LARYNGEAL MULTIHARMONIC BASIC CALL OF CARNIVOROUS BAT, *megadermalyralyra*

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ABSTRACT

Bats are the widely distributed second largest order of flying mammals. They belong to the order of Chiroptera. Chiroptera contains more than hundred genera, which shows variable feeding habits. Megadermalyralyra belong to an ancient family of carnivorous bats. Megadermatidae feeds on smaller invertebrates and vertebrates. They use multiharmonic echolocation sound and rely on hearing as their major locational sense for capturing prey. Echolocation is one of the adaptations that make bats so ecologically successful. Echolocation involves the active transmission and reception of ultrasonic calls that allows bats to essentially "see" with sound. M. lyralyraas well as other carnivorous bats is acknowledged as a good friend of farmers because they substantially prey on several insect those are injurious to crop-field and gardens. Guano (excreta matter) of carnivorous bat M. lyralyra is rich in nitrogen and phosphorous contents and so it is a better alternative to phosphorous rich chemical fertilizers. Guano is the main resource base for other diverse form of consumers in the food chain including ants, thrips, beetles, salamanders and microorganisms. Thus, recycling of the nutrients taking place by carnivorous bats and plays a vital role towards the ecosystem. Present research paper based on "Microstructure of tongue of Megadermalyralyra" with unique structural characteristic, arrangement, location and functional effect of lingual papillae (Mechanical and Gustatory). Tongue of M. lyralyra showed a cluster of tricuspid filiform as well as the scale-like filiform papillae at the rough triangular tip with smooth lateral surface. Slightly recurved hook-like filiform papillae are arranged laterally to the anterior surface. Two rows of oval shaped fungiform papillae are arranged in a characteristic fashion. At the posterior region, full developed inverted conical shaped of circumvallate papillae. In addition of specific structural and functional role of lingual papillae, the adaptive variability of the basic call i.e. bat echolocation quality are successfully adapting the M. lyralyra into carnivorous feeding habits.

***Keywords**: Carnivorous; Megadermalyralyra; Microchiroptera; Tongue.*

Introduction

The highly specialized organ of the oral cavity is tongue, which is a mobile and highly muscular in growth, protruding upwards and forwards from its floor. In addition to specialized taste receptors, it has a major function in the movementof food in the oral cavity (Stevens and Lowe, 1992). The musculature of the tongue comprises a complex of skeletal muscle fibers. These muscles provide the tongue a great mobility to manipulate, orientation of food around the mouth for efficient fragmentation and moving fragmented food backwards prior to swallowing.

The surface epithelium of tongue is raised in a series of elevation called papillae. An important feature of the mammalian tongue is taste buds, which are distributed over a wide area of the dorsal and lateral surfaces of the tongue (Nickel et. al 1973; Robinson and Winkles, 1990; Takeda et. al 1990).

In India, bats (including both suborders: Megachiroptera and Microchiroptera) are distributed ranging from Himalaya to deserts of the North-West, from the tropical forests to the East and South (Mistry, 1995). The Chiropteran fauna shows variety of feeding habits being Frugivorous, Nectarivorous, Insectivorous, Carnivorous, Piscivorous, Omnivorous and Sanguinivorous (Geluso, 1978; Patil, 2006). The morphological and anatomical adaptation of tongue for different feeding habits has already been described for a series of mammalian order (Sonntag, 1920; Iwasaki, 2002) including few species of bats (Glass, 1970).

The present study based on lingual papillae of carnivorous species, "Megadermalyralyra". M. lyralyra belongs to Class "Mammalia"; Order is "Chiroptera"; Suborder is "Microchiroptera" and Family is "Megadermatidae".

