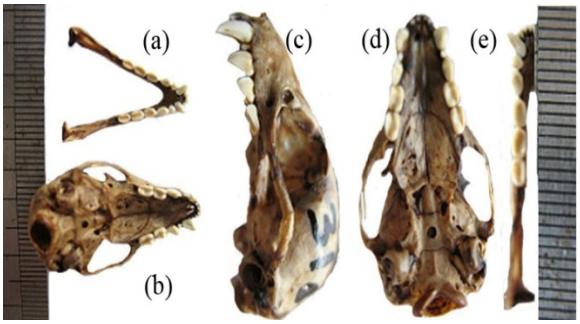

Figure 2 Skull of the greater short-nosed fruit *bat Cynopterus sphinx* (a, b) collected from the floor of “Kashmir Smasta” cave located in Mardan and a closer view of the lateral (c), and ventral (d) sides the cranium and mandible (e).

The head and body length of captured *Cynopterus sphinx* was measured77.12 mm, ear length 19.50 mm, forearm length 65.48 mm, tibia length 26.60 mm, hind foot length 17.94

mm and tail length 7.34 mm while Aziz *et al*. (2007) recorded the range of body mass between330.0-501.0 g, head and body length 85.0-115.0 mm, ear length 13.0-19.0 mm, , forearm length 59.0-75.0 mm, tibia length 21.0-30.0 mm, hind foot length 12.0-21.0 mm and tail length between 2.0-13.0 mm (Table I). The range of head and body length of the specimen recorded by Senacha *et al*. (2006) and Aziz (2007) was larger than the present study. The head and body length of *C. sphinx* specimen fall within the ranges reported by Bates and Harrison (1997). The ear length, forearm length, third metacarpal length, forth metacarpal length, fifth metacarpal, hind foot length and tail length are comparable with the measurements recorded by Bates and Harrison (1997), Matveev (2005) and Senacha *et al*. (2006). The ear length, forearm length, third metacarpal length, tibia length, hind foot length and tail length fall within the ranges described by Aziz (2007). Srinivasulu *et al.* (2010) collected specimen from South Asia with forearm length ranging from 64.0-79.0 mm, head and body 76.0-113.0 mm, hind foot 12.6-18.0 mm, tail 4.5-19.0 mm and ear 17.5-24.0 mm.

Figure 3 A fulvous fruit bat (*Rouesttus leschenaultii*) captured from Daimteshil Dargai in Malakand district.

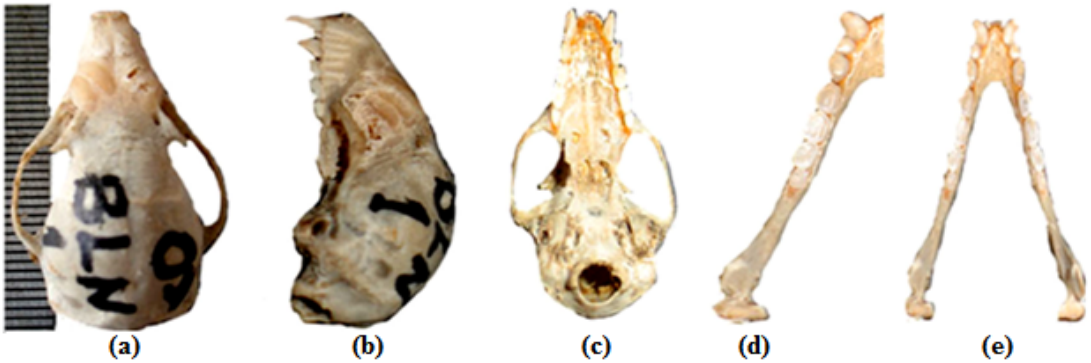

Figure 4 Dorsal (a), lateral (b) and ventral (c) view of cranium of *Rousettusleschenaultii*along with the mandibles (d, e) captured from Tura Gata tehsil Dargai in Malakand district.

