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Acoustic & morphology based identification of microchiropteran species in Chitrakoot district, Uttar Pradesh, India

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Abstract
A study has been carried out to acoustic & morphology based identification to microchiropteran bat species in district Chitrakoot of Uttar Pradesh with special reference to their distribution. Six roosting sites with the four identified species have been recognised on the basis of ecological condition and microchiropteran abundance. Microchiropteran acoustic was assessed by using Baton Bat Detector. For species identification sounds were recorded of chiropterans of various roosting sites by Baton Bat Detector. Bats 1 emit call is for 0.2 to 100 milliseconds. Body size and activity of larger species increased with altitude, call frequencies increased with the body size of bat species. This is frequency division detector, that means it take 1 second sound and create 10 second gap and then hence 1 sec sound modulates into 10 second, then hence automatically high range frequency gets down to low range frequency and then we are able to hear bat's ultrasonic sound.

Keywords: baton, echolocation, trapping, detector, acoustic, ultrasound

1. Introduction
Bats are the second largest mammal's species in numbers; they constitute 20% of all existing mammals. There are around 1,200 species of bats worldwide. They are the mammals of the order Chiroptera, having two suborders Megachiroptera and Microchirptera. There are around 120 species of Chiroptera found in India. As the major predators of nocturnal flying insects (Rainey *et al.* 1992) [5], bats play a key ecological role in temperate rain forests, therefore their distribution and habitat requirements are important to understanding and sustaining ecosystems. Chaturvedi, Surya Kant and Singh, Shivani, 2018 [7], worked out the status and distribution of Indian flying fox (*Pteropus giganteus*) in district Chitrakoot, Uttar Pradesh, India. The term 'Echolocation' was first coined by Donald Redfield Griffin to describe how bats use echoes of sounds they produce to locate objects in their path (Brigham *et al.* 2004) [1]. Microchiropteran bats are also known as "echolocating bats" because they have the ability to use echolocation in obstacle avoidance and hunting.
Most bats eat flowers, small insects, fruits, nectar, pollen and leaves, though it depends on the type of bat. Megabats usually eat fruits, and microbats generally eat insects. Some bats will squeeze fruits in their mouths and drink the juices. Vampire bats like a juice of a different type, though. They do indeed drink blood, mainly from cattle and deer, but they don't suck blood like the legends say. Bats 1 emit call is for 0.2 to 100 milliseconds. Mostly frequency increases according to bat size. Bat echolocation calls are sounds at frequencies above the range of human hearing. Body size and activity of larger species increased with altitude, call frequencies increased with the body size of bat species. Echolocation, the sonar 'sight' of bats, is analogous to the sonar used by the military. Because it is produced by living organisms rather than by machines, it is often called 'biosonar'. A simple definition is that it is the analysis by an animal of the echoes of its own emitted sound waves, by which it can build a sound picture of its immediate environment.
Infra sound is 0.1 Hz to 25Hz Short frequency sounds and infrasound can travel a long distance over 3 km. Therefore, helpful for long distance communication, used by elephants. Audible sound range is 20Hz to 20 kHz and this is medium frequency sounds Human hearing & Ultrasound is > 20kHz High frequency sounds and ultrasound travels only a short distance. Therefore, helpful for short distance target detection within 10m, used by bats.
Bats emit calls from about 12 kHz to 160 kHz, but the upper frequencies in this range are rapidly absorbed in air. Bat calls were examined with the help of Baton Bat detector. Bat surveys employ both trapping and echolocation call detection techniques to appropriately identify the bat species in study area. The climate has distinct wet dry seasons which extend from March to June, rainy seasons which extend from July to October, winter seasons which extend from November to February.
Many bat detectors are limited to around 15 kHz to 125 kHz at best. Bat detectors are available commercially and also can be self-built. Some early bat detectors used exnavy, low

frequency radio sets, simply replacing the aerial with a microphone and pre-amplifier. A bat detector is a device used to detect the presence of bats by converting their echolocation ultrasound signals, as they are emitted by the bats, to audible frequencies, usually about 300 Hz to 5 kHz.