M. Lyra lyra is a remarkably versatile species in terms of habitat use, food spectrum and modes of preycapturing. Originally these species are cave-dwelling but readily accepts human buildings as well as other wide range of other favorable habitats like hot humid caves, under roofs of old houses, crevices of wells and animal sheds and temples (Brosset 1962, Eates

1968). This species has unique facial appearance i.e. an erect and elongated nose leaf and large oval ears that joined on the forehead. Carnivorous M. lyralyra specially feeds on insects, birds, lizards, mice and other bats. According to the availability, the food variety also ranges from large arthropods (like insect, beetles, moth, dragon flies, cockroaches and crickets) to small vertebrates including mainly amphibians and reptiles (Advani 1981; Nandasena et. al; 2000). M. lyralyra bat is echo locating bat, use a range of signals when searching for insect prey. Bats primarily use echolocation for foraging. It can also be used to detect obstacles and to find roost-sites. All species of Microchiropterans seems to use echolocation for orientation and prey capture. Echolocation in insectivorous bats is aided by structures that are located on the ear and nostrils. Bats produce ultrasound through their larynx and emit them from the mouth or via their nose. Common name of this species is "Indian False Vampire Bat".Mohres (1967) reported that captive greater horseshoe bats, Rhinolophusferrumequinum (Rhinolophidae) used the echolocation calls of preferred individuals to identify and locate their roost-mates.Swartz et. al; (2007), Bayefsky- Anand et. al; (2008) mention High call repetition rates such as feeding buzzes associated with attacks on prey.Brinklovet. al., (2010), reported echolocation sound used by long-legged bat, Macrophyllum*macrophyllum* (Phyllostomidae) during hunting prey from the water's surface. Holderied*et. al*., (2011) noticed, Hemprich's big-eared bat, *Otonycterishemprichii* (Vespertilionidae) and Ratcliffe*et. al*; (2005), noticed in Indian False Vampire Bat, *Megadermalyralyra* (Megadermatidae) species rely more on prey-generated sounds sometimes combined with echolocation for detect and assess prey.

Material and Methods

Preserved material was used for this work. For histological study, the tongue was fixed in different fixative. Alcoholic Bouins, Aqueous Bouins and 10% formalin for 24 hours, then washed overnight in running tap water and dehydrated by passing through different grades of Ethyl Alcohol, cleared in Xylene and embedded in Paraffin. The sections were cut at 5-7 µm with the help of rotary microtome. For routine histological observations sections were stained with Haematoxyline-Eosin method.

Results

The tongue of Megadermalyralyra was found to be elongated and on the triangular tip of tongue, a small cluster of tricuspid papillae was present and covered by squamous stratified epithelium (Fig. 3). The anterior of the tongue shows the junction of the dorsal rough papillary surface and the smooth lateral surface. Under the outer papillary surface are the interlacing muscle bundles, running in the three different planes (Fig.4). The epithelial projections of singly pointed recurved filiform papillae are observed on lateral side of the anterior region, the papillae were directed posteriorly (Fig.5).The entire surface of these papillae was comprised by a highly keratinizedparakeratotic layer. The oval fungiform papillae arranged in a characteristic two rows, lateral to the prominent central groove (Fig.6). The fungiform papillae plays main role as a sensory organ for the taste sense. The dorsal surface of the tongue was covered mainly by a mixture of filiform papillae (Fig.1) i.e. Scale like, Tricuspid and few pointed Hook like papillae; in between laying the fungiform papillae(Fig. 7 and Fig. 8). The posterior lingual mucous glands are located deeper in the corium of the tongue; among the muscle bundles, connective tissue and blood vessels (Fig.9). These glands open into the surrounding connective tissue and the anterio-dorsal epithelial surface of tongue with the help of numerous small ducts. The circumvallate papillae formed by a group of eight to twelve elevations; situated at the base of the tongue (Fig.2) extended slightly above the general epithelial surface and are arranged in the form of an inverted 'V'(Fig. 10). Their base is surrounded by a deep circular furrow lined by an invagination of stratified epithelium, which thus forms a deep trench of the papilla. The number of large sized taste buds is found in the lateral wall of trench but very rare in the floor of the trench (Fig.11). The number of the receptor cells with prominent nucleus in the taste buds and the number and size of the taste buds is more in the circumvallate papillae of M. lyralyra as compared to other species of

bats as observed in research work. Ventral region shows about half tongue was free at the anterior with a prominent central groove. A prominent central ridge is observed and the sharp lateral margins are bordered with filiform papillae.

