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ORIGINAL ARTICLE

Prey and Nutritional Analysis of *Megaderma lyra* Guano from The West Coast of Karnataka, India

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ABSTRACT
Microchiropteran bats play a vital role in the ecosystem. They consume large volumes of insects many of which are agricultural pests and their droppings (guano) contain large amount of partly digested insect parts that form the resource base for other diverse form of consumers in the food chain including diverse microbes. These together make guano the best organic fertilizers. However, food habits of different species of bats vary depending on the species, locality, season and the ability of the bat to detect certain types of insects using morphological characteristics. Hence, an attempt is made in the present study to analyze the seasonal variations in the food habit of a microchiropteran bat, Megaderma lyra, so as to determine the insects on which they feed and also to do a nutritional analysis that include the moisture , carbohydrate, protein, lipid, ash, nitrogen, phosphorus and potassium content of their guano. The study was carried out during November 2009 to October 2010 in a maternity colony in an abandoned house which is mainly surrounded by coconut plantations and paddy fields. It is located at Karkala in D.K. district of Karnataka. To determine their insect prey, insect parts present in the bat guano were identified to ordinal level. The percent volume and percent frequency of food items present were also determined and were classified as basic food (>20%), constant food (5-20%), supplementary food (1-5%) and chance food (<1%). During the sampling period insects belonging to 15 orders were identified. The scales of fishes, legs of frogs and hair, tooth and legs of rats recorded during pre monsoon, monsoon and post monsoon were all included under Vertebrates. Of the total insect orders identified, Coleopterans formed the major food items in all the three seasons (Premonsoon, monsoon and postmonsoon) and Vertebrates alongwith Coleopterans formed major food items during monsoon and postmonsoon. Whereas Hemipterans formed the constant food in all the three seasons and Lepidopterans formed the constant food along with Hemipterans during monsoon and postmonsoon. Other insect orders quantified included Dictyoptera, Trichoptera, Orthoptera, Diptera, Hymenoptera, Odonata, Ephemeroptera, Isoptera, Neuroptera, Dermaptera, Thysanoptera and spiders. The insect orders represented in the faecal pellets though not all indirectly reflect the occurrence of agricultural pests since their presence coincides with the type of vegetation surrounding the roosting site. Nutritional analysis of the guano revealed that the guano contained maximum carbohydrate (2.8%) during pre monsoon, lipid content (9.3%) during post monsoon and protein during pre monsoon and post monsoon (8.9%) period. N-P-K analysis revealed that guano is rich in phosphorus. Also phosphorus content was recorded highest in all the seasons (6-11%) and potassium during monsoon (1.3%) and post monsoon (1.2%). However, no significant variation in the nitrogen content was recorded. Therefore, the present study indicates that the Indian false vampire bat preys substantially on several insects injurious to crops, gardens and lawns and also on rodents. Further study is needed on the potential impacts of this and other insectivorous bats on these economic pests and also on organic enrichment of bat guano in the study area.
Keywords: *Guano, insect prey, Megaderma lyra, nutritional analysis, seasonal variation, N-P-K content.*

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INTRODUCTION

Bats are the second largest, are widely distributed and are the only flying mammals. They belong to the order Chiroptera. The more than 1,200 species of bats – about one-fifth of all mammal species – are incredibly diverse. The order is divided into two sub orders, the megachiroptera and microchiroptera. The megachiropterans with only one family are all found in old world tropics and sub tropics, feed on fruits, nector and pollen and roost mostly in trees. The microchiropterans are found throughout the world and comprise 17 diverse families with 169 genera and 824 species [1]. They use high frequency echolocation and rely on hearing as their major locational sense. They may feed on insects, fruits, nectar, pollen, fish, frogs, or blood and roost in a great variety of sites including caves, mines, buildings and trees

[1]. Nearly 105 species belonging to 29 genera of 8 families are recorded with Indian subcontinent. Western Ghats is an important hotspot for bats with a mountain range, well developed forest cover and geological features. This area harbour nearly 35 species of microchiropterans distributed in different terrestrial biomes [1]. Although many people consider bats to be harmful pests, bats play pivotal roles in ecological communities and benefit humans in numerous ways. Many species of insectivorous bats prey heavily on insects that transmit diseases or are crop pests. In addition, bat guano (faeces) is often used to fertilize crops. Many tons of guano are mined each year from caves where bats aggregate in large numbers. In other words, some species eat crop pests and excrete crop fertilizer! Evidence continues to accumulate in support of the immense economic benefit of insectivorous bats for agricultural industries worldwide. Frugivorous bats are important seed dispersers, helping promote the diversity of fruiting trees in the tropics. Bats that eat pollen and nectar are important pollinators, and some plants they pollinate are economically important to humans, such as Agave and bananas (Musa). Larger bats, such as pteropodids are sometimes eaten by humans [2,3].

