



Morphological Differentiation in Some *Pipistrellus* sp. (Chiroptera) Captured from Bajaur Agency, Pakistan

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ABSTRACT

A two years survey extending from June 2014 through May 2016 was conducted in Bajaur Agency which forms the northern part of Federally Administered Tribal Areas (FATA) and never explored for chiropteran diversity prior to the present study. Five congeners namely common Pipistrelle *Pipistrellus pipistrellus*, Javan Pipistrelle *P. javanicus*, Coromandel Pipistrelle *P. coromandra*, least Pipistrelle *P. tenuis* and Kelaart's Pipistrelle *P. ceylonicus* were recorded for the first time from the study area. Average forearm length of *P. pipistrellus*, *P. javanicus*, *P. coromandra*, *P. tenuis* and *P. ceylonicus* was recorded 30.9±0.14mm, 35.13±0.53mm, 31.64±1.19mm, 28.49±1.25mm and 40.11±2.24mm, respectively. The greatest length of skull of these species was 11.75±0.35mm, 13.69±0.25mm, 12.48±0.34mm, 11.83±0.30mm and 15.00±0.15mm, respectively while their total bacular length was 1.58mm, 3.81±0.01mm, 3.82±0.47mm, 2.11±0.707mm and 5.83±2.15mm, respectively. The shape and size of the bacula were the characters that helped in clear cut identification of these bat species.

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Authors' Contribution

Hamidullah collected and analyzed the data and wrote the manuscript. This paper is the part of his PhD thesis. BR supervised the research, assisted in refining the article and arranged funds for the collection of bat specimens. AJ co-supervised and designed the research. JB assisted in surveys. AU helped in sample collection. MIK helped in lab work.

Key words

Pipistrellus, Forearm, Baculum length, Cranial parameters, FATA.

INTRODUCTION

Bats (Order Chiroptera) are remarkable for their broad geographic distribution and high diversity. They are present at all continents of the world except Antarctica and cover more than twenty percent of all living mammalian species (Simmons, 2005a, b). In human society, they are considered most feared creature that's why remained unexplored in many parts of the world (Malla, 2000). Morphologically bats are different from other mammals in various characteristics like pectoral girdle, hind limb, axial skeleton and these modifications assist them to support upright resting position (Hill and Smith, 1984).

In natural environments, bats play important role in pollination and insect control hence are helpful in improvement of the economies (Cox *et al.*, 1991; Fujita and Tuttle, 1991; Rainey *et al.*, 1995; Banack, 1998; Rahman *et al.*, 2015). Insectivorous bats consume thousands of insects in one night and help in reduction of several vectors of diseases (Adams, 2003).

The distribution range of the genus *Pipistrellus*

extends from central southern Africa, throughout Eurasia to Indonesia, Japan, New Guinea and northern Australia Solomon Islands. It also occurs in Canada, Mexico and USA. Globally, genus *Pipistrellus* is represented by 51 species, 12 species have been reported from Indian subcontinent (Koopman, 1993) while eight species exist in the territorial limits of Pakistan (Roberts, 1997).

Pipistrellus pipistrellus in Pakistan has been reported from northern areas, Kulali and Dir, Chitral in Khyber Pakhtunkhwa (KPK) (Walton, 1974). The taxonomic status of this bat species is unknown from the country. This species ranges from China and India to Japan and Taiwan through Britain and southern Scandinavia Europe and also present in Morocco. In the beginning of 19th century, British museum collected only one specimen from Kashmir, two other specimens were collected from Gilgit by University of Maryland in 1965 (Roberts, 1997).

P. javanicus (Gray, 1838) is reported from Gharial, Murree Hills and Karakar pass, KPK (Roberts, 1997). Although the distribution range of the species is very wide extending from Pakistan, Afghanistan, India to Myanmar, Indonesia, Philippines, Japan, Korea, New Guinea and perhaps in Australia. However, no literature on its distribution is available in Pakistan (Mahmood-ul-Hassan *et al.*, 2009). *P. javanicus* is a medium size insectivorous

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bat, with pelage color varying from buffy brown ventral surface to uniform brown dorsal side. The tail is enclosed within the inter-femoral membrane, eyes are smaller, muzzle is short but broader and the ear owns a tragus.