2. Material and Methods

Study area

On the basis of present state of knowledge, it is evident that no systematic study has been done on bats in Chitrakoot district of Uttar Pradesh. Chitrakoot lies between Lat. $24^0$48'54" to $25^0$12'34"N and Long. $80^0$58'26" to $81^0$34'17"E. Distance covered by district from east to west is 62 Km and North to South is 57.5Km. It is bounded in the north by Kaushambi, in the south by Satna (MP) & Rewa (MP), in the east by Allahabad and in west by Banda. Total geographical area of District is about 345291Sq. Km. the general topography is hilly and undulating cut off by numerous reveres and rivulets. Mandakini, Valmiki, Gunta, Gedua, Chakara and Jhuri rivers drain the region. Chitrakoot falls in the northern Vindhya Range of mountains spread over the states of Uttar Pradesh and Madhya Pradesh. The survey was conducted in eleven different six locations of Chitrakoot district, Mau2 (Rishiyan shaker ji Mau), Balari, Kolgadhiya, Sagrampur, Ramghat, Pampapur.

Diurnal surveys were made in 3 caves to assess bat species composition and abundance in caves visited and to look for species. One of the caves were located near Sangrampur Cave, with 2nd cave Kolgadhaiya cave located approximately 25 km from the first caves in the area known as Karwi (Chitrakoot) and 3rd cave name as Mau2 (Rishiyan Shankar Ji, Mau) is located in 70 km from the 1st cave and 55 km from the 2nd cave. Direct counts were made of roosting bats using torches. When bats were found in large groups we counted the number in a known area and examined based on the total estimated area of the colony. In each cave we measured the relative humidity (Hygrometer), temperature, elevation and light levels (Lux meter) at cave.

To identify the roosting site of bat in Chitrakoot, different methods were used. First of all map of study area was collected from Chitrakoot forest range of U.P. and with the help of map then applied pilot survey method (as per Wild Life Institute Protocol).

The study was carried out for a period of two years (March 2015 – Feb 2017) in various places of Chitrakoot districts of Uttar Pradesh such as Mau-2 (25º14'56"N;81º31'24"E), Balari(25º11'54"N; 81º9'28"E), Kolgadhaiya (25º11'41"N; 81º57'10E), Sangrampur (25º10'44"N; 80º59'33"E), Ramghat (25º10'45"N; 80º52'10"E), Pampasur (25º9'26"N; 80º54'56"E). This study investigated the species composition. Field work was conducted from March 2015 to February 2017.

Bat calls were examined with the help of Baton Bat detector and classified the bats with the help of "Srinivasulu, C., Racey, Paul A. & Mistry, Shahroukh (2010) [4] A key to the bats (Mammalia: Chiroptera) of South Asia". Bat surveys employ both trapping and echolocation call detection techniques to appropriately identify the bat species in study area. The climate has distinct wet dry seasons which extend from March to June, rainy seasons which extend from July to October, winter seasons which extend from November to February.

3. Result and discussion

District Chitrakoot has dense forest area with rich biodiversity including the forests under the Forest Department and a number of private orchards. Various types of tree species such as Mango (*Mangifera indica*), Teak (*Tectona grandis*), Sal (*Shorea robusta*), Semal (*Bombax ceiba*), Gular (*Ficus glomerata*), Pepal (*Ficus religiosa*), Banana (*Musa paradisiacal)*, Guava (*Psidium guajava*), Jambolana (*Syzygium cumini*), Banyan *(Ficus bengalensis*) etc. are found in the forests as well as orchards (Sikarwar, R.L.S.; 2011) [6].

Mainly four species of Chiroptera were identified by us. They are *Rhinopoma hardwickii* (lesser Mouse-tailed Bat), *Megaderma lyra* (greater false vampire bat), *Rhinopoma microphyllum* (greater mouse tailed bat) and *Hipposideros lankadiva* (Indian leaf-nosed Bat, Indian round leaf bat).

Even different roosting sites had different microchiropteran species in abundance in at Mau2 it was *Rhinopoma hardwickii*, at Balari it was *Megaderma lyra*, at Kolgadhaiya it was *Rhinopoma microphyllum*, at Sangrampur it was *Rhinopoma microphyllum*, at Ramghat it was Hipposideros *lankadiva* and at Pampasur it was *Rhinopoma microphyllum*.

