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COMMUNICATION

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COMMUNICATION

A review of the bacular morphology of some Indian bats (Mammalia: Chiroptera)

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Abstract: Bacular studies play a significant role in the case of bats and other mammals since it is considered an important taxon-specific character, thus helping in species discrimination. Structure of the baculum (os penis) also aids in examining and understanding cryptic diversity in bats. The baculum has been used in taxonomic studies of bats but such studies for Indian bats are few and far between. It was felt necessary to put together a comprehensive document depicting the bacular morphology of bats in India so as to be helpful for future bat studies. The penises of the bats were excised, treated with KOH, and then dyed with alizarin red to extract the bacula. The extracted bacula were measured using an oculometer, photographed, and preserved in glycerol. Of the total of 47 species of bats (belonging to nine families) collected and studied during the past decade, we present the bacular morphology of 44 species from peninsular India, Andaman Islands, and Jammu and Kashmir. Bacular morphology of eight taxa, namely, *Eonycteris spelaea*, *Rhinolophus pusillus*, *R. lepidus monticola*, *R. cognatus*, *Hipposideros* cf. *grandis*, *Myotis peytoni*, *M. horsfieldii dryas*, and *M. longipes* are presented here for the first time from India.

Keywords: Andaman Islands, baculum, cryptic species, Jammu & Kashmir, os penis, peninsular India.

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Author contribution: BS and CS planned and wrote the ms. BS and HK did the bacular studies. All the authors contributed equally to the field studies.

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INTRODUCTION

Thomas (1915), for the first time, named the os penis or the penis bone "baculum" (Hill & Harrison 1987), and put to use the study of the baculum in the taxonomy of bats and rodents. The baculum varies between species and is morphologically diverse both in terms of shape and size (Chaine 1925; Hamilton 1946; Eadie 1947; Burt 1960; Patterson & Thaeler 1982; Romer & Parsons 1986; Dixson 1995; Weimann et al. 2014). It was thought to be found only in certain mammalian groups such as Afrosoricida, Carnivora, Chiroptera, Dermoptera, Erinaceomorpha, Primates, Rodentia, and Soricomorpha (Martin 2007; Perrin et al. 2009; Schultz et al. 2016). Recently, the presence of baculum has been discovered in the Lagomorph species *Ochotona princeps* (Weimann et al. 2014), corroborating earlier findings of the baculum in *O. pusilla* by Aksenova & Smirnov (1986) and Erbajeva et al. (2011). These studies show that the baculum might be present in many more taxa than is presently known, however, a baculum is not present in all the species of certain orders, namely Carnivora, Chiroptera, Primates, and Rodentia and is vestigial or absent in felids (Didier 1949; Romer & Parsons 1986; Williams-Ashman 1990; Larivière & Ferguson 2002; Brindle & Ophie 2016).

After Thomas's (1915) pioneering work, many studies described the bacular structure of bats, amongst which some major ones include that of Davis (1947), Hamilton (1949), Krutzsch & Vaughan (1955), Topál (1958), Krutzsch (1959, 1962), Lanza (1959, 1960, 1963, 1970), Didier (1964), Corbet (1964), Brown (1967), Brown et al. (1971), Wassif & Madkour (1972), Wassif et al. (1984), Hill & Harrison (1987), Kitchener & Maharadatunkamsi (1991), Kruskop & Lavrenchenko (2000), Albayrak & Aşan (2001), Benda et al. (2004, 2011), and Rakotondramanana & Goodman (2017).

In India, some of the studies on bacular morphology of bats include those of Bhatnagar (1967), Agrawal & Sinha (1973), Topál (1975), Sinha (1976, 1983), Khajuria (1979, 1980, 1982), Srinivasulu et al. (2010, 2014, 2015, 2018), Kaur et al. (2014, 2017), and Srinivasulu & Srinivasulu (2018).

Bacular morphology is used as a discriminating character for differentiating between different species of bats (Herdina 2014). Studies on the bacular structure of different species of bats have shown the presence of cryptic species among morphologically similar taxa (Krutzsch & Vaughan 1955; Krutzsch 1959; Heller & Volleth 1984; Kitchener et al. 1986; Hill & Harrison 1987; Strelkov 1989; Bates et al. 2006, 2015; Kruskop & Borisenko 2013; Kaur et al. 2014; Goodman et al. 2015; Kruskop 2015; Srinivasulu & Srinivasulu 2018).

India is home to 128 species of bats (Srinivasulu et al. 2020), of which during the last decade we studied 47 species of bats belonging to nine families from peninsular India, Andaman Islands, and Jammu & Kashmir. A comprehensive document on the bacula of bats of India is lacking, hence the present work was planned to fill this lacuna. This work is intended to help as reference material for future bat workers in the region. In this paper, we provide the bacular morphology of 44 species of bats principally found in the Indian subcontinent.

MATERIALS AND METHODS

Male individuals of bats were collected from different parts of Telangana State, Karnataka, Kerala, Tamil Nadu, Maharashtra, Madhya Pradesh, Jammu & Kashmir, Rajasthan and the Andaman Islands after obtaining permissions from the respective forest departments over the last 10 years. Captured bats were handled in strict accordance with good animal practices and according to guidelines of the American Society of Mammalogists (Sikes 2016). Bats were identified following Bates & Harrison (1997) and Srinivasulu et al. (2010). Common names of the species are after Srinivasulu (2018). The voucher specimens were preserved and deposited in the Natural History Museum of Osmania University, Hyderabad, India. From the voucher specimens, the penis was excised and the baculum was extracted following methods outlined by Topál (1958) and Hill & Harrison (1987). The extracted bacula were stained with alizarin red and photographed using a camera mounted on a trinocular microscope. Where possible, photographs of the dorsal, lateral, and ventral aspects of each baculum were taken. The total length of the baculum starting from the basal lobes to the tip of the baculum and breadth of the base of the baculum (where possible) were measured using an oculometer. The stained bacula were then preserved in vials with 100% glycerol.

RESULTS AND DISCUSSION

A total of 47 species of bats belonging to nine families were studied (Table 1). Of these, two species, *Miniopterus fuliginosus* and *M. pusillus,* lack bacula. The bacular structure of *Hipposideros diadema masoni* could not be studied as it is known in India based only on a single female specimen (Srinivasulu et al. 2016).

Table 1. Diversity of bat species studied on mainland India and the Andaman Islands.

Scientific name	Common name
Family Pteropodidae	
Rousettus leschenaultii	Leschenault's Rousette
Pteropus medius	Indian Flying Fox
Pteropus hypomelanus	Variable Flying Fox
Pteropus melanotus	Black-eared Flying Fox
Cynopterus sphinx	Greater Short-nosed Fruit Bat
Cynopterus brachyotis	Lesser Short-nosed Fruit Bat
Eonycteris spelaea	Lesser Dawn Bat
Family Rhinopomatidae	
Rhinopoma hardwickii	Lesser Mouse-tailed Bat
Rhinopoma microphyllum	Greater Mouse-tailed Bat
Family Emballonuridae	
Taphozous longimanus	Long-winged Tomb Bat
Taphozous melanopogon	Black-bearded Tomb Bat
Taphozous nudiventris	Naked-rumped Tomb Bat
Family Megadermatidae	
Lyroderma lyra	Greater False Vampire Bat
Megaderma spasma	Lesser False Vampire Bat
Family Rhinolophidae	
Rhinolophus ferrumequinum	Greater Horseshoe Bat
Rhinolophus andamanensis	Homfray's Horseshoe Bat
Rhinolophus rouxii	Rufous Horseshoe Bat
Rhinolophus pusillus	Least Horseshoe Bat
Rhinolophus lepidus	Blyth's Horseshoe Bat
Rhinolophus lepidus monticola	Montane Horseshoe Bat
Rhinolophus cognatus	Andaman Horseshoe Bat
Rhinolophus beddomei	Lesser Woolly Horseshoe Bat
Family Hipposideridae	
Hipposideros ater	Dusky Roundleaf Bat
Hipposideros durgadasi	Durga Das's Roundleaf Bat
Hipposideros fulvus	Fulvus Roundleaf Bat
Hipposideros pomona	Pomona Roundleaf Bat
Hipposideros gentilis	Andersen's Roundleaf Bat
Hipposideros hypophyllus	Kolar Roundleaf Bat
Hipposideros galeritus	Cantor's Roundleaf Bat
Hipposideros speoris	Schneider's Roundleaf Bat
Hipposideros cf. *grandis*	Grand Roundleaf Bat
Hipposideros lankadiva	Kelaart's Roundleaf Bat
Hipposideros diadema masoni	Diadem Roundleaf Bat
Family Molossidae	
Tadarida aegyptiaca	Egyptian Free-tailed Bat
Family Vespertilionidae	
Myotis blythii	Lesser Myotis
Myotis peytoni	Peyton's Whiskered Myotis
Myotis longipes	Kashmir Cave Myotis
Myotis horsfieldii dryas	Andaman Myotis
Scotophilus heathii	Asiatic Greater Yellow House Bat
Scotophilus kuhlii	Asiatic Lesser Yellow House Bat
Tylonycteris malayana eremtaga	Andaman Greater Bamboo Bat
Pipistrellus javanicus camortae	Camorta Pipistrelle
Pipistrellus coromandra	Indian Pipistrelle
Pipistrellus tenuis	Least Pipistrelle
Pipistrellus ceylonicus	Kelaart's Pipistrelle
Hesperoptenus tickelli	Tickell's Bat
Family Miniopteridae	
Miniopterus fuliginosus	Eastern Long-fingered Bat
Miniopterus pusillus	Small Long-fingered Bat

Family Pteropodidae Gray, 1821

The bacula of seven out of 12 species of fruit bats in India are reported here.

1. *Rousettus leschenaultii* (Desmarest, 1820) Leschenault's Rousette (Image 1.I)

Material examined: NHM.OU.CHI.65d.2015, male, collected from Golconda fort (17.382N and 78.401E), Hyderabad, Telangana State, by C. Srinivasulu and Tariq A. Shah on 27.ix.2015.

The baculum is medium-sized (2.7mm long; 1.1mm broad), flat, and more or less dumb-bell shaped. The proximal end is round and broad. The apical end has two swellings and is equally as broad as the proximal end. Both the apical and the proximal regions of the baculum look raised in the lateral view. The shaft of the baculum is broad and parallel-sided.

Variations: The shape of the baculum reported here from a specimen from the Golconda fort, Telangana State, differs from that described by Agrawal & Sinha (1973) from Satara, Maharashtra. The baculum of the Telangana specimen is broad with both the apical and proximal ends being equally broad. The baculum from Maharashtra (Agrawal & Sinha 1973; Sinha 1976) has an oval-shaped larger base and the shaft narrows toward the distal end, which is smaller than the base.