P. coromandra is wide spread and a common species in Indian region. Specimens captured from Pakistan and Afghanistan is slightly larger than the individuals recorded from central India (Brosset, 1962; Gaisler, 1970). In Pakistan, *P. coromandra* has been recorded from Chakri in Punjab and Dir, Yakh Tangai in KPK (Bates and Harrison, 1997). The species lives in small groups of few individuals, preys flies, ants and small insects. Preferred roosting sites include old buildings, walls, tree plantations, crevices, ceilings of houses, under bark and sign boards.

P. tenuis (Temminck, 1840) is the smallest bat in the Indian subcontinent and its distribution ranges from Cocos eeling Isles and Christmas Isle (Indian Ocean), Afghanistan to the Moluccas, Vietnam and China. *P. tenuis* has been recorded from Malakand (Roberts, 1997), Chitral (Sinha, 1980), Multan and Chaklala (Hinton and Thomas, 1926), Chakri, Gambat, Sukkur (Siddiqui, 1961), Karachi and Malir (Walton, 1974) in Pakistan. The species roosts in cracks in walls, hollows of trees, holes, old buildings' ceilings, villages, towns, wet and humid areas and arid zones. The diet of the species varies with season. During monsoon and summer it feeds on a wide variety of insects and beetle while in winter termites, cockroaches, wingless ants and moths serve as dietary items.

Table I.- GPS coordinates of sampling sites explored for chiropteran diversity during present study.

Sampling Station	GPS location		Elevation
	Latitude	Longitude	
PayshatDormopaty	N 34° 52.149	E 071°31.827	948 m
PayshatBatkhehla	N 34° 52.334	E 071°31.902	968m
Malkana	N 34° 43.707	E 071°34.950	989
Lion cave 1 Zary	N 34° 54.145	E 071°31.630	1403m
Lion cave 2 Zary	N 34° 55.222	E 071°30.940	1365m
Kariband 1 Cave Batwar	N 34° 55.136	E 071°30.471	1390m
Kariband 2Cave Batwar	N 34° 55.234	E 071°30.499	1371m
Kariband 3 Cave Batwar	N 34° 55.296	E 071°30.495	1375m
Chalgazy Payshat	N 34°55.244	E 071°30.602	1345m
Jawer Payshat	N 34°53.508	E 071°31.714	658m
Chalgazy Jovar	N 34° 53.507	E 071°31.738	995m
Lardagy Payshat	N 34° 53.507	E 071°31.738	954m
Sango Payshat	N 34° 51.878	E 071°31.607	1018m
Dary	N 34° 34.981	E071°36.545	848m
Pacha Gul Korona Mulakaly	N 34° 47.053	E071°36.428	832m
Nawagi Zoorbander Cave Karbory	N 34° 41.703	E 071°19.840	1141m
Nawagi Zoorbander Cave Zarabanda	N 34° 41.897	E 071°20.347	1159m
Nawagi Zoorbander Cave 1 Gondo Sherghuto	N 34° 41.896	E 071°20.345	1061m
NawagiZoorbanader Cave 2 GondoSherghuto	N 34° 41.898	E 071°20.350	1065m
Nawagi Zoorbanader Cave Boky	N 34° 39.143	E 071°21.574	1158m
Nawagi Darbano cave Nagibaba	N 34°39.142	E 071°21.575	999m
Government Degree College, Nawagi	N34° 41.896	E71° 20.345	1031m
Government Higher Secondary School, Gardai	N34° 41.127	E71° 20.365	676m
Tuhaid Abad	N34° 47.07	E71° 36.476	820m
Marosa	N34° 51.324	E71° 41.812	859m
Kotky	N 34° 48.781	E 071° 34.879	818m
Raghan	N 34° 49.216	E 071° 35.023	800m
Dog	N 34° 49.107	E 071° 35.010	715m
Sha	N 34° 49.105	E 071° 0.009	720m

P. ceylonicus (Kelaart, 1852) from Pakistan has been recorded from Malir (Walton, 1974), Landhi (Wroughton, 1916) Karachi and Thatta in Sindh and Lyallpur (Roberts, 1997) in Punjab. The species is relatively larger in size and is widely distributed all over the world. Its preferred roosting sites include human habitations, old buildings, trees, wall cracks, crevices, wells, caves, old temples and under bridges. It hunts mainly flies and insects including beetles and moths *etc.*

Almost all the chiropteran species are declining in their natural habitats due to urbanization, threats from introduced species, habitat loss. However, proper monitoring and conservation efforts can assist in protection of these environment friendly creatures (Salim *et al.*, 2016).