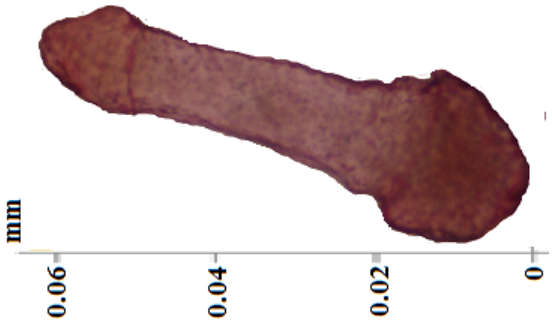

Figure 5 The baculum of fulvus fruit bat *Rousettusleschenaultii* captured in different caves from Tura Gata in Malakand district.

The head and body length, taillength, ear length, forearm length, tibia length and hind foot length was99.2 mm (89-109), 15.1 mm (13-17.5), 20.7 mm (19-22), 71.2 mm (67-74.5), 27.2 mm (25-29) and 17.6 mm (16-20.5), respectively, from the Indian state of Bengal (Das and Sinha, 1971). All the measurements except tail length of the captured specimen were in line with the ranges described by Das and Sinha (1971) (Table I). The rostrum was broad and short. The zygomatic arch was robust, anteriorly rounded off and comparatively longer as compared with that of *Rousettus*. The braincase was ovoid with a weak sagittal crest. The postorbital process was well developed.

The average condylo-canine length was

found 28.85 mm, maxillary toothrow length 10.86 mm, mandibular toothrow length 12.64 mm, greatest length of skull 32.20 mm, mandible was 24.75 mm long, posterior palatal width 9.63 mm. The zygomatic breadth was 18.81 mm, breadth of the braincase 14.50 mm, interorbital constriction 6.61 mm and anterior palatal width was 6.35 mm.

Table I: Comparison of external body measurements (mm) of *Cynopterus sphinx* (n=1) captured during present study with Aziz *et al.* (2007), Senacha*et al*. (2006), Matveev (2005) and Bates and Harrison (1997).

Body Parameters	Mean (Range)	(Range)			Male (n=13)	Female (n=8)	Present Study
	Bates and Harrison, 1997	Matveev, 2005	Senacha*et al*. 2006	Aziz *et al*. 2007	Das and Sinha (1971)		
BM	-	35.4-49.8	-	330-501	-	-	-
HB	98.8 (76.0-113.0)	-	98-108	85-115	99.2 (89-109)	99.1 (91-109)	77.12
E	20.6 (17.5-24.0)	18.1-22.2	19-23	13.0-19.0	20.7 (19-22)	20.9 (19-23)	19.50
FA	70.2 (64.0-79.0)	65.7-70.0	68-75	59.0-75.0	71.2 (67-74.5)	72.5 (67.5-76)	65.48
WS	380.4 (309.0-436.0)	-	340-378	-	-	-	-
2mt	-	-	-	-	-	-	29.54
1ph2mt	-	-	-	-	-	-	7.06
2ph2mt	-	-	-	-	-	-	6.45
3mt	47.0 (43.2-53.4)	-	-	39.0-51.0	-	-	43.30
1ph3mt	-	-	-	-	-	-	29.28
2ph3mt	-	-	-	34.0-43.0			32.62
4mt	44.4 (40.7-51.1)	-	-	-	-	-	41.21
1st Ph. 4th met	-	-	-	-	-	-	23.09
2nd Ph. 4th met	-	-	-	-	-	-	21.92
5mt	45.4 (41.1-52.1)	-	-	-			41.19
1ph5mt	-	-	-	-	-	-	21.22
2ph5mt	-	-	-	-	-	-	20.24
TIB	-	25.0-28.3	32-35	21.0-30.0	27.2 (25-29)	28 (24.5-30.5)	26.60
HF	15.6 (12.6-18.0)	12.2-15.6	14-17	12.0-21.0	17.6 (16-20.5)	17 (14.5-18.5)	17.94
T	10.9 (4.5-19.0)	6.1-12.7	15-18	2.0-13.0	15.1 (13-17.5)	15.1 (14- 19)	7.34

n - The number of specimens; BM - Body mass; HB - Head and body; E - Ear; FA - Forearm; 2mt - 2nd metacarpal; 1ph2mt - 1st Phalanx on 2nd metacarpal; 2ph2mt - 2nd Phalanx on 2nd metacarpal; 3mt - 3rd metacarpal; 1ph3mt - 1st Phalanx on 3rd metacarpal; 2ph3mt - 2nd Phalanx on 3rd metacarpal; 4mt - 4th metacarpal; 1ph4mt - 1st Phalanx on 4th metacarpal; 2ph4mt - 2nd Phalanx on 4th metacarpal; 5mt - 5th metacarpal; 1ph5mt - 1st phalanx on 5th metacarpal; 2ph5mt - 2nd phalanx on 5th metacarpal; WS - Wing span; TIB - Tibia; HF - Hind foot; T- Tail.