2. *Pteropus medius* Temminck, 1825 Indian Flying Fox (Image 1.II)

Material examined: NHM.OU.CHI.21.2012,

male, collected from Osmania University (17.422N and 78.530E), Hyderabad, Telangana State by M. Seetharamaraju on 15.ii.2012.

The baculum is medium-sized (2.7mm long, 2.7mm wide), flat, and rectangular. No difference in the dorsal or the ventral surface was observed. The distal end is broad and has a median projection, while the proximal ends are situated apart from each other. Laterally, the baculum has a straight profile.

Variations: The structure of this baculum reported here from a specimen from Osmania University, Hyderabad, Telangana State, differs slightly from that of specimens from Lucknow, Uttar Pradesh and Imphal, Manipur as described by Agrawal & Sinha (1973) and from specimens from Nasirabad and Jodhpur, Rajasthan (Sinha 1976). The baculum in adults is semicircular, and the proximal ends are situated close to each other giving a more rounded appearance with a heart-shaped concavity in the middle. The shape of the baculum in sexually immature individuals has an inverted U-shape with the proximal ends situated far apart from each other (Agrawal & Sinha 1973). The shape of the baculum that was observed by us in our specimen from Telangana with proximal ends situated far apart shows that this is probably a sexually immature specimen.

3. *Pteropus hypomelanus* Temminck, 1853 Variable Flying Fox (Image 1.III)

Material examined: NHM.OU.CHI.133.2014, male, collected from Bahadur Nala (12.071N and 92.741E), near Baratang Island, North & Middle Andaman District, Andaman & Nicobar Islands, by Bhargavi Srinivasulu and C. Srinivasulu on 21.xi.2014.

The baculum is very large (10.0mm long) with a wide, apical portion tapering to a narrower proximal portion. Dorsally, the proximal ends touch each other and have slight swellings resulting in a small concavity at the point of contact. The arms enclose a space that is broad apically and narrowly rounded off proximally. Ventrally, at the base, a concavity is seen.

Variations: The general shape of the baculum reported here from a specimen from Bahadur Nala, South Andaman, Andaman Islands is similar to that described by Lanza (1970) of the nominate form from Ternate Island, Indonesia, although in his description, the proximal ends are almost but not completely touching.

4. *Pteropus melanotus* Blyth, 1863 Black-eared Flying Fox (Image 1.IV)

Material examined: NHM.OU.CHI.192.2015, male, collected from Rutland Island (11.395N and 92.561E), South Andaman District, Andaman & Nicobar Islands, by Asad Gopi and Tauseef Hamid Dar, on 16.xii.2015.

The baculum is very large (9.0mm long), robust, and roughly rectangular with a broad base (6.0mm). The apical portion is broader than the proximal portion with a cavity in the centre which is broad at the apical portion and narrows down to a pointed tip toward the proximal portion. The baculum is concave on the ventral surface.

Remarks: The structure of the baculum of a specimen from Rutland Island, South Andaman, matches the description by Lanza (1970) of that of *Pteropus melanotus tytleri* from the Andaman Islands.

5. *Cynopterus sphinx* (Vahl, 1797) Greater Short-nosed Fruit Bat (Image 1.V)

Material examined: NHM.OU.CHI.10.2012, male, collected from Osmania University (17.422N and 78.530E), Hyderabad, Telangana State, by P. Venkateswarlu, on 02.ii.2012.

The baculum is short (2.0mm long, 1.3mm wide). The base of the baculum is high and broad (1.3mm) and has well-developed shoulders that join medially, into a tall and narrow shaft ending with a narrowly rounded tip. The proximal border of the baculum has uneven edges. The ventral surface of the baculum is concave in appearance.

Remarks: The structure of the baculum of a specimen from Osmania University, Hyderabad, Telangana State, matches the description provided by Bates & Harrison (1997) of the specimen from Haldwani, Uttarakhand, India. It slightly differs from that described by Agrawal & Sinha (1973) from Kolkata, West Bengal, in which the shaft is short and distal end is bulbous.

6. *Cynopterus brachyotis* (Müller, 1838) Lesser Short-nosed Fruit Bat (Image 1.VI)

Material examined: NHM.OU.CHI.121.2015, male, collected from Devpur (12.862N and 92.867E), near Mayabunder, North & Middle Andaman District, Andaman & Nicobar Islands, by C. Srinivasulu and Aditya Srinivasulu, on 19.x.2015.

Only the Andaman population of this species was studied. The baculum is small (1.1mm long). The base is broad with high shoulders. The base then joins medially to continue to a broad shaft, which ends with a broadly rounded tip. The baculum is concave in its ventral aspect.

Variations: In the Andaman populations, we have observed variations; in some, the shaft is much shorter and stouter, and no development of shoulders was observed. A much more detailed study is needed to

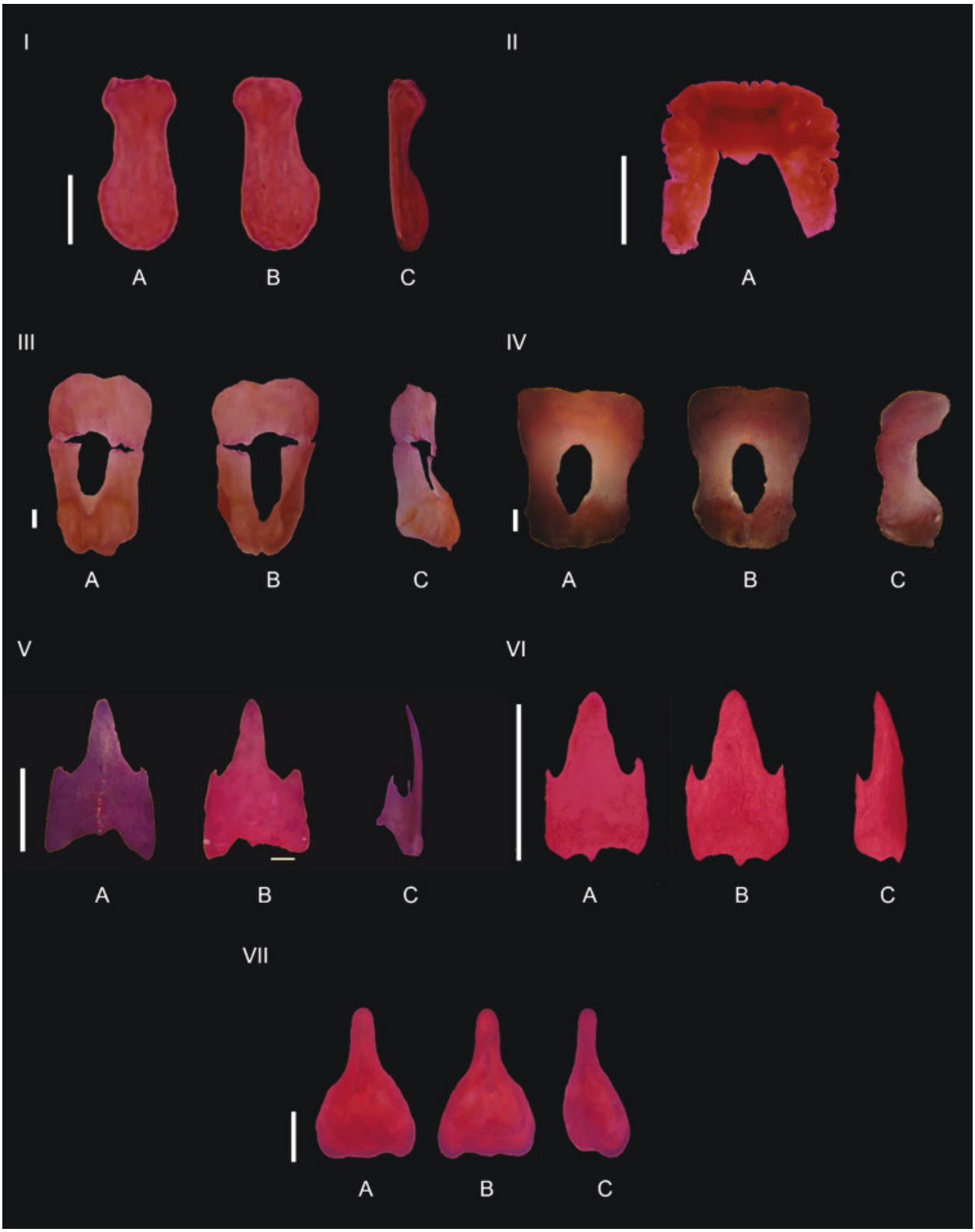

Image 1. Bacula of selected species belonging to the family Pteropodidae in India: I—*Rousettus leschenaultii* | II—*Pteropus medius* | III—*Pteropus hypomelanus* | IV—*Pteropus melanotus* | V—*Cynopterus sphinx* | VI—*Cynopterus brachyotis* | VII—*Eonycteris spelaea*. (Scale: 1mm). A—Dorsal view | B—Ventral view | C—Lateral view.

ascertain the presence of any cryptic species/subspecies among the island forms.

Remarks: The structure of the baculum of a specimen from Devpur, near Mayabunder, Middle Andaman, Andaman Islands, differs in lacking the two projections on either side of the base as described by Bates & Harrison (1997) of specimens from Tamil Nadu, India and Agrawal & Sinha (1973) from Goa, India. We also observed that the shaft of the baculum of this species is broad, and not narrow and tall as in *C. sphinx*.

7. *Eonycteris spelaea* (Dobson, 1871) Lesser Dawn Bat (Image 1.VII)

Material examined: NHM.OU.CHI.41.2012, male, collected from Baratang Island (12.095N and 92.749E), North & Middle Andaman District, Andaman & Nicobar Islands, by Bhargavi Srinivasulu and G. Chethan Kumar, on 04.vii.2012.

The baculum of *Eonycteris spelaea* is being reported for the first time. The baculum of the specimen from the Baratang Island, Andaman Islands, is medium-sized (3.1mm long), with a broad base (2.0mm). The base is slightly notched in the centre on the proximal border. The distal portion has a short shaft ending with a rounded-off tip.

Remarks: The baculum structure of *Eonycteris spelaea* described in the present work differs greatly from that described by Krutzsch (1959 & 2005) from Soka, Bali, Indonesia and from Batu caves, near Kuala Lumpur, West Malaysia respectively. It is for the first time that the baculum of this species is described from India.