Chiropteran diversity of Bajaur Agency in FATA was never explored, the present study was therefore planned to ascertain the presence or absence of bat species belonging to the genus *Pipistrellus*.

MATERIALS AND METHODS

A 2-year survey extending from June 2014 through May 2016 to explore chiropteran diversity of the genus *Pipistrellus* was conducted in Bajaur Agency. All the potential roosting sites were searched and locales were also interviewed to find as many bat roosts in the study area as possible. The coordinates of each sampling site were recorded through global positioning system (GPS) (Garmin etrax H) (Table I).

Study area

The study was conducted at Bajaur agency (34°55' and North latitudes 71°30' East longitudes) in the Federally Administered Tribal Areas (FATA) covering an area of 27,220 km². The north western part of the area is surrounded by Afghanistan, province Khyber Pakhtunkhwa (KPK) lies on the eastern side while southern boundary is covered by the Baluchistan province. Bajaur forms the northern most part of FATA with human population of 3.341 Million. Only 3.1% of the population resides in established towns hence Bajaur is the most rural administrative unit in Pakistan. Forest type is the sub-tropical dry mixed deciduous scrub forest and dry subtropical temperate semi-evergreen scrub forest (Roberts, 1997). Average minimum and maximum temperature is recorded as 15°C and 30°C, respectively while average humidity is 65%.

Bats sampling

Bat specimens were captured through hand nets and mist nets from different habitats like fruit gardens, cultivated lands, wetlands, grasslands, woodlands, open

fields, caves and old buildings. Each captured specimen was weighed using Pesola balance (10050 Swiss made), measured. The collected bats samples were identified up to the species level and were released and those specimens that were not identified in the field were brought to the laboratory and their skulls and bacula were prepared and measured following (Bates and Harrison, 1997; Bates *et al.*, 2005; Javid *et al.*, 2011; Salim *et al.*, 2016; Salim *et al.*, 2017).

RESULTS AND DISCUSSION

During present survey, a total of 46 bat specimens belonging to the genus *Pipistrellus* were recorded from the study area. These congeners include *P. pipistrellus*, *P. javanicus*, *P. coromandra*, *P. tenuis* and *P. ceylonicus*.

Pipistrellus pipistrellus (Schreber, 1774)

Only two male specimens were collected through mist net from Malkana Salarzo (34° 43.707' E N 34° 43.707') in Bajaur agency during the study period. The wings of this species are relatively narrower. The wings and interfemoral membranes are uniformly brown and naked. Throat and belly were paler with dark grey hair base. The ears are short but broader with rounded tip, tail was shorter than the length of head and body. The tragus is almost half the height of the pinna. Mean body mass of *P. pipistrellus* (n = 2) was 5.75±0.37g, forearm length was 30.9±0.14mm, wingspan 127.5±24.75 while tail length was recorded 31.9±2.26mm. Similarly, greatest length of skull was measured 11.75±0.35mm, condylo-canine length was 10.85±0.49mm and Maxillary toothrow length was 4.30±0.14mm. Total bacular length of a single *P. pipistrellus* specimen was recorded 1.58mm (Table II). All these features are in line with the findings of Roberts (1997) and Bates and Harrison (1997).

Pipistrellus javanicus (Gray, 1838)

During present survey, 8 specimens (2♂, 6♀) of *P. javanicus* were recorded from Government Degree College Nwawagi Bajaur agency (N34° 41.896' E71° 20.345'). This species has uniformly brown dorsal surface, the tips of the hairs are buffy brown on the ventral side. Mean body mass of the captured specimens were 8.08±1.09g, their head and body length was 46.65±1.58mm while the ear was 8.50±1.25mm long. Average forearm length was 35.13±0.53mm, length of 3rd metacarpal was 38.68±1.21mm, length of 4th metacarpal was 31.3±1.79mm while 5th metacarpal was 31.15±1.35mm long. Mean wingspan was 217.67±5.75mm and tail length was recorded 30.34±0.97mm (Table II).