All examined mammals have at least two sets of lingual salivary glands:VonEbner's glands and Weber's glands. A third set of glands, Blandin and Nuhn'sglands are present in some mammals. Elizalde- Arellano et. al; (2004) also observed large Von Ebner's serous glands, which may be associated with piscivorous feeding habit. Tandleret. al; (1997) noticed the third sets of long lingual glands in the mid-tongue region of the tongue of vampire bat, Desmodusrotundus. Akisaka and Oda, (1978) noticed in rats and Jahnke and Baur (1979) in rabbit.

Fig 1

Fig 2

Fig 3

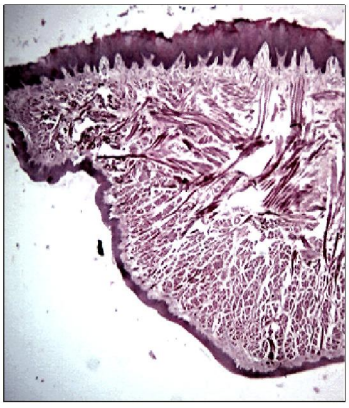
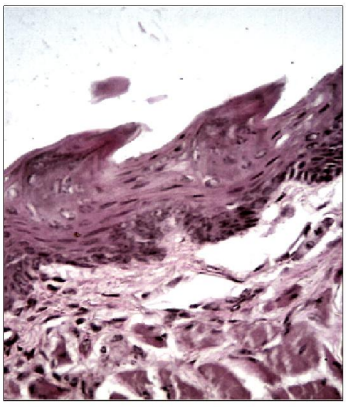


Fig 4



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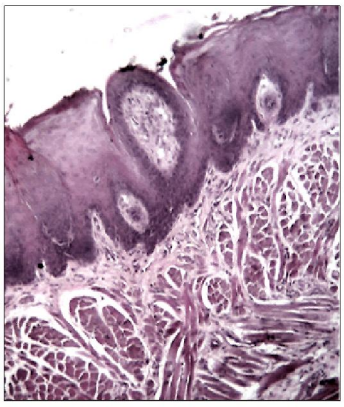

Fig 6

Fig 1: Dorsal surface of tongue with triangular anterior tip. A prominent central groove covered the posterior region.

Fig 2: Tongue of *M. lyralyra* at the postero-dorsal surface showing two circumvallate papillae at the posterior region surrounded by small filiform papillae.

Fig 3: Anterior triangular tip has a cluster of smaller tricuspid papillae.

Fig 4: T.S of tongue of *Megadermalyralyra* with anterior region shows the junction of the rough papillary surface with smooth lateral surface. Beneath the outer papillary surface, the interlacing muscle bundles are running in three different planes.

Fig 5: Part of the section to shows the singly pointed recurved filiform papillae lie laterally to the anterior region. The entire surface of these papillae comprised of a highly keratinized parakeratotoic layer.

Fig 6: Section showing oval shaped fungiform papilla arranged in a characteristically into tworows lateral to the central groove on the dorsal surface of the tongue are surrounded by filiform papillae.