Family Rhinopomatidae E. Geoffroy, 1818

The bacula of both species of mouse-tailed bats in India are reported here.

8. *Rhinopoma hardwickii* (Gray, 1831) Lesser Mouse-tailed Bat (Image 2.I)

Material examined: NHM.OU.CHI.16.2015, male, collected from Mukta Bhai (20.583N and 79.506E), Doma, Chimur, Chandrapur District, Maharashtra, by Tariq A. Shah and G. Devender, on 27.ii.2015.

The baculum is very small (1.0mm long), with a unique shape. The proximal portion (0.3mm wide) has two arms which are placed widely from each other. In between the two arms of the proximal portion, a small process extends downward, which sometimes gets easily broken leaving behind a tiny projection that can be seen on the lateral aspect. The arms of the proximal portion are broadly rounded off. The shaft of the baculum is thick and parallel-sided. The shaft starts from the mid-portion of the base of the baculum and ends with a broadly rounded tip.

Remarks: The structure of the baculum of the specimen from Chimur, near Chandrapur, Maharashtra is slightly similar to that of specimens from Solayan, Nagaur District, Rajasthan (Sinha 1976). The baculum of the present specimen differs in having a broad base with arms extending outward and a shorter parallel-sided shaft.

9. *Rhinopoma microphyllum* (Brünnich, 1792) Greater Mouse-tailed Bat (Image 2.II)

Material examined: NHM.OU.CHI.138h.2015, male, collected from Juna Mahal (23.826N and 73.714E), Dungarpur District, Rajasthan, by Tariq A. Shah, on 29.x.2015.

The baculum is very small (0.7mm long) and triangular. It is concave on the ventral aspect. Two projections are observed on either side of the base (0.3mm wide) leading to the formation of a concavity in the mid-portion of the base of the baculum. The base extends into a parallel-sided shaft, which narrows in a rounded-off tip toward the apex. In the lateral aspect, the baculum shows a straight profile.

Remarks: The baculum of the specimen from Juna Mahal, Dungarpur, Rajasthan resembles that described by Sinha (1976) from Jodhpur, Rajasthan. The structure of the baculum of the specimen from Delhi (Agrawal & Sinha 1973) differs in structure from that of the Rajasthan specimens examined during the present study and also by Sinha (1976). Further studies are needed to ascertain any cryptic diversity among populations of *R. microphyllum* in India.

Family Emballonuridae Gervais, 1855

The bacula of three out of six species of tomb bats in India are reported here.

10. *Taphozous longimanus* (Hardwicke, 1825) Long-winged Tomb Bat (Image 3.I)

Material examined: NHM.OU.CHI.5.2015, male, collected from Old High Court (21.153N and 79.071E), Civil Lines, Nagpur, Nagpur District, Maharashtra, by G. Devender and Tariq A. Shah, on 24.ii.2015.

The baculum is very small (0.4mm long), flat, blunt, and irregular in shape. The proximal end is broad and the distal end is somewhat broadly pointed. The distal end shows a slight concavity on the ventral surface.

Remarks: The baculum structure of the specimen from Nagpur, Maharashtra, is similar in structure with

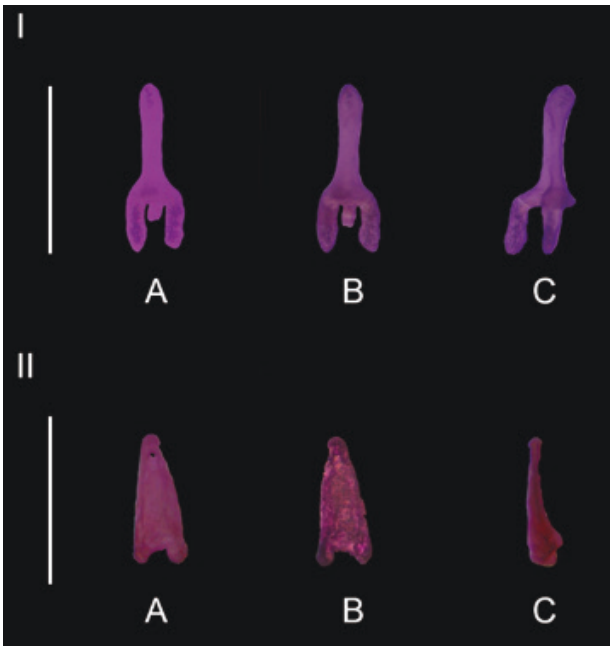

Image 2. Bacula of species belonging to the family Rhinopomatidae in India: I—*Rhinopoma hardwickii* | II—*Rhinopoma microphyllum* (Scale: 1mm). A—Dorsal view | B—Ventral view | C—Lateral view.

that described by Sinha (1976) from Kota, Rajasthan.

11. *Taphozous melanopogon* Temminck, 1841 Black-bearded Tomb Bat (Image 3.II)

Material examined: NHM.OU.CHI.18.2015, male, collected from Ambai-Nimbai (19.783N and 79.577E), Chimur, Chandrapur District, Maharashtra, by G. Devender and Tariq A. Shah, on 27.ii.2015.

The baculum is very small (1.0mm long), with a slightly broad base and a knob-like tip. No noticeable difference between the proximal and apical portions is observed. Additionally, there is no demarcation between the ventral and dorsal surfaces, as it is cylindrical.

Remarks: The baculum structure of the specimen from Chimur, Chandrapur, Maharashtra, is similar to that described by Sinha (1983) from Patna, Bihar. Another baculum of this species was described from Tennaserim, Myanmar (=Burma) (Agrawal & Sinha 1973), where the baculum was also cylindrical and knob-like, similar to that described by Sinha (1983) and that observed in the present specimen. The Tennaserim baculum had a swollen distal end with a crescent-shaped notch at the tip.

12. *Taphozous nudiventris* (Cretzschmar, 1830-31) Naked-rumped Tomb Bat (Image 3.III)

Material examined: NHM.OU.CHI.65f.2015, male, collected from Golconda Fort (17.382N and 78.401 E), Hyderabad, Telangana State, by C. Srinivasulu and Aditya Srinivasulu, on 27.ix.2015.

The baculum is very small (0.5mm long) and resembles the shape of a shoe. The base of the baculum is broader than the apex and continues into a parallel-sided straight shaft which becomes narrower and pointed near the apex. In the lateral aspect, a slight concavity is seen just above the base rendering the dorsal aspect of the baculum near the base to be slightly curved to the outside.

Remarks: The baculum structure of the specimen from the Golconda Fort, Telangana State, differs from that described by Sinha (1976) from Kota, Rajasthan, in which the baculum was described to be lingulate in structure with a narrow and concave base.

Family Megadermatidae H. Allen, 1864

The bacula of both the species of false vampire bats in India are reported here.

13. *Lyroderma lyra* E. (Geoffroy, 1810) Greater False Vampire Bat (Image 4.I)

Material examined: NHM.OU.CHI.12.2014, male, collected from Naramvarigudem (17.250N and 81.068E), Bhadradri Kothagudem district, Telangana State, by G. Devender and K. Krishna Prasad, on 25.i.2014.

The baculum is very small (0.5mm long), with two semi-curved, concave, small, simple, thin bones that are arranged beside one another without any medial attachment inside the penis. One bone has a very slightly expanded base and narrowly pointed apex, while the other has a wavy lateral border and has the proximal and apical portions narrowly rounded off.

Remarks: The bacular structure of the specimen from Naramvarigudem, Khammam, Telangana State matches that described by Sinha (1976) from Ranthambore, Sawai Madhopur, Rajasthan.

14. *Megaderma spasma* (Linnaeus, 1758) Lesser False Vampire Bat (Image 4.II)

Material examined: NHM.OU.CHI.49.2016, male, collected from 10th Block (11.933N and 75.795E), Forest Quarters, Aralam Wildlife Sanctuary, Kannur district, Kerala, by Bhargavi Srinivasulu and G. Devender, on 13.x.2016.

The baculum is small (1.3mm long), and resembles a tuning fork. The thick base has a bone extending down from it in the form of a stalk. The shaft is made of two arms which extend toward the distal end and have narrowly rounded off tips. The arms converge as

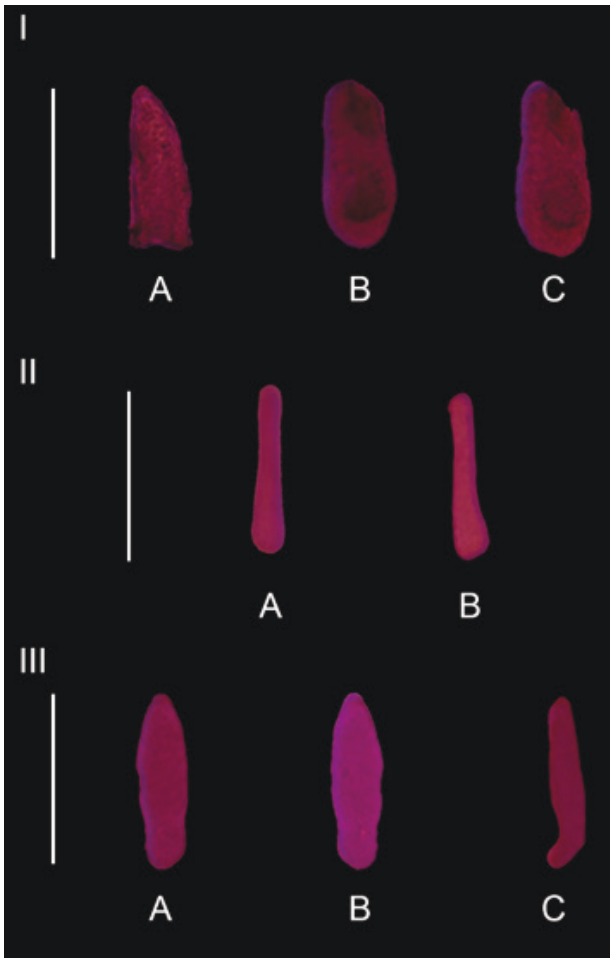

Image 3. Bacula of selected species belonging to the family Emballonuridae in India: I—*Taphozous longimanus* | II—*Taphozous melanopogon* | III—*Taphozous nudiventris* (Scale: I & III 0.5mm; II 1mm). A—Dorsal view | B—Ventral view | C—Lateral view.