Fig 1: *Rhinopoma hardwickii*

Fig 2: *Megaderma lyra*

Fig 3: *Rhinopoma microphyllum* **Fig 4:** *Hipposideros lankadiva*

Bats produce ultrasonic sounds for the purpose of moving about in the darkness. They send the ultrasonic sound as an echo which may hit any object and return back to the bat, implying that there is an object ahead. This is called echolocation call. Bats contract their middle ear muscles when emitting a call, so they can avoid ear splitting themselves. The time interval between the call and echo allows them to relax these muscles, so they can hear the returning echo. Received frequency applies Doppler Rule.

Echolocation which is the sonar 'sight' of bats is similar to the sonar used by the military because it is produced by living organisms rather than by machines, hence it is often called 'bio sonar'.

A simple definition is that it is the analysis by an animal of the echoes of its own emitted sound waves, by which it can build a sound picture of its immediate environment.

Table 1: Detailed Account on the Roosting Sites of different microchiropteran species in District Chitrakoot, U.P.

S.N.	Location of the Roost	GPS coordinates	Elevation(m. asl)	Type of the Roost	Species Name	Method Used to Count Bats	Protection Information
1.	Mau-2	25º14'56"N; 81º31'24"E	33m	Cave	*Rhinopoma hardwickii*,	Visual Count	Protected
2.	Balari	25º11'54"N; 81º9'28"E	59 m	Mud House	*Megaderma lyra*	Visual Count	Protected
3.	Kolgadhaiya	25º11'41"N; 80º57'10"E	98 m	Cave	*Rhinopoma microphyllum*	Visual Count	Not Protected
4.	Sangrampur	25º10'44"N; 80º59'33"E	207 m	Dense Cave in mountain	*Rhinopoma microphyllum*	Cave Estimation	Not Protected
5.	Ramghat	25º10'45"N; 80º52'10"E	126 m	Historic Building & Old Tempal	Hipposideros *lankadiva*	Estimation	Protected
6.	Pampasur	25º9'26"N; 80º54'56"E	241 m	Cave & Monk House	*Rhinopoma microphyllum*	Visual Count	Protected

We did this with the two types of the identification technique.

a. Species with the help of identification key "Srinivasulu, C., Racey, Paul A. & Mistry, Shahroukh (2010) [4] A key to the bats (Mammalia: Chiroptera) of South Asia".
b. By recording sound with the help of Baton Bat Detector and its match

Important measurements by Identification Key

Forearm Length (FA), Head body length (HB), Tail Length (TL), Hindfoot Length (HL) and Ear Length (EL). After taking this measuring points then match with "Srinivasulu, C., Racey, Paul A. & Mistry, Shahroukh (2010) [4] A key to the bats (Mammalia: Chiroptera) of South Asia".

Identified Species of Chiroptera

Sp1- *Rhinopoma hardwickii* (Lesser Mouse-tailed Bat)
Sp2- *Megaderma lyra* (Greater False Vampire Bat),
Sp3- *Rhinopoma microphyllum* (Greater-mouse Tailed Bat),
Sp4- *Hipposideros lankadiva* (Indian Leaf-nosed Bat, Indian Round leaf Bat)
All identified Microchiroptera morphological identification is given below.

