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Foraging behaviour of the microchiropteran bat, *Hipposideros ater* on chosen insect pests

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ABSTRACT

In the biological spectrum, microchiropteran bats play a crucial role in reducing the population of pest insects. The dusky leaf-nosed bat, *Hipposideros ater* (body wt. 3.5±0.2 g) is a well known predator of nocturnal flying insects. This species of bat keeps a check on agricultural pests while it forages during night time. An attempt has been made to study the foraging behaviour and food habit of this bat. The food items of *H. ater* were examined from culled parts of the prey insects collected from their feeding roosts as well as from faecal pellet analysis. In addition, a sample collection of insect pests from the foraging area is compared with the diet of this foraging bat species. The results reveal that the foraging time of *H. ater* and the activity period of insect pests coincide in the study area. Moreover, this bat species control major pests of stored grains (*Tribolium* spp) which constitute 55.83% of coleopteran, and the rest includes lepidopteran pests such as *Hippotion celerio* (pest of grapevine), *Nausinoe geometralis* (pest of jasmine), *Othreis meterna, Othreis fullonica* (pests of citrus and grapevine) and *Nelanitis leda ismene* (pest of rice) whose larvae and adults are serious pests in South India. During winter seasons, *H. ater* feeds on the dipteran insects, especially mosquitoes, which constitute 98.33% of the total intake. Comparison of food habit of *H. ater* roosting at different localities in Tirunelveli district indicates that they are selective but opportunistic in feeding their prey insects. The nocturnal foraging behaviour, echolocation capability, dentition and flight maneuverability of this bat species are the adaptations that enhance their ability to capture nocturnal prey insects in open space during their foraging flight.

Key words: Microchiropteran bat, foraging behaviour, crop pest management

INTRODUCTION

Among various pests, farmers encounter, insects are the chief competititors against which they have to fight for ever. The agro-ecosystem analysis indicates that bats are the real agents who do pest control in tropical plains and in the rain forest of India (Vanitharani, 2004). The twilight foraging by the bats has potential benefits especially in tropical regions where insect diversity is high. Bats are well known predators of many nocturnal insect pests which are important in the field of agriculture; Eg. *Myotis lucifugus* (Belwood and Fenton, 1976), *Eptesicus fuscus* (Whitaker, 1995), *Tadarida brasiliensis mexicana* (Whitaker *et al.,* 1996) and *Pipistrellus mimus* (Whitaker *et al.,* 1999). The enormous insect consumption of bats is valuable to agriculture and particularly to local farmers which have attracted the farmers towards the role of bats as agricultural pest controlling agents (Murphy, 1993; Whitaker, 1993; Tuttle, 1995). Agro-ecosystems underpin the economics of local, regional and nation and the value of pest control service rendered by bats helps to maintain the ecological integrity of agro-ecosystem. The most common insect orders consumed by bats are Coleoptera, Lepidoptera, Diptera, Hymenoptera and Isoptera (Verts *et al*., 1999; Pavey *et al*., 2001).

It is usually possible to identify most of prey insects reminants to reasonable level i.e. at least to the order level (Whitaker, 1978). It is rather easier because most bats do not eat many different kinds of insects at one time. Thus a single stomach or faecal pellet often contains one to four kinds of insect reflecting their successful feeding. Coutts *et al*. (1973) found that faecal pellet analysis is easier because the layer of 'scum' present on the stomach content is absent when they are expelled out. An important advantage of analysing culled parts is greater easy and accurate in identification of prey since individual items are often large and diagnostic (wing and head parts) but will not allow estimation of relative volumes of various food items. Much useful data on food habits of bats have been gained by culled parts (Laval and Laval, 1980; Belwood and Fullard, 1984).

Insectivorous bats have many morphological adaptations that allow them to capture and handle prey in flight and their teeth are also more crucial (Evans and Sanson, 1998). Wing morphology aids the bats to do various flight performances and to capture prey in their aerial feeding habits (Norberg and Rayner, 1987). The size of the bat, wing loading, maneuverability and flight expense affords a big role on bats to be on their wings (Vanitharani, 1998) which in turn is reflected in their hunting ability during foraging. All hipposiderid bats capture the prey in their aerial hawking, a behaviour by which a bat captures a flying insect (Pavey and Burwell, 2000). The objective of the present study was to investigate the foraging and pest controlling behaviour of a microchiropteran bat *Hipposideros ater.*

MATERIALS AND METHODS

The study was conducted in and out Tirunelveli (8^0 44' N lat. $74^0$42E long), Tamil Nadu (May 2001-December 2003). The general climatic conditions of study area are typically tropic. The leaf-nosed bat, *H. ater* (3.5± 0.02 gm) is a smaller hipposiderid insect-eating bat commonly available in the study area but declining at a faster rate and need conservation. Dietary habit study on *H.ater* was done by faecal pellet analysis and examination of culled parts collected beneath the roost. Stomach content analysis was not preferred to avoid unnecessary killing of bats. Insect collections were made in parallel to pellet collection though insect traps set in the foraging area.