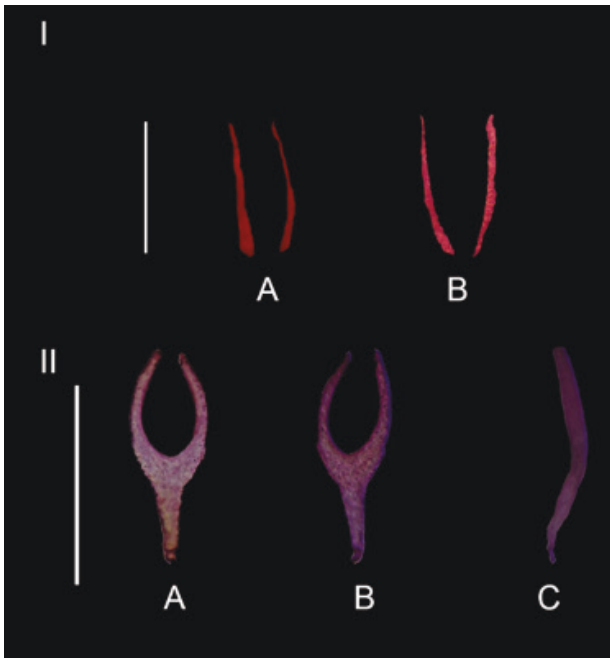

Image 4. Bacula of species belonging to the family Megadermatidae in India: I—*Lyroderma lyra* | II—*Megaderma spasma* (Scale: I 0.5mm; II 1mm). A—Dorsal view | B—Ventral view | C—Lateral view.

they reach the apical portion to form a 'U' shape. When observed in the lateral aspect, the baculum shows concavity on the ventral side.

Remarks: The baculum structure of the specimen from Aralam Wildlife Sanctuary, Kerala matches that described by Bates & Harrison (1997) from Pilikutthuwa, Sri Lanka and Sinha (1983) from India (exact locality not known).

Family Rhinolophidae Lacépède, 1799

The bacula of seven out of 19 species of horseshoe bats in India are reported here.

15. *Rhinolophus ferrumequinum* (Schreber, 1774) Greater Horseshoe Bat (Image 5.I)

Material examined: NHM.OU.CHI.27a.2016, male, collected from Bumzov Cave (33.769N and 75.213E), Martand, Anantnag District, Jammu and Kashmir, by Tariq A. Shah, on 30.iv.2016.

The baculum is large (4.7mm long), and spindle-shaped. The base is broad (1.5mm) and has a deep concavity on the ventral surface. The shaft is thick, initially near the base it is parallel-sided, a bit further up it expands into a spindle shape, and later converges into a narrowly pointed tip.

Remarks: The baculum structure of the specimen from Bumzov cave, Jammu & Kashmir matches that described by Topál (1975) from Bumzov cave, Jammu & Kashmir, and Bates & Harrison (1997) from Abbottabad, Pakistan.

16. *Rhinolophus andamanensis* (Dobson, 1872) Homfray's Horseshoe Bat (Image 5.II, 5.III)

Materials examined: NHM.OU.CHI.72.2014, male, collected from Baratang Island (12.095N and 92.749E), North & Middle Andaman District, Andaman & Nicobar Islands, by Chelmala Srinivasulu and Asad Gopi, on 15.x.2014; NHM.OU.CHI.31.2012, male, collected from Baratang Island (12.095N and 92.749E), North & Middle Andaman District, Andaman & Nicobar Islands, by Bhargavi Srinivasulu and G. Chethan Kumar, on 04.vii.2012.

The baculum (typical form, Image 5.II) is medium-sized (3.1mm long). The base is broad (1.0mm), four-pronged and has a V-shaped fissure that appears deep

on the ventral aspect and shallow on the dorsal aspect. The broad base extends to about 25% of the length of the baculum and then narrows into a thin parallel-sided long shaft, which curves slightly near the apical region.

Variation: The second type of baculum (Image 5.III) has also been observed among individuals of the same population of this species. The baculum is medium-sized (2.2mm). The base is small and three-pronged with a small concavity on the ventral aspect. The base extends into a thin, long, parallel-sided shaft which ends in a narrowly rounded off tip. In the lateral aspect, the shaft shows slight curvature toward the apical region (Srinivasulu et al. 2019).

Remarks: The structure of the baculum of the specimen from Baratang Island, Andaman Islands, shows slight similarity to that described by Sinha (1983) from North Andaman, Andaman Islands.

17. *Rhinolophus rouxii* (Temminck, 1835) Rufous Horseshoe Bat (Image 5.IV)

Material examined: NHM.OU.CHI.15.2017, male, collected from Karagal Village (14.1897N and 74.8138E), Shivamogga District, Karnataka, by Bhargavi Srinivasulu and G. Devender, on 15.v.2017; NHM.OU.CHI.66.2016, male, collected from Kerala Agriculture University – Periyar Hostel (10.5502N and 76.27837E), Vellanikkara, Thrissur District, Kerala, by Bhargavi Srinivasulu and Tariq A Shah, on 31.x.2016.

The baculum is medium-sized (2.3mm long), with a long, thin shaft and expanded base. The expanded base has a deep sulcus on the ventral aspect. The middle portion of the base has an uneven border and the sides are slightly longer than the middle portion. Apically the shaft is narrowly rounded-off. Laterally it has a slight curvature starting from the distal end to the base. The base of the baculum shows a more rounded appearance laterally. Ventral basal emarginations are deeper than the dorsal ones. The ventral surface shows a wide median depression. The tip is acutely pointed when seen laterally.

Remarks: The structure of the baculum of the specimen from Kargal, Shivamogga, Karnataka matches that described by Topál (1975) from Udaygiri, Odisha, and Mahabaleshwar, Maharashtra, and Bates & Harrison (1997) from Talewadi, Karnataka. The baculum of the present specimen differs slightly in having a slight curvature of the shaft toward the apical region visible in the lateral aspect. The taxon *R. indorouxii* Chattopadhyay et al. (2012) was described as separate from *R. rouxii* based on echolocation calls and cytb sequences, however, the *nomen* is treated as invalid by Hutson et al. (2019). The baculum structure of the populations described as *R. indorouxii* (Image 5.V; here treated as *R.* cf. *rouxii*) is roughly similar to that of *R. rouxii* and differs slightly in having a small, not so rounded base. The shaft shows slight curvature and the tip of the shaft is slanting and flat.

18. *Rhinolophus pusillus* (Temminck, 1834) Least Horseshoe Bat (Image 5.VI)

Material examined: NHM.OU.CHI.14.2017, male, collected from Karagal Village (14.1897N and 74.8138E), Shivamogga District, Karnataka, by Bhargavi Srinivasulu and G. Devender, on 15.v.2017.

The baculum of the specimen from Kargal, Shivamogga, Karnataka, is medium-sized (3.5mm long), with a deeply forked broad base (1.0mm). The shaft is long, thin, and cylindrical, ending in a narrowly rounded-off tip. The tip of the baculum shows a slight flattening at an angle. On the lateral aspect, a pronounced curvature is observed in the middle region of the shaft.

Remarks: This is the first time that the baculum of this species from India is described.

19. *Rhinolophus lepidus* (Blyth, 1844) Blyth's Horseshoe Bat (Image 5.VII)

Material examined: NHM.OU.CHI.28.2015, male, collected from Kandri Mine Cave (21.412N and 79.268E), Nagpur, Nagpur district, Maharashtra, by G. Devender and Tariq A. Shah, on 03.iii.2015.

The baculum is medium-sized (3.5mm long), with a slightly forked broad base. The base (0.8mm) shows the presence of a thin sulcus on the ventral surface. The shaft is narrow, long, cylindrical, ending in narrowly pointed tip. The lateral profile of the baculum is straight.

Remarks: The structure of the baculum of the specimen from Nagpur, Maharashtra, matches that described by Sinha (1976) from Ranthambore, Sawai Madhopur, Rajasthan.

19a. *Rhinolophus lepidus monticola* Andersen, 1905 Montane Horseshoe Bat (Image 5.VIII)

Material examined: NHM.OU.CHI.19.2016, male, collected from Bumzov Cave (33.769N and 75.213E), Martand, Anantnag District, Jammu and Kashmir, by Tariq A. Shah, on 30.iv.2016.

The baculum of the specimen from Anantnag, Jammu & Kashmir is large (4.5mm long), longer than the nominate subspecies. It has a broad base (1.0mm) with a shallow proximal emargination. The emargination is shallower than that of *R. lepidus*. The base has a thin sulcus on the ventral surface, which extends into a