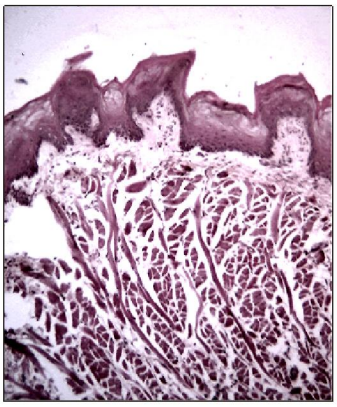

Fig 7

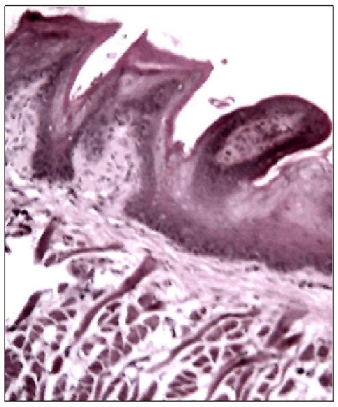

Fig 8

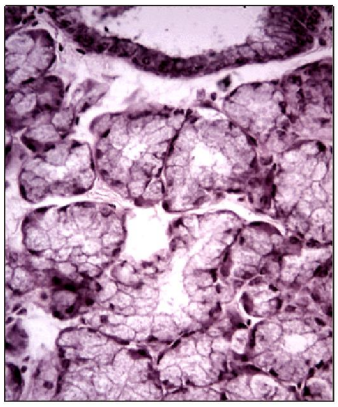

Fig 9

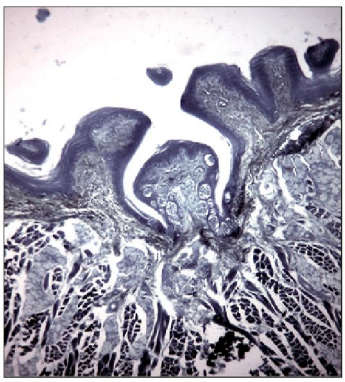

Fig 10

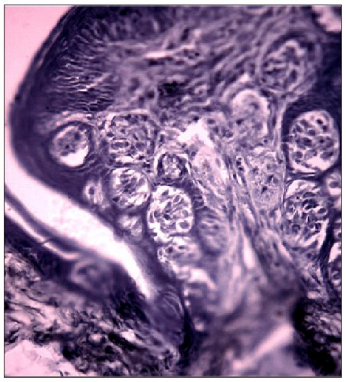

Fig 11

Fig 7: Part of the section show anterio-dorsal surface of the tongue was covered by different types of filiform papillae on the dorsum of tongue.

Fig 8: Section showing the scale like filiform papillae and the oval shaped fungiform papilla surrounded by thick layer of stratified squamous epithelium.

Fig 9: Section show various bunches of mucous glands occurred in the corium of the tongue among the muscle bundles, connective tissue and blood vessels. These posterior lingual glands had numerous small ducts open into the surrounding connective tissue and the anterio- dorsal epithelial surface of the tongue.

Fig10: Section show enlarged part of the circumvallate papilla at the posterior region. The circumvallate papilla form a group of eight to twelve elevations situated at the base of the tongue and are arranged in the form of a "V".

Fig 11: The numbers of taste buds are found in the lateral wall of trench but very rare in the floor of the trench.

Discussion

In present research paper, we consider the microstructure of different types of lingual papillae of M. lyralyra showing it's adaptation for carnivorous feeding habits. Carnivorous bats consume a variety of animal besides small terrestrial vertebrates in their diets. These phenomenon appear to be restricted to Microchiroptera in the family's of Nycteridae, Megadermatidae, Phyllostomidae and Vespertilionidae. The unique feature of carnivorous bat is comparatively different from other phyletic species line of bats. In carnivorous bats, their important characteristic associated with wing morphology, aerodynamics, foraging and echolocation behaviors.

Most bat species of order Chiroptera, echolocation sounds producing vocal signals in their larynges. Unlike flight, echolocation is

not a characteristic of all bats. Most species of flying foxes and their Old World relative do not echolocate. Echo locating bats use a range of signals when searching for insect prey (Kalko& Schnitzler 1993 and Maltby et. al; 2009). It is now widely recognized that the signal that one bat uses to collect information about its surroundings also can serve in communication (Jones &Siemers 2011). All of the larger Microchiropteran bats echolocate for prey detection.