Megaderma lyra belongs to an ancient family of carnivorous bats Megadermatidae feed on small as well as large insects, frogs, fishes, small mammals and birds. They roost in abandoned houses, attics of houses, caves, temples, crevices of trees. They range from Afghanistan to southern China to Pakistan, India, Burma, Srilanka, Thailand and Malaysia. In the Indian subcontinent they are reported from Jammu-Kashmir, Himachal Pradesh, Gujarat, Maharashtra, Kerala, Tamilnadu, Andhra Pradesh, Orissa, Madhya Pradesh, Uttar Pradesh, Bihar, Bengal, Assam and Meghalaya [1]. In Karnataka they are reported from Honkan, Hangal, Devikop, Sirsi, Jog, Honnvar, Kardibetta forest, Sagar, Kolar, Seringapattam, Belgaum and Puttur [1,4].

The food habits of Insectivorous bats has been fairly documented from temperate countries[5,6,7,8,9,10]. The prey of *M lyra* has been well documented in general [1][2][11], as well as in certain areas like Rajasthan [12], Central and Western India, Bihar and Bangladesh[1]; Tamil Nadu[13]; Srilanka[14]. These bats consume large volumes of insects which are agricultural pests and their droppings (guano) form the resource base for other diverse forms of consumers in the food chain[15,16]. Fenelio *et al*.(2006) reported the ingestion of bat guano by cave adapted salamanders to meet their energy demands [17]. Depending upon the food habits of bats the guano produced supports diverse organisms that include arthropods, fungi, bacteria and salamanders representing different trophic levels. Consumers in this system feed directly on guano or microbes and/or arthropods that live on guano [18]. Energy flow in this trophic cascade is therefore based on guano production by the roosting bats [19]. Guano has long been mined from caves for use as fertilizers due to its high nitrogen and phosphorus content, the primary limiting factors of the plant growth [20,21]. Reichard (2010) demonstrated growth promoting activity of bat guano to be species specific on plant communities and hence emphasized on more in depth experimental and field studies [22]. Sridhar *et al*. (2006) also demonstrated the organic manure quality of cave bat, *Hipposideros speoris* guano on crop production [23].

Although few more studies on insect prey of *M lyra* has been done [1][13], no published data are available for seasonal variation in food habits of *M. lyra* from Karnataka. Eventhough several studies have compared the impact of guano from different bat species on cave ecology [18][24][25], seasonal variation in nutritional composition of guano has received no attention. Hence, the present study reports the seasonal variation in the insect prey of *M. lyra* and a preliminary report on its guano composition.

MATERIALS AND METHODS

Study area: A diurnal roost of Indian False vampire bat, *Megaderma lyra* is located in an abandoned house in Yennehole village of Karkala taluk, (13° 12′ 53″ N ; 74° 59′ 47″ E) Dakshina Kannada, Karnataka. This house is surrounded by coconut, areca nut and banana plantations, paddy fields, woodlands, hills and other residences. There are around 12 -15 bats roosting in this house day and night. A few also roost in cowshed next to this house and often move between these two constructions. However, sampling is done only from the house.

Sampling- Papers were spread over the floor at five different spots under the roosting site and the droppings were collected periodically over three seasons viz., Pre monsoon (Feb--May), Monsoon (June—September) and Post monsoon (October—January) of October 2009 to November 2010. Faecal pellets collected for insect prey were properly labeled and preserved in 70% alcohol and analyzed microscopically using the method described by Whitaker [26]. The remaining pellets were kept at -20^{o} C for further nutritional analysis.