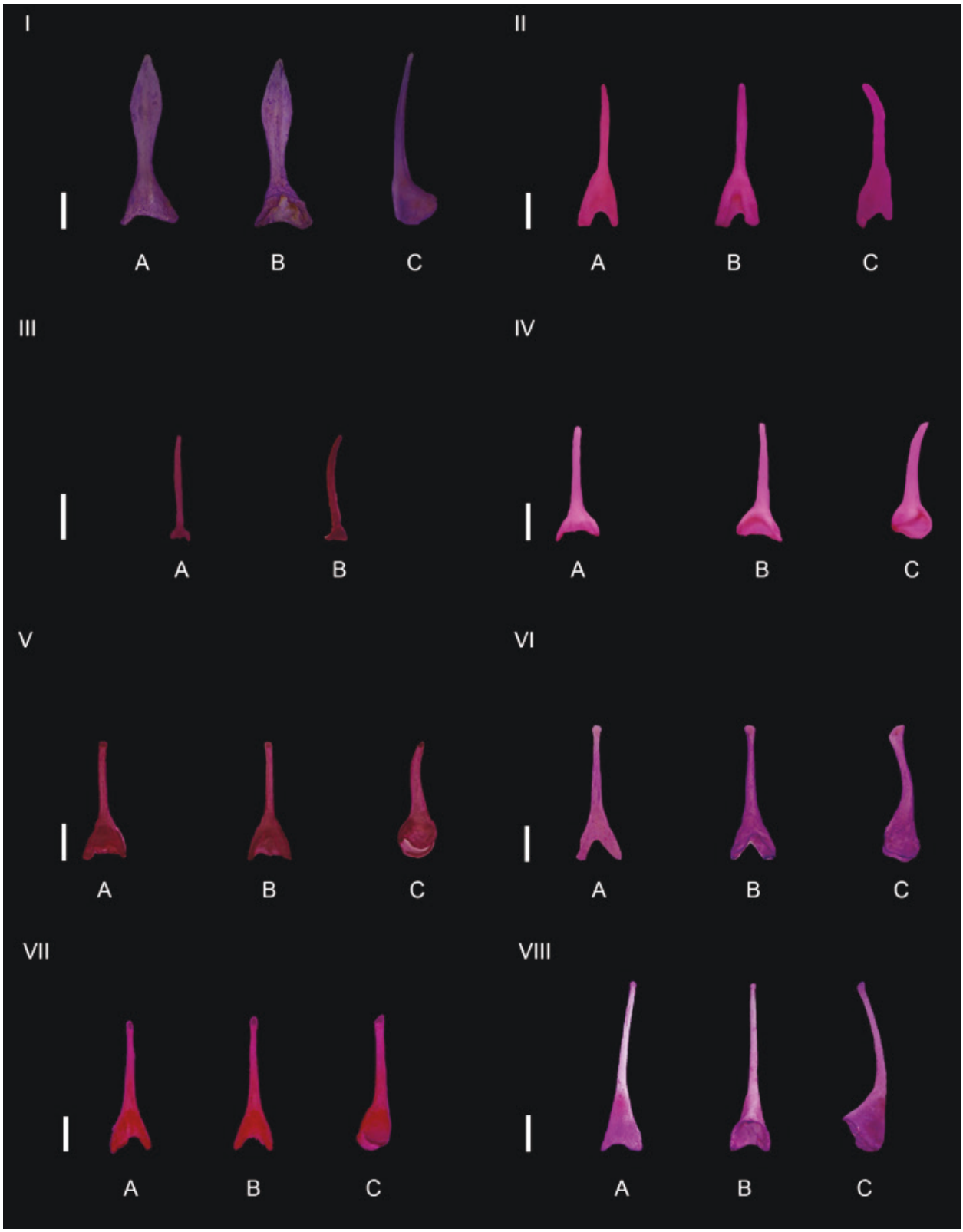

Image 5. Bacula of selected species belonging to the family Rhinolophidae (in part) in India: I—*Rhinolophus ferrumequinum* | II—*Rhinolophus andamanensis* (from Baratang Island) | III—*Rhinolophus andamanensis* (from Baratang Island) | IV—*Rhinolophus rouxii* | V—*Rhinolophus* cf. *rouxii* | VI—*Rhinolophus pusillus* | VII—*Rhinolophus lepidus* | VIII—*Rhinolophus lepidus monticola* (Scale: 1mm). A—Dorsal view | B—Ventral view | C—Lateral view.

concavity. The shaft is thin, long, and cylindrical ending in a tapered and pointed tip. In the lateral profile, a pronounced curvature starting from just above the broad base to the tip is observed.

Remarks: This is the first time that the baculum of this subspecies is described.

20. *Rhinolophus cognatus* (Andersen, 1906) Andaman Horseshoe Bat (Image 6.I, 6.II)

Materials examined: NHM.OU.CHI.94.2015 male, collected from Baratang Island (12.095N and 92.749E), North & Middle Andaman District, Andaman & Nicobar Islands, by C. Srinivasulu and Aditya Srinivasulu, on 14.x.2015; NHM.OU.CHI.127.2014, male, collected from Interview Island (12.888N and 92.687E), North & Middle Andaman District, Andaman & Nicobar Islands, by Asad Gopi and Tauseef Hamid Dar, on 12.xi.2014.

The baculum of the specimen from Baratang Island is medium-sized (3.0mm long), with a long, thin shaft, and thick and bulbous tip. The base is wide (0.7mm) with a distinct deep concavity very clearly visible in the ventral aspect. In the dorsal aspect, a slight sulcus is seen on the base. The shaft shows a distinct curvature in the lateral aspect, just above the base.

Variation: In a population of this species on Interview Island, the baculum structure, although quite similar, shows slight variations. The baculum is medium-sized (2.0mm long), has a deep sulcus at the base and a long shaft ending with a bulbous tip. The baculum is straight in lateral profile.

Remarks: This is the first time that the baculum of this Indian endemic species is described.

21. *Rhinolophus beddomei* (Andersen, 1905) Lesser Woolly Horseshoe Bat (Image 6.III)

Material examined: NHM.OU.CHI.10.2013, male, collected from Shivagange (13.169N and 77.222E), Bengaluru Rural District, Karnataka, by Bhargavi Srinivasulu and Harpreet Kaur, on 13.xi.2013.

The baculum of the specimen from Shivagange, Karnataka, is large (5.8mm long) and is comprised of a thick and triangular base and a narrow distal shaft. The margin of the broad base (2.2mm) has a deep sulcus dorsally and a deep groove ventrally. The shaft is long and ends with a rounded tip. The basal processes are shorter than the shaft and are well separated by the deep groove on the base.

Remarks: The structure of the baculum of the specimen from Shivagange, Bengaluru rural, Karnataka, matches that described by Srinivasulu et al. (2015) from Sandur, Bellary district, Karnataka.

Family Hipposideridae Lydekker, 1891

The bacula of 10 out of 16 species of roundleaf bats in India are reported here.

22. *Hipposideros ater* Templeton, 1848 Dusky Roundleaf Bat (Image 7.I)

Material examined: NHM.OU.CHI.9.2018, male, collected from Navarkulam (11.9614N and 79.8059E), Pondicherry, Tamil Nadu, by Tariq A. Shah, on 01.vii.2018.

The baculum is small (1.6mm long). The base is small, with a slight concavity in the middle. The shaft is long and cylindrical and tapers into a narrowly pointed tip. A slight curvature starting from about one quarter the length of the shaft to the tip is observed in the lateral aspect.

Remarks: The structure of the baculum of the specimen from Navarkulam, Pondicherry, matches that described by Topál (1975) from Konark, Odisha.

23. *Hipposideros durgadasi* (Khajuria, 1970) Durga Das's Roundleaf Bat (Image 7.II)

Material examined: NHM.OU.CHI.28.2014, male, collected from Therahalli (13.133N and 78.095E), Kolar district, Karnataka, by Harpreet Kaur and Bhargavi Srinivasulu, on 13.v.2014.

The baculum is small (1.5mm long), with a distinct 'C' shape in the lateral aspect. The base of the baculum is squarish, simple, and the shaft gradually tapers towards the pointed tip. On the dorsal aspect, a conspicuous constriction is seen just above the base.

Remarks: The structure of the baculum of the specimen from Hanumanahalli, Kolar district, Karnataka, matches that described by Topál (1975) from Gwarighat, Madhya Pradesh.

24. *Hipposideros fulvus* (Gray, 1838) Fulvus Roundleaf Bat (Image 7.III)

Material examined: NHM.OU.CHI.9.2014, male, collected from Naramvarigudem (17.250N and 81.068E), Bhadradri Kothagudem District, Telangana State, by G. Devender and K. Krishna Prasad, on 25.i.2014.

The baculum is small (1.8mm long), with a thick base and a long slender shaft. The base is small and has no appearance of any concavity. The shaft is long, slender, showing slight curvature along the length and tapers to a pointed tip. In the lateral view, a slight curvature of the shaft is clearly visible.

Remarks: The structure of the baculum of the specimen from Naramvarigudem, Bhadradri Kothagudem district, Telangana State matches that described by Topál (1975) from Bhaja, Maharashtra; from Jodhpur,

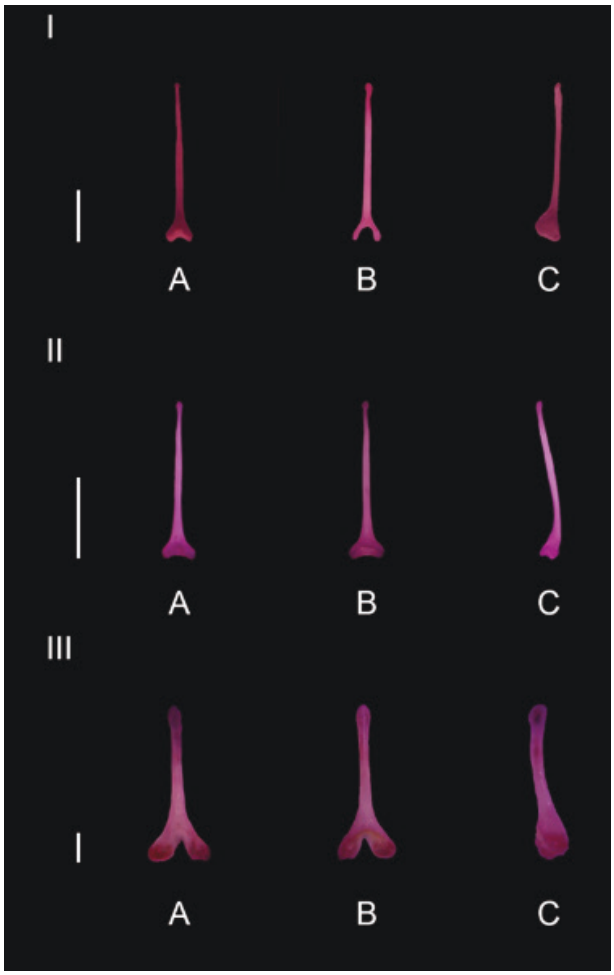

Image 6. Bacula of selected species belonging to the family Rhinolophidae (in part) in India: I—*Rhinolophus cognatus* (from Interview Island) | II—*Rhinolophus cognatus* (from Baratang Island) | III—*Rhinolophus beddomei* (Scale: 1mm). A—Dorsal view | B—Ventral view | C—Lateral view.

Rajasthan described by Sinha (1976) and that described by Bates & Harrison (1997) from Sri Lanka.

25. *Hipposideros pomona* Andersen, 1918 Pomona Roundleaf Bat (Image 7.IV)

Material examined: NHM.OU.CHI.2.2018, male, collected from Ranipuram (12.4262N and 75.3623E), Kasaragod District, Kerala, by Sreehari Raman, on 25.xi.2017.

The baculum of the specimen from Ranipuram, Kasaragod district, Kerala, is small (1.7mm long), with a thick base and a bifid tip. The base is thick with a small concavity in the middle. The shaft of the baculum is long, slender, straight-sided, and ends with a bifid apical portion.

Remarks: The strucutre of the baculum of the specimen from Ranipuram, Kerala matches that described by Srinivasulu & Srinivasulu (2018) based on a historic specimen collected from Travancore, southern India.

26. *Hipposideros gentilis* Andersen, 1918 Andersen's Roundleaf Bat (Image 7.V)

Material examined: NHM.OU.CHI.135.2014, male, collected from Baratang Island (12.095N and 92.749E), North & Middle Andaman District, Andaman & Nicobar Islands, by Tauseef Hamid Dar and Asad Gopi, on 22.xi.2014.

The baculum is very small (0.6mm long), simple, tapering gradually to a tip.