Megadermalyralyra, a species with short broad band multiharmonic basic call in typical orientation situation, like emerging and re-entering a day roost, passing through vegetation and during capturing the flying insects. However,bat species using different basic call according to different situation. Thus the adaptive variability of the basic call types is an important characteristic of bat echolocation system, which permits a robust performance in different habitats and behavioral situations. M. lyralyra rely on echolocation to successfully detect, localize and catch silent prey from the ground (Schmidt et. al., 2000) or protruding from the water surface (Marimuthu et. al; 1995). Indian False Vampire Bat Megadermalyralyra will rely more on prey-generated sounds. After detecting prey, M. lyralyra stop echo locating and relies on prey-generated cues to locate its target (Bell 1985). Sometimes, prey-generated sounds combined with echolocation to detect and assess prey (Ratcliffe et. al; 2005). But some species Nycterisgrandis (Fenton et. al; 1983) and Trachopscirrhosus (Barclay et. al; 1982) continue to produce echolocation calls even when relying on prey-generated cues.

Mostly carnivorous bats, including M. lyralyra have short and broad wings. These features of wing enhance slow flight, highly skillful movement and good lifting capacity. These characteristic features of wings are essential for hunting small terrestrial vertebrates when passing through areas of high clutter. During flying in clutter areas, i.e. within high vegetation, bats are convenient with short wings and slow speed. This carnivorous bat will not hunt the prey with continuous flight because it is difficult to land on a prey, to catch it and then take off again.Generally, *M. lyralyra* foraging in a clutter area by sit and wait mode of pattern.

Present study aims to describe the morphology of tongue of *M. lyralyra* in relation with its carnivorous feeding habit. The shape and location of lingual papillae dependsupon, which type of diet consumed by bat. Structural features of lingual papillae are appropriate with their function. Some degree of structural variation especially in shape and number of papilla on the dorsal surface of the tongue was identified in different species of bats. Three types of papilla were identified in insectivorous bats whereas four types of lingual papillae (i.e. Filiform, Fungiform, Conical and Vallate) are present in Fruit-eater bats.

In study, it was seen that fungiform on the dorsum located at the tip of tongue, root, lateral sides as well as these are characteristically arranged into two rows lateral to the prominent central groove. The main function of the fungiform papillae was the taste sensor because it contained the taste bud (Hwang and Lee 2007) and its number depend upon different type of food consumed by bat species (Chung &Kwun 1977). Number of vallate papillae in bats is also different and depends upon its food habit. Most Fruit-eater bats have three vallatepapillae and insectivorous as well as carnivorous bats have two (Son *et. al*; 2000 and Gregorin 2003). Ciliated and mucous cells occurred in the peripapillary trench of circumvallate papillae, which are helpful for circulation of saliva, wetting the taste pore and removal of debris from peripapillary trench.

The shape and distribution of different types of lingual papillae specially, filiform papillae making a rough surface in the front of tongue areeffective in touching and taking of the food particles but posterior papilla participate in transportation of food. In carnivorous bats, the structure of the tongue is extremely complex andthe epithelium of the anterior half of the tongue is extremely keratinized if compared with the posterior half.

In carnivorous bats, serous glands and mucous glands present in more number, because these bat species feeds on small arthropods to vertebrate, those have rough fragmented body parts. Due to this reason, they need high percentage of salivary secretion for making food more lubricant and easily swallowable.

The posterior surface of tongue covered by smooth mucosa and large posterior lingual glands i.e. serous glands located in front of the medial circumvallate papillae along the margins of the tongue near it's root and under the mucosa of the lymphatic area (Couchmanet.al ; 1979). The serous glands embedded among in connective tissue beneath the muscle bundles. The serous glands had small ducts for secretion transportation and specially found deeply into the posterior region of the tongue.

The specific feeding habits of carnivorous bats are considered as a natural predator, which provide direct benefits to the agro forestry by Insect-pest Suppression service (Ramteke et. al; 2012a). Their diet includes small mammals, birds, frogs and insects (Hill and Smith 1984). Bats especially pregnant and lactating females, those have very high energy demands can eat large numbers of arthropods. A maternity colony of one million Brazillian free-tailed bats consume in the region of 8.4 metric tons of insect in a night (Kunz et.al; 2011). Many of the species consumed agricultural pests and disease vectors. Due to increase numbers of insect, developing pesticide resistance in the form of insectivorus bat because biological controls more important against pesticide use. Guano of bats, used as natural fertilizers on agricultural crop. Guano may be primary limiting nutrients of most plant life because it very rich in nitrogen and phosphorous (Fenton 1983). Owing to its feeding habits, the False Vampire Bats acknowledged as a good friend of farmers. Farmers generally call it the "Goddess Laxmi" and provide it food during harsh weather. Single Colony of M. lyralyra ranging from 25 to 240 individuals and are helpful to consume rats and mice, which destroy different grains stored in bags (Sinha, 1986).