Prey analysis of guano - The pellets were soaked in a petridish containing 70 percent alcohol and teased apart individually using fine needles under a microscope. Each pellet was searched for the partially digested insect parts (leg, wings, antenna and mouth parts) and were identified using the Standard keys given in entomological guide books [27] and papers focused on bat diets [26]. The

percentage volume and percentage frequency of the foods consumed for each month were calculated for the entire study period by using the following formulae given by Whitaker [26].

$$\text{Percentage volume (\%)} = \frac{\text{Sum of individual volume}}{\text{Total volume of sample}} \times 100$$

$$\text{Percentage frequency (\%)} = \frac{\text{Number of pellets in which food items present}}{\text{Total number of pellets used}} \times 100$$

The prey items were categorized into four classes: basic food (**>** 20%), constant food (5-20%), supplementary food(1-5%) and chance food(**<**1%) as described by Verzhutskii and Ramanujam [28].

Nutritional analysis: The guano sample was thoroughly mixed and diluted (1:20) using distilled water. The pH was recorded using pH meter [23]. Moisture content, Carbohydrate, Lipid, Protein and Nitrogen were determined by using methods described by Sadasivam *et al*. [29]. Ash content, Phosphorus and Potassium content were determined by using the methods of Baruah *et al*. [30]. Nutritive value was calculated using following formula given by Indrayan *et al*. [31]

Nutritive value = 4 x % of protein + 9 x % of fat + 4 x % of carbohydrate

RESULTS

Faecal pellets collected from five different screened spots of the bat roosting site were mixed and 10 randomly selected pellets were analysed for the prey. The faecal pellets collected were blackish brown and 9-11mm long . The pellets were soft when they contained only insect parts and hair but were very sticky, dirty and comparatively hard to tease apart when they contained vertebrate parts (bony structures of frogs and rats, scales of fishes).

A total of 15 insect orders were identified. During pre monsoon Coleoptera formed the basic food, Hemiptera, Trichoptera and Vertebrates formed the constant food. Lepidoptera, Dictyoptera, Diptera, Orthoptera, Odonata and Hymenoptera formed the supplementary food and Neuroptera, Dermaptera and Aranae formed the chance food. During monsoon Coleoptera and Vertebrates formed the basic food, Hemiptera and Lepidoptera formed the constant food, Dictyoptera, Orthoptera and Ephemeroptera formed the supplementary food and Trichoptera and Hymenoptera formed the chance food. During post monsoon Coleoptera and Vertebrates formed the basic food. Hemiptera, Lepidoptera and Trichoptera formed the constant food. Dictyoptera, Diptera, Odonata and Hymenoptera formed the supplementary food and Orthoptera, Isoptera, Dermaptera, Thysanoptera and Aranae formed the chance food (Fig.1). Figure.2 explains that of all the major dietary items coleopteran insects were consumed more by the bats throughout the year. However, Vertebrates (fishes, amphibians, mammals) were eaten more during monsoon and postmonsoon. Scaraebidae, carabidae and elateridae beetles were the major coleopterans. Apart from Vertebrates consumed during monsoon and postmonsoon period, Hemipterans formed the second major food item which was also consumed throughout the year but was consumed more in September-October. Delphacidae and pentatomidae bugs were the major hemipterans. Even lepidopterans are preferred throughout the year but they form major food through June to August. Orders like Neuroptera, Isoptera, Dermaptera, Thysanoptera, Ephemeroptera and Aranae (spiders) were found in lower amount throughout the study period.

Nutritional analysis of the guano revealed that the guano contained maximum carbohydrate (2.8%) during pre monsoon, lipid (9.3%) during post monsoon and protein (8.9%) during pre monsoon and post monsoon period. N-P-K analysis revealed that *M. lyra* guano is phosphorus rich . Of N-P-K analysis, phosphorus content was recorded highest in all three seasons (6-11%) and potassium during monsoon (1.3%) and post monsoon (1.2%). However, no significant variation in the nitrogen content was recorded throughout the year (Fig.3). Having estimated the carbohydrate, protein and lipid content of guano, the nutritive value of guano during Premonsoon, Monsoon and Postmonsoon was reported to be 122.4, 94.6 and 124.4 cal/100gm respectively. Moisture content was highest during monsoon (32.3%) followed by postmonsoon (22.8%) and least during premonsoon (9.7%). Ash content of the guano was highest during Premonsoon (32.7%) and Monsoon (32.6%) and least during Postmonsoon (25.9%).