Remarks: The structure of the baculum of the specimen from Baratang Island, Andaman Islands, matches that of *H. pomona* described by Douangboubpha et al. (2010) from Thailand and Zubaid & Davison (1987) from Peninsular Malaysia. A slight variation in the baculum structure was observed in some populations, in which the baculum (0.5mm) shows a rounded base with a slight concavity near the apical region, and ends with a squarish tip.

27. *Hipposideros hypophyllus* Kock & Bhat, 1994 Kolar Roundleaf Bat (Image 7.VI)

Material examined: NHM.OU.CHI.19.2014, male, collected from Hanumanahalli (13.158N and 78.291E), Kolar District, Karnataka, by C. Srinivasulu and Aditya Srinivasulu, on 12.v.2014.

The baculum is medium-sized (2.5mm long), straight-sided, and a slightly round and broad base. There is a prominent concavity present at the base ventrally. The shaft of the baculum is long and gradually tapers into a bifid distal end. When viewed laterally, the tip appears bulb-like and the base is sharply angulated.

28. *Hipposideros galeritus* (Cantor, 1846) Cantor's Roundleaf Bat (Image 8.I)

Material examined: NHM.OU.CHI.35.2014, male, collected from Shivagange (13.169N and 77.222E), Bengaluru Rural District, Karnataka, by Bhargavi Srinivasulu and Harpreet Kaur, on 16.v.2014.

The baculum is very small (0.7mm long), with a broad base, gradually tapering shaft and a blunt tip. There is a faint concavity present near the base on the ventral aspect. In the lateral view, the shaft is faintly curved.

Remarks: The structure of the baculum of the specimen from Shivagange, Karnataka matches that described by Topál (1975) from Ajanta, Maharashtra.

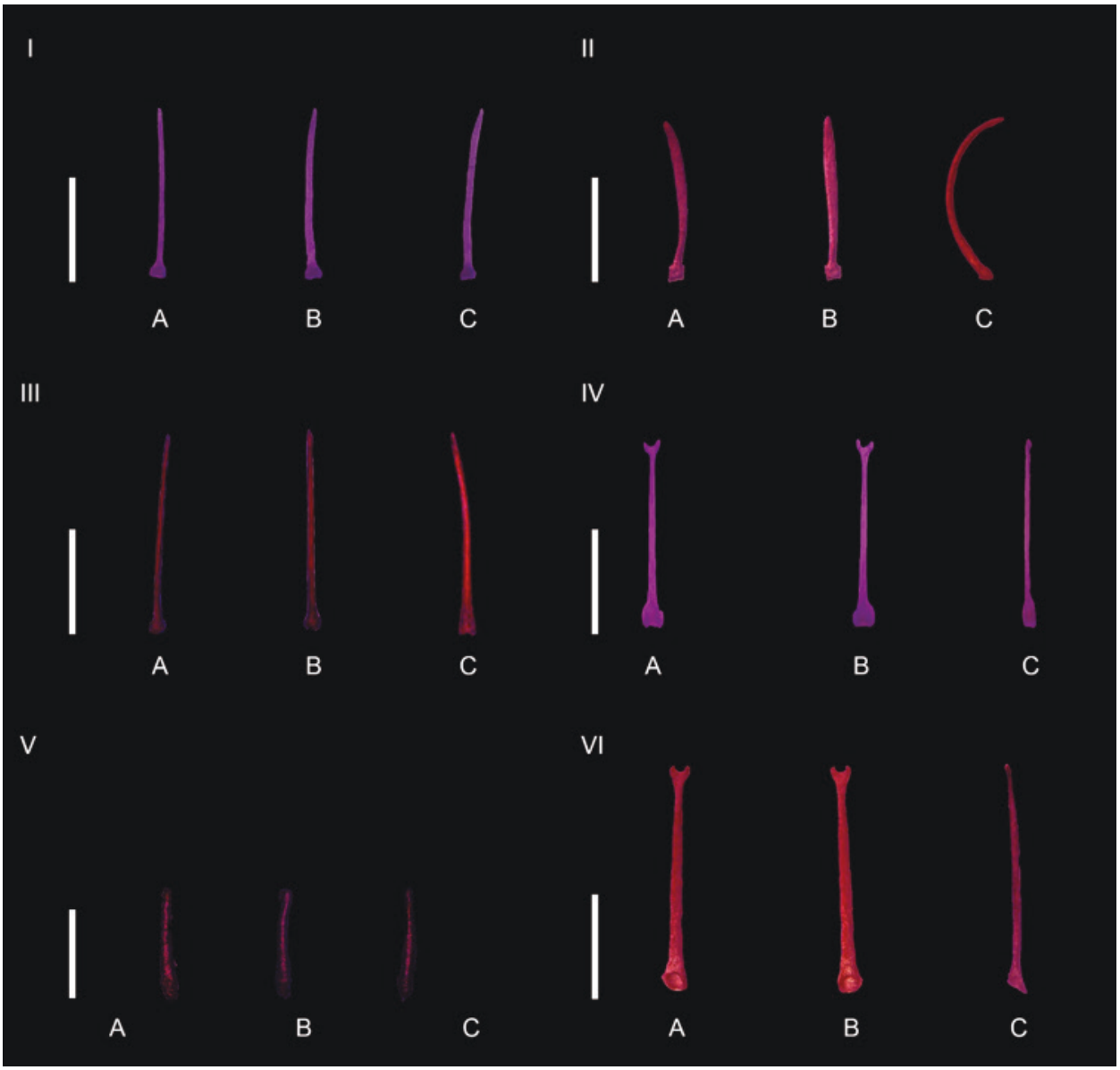

Image 7. Bacula of selected species belonging to the family Hipposideridae (in part) in India: I—*Hipposideros ater* | II—*Hipposideros durgadasi* | III—*Hipposideros fulvus* | IV—*Hipposideros pomona* | V—*Hipposideros gentilis* | VI—*Hipposideros hypophyllus* (Scale: V 0.5mm; Scale: I–IV & VI 1mm). A—Dorsal view | B—Ventral view | C—Lateral view.

29. *Hipposideros speoris* (Schneider, 1800) Schneider's Roundleaf Bat (Image 8.II)

Material examined: NHM.OU.CHI.32.2013, male, collected from Hanumanahalli (13.158N and 78.291E), Kolar District, Karnataka, by G. Devender and Tariq A. Shah, on 14.xii.2013.

The baculum is very small (0.5mm long), with a slightly expanded base, a straight shaft, and a notched, broad tip. Laterally, it shows the presence of a slight curvature of the shaft from the base to the apical region.

Remarks: The structure of the baculum of the specimen from Hanumanahalli, Karnataka matches that described by Topál (1975) from Elephanta, Maharashtra.

30. *Hipposideros* cf. *grandis* (G.M. Allen, 1934) Grand Roundleaf Bat (Image 8.III)

Material examined: NHM.OU.CHI.177.2015, male, collected from V.K. Pur (10.726N and 92.576E), Little Andaman, Andaman & Nicobar Islands, by Asad Gopi and Tauseef Hamid Dar, on 05.xii.2015.

The baculum is small (1.2mm long), with a roughly U-shaped structure. The apical processes are long with lateral thickenings and converge toward the apex. The tips are not in contact with each other. The outer margins

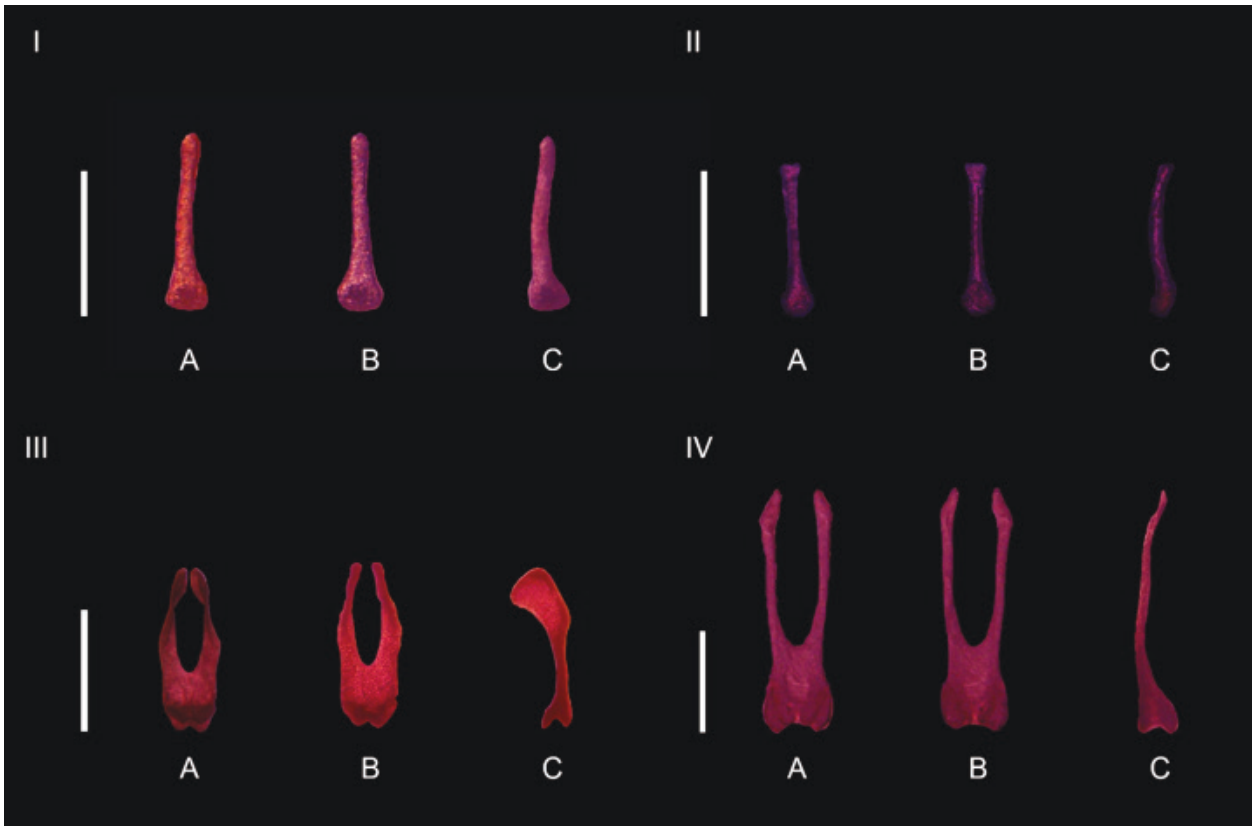

Image 8. Bacula of selected species belonging to the family Hipposideridae (in part) in India: I—*Hipposideros galeritus* | II—*Hipposideros speoris* | III—*Hipposideros* cf. *grandis* | IV—*Hipposideros lankadiva* (Scale: I & II 0.5mm; III & IV 1mm). A—Dorsal view | B—Ventral view | C—Lateral view.

of the apical process are projecting. The proximal end is grooved in the middle, and a concavity is present at the base of the proximal end.