Average greatest length of skull (n=6) of *P. javanicus* was 13.69±0.25mm, mean breadth of braincase was 6.76±0.19mm, zygomatic breadth was 8.81±0.14mm, condylo-canine length 12.6± 0.25mm while maxillary tooththrow length was measured 4.80±0.14mm. The dental

formula of the species is 2123/3123=34. Total length of a baculum (n = 2) was 3.81±0.01mm (Table II). Similar results have been documented by Roberts (1997) and Bates and Harrison (1997) from Pakistan and Indian subcontinent, respectively.

Table II.- Body mass (Mean±SD, g) and external body measurements (Mean±SD, mm) of five species of the genus *Pipistrellus* captured from Bajaur agency, FATA.

	<i>P. pipistrellus</i> (n=2)	<i>P. javanicus</i> (n=8)	<i>P. coromandra</i> (n=21)	<i>P. tenuis</i> (n=11)	<i>P. ceylonicus</i> (n=4)
Body parameters					
Body mass	5.75±0.37	8.08±1.09	3.86±0.48	5.15± 0.48	5.15±0.48
Head and body length	44.65±1.63	46.65±1.58	39.47±3.41	36.38±2.12	51.30±6.78
Ear length	11±0.14	8.50±1.38	9.17±1.39	7.56±1.82	12.16±1.21
Tragus length	4.3±0.28	3.77±0.65	3.68±0.58	3.23±0.53	5.58±1.22
Forearm length	30.9±0.14	35.13±0.53	31.64±1.19	28.49±1.25	40.11±2.24
Thumb with claw	6.75±0.35	4.76±0.99	3.97±1.10	4.10±1.12	7.85±2.06
3 rd metacarpal length	30.5±0.64	31.68±1.21	28.07±1.80	25.81±1.21	36.90±1.86
1 st Phalanx on 3 rd metacarpal	7.25±1.77	11.62±0.54	10.94±1.28	10.15±0.59	13.65±2.26
2 nd Phalanx on 3 rd metacarpal	5.75±1.77	9.87±0.95	7.98±0.94	8.21±0.38	12.80±2.01
4 th metacarpal length	29.65±0.49	31.37±1.79	27.83±1.82	26.13±0.82	35.12±1.92
1 st Phalanx on 4 th metacarpal	7.00±1.41	11.54±0.88	10.20±1.28	10.30±0.93	11.42±0.79
5 th metacarpal length	30.3±0.57	31.15±1.35	28.16±1.40	26.13±1.02	34.29±0.90
1 st phalanx on 5 th metacarpal	5.4±0.57	8.06±0.71	7.70±0.96	6.66±1.00	9.01±1.68
Wingspan	127.5±24.75	217.67±5.75	176.00±17.73	178.91±21.35	233.75±11.21
Tibia length	10.6±0.85	13.46±0.88	11.122.97	11.46±1.25	18.23±4.59
Calcaneal length	4.2±0.99	4.03±0.22	4.24±1.11	3.25±0.51	6.60±1.33
Hind foot length	6.4±0.57	5.34±0.5	5.75±1.12	5.50±1.20	8.53±1.24
Tail length	31.9±2.26	30.34±2.97	27.19±3.63	25.59±3.44	43.38±2.38
Cranial measurements					
	(n=2)	(n=6)	(n=4)	(n=6)	(n=2)
Condylo-canine length	10.85±0.49	12.67±0.25	11.54±0.5	10.54±0.12	13.10±0.14
Condylo-basal length	10.00±0.00	13.2±70.44	11.83±0.29	11.01±1.60	12.60±0.57
Maxillary tooththrow	4.3±0.14	4.80±0.14	4.32±0.22	3.91±0.27	5.85±0.07
Mandibular tooththrow	4.45±0.07	5.01±0.39	4.33±0.63	4.11±0.23	6.04±0.08
Greatest length of skull	11.75±0.35	13.69±0.25	12.48±0.34	11.83±0.30	15.00±0.15
Mandible length	7.95±0.07	10.21±0.45	9.07±0.23	7.80±0.30	11.00±0.14
Posterior palatal width	3.35±0.21	6.06±0.46	5.42±0.48	4.83±0.29	6.83±0.38
Zygomatic breadth	7.65±0.12	8.81±0.14	6.55±0.80	7.52±0.14	9.89±0.13
Breadth of braincase	6.05±0.21	6.68±	6.45±0.37	6.04±0.12	7.00±0.00
Postorbital constriction	3.35±0.21	3.55±0.22	3.36±0.09	3.25±0.24	4.05±0.21
Anterior palatal width	6.9±0.14	4.35±0.21	3.75±0.09	3.64±0.72	6.04±0.08
Bacular measurements					
	(n=1)	(n=2)	(n=6)	(n=2)	(n=3)
Total baculum length	1.58	3.81±0.01	3.82±0.47	2.11±0.707	5.83±2.15
Shaft length	1.19	2.401±0.00	2.70±0.45	1.59±0.318	5.31±2.22
Proximal branch length	0.02	1.209±0.01	0.81±0.18	0.50±0.141	0.46±0.22
Distal branch length	0.35	0.70±0.71	0.24±0.08	0.20±0.00	0.22±0.07
Proximal branch Width	0.02	0.708±0.14	0.64±0.14	0.39±0.040	0.80±0.20
Distal branch width	0.35	0.365±0.01	0.21±0.00	0.20±0.00	0.29±0.11