DISCUSSION

Although there is considerable variation in the relative proportions of insects consumed by different species, most insectivorous bats eat large quantities of lepidopterans (moths), coleopterans (beetles), dipterans (flies), homopterans (cicadas, leaf hoppers),and hemipterans (true bugs) [5][32][33,34,35,36]. Some species also eat unusual prey items such as scorpions and spiders. In India 15% of total agricultural

production is lost by insect pests every year [37]. An estimated 99% of potential crop pests are limited by natural ecosystems of which some fraction can be attributed to predation by bats [38].

Bates and Harrison (1997) stated that *M. lyra* is a semi carnivorous species as it feeds both on insects and vertebrates and hence has a high proportion of prey category which is very obvious in the present study. Many other species of bat species like *Pteronontus gymnonotus* and *P. daviyi* also prefer coleopterans as their primary food [39]. Indian bats like *Hipposideros commersoni* , *H lankadiva* (Phillip,1980) also prefer coleopteran insects as their major food. Among microchiropterans Hipposiderid bats generally prefer beetles and moths[40].

In the present study coleopterans form the major food (Fig.1 and 2) which is also reported by Balasingh and Ramanujam *et al*. [13]. This is not surprising because coleopterans form the largest insect order in the world comprising of one third of all insect species and their hard chitinous exoskeleton passes undigested when compared to the soft bodied insects [6]. Scaraebidae, caraebidae, elateridae were the most found among coleopterans and incidentally they include pests of coconut and rice. Vertebrates and hemipterans formed the second major in the list of food item in the present study but is chance food of *M. lyra* in Tamil Nadu [13]. Delphacidae and Pentatomidae were the most common among hemipterans which include rice pests. *Megaderma lyra* guano is reported to contain fish, frogs and mice which is in agreement with the present study [11,12,13]. Thus, the present study indicates that prey don't vary much with the regions but their proportion changes depending upon the availability and *M. lyra* preys substantially on various insects which are agricultural pest and rodents as well.

This bat feeds on arthropods mostly insects, vertebrates and after digestion excretes parts of insects, spiders and bones, scales, hair of vertebrates .This inturn forms the resource base for large number of organisms like ants, thrips, beetles, salamanders and microorganisms. Thus, recycling of the nutrients take place. Fenelio *et al*. (2006) reported coprophagy in cave salamanders indicating *M.grisescens* guano to be resource base for the vertebrates.They also reported that guano contains nutrients roughly equivalent to potential prey items in cave ecosystem [17]. The guano in the present study is rich in lipid and proteins (Fig.3) since the bat food is rich in protein, phospholipids and minerals most of the time during a year. Sikazwe and Waele (2004) reported that the Zambia cave guano deposits were relatively depleted in nitrogen and potassium which are mobile elements and enriched in phosphorus which is relatively immobile [41]. Insectivorous and sanguivorous bat guano is rich in nitrogen than the frugivorous bat guano and phosphorus content of the guano of these three types of bats do not vary significantly [42]. Previous studies have found high phosphorus content in both insectivorous and sanguivorous bat guano due to phospholipids in blood and phosphates in insects [25]. In the present study too it is observed that the carnivorous bat, *M. lyra* guano is rich in phosphorus (Fig.3). This may not be surprising since this bat feeds both on insects and vertebrates that can contribute substantially to its proximate composition. The manure quality of guano also has been demonstrated by Sridhar *et al*. (2006) and Reichard (2010) and the guano in the present study is rich in phosphorus and nutritive value and is known to contain lower amount of other minerals therefore can be a better alternative to phosphorus rich chemical fertilizers.