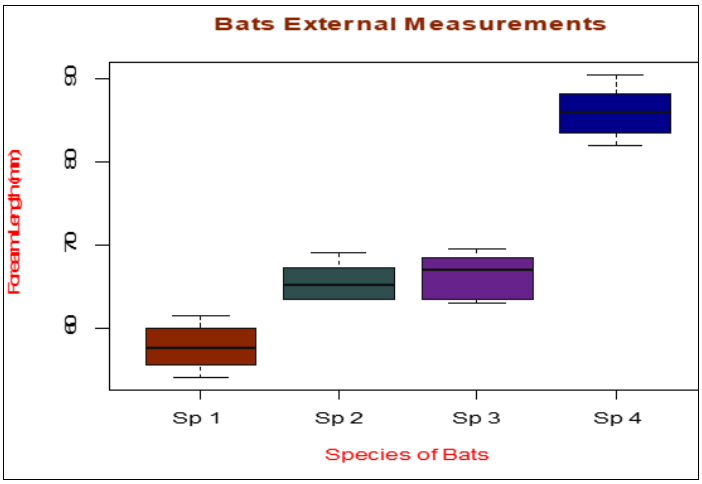

Fig 5: Box plot of Forearm Length (FA) (mm) of Different Species of Bats

A detailed morphological study was done on the four identified species, that are *Rhinopoma hardwickii* (lesser mouse tailed bat), Megaderma lyra (greater false vampire bat), *Rhinopoma microphyllum* (greater mouse tailed bat) and Hipposideros lankadiva (Indian leaf nosed bat / Indian round leaf bat). All the four species were examined in detail and their measurements were recorded. They were classified on the basis of their forearm length, head body length, Tail length, hind foot length and Ear length, which were very helpful in their classification and identification.

For the forearm length *Rhinopoma hardwickii* was found to be of the range on 54.0-61.5 mm, *Megaderma lyra* to be 63.5-69.0 mm, *Rhinopoma microphyllum* to be of 63.5-69.5 mm and Hipposideros lankadiva to be of 82.0-90.5 mm in length (Fig.5).

For the Head body length the four species were measured in detail and carefully and the measurements were recorded. *Rhinopoma hardwickii* was found to be of the range on 59.5-68.0 mm, Megaderma lyra to be 82.0-88.0 mm, *Rhinopoma microphyllum* to be of 78.5-81.5 mm and Hipposideros lankadiva to be of 88.0-97.0 mm in length (Fig.6).

Tail length also is very helpful tool to segregate three species only that are *Rhinopoma hardwickii* (lesser mouse tailed bat), Rhinopoma microphyllum (greater mouse tailed bat) and Hipposideros lankadiva (Indian leaf nosed bat / Indian round leaf bat). They were found to be as follows, for *Rhinopoma hardwickii* was found to be of the range on 58.6-67.5 mm, *Rhinopoma microphyllum* to be of 54.0-66.5 mm and Hipposideros lankadiva to be of 46.4-52.0 mm in length (Fig.7).

Hind foot length is also very helpful in classification and identification. When carefully observed for the four species the measurements were as follows, *Rhinopoma hardwickii* was found to be of the range on 11.0-14.5 mm, Megaderma lyra to be 16.5-19.5 mm, *Rhinopoma microphyllum* to be of 15.5-18.0 mm and Hipposideros lankadiva to be of 15.5-17.5 mm in length (Fig.8).

Last parameter which was taken for the classification and

identification of species is Ear length which also was found to be of great importance for bat identification, *Rhinopoma hardwickii* was found to be of the range on 17.5-20.5 mm, Megaderma lyra to be 33.5-40.5 mm, Rhinopoma microphyllum to be of 18.5-21.0 mm and Hipposideros lankadiva to be of 22.9-27.0 mm in length (Fig.9).