Measurements like greatest length of skull, condylo-basal length, mandibular toothrow length, mandible length and interorbital constriction was slightly larger than the measurements reported by Matveev (2005) while all these measurements were fall within the measurements reported by Bates and Harrison (1997) from India , Bangladesh and Sri Lanka. The greatest length of skull, condylobasal length, zygomatic breadth, cranial width, interorbital width , length of maxillary toothrow and length of mandibular toothrow was 33.1 mm (32-34), 31.9mm (30.6-32.5), 20.7 mm (19-22.3), 20.4 mm (18.8-21.6), 14.2 mm (13.3-14.5), 6.5 mm (5.8-7), 11.3 mm (10-12) and 12.4 mm (11.6-13), respectively, from the Indian state of Bengal reported by Das and Sinha (1971). All the measurements of the *C. sphinx* recorded during the survey fell within the ranges described by Das and Sinha (1971) (Table II).

The *R. leschenaultii* (n=22) were captured during the present study from Tura gata, Cupni,

Brah and Daim in Malakand division. Mean body mass of the captured *R. leschenaultia* specimens was 86.05±18.10 g (Table III).

Table II: Comparison of cranial measurements (mm) of *Cynopterus sphinx* (n=1) captured during present study with Bates and Harrison (1997) and Matveev (2005).

Cranial Parameters	Bates and Harrison, 1997 (Range)	Matveev, 2005	Das and Sinha (1971)		Present Study
			Male (n=13)	Female (n=8)	
Greatest length of skull	30.2-34.9	31.74	33.1 (32-34)	33.1 (31.7-34.5)	32.20
Condylo-canine length	-	29.52	-	-	28.85
Condylo-basal length	28.4-33.3	29.66-30.12	31.9 (30.6-32.5)	31.9 (30.8-33.3)	30.38
Maxillary toothrow length	10.2-12.2	11.17	11.3 (10-12)	10.8 (10.5-11)	10.86
Mandibular toothrow length	10.3-13.5	12.26	12.4 (11.6-13)	12.2 (11.8-12.6)	12.64
Mandible length	22.7-27.5	-	-	-	24.75
Zygomatic breadth	18.8-23.1	-	20.7 (19-22.3)	20.4 (18.8-21.6)	18.81
Breadth of braincase	11.1-14.8	-	14.2 (13.3-14.5)	14.2 (13.2-15)	14.50
Anterior palatal width	-	7.10	-	-	6.35
Posterior palatal width	-	9.43	-	-	9.63
Interorbital constriction	5.4-7.7	-	6.5 (5.8-7)	6.5 (6-7)	6.61

The head and body length was 120.09±7.80 mm and the ear was 19.41±0.85mm long. Forearm and thumb were 80.23 ± 3.26 mm and 27.79±1.22 mm long, respectively. The length of 2nd metacarpal was 36.14±1.91 mm while its 1st and 2nd phalanges were 8.59±0.67 mm and 8.50±0.60 mm, respectively. The length of 3rd metacarpal was 52.59±2.48 mm and its 1st and 2nd phalanges were 34.91±1.93 mm and 43.29±2.21mm, respectively. Length of the 4th metacarpal and 1st and 2nd phalanges on 4th metacarpal was 51.27±3.06 mm, 27.18±1.82 mm and 28.18±1.79 mm, respectively.

Similarly, 5th metacarpal was 49.23±2.74 mm long while 1st and 2nd phalanges on 5th metacarpal were 25.45±1.50 mm and 25.50±1.71 mm, respectively. Average wingspan was 431.82±44.77 mm while tibia, calcar, hind foot and tail were 38.23±2.91 mm, 6.77±0.97 mm, 19.05±1.25 mm and 13.68±2.17 mm, respectively. Forearm length of the specimens captured from Lahore and Malakand averaged almost similar as reported by (Roberts, 1997), but their head and body length was larger. Specimens of *R. leschenaultii* collected by Bates and Harrison (1997) from Pakistan and India had similar hind foot, forearm and thumb length. Their 2nd phalanx on 3rd metacarpal also had the same length but their mean head and body length was large, tail was slightly larger and ear had almost the same length as compared with the specimens collected during present study (Table III).