Pipistrellus coromandra (Gray, 1838)

A total of 21 (8♂, 13♀) specimens of *P. coromandra* were captured through mist net from Laradagy Salarzo Bajaur agency (N34° 53.507' E71° 31.738'). Pelage of the captured specimens was brown from dorsal side while it was paler from ventral side. The mean body mass of captured *P. coromandra* specimens was 3.86±0.48mm, head and body length was 39.47±3.21mm while their average forearm was recorded 3.21±1.02mm. Average length of 3rd metacarpal was 28.07±1.80mm, length of 4th metacarpal was 27.83±1.82mm and length of 5th metacarpal was measured 28.16±1.40. Mean wingspan was 176±17.73mm and the tail was 27.19±3.63mm long (Table II).

Cranial measurements of *P. coromandra* (n=4) captured during present survey are mentioned in Table II. Mean greatest length of skull, breadth of braincase, zygomatic breadth and post-orbital constriction was measured 12.48±0.34mm, 6.45±0.37mm, 6.55±0.80mm and 3.36±0.09mm, respectively. Mean condylo-canine length was 11.54±0.05mm while anterior and posterior palatal width was recorded 3.75±0.09mm and 5.42±0.48mm, respectively. Average maxillary tooththrow length, mandibular tooththrow length and mandible length was recorded 4.32±0.22mm, 4.33±0.63mm and 9.07 ±0.23mm, respectively. The dental formula was 2123/3123=34. Total baculum length of *P. coromandra* (n=6) was 3.82±0.47mm, shaft length was 2.70±0.47mm, proximal branch length was 0.81±0.18mm, distal branch length was 0.24±0.08mm, proximal branch width was 0.64±0.14mm and the distal branch width was 0.21±0.00mm (Table II). Morphological characteristics of the captured specimens of *P. coromandra* are in line with those documented by Roberts (1997) and Bates and Harrison (1997).

Pipistrellus tenuis (Temminck, 1840)

A total of 11 (2♂, 9♀) specimens of *Pipistrellus tenuis* were captured from Government higher secondary school Gardi (N34° 41.127' E71° 20.365') in Bajaur agency. Ventral surface of these specimens was paler with buffy

brown hair tips while dorsal pelage was brown. Similar features have been documented by Javid *et al.* (2011). The mean body mass of the specimens captured during present survey was 5.15±0.482g, head and body length was 36.38±2.12mm and forearm length 28.49±1.25mm. Average length of 3rd metacarpal, 4th metacarpal and 5th metacarpal was 25.81±1.21mm, 26.13±0.82mm and 26.13±1.02mm, respectively. Average wingspan was 178.91±21.35mm while tail length was measured 25.59±3.44mm (Table II).