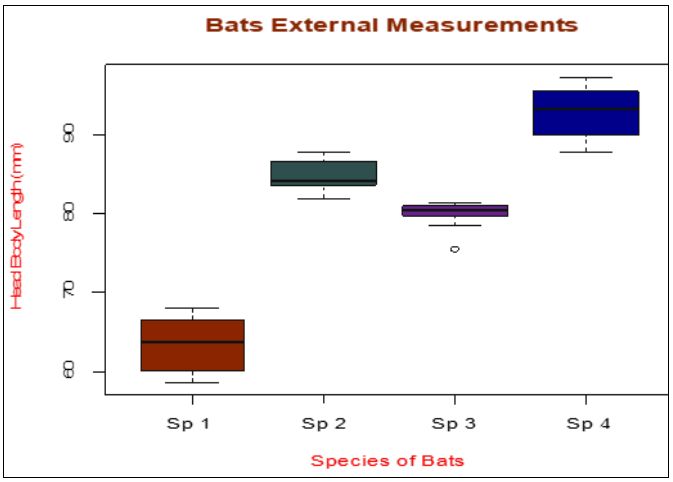

Fig 6: Box plot of Head Body Length (HB) (mm) of Different Species of Bats

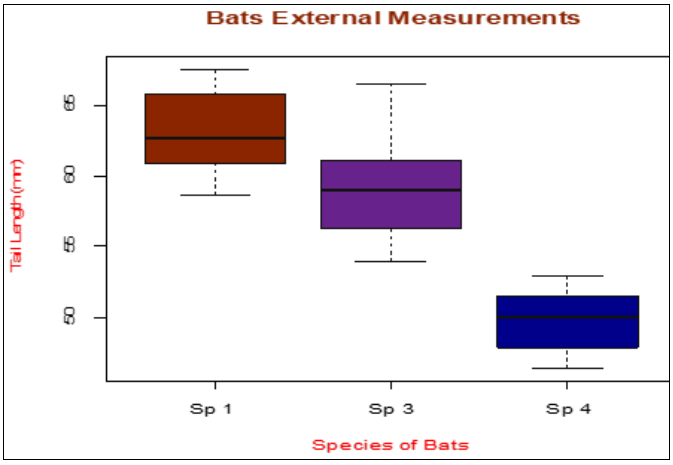

Fig 7: Box plot of Tail Length (TL) (mm) of Different Species of Bats

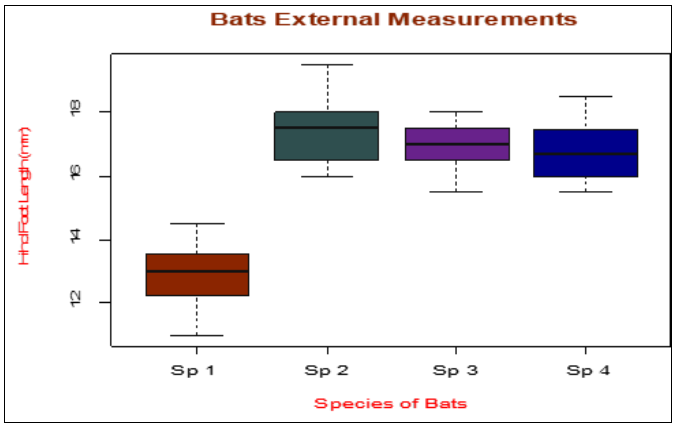

Fig 8: Box plot of Hind Foot Length (HF) (mm) of Different Species of Bats

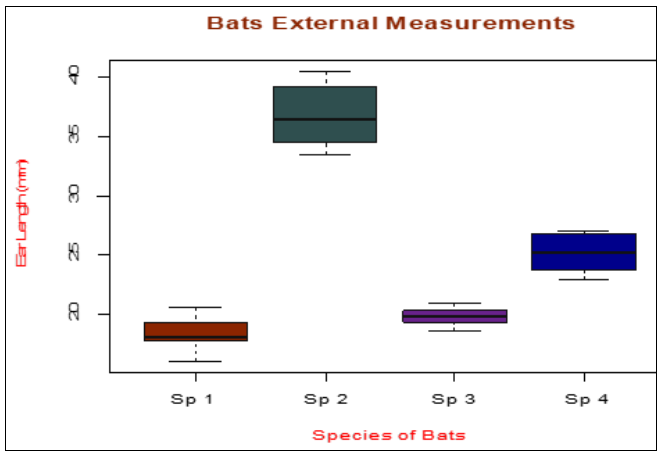

Fig 9: Box plot of Ear Length (EL) (mm) of Different Species of Bats

Acoustic Survey: Baton Bat Detector

Bat echolocation calls are sounds at frequencies above the range of human hearing. For species identification sounds were recorded of chiropterans of various roosting sites by Baton Bat Detector.

This is frequency division detector, that means it take 1 second sound and create 10 second gap and then hence 1 sec sound modulates into 10 second, then hence automatically high range frequency gets down to low range frequency and then we are able to hear bat's ultrasonic sound.

Frequency x= 1/10x

We assessed microchiropteran acoustic by using Baton Bat Detector. A single call emitted for 0.2 to 100 milliseconds; mostly frequency increases according to chiropteran's body size whereas body size and activity of larger species increased with altitude.