Conclusion

The diversity of feeding habits directly reflects on morphological structure of tongue and arrangement of mechanical and gustatory papillae. The tongue of *Megadermalyralyra* showed specific structure, distribution and characteristic arrangement of lingual papillae in relation with their carnivorous feeding habits

References

1. Advani, R. (1981). Seasonal fluctuations in the feeding ecology of the Indian False Vampire, Megadermalyralyra (Chiroptera: Megadermatidae) in Rajasthan. Zeischrift fur Saugetierkunde46: 90-93.
2. Bell, G.P. (1985). The sensory basis of prey location by the California leaf-nosed bat MacrotusCalifornicus (Chiroptera :Phyllostomidae). Behavioural Ecology and Sociobiology. 16: 343-347.
3. Barclay, R.M.R. (1982). Interindividual use of echolocation calls: cavesdropping by bats. Behavioural Ecology and Sociobiology. 10: 271-275.
4. Brinklov, S., Kalko, E. K. V. and Surlykke, A. (2010). Dynamic adjustment of biosonar intensity to habitat clutter in the bat Macrophyllummacrophyllum(Phyllostomidae). Behavioural Ecology and Sociobiology. 64: 1867-1874.
5. Chung, Y. M.,Kwun H.S. (1977). A morphological study on the tongue of the vertebrates. I. Comparative macroscopic and microscopic observations. J. Catholic Medical College. 30: 531-555.
6. Couchman, J. R., Gibson, W.T., Thom, D.,Weaver, A.C., Rees, D. A., Parish, W.E. (1979). Fibronectin distribution in epithelial and associated tissues of the rat. Dermatol. Res. 266(3): 295-310.
7. Elizalde- Arellano, C., Uria- Galicia, E., Lopez-Vidal, J.C.(2004). Morfologia lingual Del murcielagoPiscivoroNoctilioLeporinus (Chiroptera: Noctilionidae). ActaZoologica Mexicana (n.S.) 20 (2): 69-78.
8. Fenton, M. B., Gaudet, C.L., Leonard, M. L.(1983). Feeding behaviour of Nycterisgrandis and Nycteristhebaica (Nycteridae) in captivity. Journal of Zoology (London), 200: 347-354.
9. Geluso, K. N.,(1978). Urine concentrating ability and renal structure of insectivorous bats. J. Mamm. 59: 312-323.
10. Glass, B. P., Slaughter, B. H., Walton, D. W.(1970). Feeding mechanisms of bats and a Chiropteran biology symposium.