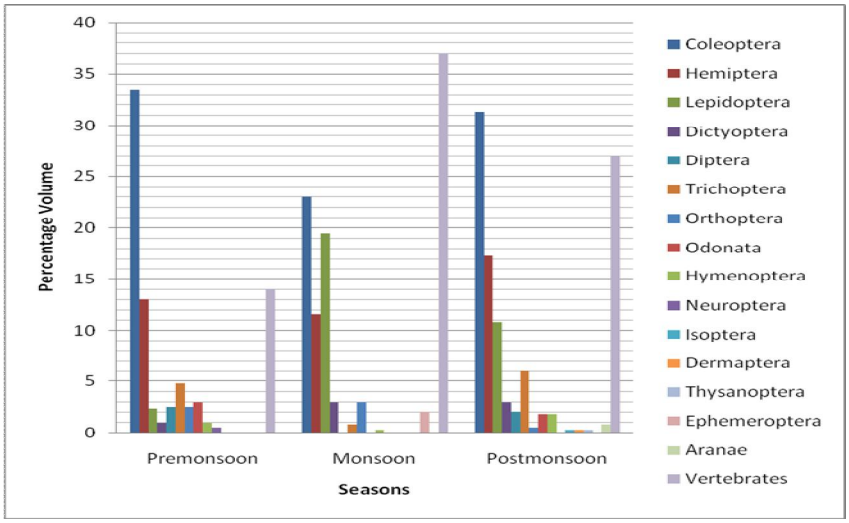

Figure.1: Estimated percent volume of food of *Megaderma lyra* from Yennehole, Dakshina Kannada, Karnataka, India, based on guano analysis.

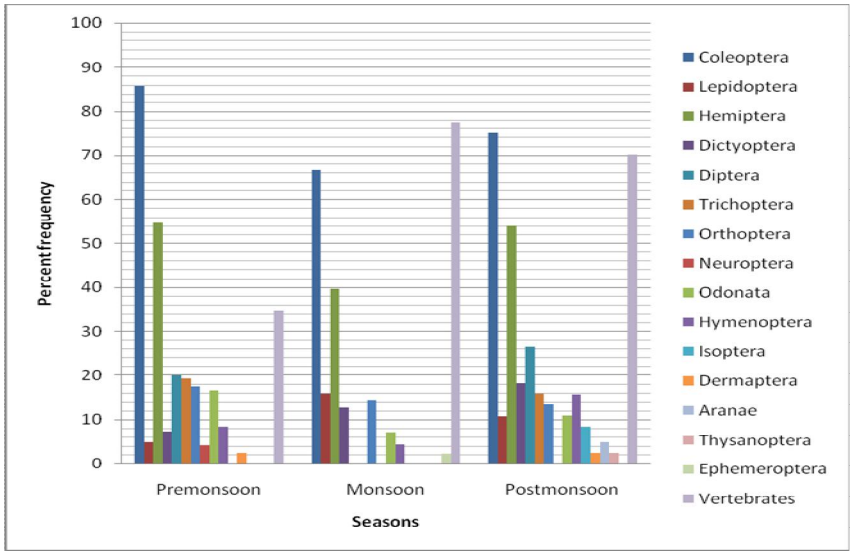

Figure.2: Estimated percent frequency of food of *Megaderma lyra* from Yennehole, Dakshina Kannada, Karnataka, India, based on guano analysis.

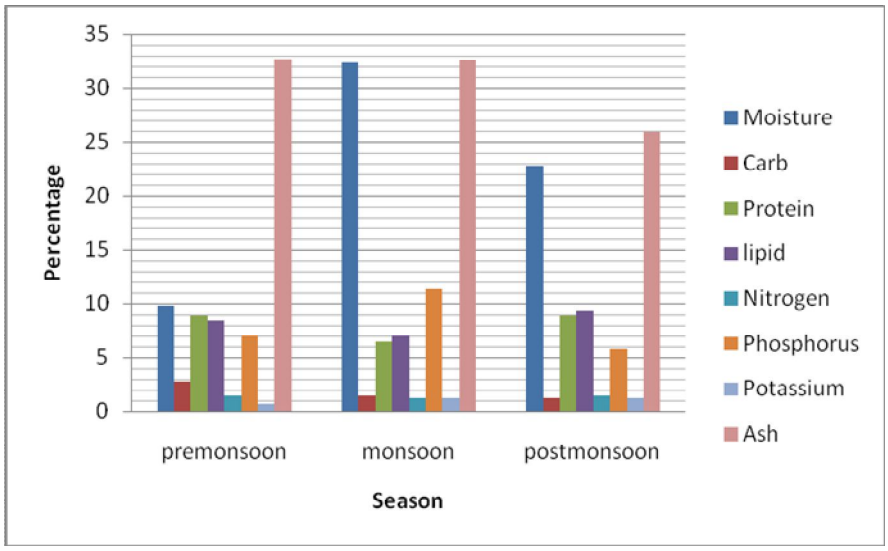

Figure.3: Seasonal variation in nutritional composition of *Megaderma lyra* guano.

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