Function of Baton Bat Detector

They can be analyzed using the spectrogram technique, but a high-frequency detector must be used instead of an ordinary microphone to capture the sounds and shift them down into the audible frequency range. In this Bat Scan program, digital audio from a bat detector is analyzed using the computer sound card to produce a spectrogram plot of frequency versus time. These spectrograms can then be used to identify the species of bat producing the call.

A spectrogram of Baton Bat detector is simply a plot of the frequency components of sound as a function of time that can be used to identify the source of particular sounds by the structure of the audio spectrum.

Scan input, scan file, analyze file.

Although the calls of most bats are not audible to the human ear, the loudness of bat echolocation calls can still be measured. This is expressed in decibels (dB), and for comparison is usually measured at a fixed distance from a bat's mouth (at 10 centimeters or about four inches). Intense echolocation calls measure 110 dB or more (equivalents in strength to a smoke detector alarm). Faint echolocation calls measure as little as 60 dB (the intensity level of normal human conversation). The echolocation calls of bats differ with respect to their environment where they forage. Bats that feed in open spaces produce the most intense calls. In contrast,

those that forage in cluttered areas, such as deep in the forest, usually produce low intensity calls.

Although the intensity of bat sound is so high, we cannot hear it because it is of high frequency. Frequency is measured in kilohertz (kHz), where one hertz is one cycle per second. The frequencies used in echolocation by bats fall usually between 25 and 100 kHz, although some species emit ultrasonics as high as 200 kHz.

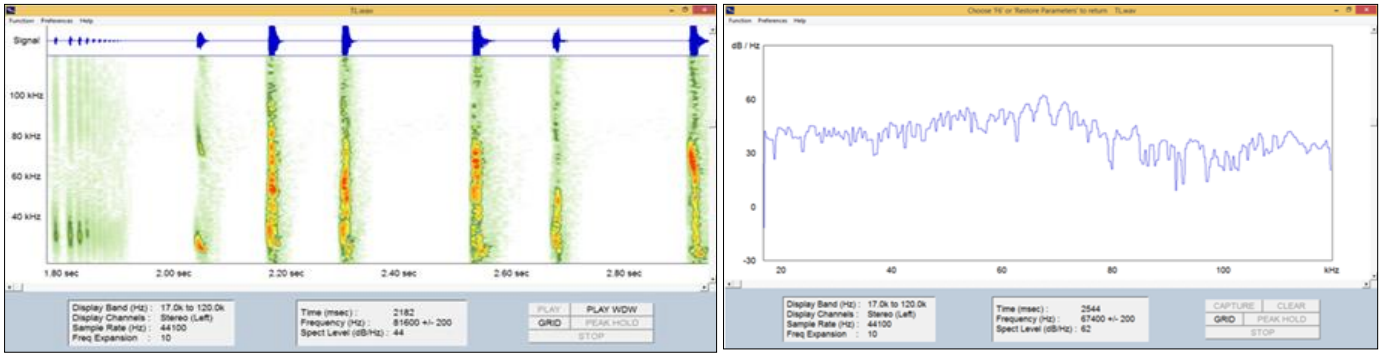

Fig 10: Spectrogram & Peak Frequency graph of *Rhinopoma hardwickii* (Lesser Mouse-tailed Bat) through the Baton Bat Detector

Rhinopoma hardwickii (lesser mouse-tailed bats) are measured to be "acoustically primitive" because they use signals with four or more harmonics and with little frequency variation (Whitaker Jr. and Yom-Tov, 2002). They emit long constant frequency (CF) calls at 30 to 34 kHz with peak energy at 32 kHz (Davis, 2007). They emit these CF sounds when flying in open spaces for approximately 48ms. when they fly in groups, lesser mouse-tailed bats emit CFs in three bands. However, when they fly solo the bat emits CFs in only one band. Frequency modulated (FM) sounds are produced only as they leave their roost or shortly before landing (Whitaker Jr. and Yom-Tov, 2002).