Specimens collected from SW-China had a slightly smaller head and body length, hind foot length and wingspan and their body mass and forearm length were smaller than our collected specimens. Their ear was, however, almost similar in length to the present collection (Aeshita *et al*. 2006) (Table III). Matveev (2005) collected specimens of *R. leschenaultia* from combodian specimens had larger body mass, tail, hind foot length, forearm length and tail. However their tibia was slightly smaller and ear was almost of the same length as recorded during present study (Table III). The dental formula of *R. Leschenaultia* was (2132/2133=34). The greatest skull length averaged 36.97±1.11 mm while mean breadth of braincase was 15.33±0.0.42 mm and zygomatic breadth was recorded 21.65±0.93 mm.

The inter-orbital constriction was 7.60±0.49 mm. The condylo-canine length was 33.98±1.16mm and condylo-basal length 35.41±0.93 mm. The maxillary and mandibular toothrow lengths averaged 14.08±0.44 mm and 15.51±0.47 mm, respectively while the mandible length averaged 28.95±0.90 mm long. The mean anterior and posterior palatal widths of the skull were 7.37±0.65mm and 11.09±0.44 mm, respectively (Table IV). Cranial measurements made by Roberts (1997), Bates and Harrison (1997) and Matveev (2005) were in line with the present study (Table IV). Mean total baculum length of the specimens (n=8) was 2.13±0.50mm. The width of proximal and distal extreme of the baculum was 0.73±0.35 mm and 0.64±0.30mm, respectively. The mid width of the

baculum was 0.38±0.32 mm. The bacula were 0.56±0.35 mm high (Table V).

Table III: Comparison of external body measurements (mm) of *Rousettus leschenaultia* (n=22) captured during present study with other studies.

Body Parameters	Mean±SD					
Range	**Bates and Harrison, 1997**	**Roberts, 1997**	**Matveev, 2005**	**Aeshita *et al*. 2006**		**Present Study (n=22)**
BM	-	-	-	43.00±8.00	44.30±5.50	86.05±18.10
Range	-	-	105.0-107.0	-	-	60.00-137.00
HB	125.9±8.5	131		118.0±10.0	123.0±6.9	120.09±7.80
Range	111.0-147.0	120-145	-	-	-	111.00-134.00
E	20.8±1.5	21	-	18.0±1.0	18.0±1.4	19.41±0.85
Range	17.5-24.0	19-23	17.4-19.4	-	-	18.00-21.00
FA	80.6±2.9	79	-	71.0±3.0	72.0±3.0	80.23±3.26
Range	75.0-86.0	-	82.2-86.5	-	-	75.00-86.00
THC	27.3±1.4	30	-	-	-	27.79±1.22
Range	24.4-31.1	-	-	-	-	25.00-30.00
2mt	-	-	-	-	-	36.14±1.91
Range	-	-	-	-	-	33.00-40.00
1ph2mt	-	-	-	-	-	8.59±0.67
Range	-	-	-	-	-	8.00-10.00
2ph2mt	-	-	-	-	-	8.50±0.60
Range	-	-	-	-	-	8.00-10.00
3mt	-	-	-	-	-	52.59±2.48
Range	-	-	-	-	-	48.00-57.00
1ph3mt	-	-	-	-	-	34.91±1.93
Range	-	-	-	-	-	31.00-39.00
2nd Ph. 3rdmt	42.6±1.6	-	-	-	-	43.29±2.21
Range	39.6-46.2	-	-	-	-	40.00-46.00
4mt	-	-	-	-	-	51.27±3.06
Range	-	-	-	-	-	45.00-56.00
1ph4mt	-	-	-	-	-	27.18±1.82
Range	-	-	-	-	-	23.00-30.00
2ph4mt	-	-	-	-	-	28.18±1.79
Range	-	-	-	-	-	25.00-31.00
5mt	-	-	-	-	-	49.23±2.74
Range	-	-	-	-	-	45.00-54.00
1ph5mt	-	-	-	-	-	25.45±1.50
Range	-	-	-	-	-	22.00-28.00
2ph5mt	-	-	-	-	-	25.50±1.71
Range	-	-	-	-	-	22.00-28.00
TIB	-	-	-	-	-	38.23±2.91
Range	-	-	36.8-39.2	-	-	33.00-43.00
HF	18.7±1.7	22	-	17.0±2.4	16.0±1.3	19.05±1.25
Range	15.0-22.0	-	19.5-20.9	-	-	16.00-21.00
T	15.6±2.7	14	-	-	-	13.68±2.17
Range	8.0-21.0	10-18	17.0-17.3	-	-	10.00-17.00
WS	-	-	-	428.0±30.0	447.0±23.0	431.82±44.77
Range	-	-	-	-	-	370.00-534.00