Fresh faecal pellets were collected from the day roost by spreading polythene sheets once in a fortnight. Twenty pellets were randomly selected and their dried weight (0.15 gm) was taken to 0.01 gm accuracy by using digital balance (OHAUS-USA). The pellets were soaked in 70 percent alcohol and teased apart individually using fine needle under microscope. Then they were mounted in DPX on glass slides. Each slide was systematically searched for identifiable insect parts under binocular microscope (Olympus CH2Oi. Japan). Identifications were made with the help of authenticated literatures (Borror, 1992) available on Indian insects. Common insects collected from the foraging area helped in easy comparison of prey selection of the bat and the major pest prevailing in the study area. The percentage frequency of insect orders consumed for each month and percentage volume of preferred insect orders by *H. ater* were calculated for the entire study period by using the following formulae (Kunz, 1988).

$$(1)\text{Percentage frequency} = \frac{\text{Number of occurrence of categories}}{\text{Total occurence of all categories}} \text{x100}$$

$$(2)\text{Percentage Volume} = \frac{\text{Sum of individual volumes}}{\text{Total volume of the sample}} \text{x100}$$

Total volume of the sample occurrence of mosquito fragments in the faecal pellets during November and December months prove the role of *H.ater* in mosquito control. So faecal pellets were analysed for mosquito parts during the winter season of 2005 in the study area.

The study was conducted for a comparison of percentage frequency of major insect orders consumed by five different colonies of *H. ater* roosting in five different localities such as automobile workshop (LTW) urban area, unused chamber of Sarah Tucker College (STC), Perumalpuram and the next colony is roosted in a lumber room of Kulavanigar puram (KVP). (residential places), Therkukallur at Cheranma hadevi (CDV) and Murapanadu (MN) (agroecosystems). This comparison was done only during the rainy seasons when the insect density is high in the study area which also fortunately correlates with the winter breeding season of *H.ater*. The data were subjected to oneway ANOVA and Tukey Test, significance expressed at 5% level.

RESULTS

The results of faecal analysis show that important insect orders belonging to (Figure 1) Coleoptera, Lepidoptera, Diptera and Hemiptera were consumed as major and constant dietary items of *H. ater* throughout the year. This has been expressed in terms of percentage frequency. Similarly Figure 2 explains that Hymenoptera, Trichoptera, Neuroptera and Dermaptera were less preferred and their occurrence in the faecal remains seem to be scanty throughout the year.

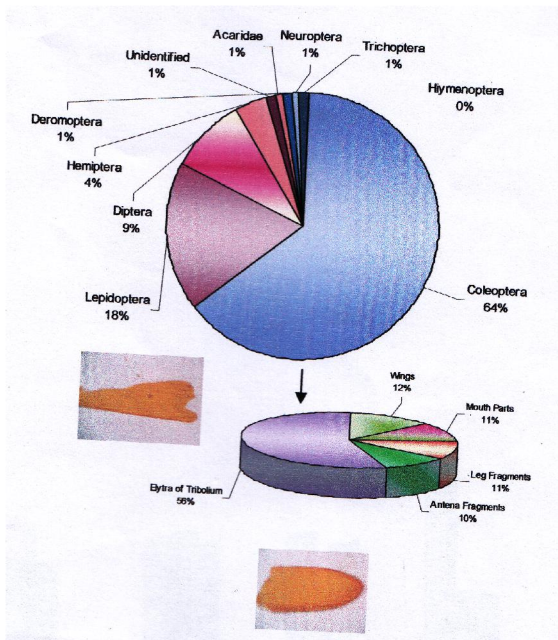

Figure 1. Percentage volume of insect orders consumed by *H.ater* showing coleopteran as the primary insect order by elytra of *Tribolium* spp.