Southern Methodist Univ. Press, Dallas, Texas. 339: 84-92.
11. Gregorin, R. (2003). Comparative morphology of the tongue in the Free-tailed bats (Chiroptera- Molossidae).
12. Iheringia. Serie. Zool. Porto. Alegre. 93: 213-221.
13. Holderied, M., Korin, C., Moritz, T.(2011). Hemprich's long-eared bat (Otonycterishemprichii) as a predator of Scorpions: whispering echolocation, passive gleaning and prey selection. Journal of Comparative Physiology A. 197: 425-433.
14. Hwang, H., Lee, J.(2007). Morphological study on the dorsal lingual papillae of Myotismacrodactylus. Korean J. Ele. Micro. 37 (3): 147-156.
15. Iwasaki, S. (2002). Evolution of the structure and function of the vertebrate tongue. J. Anat. 201(1): 1-13.
16. Jahnke, K., Baur, P. (1979). Freeze-facture study of taste bud pores in the foliate papillae of the rabbit. Cell. Tissue. Res. 200(2): 245-256.
17. Jones, G., Siemers, B. (2011). The communication potential of bat echolocation pulses. Journal of Comparative Physiology. A. 197: 447-457.
18. Kalko, E.K.V., Schnitzler, H.U. (1993). Plasticity in echolocation signals of European Pipistrelle bats in search flight: Implications for habitat use and prey detection. Behavioural Ecology and Sociobiology. 33: 415-428.
19. Malthy, A., Jones, K.E., Jones, G. (2009). Understanding the evolutionary origin and diversification of bat echolocation calls. In: Handbook of Mammalian Vocalization : An Integrative Approach (Ed. By S.M. Brudzynski), Pp. 37-48. Oxford : Academic Press.
20. Marimuthu, G., Habersetzer, J., Leippert, D.(1995). Active acoustic gleaning from the water surface by the Indian False Vampire Bat, Megadermalyra. Etholgy. 99: 61-74.
21. Mistry, S. (1995). Bats of India. Bats 13(2): 11-15.
22. Mohres, F.P.(1967). Communicative characters of sonar signals in bats. In: Animal Sonar System: Biology and Bionics. Vol.2 (Ed. By R.-G. Busnel), Pp. 939-945. Jouy-en-Josas, France: Laboratoire de PhysiologieAcoustique.
23. Nickel, R., Schummer, A., Seiferle, E.(1973). The Viscera of the domestic mammals. Berlin: Verlag. Paul. Parey. 21-74.
24. Patil, K.G. (2006). Comparative studies on the kidney of three species of Indian bats. Ph.D. Thesis, R.T.M.Nagpur, Univ. Pp. 85.
25. Ramteke, A.V., Zade, S.B., Patil, K.G.(2012a). Insect-Pest suppression and Ecosystem Services of Insectivorous Bat, Taphozouslongimanus (Emballonuridae). Proceedings of National Congress: Stepping up with Bio- Scientific Technologies INNERVATE 2012, Pp. 193-197.
26. Ratcliffe, J.M., Raghuram, H., Marimuthu,G., Fullard, J. H., Fenton, M.B.(2005). Hunting in unfamilian space: Echolocation in the Indian False Vampire Bat, Megadermalyra, when gleaning prey. Behavioural Ecology and Sociobiology, 58:157-164.
27. Robinson, P.P., Winkles, P.A. (1990). Quantitative study of fungiform papillae and taste buds on the cat's tongue. Anat. Rec. 225: 108-111.
28. Schmidt, S., Hanke,S., Pillat, J. (2000). The role of echolocation in the hunting of terrestrial prey-new evidence for an underestimated strategy in the gleaning bat, Megadermalyra. J. Comp. Physiol. A. 186: 975-988.
29. Son, S., Lee, H., Lee, J. (2000). Ultrastructural observations of the lingual papillae of the Korean greater horseshoe bat, Rhinolophusferrumequinum Korai. J. Basic. Sci. Res. Inst. 14: 65-72.
30. Sonntag, C.G. (1920). The comparative anatomy of the tongues of the Mammalia. A. XI. Marsupialia and Monotremata. Proc. Zool. Soc. London. 701-762.
31. Stevens, A., Lowe, J.(1993). "Histology", Mosby, Year Book Europe, Ltd. Pp: 378.
32. Swartz, C., Tressler, J., Keller, H., Vanzant, M.,Ezell., Smotherman, M. (2007). The tiny difference between foraging and communication buzzes ultered by the Mexican Free-tailed bat,

Tadaridabrasiliensis. Journal of Comparative Physiology A. 193: 853-863.
33. Takeda, M., Obara, N., Suzuki, Y.(1990). Keratin filament of epithelial and taste-bud cells in the circumvallate papillae of adult and developing mice. Cell. Tissue. Rec. 260: 41-48.
35.
34. Tandler, B., Toyoshima, K., Seta, Y., Phillips, C. J.(1997). Ultrastructure of the salivary glands in the midtongue of the Common Vampire Bat, Desmodusrotundus. Anat.Rec.249(2):196-205.