Mean greatest length of skull of *P. tenuis* (n=6) was 11.83±0.300mm, breadth of braincase was 6.04±0.23mm while the zygomatic breadth was recorded 7.52±0.14mm. Average condylo-canine length, maxillary tooththrow length, mandibular tooththrow length and mandible length was measured 10.54±0.12mm, 3.91±0.27mm, 4.83±0.29mm and 7.80±0.36mm. The dental formula was 2123/3123=34. Average total length of *P. tenuis* (n=2) was 2.11±0.70mm (Table II). All the external body, cranial and bacular features of the captured *P. tenuis* specimens are in line with Javid *et al.* (2011).

Pipistrellus ceylonicus (Kelaart, 1852)

During present survey, 4 specimens (3♂, 1♀) of *P. ceylonicus* were captured from Tuhaidabad Mulakaly (N34° 47.07' E71° 36.476'), Godar Jandool (N34° 49.394' E71° 40.724') and Ghagi Shalkandi (N34° 51.322 ' E71° 41.822'). The belly fur of the captured specimens was paler. The dorsal fur was silky, ears were squarish in shape and were larger in size. The tragus was of half the height of the ear and triangular in shape. All these features are in line with the findings documented by Bates and Harrison (1997). Mean body mass of captured *P. ceylonicus* specimens was 5.85±1.04g, head and body length was 51.30±6.46mm while their mean ear length was 12.16±1.81mm. Forearm was 40.1±12.24mm long. Mean length of 3rd metacarpal was 36.90±1.86mm, length of 4th metacarpal was 35.12±1.92mm while length of 5th metacarpal was 34.29±0.90mm. Average wingspan and tail length was 233.75±11.21mm and 43.38±2.38mm, respectively (Table II).

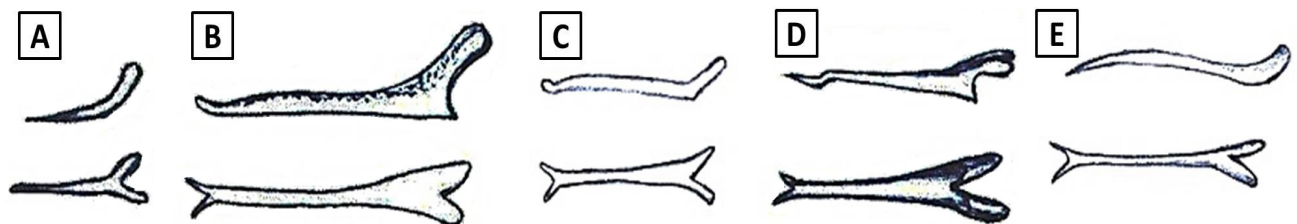


Fig. 1. Bacular features of *P. pipistrellus* (A), *P. javanicus* (B), *P. coromandra* (C), *P. tenuis* (D) and *P. ceylonicus* (E).

Mean greatest length of skull of *P. ceylonicus* (n=2) was 15.00±0.71mm, breadth of braincase was 7.00±0.00mm while zygomatic breadth was 9.89±0.13mm. Mean condylo-canine length was 13.10±0.14mm, maxillary tooththrow length 5.85±0.07mm, mean mandibular tooththrow length was 6.04±0.08mm and mandible was 11.00±0.14mm long. The dental formula was 2123/3123=34 (Table II). Average total length of baculum of male *P. ceylonicus* (n=3) specimens was recorded 5.83±2.15 (Table II). The morphological features of the captured specimens of *P. ceylonicus* are in line with the findings of Roberts (1997) and Bates and Harrison (1997). The bacular features that helped in clear cut identification of all the five congeners recorded during present survey are mentioned in Table II and shown in Figure 1.

During present survey, 46 bat specimens representing five species including *P. pipistrellus*, *P. javanicus*, *P. coromandra*, *P. tenuis* and *P. ceylonicus* were recorded from Bajaur agency, FATA, The area which was never explored for chiropteran diversity prior to the present study. In addition to the morphological characteristics, the size and shape of the bacula helped in clear identification of captured *Pipistrellus* species.

Statement of conflict of interest

Authors have declared no conflict of interest.

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