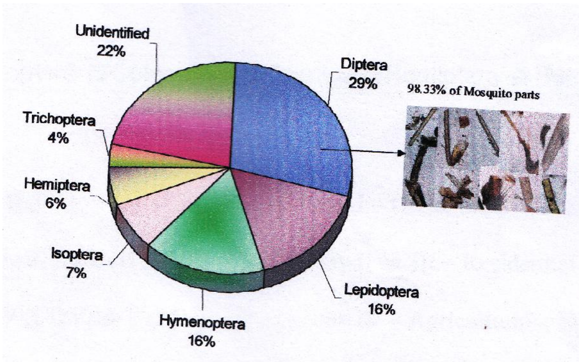

Figure 2. Percentage frequency of mosquito remnats among the dipteran insects consumed by *H.ater.*

The consumption rate has been evaluated by the calculation of percentage volume for each order of insects consumed by the bat. The percentage volume of preferred insect orders of *H. ater* are Coleoptera (63.36% vol.), Lepidoptera (18.13%), Diptera (8.90%) and Hemiptera (3.78%). Orders like Hymenoptera (0.23%), Trichoptera (1.44%), Neuroptera (0.75%) and Dermoptera (1.35%) were found with lower amount throughout the study period.

Of all the major dietary items, coleopteran insects were consumed more by the bats throughout the year except in the month of November. The consumption rate reached its peak during the month of September (80.95% in 2001; 80.75% in 2002 and 70.04% in 2003). The consumption is less in November (31.78% in 2001; 30.08% in 2002 and 32.01% in 2003). During this month lepidopteran ranks first. Figure 3 explains the percentage frequency of major insect orders consumed by the *H.ater* during 2001-2003. Among the coleopteran insects, the *Tribolium sps.* of beetles constitute 55.38% of the total consumption. They are represented by their elytra in the faecal pellets.

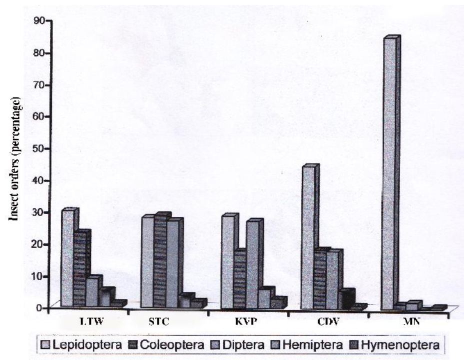

Figure 3. Insects consumed belong to different orders by *H.ater* roosting in automobile workshop (LTW), Sarah Tucker College (STC), Kulavanigar puram (KVP), Cheranmahadevi (CDV) and Murapanadu (MN).

Consumption rate of lepidopteran insects is high during the month of November (41.89% in 2001; 42.85% in 2002 and 44.13% in 2003) and December (32.9% in 2002 and 31.13% in 2003). Similar to lepidopteran dietary preference, dipterans were also preferred more during November and December when compared to the consumption of these insects with the rest of months of the study period. Mosquitoes constitute 98.33 % among of the dipteran prey items (Figure 4) during the month of November and December, 2005.

Figure 3 explains the comparison of the major food items of *H.ater* roosting in different localities. All the five colonies preferred lepidopteran prey items markedly in a high rate during their breeding and early lactation period. Among the five colonies, the colonies belonging to agricultural background top first (44.52% vol and 84.75% vol) indicating the availability of moths in the agricultural fields. Other three colonies show more or less same level of consumption of moths (urban colony - 27% vol; the residential colonies – 28.08% vol and 28.84% vol). The second choice of food item in all these selected colonies is coleopterans followed by dipterans, hemipterans and hymenopterans. Their consumption rates in all the five colonies do not show notable variation among them. These comparisons of food selection by these five colonies were dealt statistically by ANOVA. It indicates no significance difference (F= 2.87 at 5% level of significance) between the five colonies in their preference of food item.

The comparison between two colonies located in the urban ecosystem has no much variation (T= 0.79 at 5% level of significance). In addition, the value shows positive correlation (0.9349) in their food choice. Similarly the two colonies located in the agricultural area also show the similar results (T = .09 at 5% level of significance). In addition both the colonies show positive correlation (0. 8991) in their food preference.

DISCUSSION

Hipposideros ater emerges from their roosts for foraging during twilight which is the peak activity time for many of the insect pests preyed by them. The dietary selection of many microchiropteran bats mainly includes coleopterans, lepidopteran, dipteran, orthopteran and hemipteran group of insects (Anthony and Kunz, 1977; Whitaker *et al.*, 1999). Incidentally they are the insect groups which include our predominant crop pest. In India 15% of total agricultural production is lost by insect pests every year (Krishnan, 1993).