Remarks: The baculum of the specimen from Little Andaman, Andaman Islands matches that described by Agrawal & Sinha (1973), as *Hipposideros larvatus grandis*, from Prome, Myanmar (=Burma); however, a slight difference is observed. Agrawal & Sinha (1973) mention that the arms are narrower in the middle than at the apex, however in the baculum of the present specimen the arms narrow toward the apex. This is the first time that the baculum of this species from India is described.

31. *Hipposideros lankadiva* (Kelaart, 1850) Kelaart's Roundleaf Bat (Image 8.IV)

Material examined: NHM.OU.CHI.59.2015, male, collected from Chikatimori (19.11N and 79.09E), Maliyal, Jannaram, Mancherial District, Telangana State, by G. Devender and G. Chethan Kumar, on 25.ix.2015.

The baculum is medium-sized (2.4mm long), with two apical processes extending from the base. The baculum is longer than broad and slender in appearance. The basal portion of the baculum is broad, with a small concavity in the middle. From the base, the broad shaft extends to 1/3rd the length of the baculum after which two apical processes arise from the broad shaft. These are thin and tall and run parallel to each other. Toward the apical portion, they slightly bend toward each other. The tips of the apical processes are narrowly rounded off. Laterally, the apical processes exhibit uneven borders and a pointed tip and a gentle bend toward the forked base.

Remarks: The structure of the baculum of the specimen from Jannaram, Mancherial district, Telangana State matches that described by Agrawal & Sinha (1973) from Garo Hills, Meghalaya.

Family Molossidae Gervais, 1856

The baculum of one out of three species of free-tailed bats in India is reported here.

32. *Tadarida aegyptiaca* (E. Geoffroy, 1818) Egyptian Free-tailed Bat (Image 9)

Material examined: NHM.OU.CHI.45.2014, male, collected from Shiva Temple (15.317N and 76.464E),

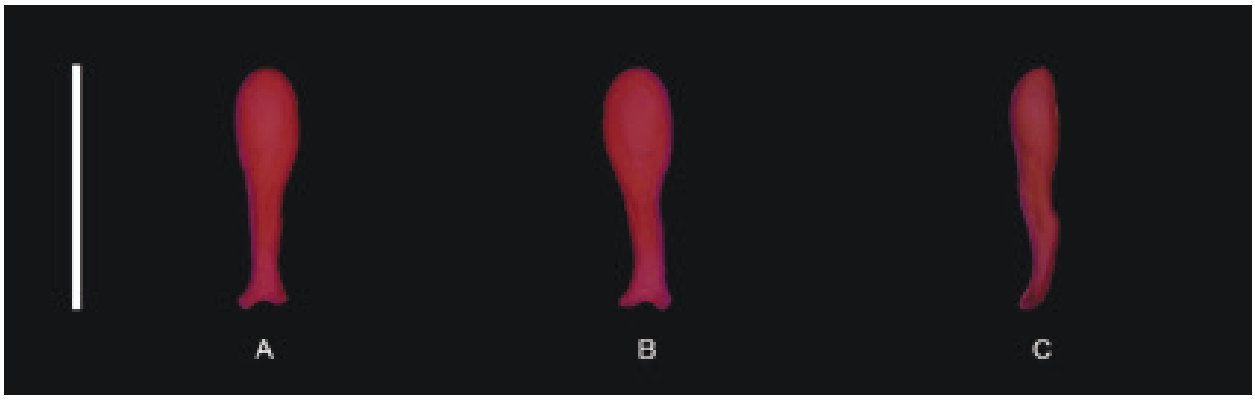

Image 9. Bacula of selected species belonging to the family Molossidae (*Tadarida aegyptiaca*) in India (Scale: 0.5mm). A—Dorsal view | B—Ventral view | C—Lateral view.

Hampi, Bellary District, Karnataka, by Tariq A. Shah and C. Srinivasulu, on 19.v.2014.

The baculum is very small (0.5mm long). The base is small and has a concavity in the middle. It continues into a parallel-sided thick shaft, which expands into a bulbous apical region.

Remarks: The structure of the baculum of the specimen from Hampi, Karnataka, differed from that described by Agrawal & Sinha (1973) from Alwar, Rajasthan, in having a distinct shaft ending with a bulbous apical region, however, it matches that described by Sinha (1976) from Kota, Rajasthan.

Family Vespertilionidae Gray, 1821

The bacula of 12 out of 65 species of evening bats in India are reported here.

33. *Myotis blythii* Tomes, 1857 Lesser Myotis (Image 10.I)

Material examined: NHM.OU.CHI.20.2016, male, collected from Bumzov Cave (33.769N and 75.213E), Martand, Anantnag District, Jammu and Kashmir, by Tariq A. Shah, on 30.iv.2016.

The baculum is very small (0.9mm long), broad (0.6mm) and triangular. On the dorsal surface, a small knob-like projection is seen medially on the base of the baculum. The baculum is concave on the ventral surface. The shaft is broad and parallel-sided, narrowing slightly toward the apical region and ends with a broadly rounded tip. A faint ridge is seen connecting the knob-like projection on the base to the tip of the baculum.

Remarks: The structure of the baculum of the specimen from Bumzov cave, Jammu & Kashmir matches that described by Albayrak & Aşan (2001) from Turkey.

34. *Myotis peytoni* Wroughton & Ryley, 1913 Peyton's Whiskered Myotis (Image 10.II)

Material examined: NHM.OU.CHI.06.2017, male, collected from Makuta (12.077N and 75.725E), Kodagu district, Karnataka, by Bhargavi Srinivasulu and G. Devender, on 07.v.2017.

The baculum of the specimen from southern Karnataka is very small (0.8mm long), broad (0.5mm) and triangular. The ventral surface is concave and the dorsal surface is uneven in texture. The mid-point of the base is slightly raised on the dorsal surface. The base extends in the form of a broad, parallel-sided shaft which joins roughly in a triangular shape at the apical region and ends in a rounded tip. The proximal border is uneven in nature. Laterally, a concavity is observed on the ventral surface to give an appearance of a boat shape to the baculum.

Remarks: This is the first time that the baculum of this Indian endemic species is described.

35. *Myotis longipes* Dobson, 1873 Kashmir Cave Myotis (Image 10.III)

Material examined: NHM.OU.CHI.24.2016, male, collected from Bumzov Cave (33.769N and 75.213E), Martand, Anantnag District, Jammu and Kashmir, by Tariq A. Shah, on 30.iv.2016.

The baculum of the specimen from Bumzov Cave, Jammu & Kashmir is very small (0.4mm long) and flat. It is distinctly shaped not being typically 'triangular' as in other species of *Myotis* studied during the present study. The base is wide and has a slight concavity in the middle. The base extends onto a parallel-sided tall shaft, which ends in a narrowly pointed tip.

Remarks: The bacular structure of the specimen from Jammu and Kashmir roughly matches with that provided by Hanak and Gaisler (1969) from Afghanistan.

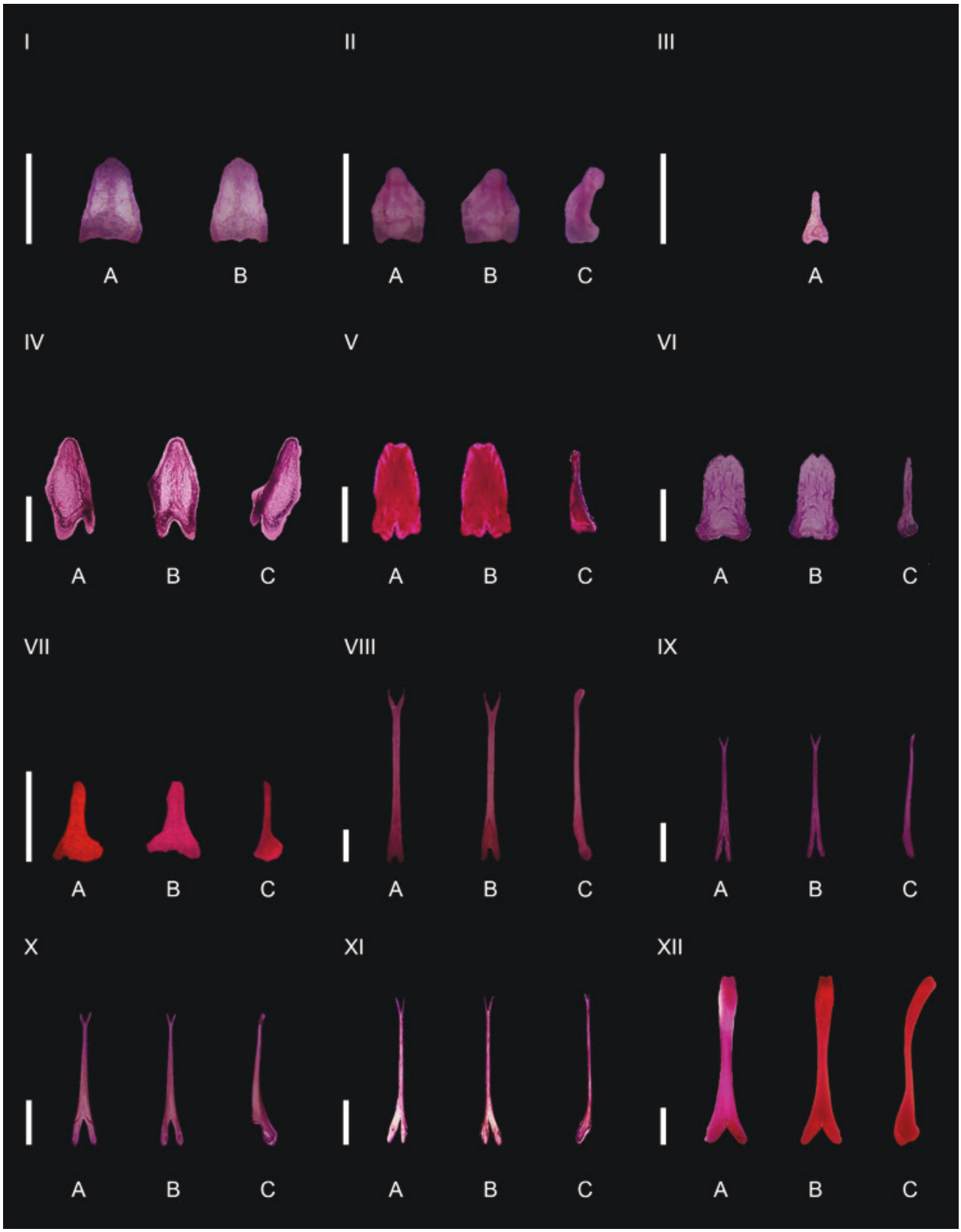

Image 10. Bacula of selected species belonging to the family Vespertilionidae in India: I—*Myotis blythii* | II—*Myotis peytoni* | III—*Myotis longipes* | IV—*Myotis horsfieldii dryas* | V—*Scotophilus heathii* | VI—*Scotophilus kuhlii* | VII—*Tylonycteris malayana eremtaga* | VIII—*Pipistrellus javanicus camortae* | IX—*Pipistrellus coromandra* | X—*Pipistrellus tenuis* | XI—*Pipistrellus ceylonicus* | XII—*Hesperoptenus tickelli* (Scale: I to VI, VIII to XII 1mm; VII 0.5mm). A—Dorsal view | B—Ventral view | C—Lateral view.