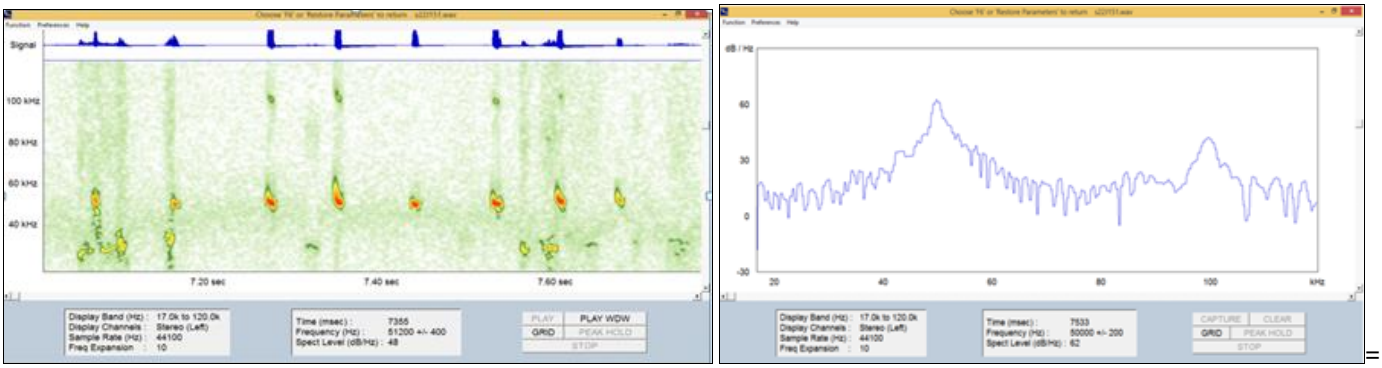

Fig 11: Spectrogram & Peak Frequency graph of Megaderma *lyra* (Greater False Vampire Bat) through the Baton Bat Detector

The Indian pygmy bat *Pipistrellus mimus* is an example of high intensity, or 'shouting' echolocators, while the Indian false vampire bat *Megaderma lyra* is an example of low intensity, or 'whispering' bats.

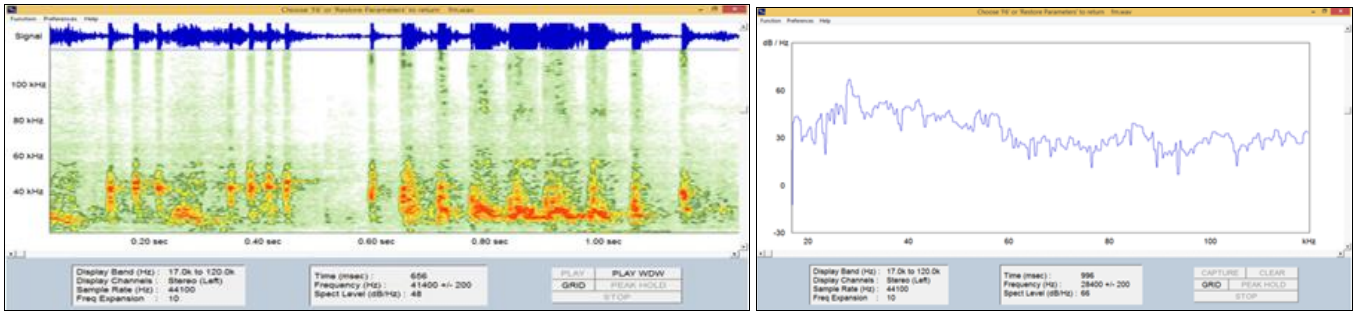

Fig 12: Spectrogram & Peak Frequency graph of Rhinopoma *microphyllum (*Greater mouse-tailed bat) through the Baton Bat Detector\

The greater mouse-tailed bat (*Rhinopoma microphyllum* Brunnich 1782) is reported for the first time in Algeria from two caves of the Boukaïs region (Bechar). Noseleaf shape, forearm and tail lengths clearly identified this species. The frequency of maximal energy of echolocation calls varied from 28.2 to 31.2 kHz 22-37 kHz for hand released individuals.