Like *H. ater*, many of the Indiana bat species like *Nycticesus humaralis* and *Lasiurus borealis* (George *et al.*, 1995) and *Pteronontus gymnonotus* and *P. daviyi*

(Molinari *et al*., 2001) also prefer coleopteran insects as their primary food item. Indian bats like *Hipposideros commersoni* (Whitaker and Black, 1976), *H. lankadiva* (Phillips, 1980) and *Megaderma lyra* (Balasingh, 1990) also prefer coleopteran insects as their major dietary items. Among microchiropterans, hipposiderid bats generally prefer beetles and moths (Whitaker and Black, 1976). In addition coleopteran and lepidopteran insects appear to be the two most important insect orders in the diet of Indiana bats (Kurta and Whitaker, 1996).

The remarkable major representatives among the coleopterans are the *Tribolium* spp. of insects in the food items of *H.ater* in the present study. This higher choice of *Tribolium* spp. of beetles is due to the presence of Tamil Nadu warehouse very close (2 km) to the roosting site with a capacity of 18,500 metric tons. This godown constantly stores food grains like rice, wheat, red jowar, and paddy seed along with sugar throughout the year. The authorities inform that the major pests that make holes in the stored grains are the *Tribolium* beetles. The public of the neighbourhood also faced these problems due to these *Tribolium* beetles. It is also reported as the major pest of stored grains (Nair, *et al.,* 1976; David *et al.,1992).*

The next major nocturnal pest in the agro-ecosystem is caterpillars of moths which are grouped under Lepidoptera, the second order of food choice of *H. ater*. The collection of culled insect parts like wings in the roost and faecal pellet analysis together have confirmed that these bats have consumed many varieties of moths which were available in the foraging area. If a single moth is consumed, automatically that will prevent the laying of 200-400 eggs (depends on species) which in turn will hatch into caterpillars the major pests of agricultural crops. The studies of Pavey and Burwell (2000) in Australia support the fact that the faecal pellets of *H. ater* contain 90% of lepidopteran scales. Ramanujam and Verzhutskii (2004) have also reviewed 31.81% of coleopteran in the pellets of *H. ater* in Auravilli, South India along with lepidopteran (21.64%) moths. Phillips (1980) reported beetles in the diet of *H. lankadiva*. Whitaker and Black (1976) found beetles exclusively in the faeces of *H. commersoni*. Eckrich and Neuweiler (1988) noticed *H. lankadiva* to feed mainly on beetles and suggested them as selective feeders.

In the present study on *H. ater,* consumption of lepidopteran rate tops the dietary preference of during November and December which is their parturition and lactation period. It also correlates with the high occurrence of moth population and the monsoon of the study area.

In pellet analysis, lepidopterans were represented by scales. The identification of the moth species is a very difficult task (Mani, 1971). The culled spit outs and the moth wings collected from the roosting site of *H.ater* have proved that a handful number of lepidopteran and coleopteran pests seem to be the food items of *H. ater*. The remarkable such pests are *Hippotion celerio* (pest of grapevine), *Nausinoe geometralis* (pest of jasmine), *Othreis meterna, O. fullonica* (pest of citrus and grapevine), *Melanitis leda ismene* (rice) and also June beetle (a coleopteran) whose larvae and adults are serious pest in South India (Nair, *et al.,* 1976; David, *et al.,* 1992).

Order Diptera that includes the mosquitoes and other flies is the next order of insects which are preferred by *H. ater*. Their consumption volume reaches 23.06% during the winter months which is the peak breeding time of these insects. Out of these dipteran consumption 98.33% traces were of mosquitoes. In addition evidence of a higher volume of mosquito consumption was found during the months of November and December. This is an indication that *H. ater* do help in control of mosquitoes which are the major and complex problem in the urban ecosystem. It is also true that in general, mosquitoes that bite human and other mammals prefer to fly at a height less than 25 ft (Yuval *et al.,*1993) which is the foraging canopy for the hipposiderid bats (Vanitharani, 1998). As the timing of peak activity and swarming area of mosquitoes and bats overlap each, it is clear that *H.ater* pulls down the high hatches of mosquitoes around their roosting sites as well as in the foraging area.