However, it differs from that depicted in Hanak and Gaisler (1969) in having a parallel-sided tall shaft, and a flat appearance.

36. *Myotis horsfieldii dryas* (Andersen, 1907) Andaman Myotis (Image 10.IV)

Material examined: NHM.OU.CHI.125.2015, male, collected from Bamboo Nullah (12.856N and 92.875E), near Mayabunder, North & Middle Andaman district, Andaman & Nicobar Islands, by C. Srinivasulu and Aditya Srinivasulu, on 19.x.2015.

The baculum is very small (2.3mm long), saddle-shaped, with a deep median emargination on the base (1.5mm wide). On the dorsal surface, a projection is seen on the basal margin of the baculum. The baculum becomes slightly narrower toward the apical portion and ends in a narrowly rounded off tip. The tip and the bony projection are connected by means of a ridge on the dorsal surface of the baculum. Ventrally, the baculum shows a concavity. The distal end of the baculum is blunt, without any abrupt constrictions.

Remarks: The structure of the baculum of the specimen from Mayabunder, Andaman Islands roughly matches the general structure of that described by Bates & Harrison (1997) from Venniar Estate, Tamil Nadu, however, the baculum of the present specimen differs from that described by Bates & Harrison (1997) in being triangular with a deep emargination on the basal margin and a well-defined ridge on the dorsal surface. This is the first time that the baculum of this subspecies endemic to Andaman Islands is described.

37. *Scotophilus heathii* (Horsfield, 1831) Asiatic Greater Yellow House Bat (Image 10.V)

Material examined: NHM.OU.CHI.27.2015, male, collected from Nagardan Qila (21.337N and 79.315E), Ramtek, near Kandheri Moil, Nagpur District, Maharashtra, by Tariq A. Shah and G. Devender, on 03.iii.2015.

The baculum is small (1.8mm long). The base is broader (1.0mm) than the apex and shows the presence of a deep median emargination, with a shaft being as thick as the base. The broad base extends in the form of a parallel-sided shaft, which is as broad as the base. The broad shaft narrows slightly toward the apex and ends in a broadly rounded apex. At the apex, a slight concavity is observed. In the lateral profile, the baculum is thick at the base and shows a slight curvature as it extends toward the apex.

Remarks: The structure of the baculum of the specimen from Nagardan Qila, Maharashtra matches roughly with that described by Hill & Harrison (1987) from Tori, Pakistan. The baculum, however, differs from that depicted in Hill and Harrison (1987) in having a single deep emargination in the base, a concavity at the tip on the dorsal and ventral aspects and being broad and stout in the lateral aspect.

38. *Scotophilus kuhlii* (Leach, 1821) Asiatic Lesser Yellow House Bat (Image 10.VI)

Material examined: NHM.OU.CHI.67.2015, male, collected from Singaraipet Beat, Thallapet (19.07N and 79.09E), Mancherial District, Telangana State, by G. Devender and K. Krishna Prasad, on 30.ix.2015.

The baculum is small (1.6mm long). The base is broad, with a slight concavity in the centre. The shaft is parallel-sided, as broad as the base and narrows toward the apical region where it shows the presence of a deep notch at the tip. The tip seems pointed due to the presence of the deep notch. Laterally the baculum is straight and thin with a rounded base.

Remarks: The structure of the baculum of the specimen from Thallapet, Mancherial District, Telangana State roughly matches that described by Hill & Harrison (1987) from Chiang Mai, Thailand. However, the baculum differs from that depicted in Hill and Harrison (1987) in having a single shallow emargination at the base and a deep notch at the tip.

39. *Tylonycteris malayana eremtaga* Srinivasulu et al. 2018 Andaman Greater Bamboo Bat (Image 10.VII)

Material examined: NHM.OU.CHI.151.2015, male, collected from Chipo (13.527N and 93.013E), North & Middle Andaman District, Andaman & Nicobar Islands, by Asad Gopi and Tauseef Hamid Dar, on 06.xi.2015.

The baculum is very small (0.4mm long), with a broad concave base. The shaft of the baculum is long, straight, with a slight concavity just beneath the rounded tip. In lateral aspect, the shaft of the baculum is long and straight, and the base is much flared.

Remarks: The structure of the baculum of the specimen from Chipo, North Andaman, Andaman Islands roughly matches that described by Hill & Harrison (1987) from Bukit Lagong Forest Reserve, Kepong, Selangor, Malaya. However, it differs in having a much flared base, a long and straight shaft.

40. *Pipistrellus javanicus camortae* (Miller, 1902) Camorta Pipistrelle (Image 10.VIII)

Material examined: NHM.OU.CHI.158.2015, male, collected from Devpur (12.862N and 92.867E), near Mayabunder, North & Middle Andaman District,

Andaman & Nicobar Islands, by Tauseef Hamid Dar and Asad Gopi, on 18.xi.2015.

The baculum is large (5.3mm long), long, and slender. The base is narrow, and the proximal portion shows the presence of a shallow V-shaped fissure. The apical portion is wider than the basal portion. The shaft of the baculum is long, parallel-sided and at the apical portion, the shaft bifurcates into two arms. The tips of the arms show a slight inward curvature. In lateral view, the baculum has a slightly curved profile. The apical portion shows the presence of a concavity just beneath the bifid tip on the ventral surface giving the appearance of slight curvature of the baculum near the tip. The proximal portion extends slightly and is in line with the apical curvature of the baculum.

Remarks: The structure of the baculum of the specimen from Mayabunder, Middle Andaman, Andaman Islands matches that described by Soota & Chaturvedi (1980) from Tee Top, Car Nicobar, Andaman & Nicobar Islands, and Hill & Harrison (1987) from Car nicobar. However, the baculum does not show as much curvature of the shaft in the lateral profile as is depicted in Hill and Harrison (1987).

41. *Pipistrellus coromandra* (Gray, 1838) Coromandel Pipistrelle (Image 10.IX)

Material examined: NHM.OU.CHI.53.2016, male, collected from Chembanoda (11.6384N and 75.865E), Perivanamuzhi, Kozhikode District, Kerala, by Bhargavi Srinivasulu and G. Devender, on 19.x.2016.

The baculum is medium-sized (3.1mm long). The proximal lobes of the base of the baculum are narrow and have a deep emargination. The shaft is long, ending with a bifid tip. The apical lobes are thick, short and deflected slightly outward. Toward the apical region, the shaft shows a slight curvature on the dorsal surface observed in the lateral profile. The tip also shows a slight downward curvature.

Remarks: The structure of the baculum of the specimen from Kozhikode, Kerala, matches that described by Hill & Harrison (1987) from near Mirzapur, Uttar Pradesh, India.

42. *Pipistrellus tenuis* (Temminck, 1840) Least Pipistrelle (Image 10.X)

Material examined: NHM.OU.CHI.1.2013, male, collected from Gachibowli (17.440N and 78.352E), Hyderabad District, Telangana State, by Harpreet Kaur, on 24.i.2013.

The baculum is medium-sized (3.3mm long). The proximal lobes of the narrow base are well developed and have a deep emargination. The lobes have processes on them and are deflected outward. The shaft is long, slightly thick, ending in a bifid tip. The apical lobes are short. In the lateral aspect, a concavity is seen just above the base, followed by the presence of a distinct process immediately above it. The apical region does not show any curvature on the lateral aspect.

Remarks: The structure of the baculum of the specimen from Hyderabad, Telangana State matches that described by Hill & Harrison (1987) from the Coast of Sabah, Borneo. In the baculum of the present specimen, the shaft has a straight profile, and shows the presence of processes on the proximal lobes unlike that depicted by Hill & Harrison (1987).

43. *Pipistrellus ceylonicus* (Kelaart, 1852) Kelaart's Pipistrelle (Image 10.XI)

Material examined: NHM.OU.CHI.8.2012, male, collected from Osmania University Campus (17.417N and 78.531E), Hyderabad, Telangana State, by Bhargavi Srinivasulu and C. Srinivasulu, on 23.i.2012.

The baculum is medium-sized (3.8mm long). The basal lobes are well-developed and are deflected outward. The shaft is slender and tall. The tip is bifid, and the apical lobes are thin with a deep emargination separating them. In the lateral aspect, the shaft exhibits a straight profile.

Remarks: The structure of the baculum of the specimen from Osmania University, Telangana State matches that described by Hill & Harrison (1987) from Astoli, Belgaum, Karnataka, although in their depiction, the shaft of the baculum is shown to have a slight curvature on the lateral aspect.

44. *Hesperoptenus tickelli* (Blyth, 1851) Tickell's Bat (Image 10.XII)

Material examined: NHM.OU.CHI.155.2015, male, collected from Devpur (12.862N and 92.867E), near Mayabunder, North and Middle Andaman District, Andaman & Nicobar Islands, by Tauseef Hamid Dar and Asad Gopi, on 16.xi.2015.

The baculum is large (4.5mm long). The base of the baculum expands to form paired basal lobes separated both dorsally and ventrally by median V-shaped fissure. The shaft of the baculum is long, parallel-sided and expands as it approaches the tip. The tip shows a slight concavity in the middle. When viewed laterally, the shaft shows curvature starting at the midpoint gradually to the tip.

Remarks: The structure of the baculum of the specimen from Devpur, Middle Andaman, Andaman

Islands roughly matches to that described by Hill (1976) and Hill & Harrison (1987) both from Sri Lanka. The present baculum differs from that earlier described in having the apical region expanded and a gradual curvature from the midpoint of the shaft to the tip. It also differs in having a concavity at the tip.

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