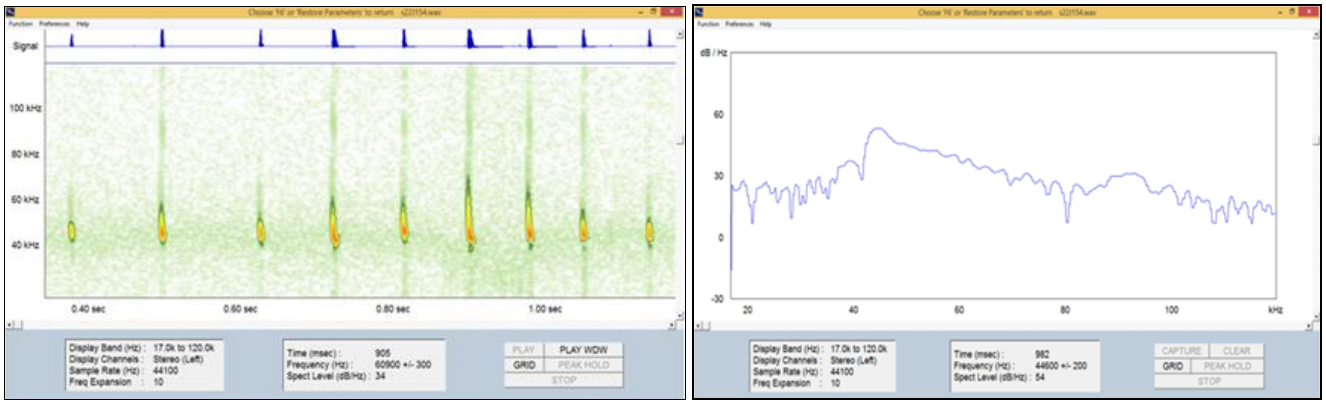

Fig 13: Spectrogram & Peak Frequency graph of Hipposideros *lankadiva* (Indian Leaf-nosed Bat, Indian Round leaf Bat) through the Baton Bat Detector

4. Discussion

The result of present study demonstrate a extensive and detailed data for identifying the four species *Rhinopoma hardwickii* (Lesser Mouse-tailed Bat), Megaderma *lyra* (Greater False Vampire Bat), Rhinopoma *microphyllum* (Greater-mouse Tailed Bat), Hipposideros *lankadiva* (Indian Leaf-nosed Bat, Indian Round leaf Bat) found in Chitrakoot district and classifying them on the basis of morphological data in which we used 5 parameters forearm length, head body length, tail length, hind foot length and ear length. Acoustic data also was helpful in classifying and identification of the four species, for which we used Baton Bat Detector for it. After recording the frequencies which the help of the detector we plotted spectrogram and peak frequency graphs of the four species. The graphs resulted to be of the great importance in segregating and classifying the four bats species as all the bats emit different and special kind of frequency and can be useful for their identification.

But for the morphological data the range was more towards the young population because the young bats were easily captured and the older were tough to capture. Although growth rates of individually marked bats also show variation with the increasing age, this variation mostly reflects differences among individuals of the same age (Hoying and Kunz 1998).

Many more scientist were also involved, whose work guided us and enlightened us. Jitendra Kumar and Amita Kanaujia (2014) [2] worked on Distribution and population status of Fruit-bat (*Pteropus giganteus*) in district Lakhimpur-Kheri, Uttar Pradesh and used several tools to classify the species. Bats Echolocation tools and technique used by Brigham, R.M., *et al*., eds. 2004 [1] was also helpful. Extensive and more detailed work need to be done for further classification and extensive identification of the bats in the area.

5. Conclusion

The present work on morphological and acoustics survey of the four species found at six different sites at Chitrakoot district UP aims to assess the eco-status of chiropteran diversity. The observation reflects that the variation in number of chiropteran in the six different sites reflects their conservation status in the district. Some species were found in the non-protected state and steps need to be taken by both public sector volunteers and private sector volunteers to save this beautiful species and help the nature to make balance as Chiropterans are the important connecting link in many different food chains and food webs. Local sensitization is necessary for it so that people start loving the animal and get above all superstitions prevalent in the present society.

6. References

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