Hunting coleopterans by *H.ater* is easier because beetles are relatively slow fliers. Bats prefer beetles as they have high level of fatty acid (Shalk and Brigham, 1995) which meets the energy demand of the bats. This may be the reason for *H.ater* to select more beetles in their dietary items. Another reason for KVP colony is the availability of smaller beetles of *Tribolium* spp. in the storage godown which is located close to the roosting site. Morphology of teeth, jaws and canine results in the incorporation of moths and beetles in the diet of hipposiderid bats (Bogdanowicz *et al*., 1999). *H. ater* has a small head with wide mouth. Though they have weak dentition, their canines are strong enough to break the exoskeleton of smaller beetles. Their molars with multiple edge help in easy mastigation. The wing morphology aids these bats to do various flight performances to catch the detected prey by echolocation. After prey capture the dental morphology aids the bat to consume them.

The dietary analysis and the morphology of *H.ater* confirm their role as a pest control in both agro and urban ecosystems and keep a check on major nocturnal pests. But these bats are in danger due to habitat destruction and interferences by human. So providing artificial roosts to replace the lost habitat may allow and encourage them to continue their pest control service in the ecosystem. Encouraging bats to live in bat houses near our home, farm and orchard will provide considerable reduction in pests. Participants of first Agrobat workshop held in 1999 at Texas recommended the bat conservation societies and chiropterologists all over the world to encourage the farmers to build bat houses and bat boxes in their agro-ecosystem to lessen the trouble of pest management (Mac Cracken and Long , 1999).

REFERENCES

Anthony, E. I. P. and Kunz, T. K. 1977. Feeding strategies of little brown bat, *Myotis lucifugus* in Southern New Hampshire. *Ecology*, **58**:775-786.

Balasingh, J. 1990. The behaviour of the Indian false Vampire bat, *Megaderma lyra* Geoffroy, 18130 : Field Ethological Studies. Ph. D., Thesis, Madurai Kamaraj University, Madurai, Tamil Nadu, India.

Belwood, J. J. and Fenton, M. B. 1976. Variation in the diet of *Myotis lucifugus* (Chiroptera- vespertilinoidae). *Canadian Journal of Mammology,* **54**: 1674-1678.

Belwood, J. J. and Fullard, J. H. 1984. Ecolocation of foraging behaviour in Hawaiian hoary bat *Lasiurus cinereus. Canadian Journal of Zoology,* **62**:2113-2120.

Bogdanowicz, W., Fentosn, M. B. and Daleszczyk, K. 1999. The relationship between echolocation calls, morphology and diet in insectivorous bats. *Journal of Zoology, London.* **247**: 381-393.

Borror, D. 1992. An Introduction to the study of insects. Harcourt Bace College Publishers, USA.879-896.

Coutts, R. A., Fenton, M. B. and Glen, E. 1973. Food intake by captive *Myotis lucifugus* and *Eptesicus fuscus. Journal of Mammology,* **54**: 985-990.

David, B. V., Muralirangan, M. C. and Muralirangaran, M. 1992. Insect pests. **In:** Harmful and beneficial insects. (David, B.V. ed.). Popular Off-set press, Madras. 70-75.

Eckrich, M. and Neuweiler, G. 1988. Food habits of the sympatric insectivorous bat *Rhinolophus rouxi* and *Hipposideros lankadiva* from Srilanka. *Journal of Zoology, London*, **215**: 729-737.

Evans, A. R. and Samson, G. D. 1998. The effect of tooth shape on the break down of insects. *Journal of Zoology,* London. **246**: 391-400.

George, A. F., Whitaker, J. O., Rejca, K. and Taylor, J. S. 1995. Food of evening bat (*Nycticesus humaralis)* and Red bat (*Lasiurus borealis*) from Southern Illinois, Transations of the Illinois state. *Journal of Academy of Science*, **88:**139-143.

Krishnan, N. T. 1993. Economically important pest. **In:** Economic Entomology. (Krishnan N. T. ed.). J. J. Publications. Madurai. 4-78.

Kunz, T. H. 1988. Food habit analysis of insectivorous bats. **In:** Ecological and behavioural methods for the study of bats (Kunz, T. H. ed.), Simithsonian Institution Press, Washington, London. 171-209

Kurta, A. and Whitaker, J. O. 1996. Diet of endangered Indiana bat, *Myotis sodalis* in Michigan. *Bat Research News,* **37**:139.

Laval, R. K. and Laval, M. L. 1980. Prey selection by neotropical foliage gleaning bat, *Micronycteris megalotis. Journal of Mammology*, **61:** 327-330.