BM - Body mass; HB - Head and body; E - Ear; FA - Forearm; THC- Thumb with claw; 2mt - 2nd metacarpal; 1ph2mt - 1st Phalanx on 2nd metacarpal; 2ph2mt - 2nd Phalanx on 2nd metacarpal; 3mt - 3rd metacarpal; 1ph3mt - 1st Phalanx on 3rd metacarpal; 2ph3mt - 2nd Phalanx on 3rd metacarpal; 4mt - 4th metacarpal; 1ph4mt - 1st Phalanx on 4th metacarpal; 2ph4mt - 2nd Phalanx on 4th metacarpal; 5mt - 5th metacarpal; 1ph5mt - 1st phalanx on 5th metacarpal; 2ph5mt - 2nd phalanx on 5th metacarpal; WS - Wing span; TIB - Tibia; HF - Hind foot; T- Tail.

Table IV: Comparison of cranial measurements (mm) of *Rousettusleschenaultii*captured during present study with Bates and Harrison (1997) and Matveev (2005).

Body Parameters	Mean±SD		
Range	Bates and Harrison, 1997	Matveev, 2005	Present Study
CBL	35.8±1.1	38.51	35.41±0.93
Range	35.5-37.7	-	33.70-36.78
Condylo-basal length	-	36.81	33.98±1.16
Range	-	-	32.05-36.75
Maxillary toothrow length	14.2±0.5	14.78	14.08±0.44
Range	13.5-15.2	-	13.50-14.90
Mandibular toothrow	15.7±0.5	16.17	15.51±0.47
Range	14.8-16.7	-	14.80-16.30
Greatest length of skull	37.3±1.1	40.13	36.97±1.11
Range	34.9-39.4	-	35.45-38.87
Mandible length	29.4±0.9	-	28.95±0.90
Range	27.6-31.1	-	27.70-30.50
Zygomatic breadth	22.5±0.9	-	21.65±0.93
Range	20.2-24.0	-	20.33-23.58
Breadth of braincase	15.3±0.4	-	15.33±0.42
Range	14.4-16.0	-	14.58-16.25
Anterior palatal width	-	8.39	7.37±0.65
Range	-	-	6.45-9.50
Posterior palatal width	-	11.60	11.09±0.44
Range	-	-	10.38-12.00
Interorbital constriction	7.6±0.5	-	7.60±0.49
Range	6.9-8.8	-	6.92-8.75

Table V: Mean bacular measurements (mm) of *Rousettus leschenaultii* captured from Tura Gata in Malakand district.

Bacular Parameters	Mean± SD (n=8)	Range
Total baculum length	2.13±0.50	0.95-2.63
Width of proximal extreme	0.73±0.35	0.02-1.23
Width of middle extreme	0.38±0.32	0.00-0.73
Width of distal extreme	0.64±0.30	0.02-0.98

According to Shahbaz *et al*. (2014) total length of the baculum was 3.075 mm, length of shaft 1.275 mm, width of proximal branch 0.925 mm and width of distal branch was measured 0.800 mm. According to Agrawal and Sinha (1973), the baculum was dumbbell-shaped, its proximal end was ovoid and larger than the distal.

The baculum of the specimen from the Sri Lanka was small and peg-shaped. Similarly, the baculum of *Rousettus leschenaultii* captured from Tura Gata in Malakand district was exactly the same as that of the baculum described by Agrawal and Sinha (1973). Indian flying fox *Pteropus giganteus* was also recorded during present survey. The species is unmistakable as it is the largest bat of the Indian sub-continent (Roberts, 1997).

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