Mani, M. S. 1971. Moths. **In:** Insects. National Book Trust Publication, New Delhi, India. 84-96.

MacCracken, G. F. and Long, L. F. 1999. Nature's Crop Dusters-Excerpts from Abstract Presentation, First Agrobat Workshop in Bat Conservation International Newsletter.www. batcon. org. news 2/scripts

Molinari, J., Aseenacao, A. D. and Kalko, E. K. V. 2001. Feeding ecology of the nacked – backed bats, *Pteronontus gymnonotus* and *P. daviyi* in Venezuala. *Bat Research News,* **42**: 134.

Murphy, M. 1993. A farmer's best friend. *Bats*, 11 : 23.

Nair, K. K., Anantha Krishnan, T. N. and David, B. V. 1976. General and applied Entomology. (Jasswal, P. L., Wadhwani, A. M., Singh, C. and Bawa, S. eds.). Tata Mc-Graw-Hill Publishing Company Limited, New Delhi. 130 - 362.

Norberg, U. M. and Rayner, J. M. V. 1987. Ecological morphology and flight in bats (Mammalia, Chiroptera) : Wing adaptations, flight performance, foraging strategy and echolocation. *Philosophical Transaction of the Royal Society,* London, **316:** 335-427.

Pavey, C. R. and Burwell, C. J. B. 2000. Foraging ecology of three species of *Hipposiderid bats* in tropical rain forest in north east Australia. *Wildlife Research,* **27**: 283-287.

Pavey, C. R., Burwell, C. J., Grunwald, J. E., Marshall, C. J. and Neuweiler, G. 2001. Dietary benefits of twilight foraging by insectivorous bats. *Hipposideros speoris. Biotropica,* **33**:670-681.

Phillips,W. W. A. 1980. Manuel of the mammals of SriLanka. Part.I Wildlife and Nature Production Society of Srilanka. 1-116.

Ramanujam, M. E. and Verzhutskii, B. 2004. Prey of the Dusky leaf nosed bat, *Hipposideros ater,* Templeton in Aurovilli, South India, *Journal of Zoology's Print,* **19**: 1698.

Shalk, G. and Brigham, R. M. 1995. Prey selection by insecti vorous bats; Are essential fatty acids important? *Canadian Journal of Zoology*, **73**: 1855-1859.

Tuttle, M. D. 1995. Saving North Americans beleaguered bats. *Natural Geographic Society,* **188**: 36-57.

Vanitharani, J. 1998. Studies on the changes of wing morphology and body weight in few species of South Indian Bats. Ph.D., Thesis, Madurai Kamaraj University, Madurai, Tamil Nadu. S. India.

Vanitharani, J. 2004. The emerging trends in the bio-diversity of bats in Tamil Nadu. *Mapana Journal of Science,* 14-27.

Verts, B. J., Carraway, L. N. and Whitaker, J. O. 1999. Temporal variation in prey consumption by big brown bats, Exptesicus fuscus in a maternity colony. *Science,* **73**: 114-120

Whitaker, J. O. 1978. Food habit analysis of insectivorous bats *In*: Ecological and behavioural methods for the study of bats, (Kunz, T. H. ed.), Smithsonian Press, Washington. 171-189 **PP**.

Whitaker, J. O. 1993. Bats, Beetles and Bugs. More big brown bats as agricultural pests. *Bats,* **11**:23.

Whitaker, J. O. 1995. Food of the big brown bat, *Eptesicus fuscus* from maternity colonies in India and Illinois. *American Midland Naturalist,* **134**: 346-360.

Whitaker, J. O. and Black, L. H. 1976. Food habits of cave bats from Zambia, Africa. *Journal of Mammology*, **57**: 199-204.

Whitaker, J. O., Neefus, C. and Kunz, T. H. 1996. Dietary variation in the Mexican free tailed bat *Tadarida brasiliensis mexicana. Journal of Mammology,* **77**: 716-724.

Whitaker, J. O., Issac, S. S., Marimuthu, G. and Kunz, T. H. 1999. Seasonal variation in the diet of the Indian pygmy bat, *Pipistrellus mimus* in South India. *Journal of Mammology,* **80**: 60-70.

Yuval, B. M., Weskesa, W. J. and Wakshino, R. K. 1993. Effect of body size on swarming behaviour and mating success of male *Anopheles freedorni*.*Journal of Insect Behaviour,* **6**: 333-342.

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