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STUDY ON FORAGING HABITATS AND PHYSICAL CHARACTERISATION OF BAT GUANO IN SOME SELECTED SPECIES OF CAVE BATS IN KORCHI AND DHANORA REGION OF DISTRICT GADCHIROLI (M.S).

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Abstract

Bats play a vital role in the ecosystem They consume large volumes of insects many of which agricultural pests and their droppings drop (guano) contain large amount of partly digested 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 type of insects using morphological characteristics. Hence an attempt is made in the present-day study to analyse the food habit of a bats, so as to determine the insects on which they feed and also to do a nutritional analysis that include Food Residues, Shape, Size, Weight, Colour, Texture and odour of Bat Guano. The study was Carried during October 2023 to March 2024 mainly focus on Korchi and Dhanora taluka in the Gadchiroli Region. To determine the Dietary diversity in the bat guano were identified in ordinal manner.

Keywords: *Foraging, Guano, Chiroptera, Emblematic, Caves, Sanguivorous*

Introduction

Bats are emblematic hosts of caves. They constitute a diverse group of mammals belonging to the order Chiroptera, which colonizes all the terrestrial ecosystems, accepts the Polar Regions and some oceanic islands. They form a one of the largest non-human aggregations and gives the most abundant mammals in terms of number of individuals. Over 1,400 species of Bats have been identified worldwide which means that one in five (20%) Mammal's species is Bats. The Bats have variable weights ranging from 2 gm upto the 1.6 kg. The smallest species Craconycteristhon flangyia having a weight of 2gm and the Largest Bat species goes upto 1.6 Kg Pteropus neohibernicus. Analysis of faecal (Guano) matter of Bats. Allows identification of their great dietary diversity. There some species are Insectivorous, Frugivorous, Herbivorous, Nectivorous, and even Sanguivorous (Feeding on Blood) bats (vampires). Globally about 70% of bats are Insectivorous. They are among of the biggest predator of flying insects and prove to be valuable pest management agents in natural and man-madeEcosystems of Lepidoptera (Butterflies), Coleoptera (Beetle), Diptera (flies) Homopteran (cicadas and leaf hoppers), and Hemipterans (true bugs) insects. Bats are often eating all the night and then return to their nurse and rest during periods of low insect activity, on the contrary, herbivorous Bats feed on various segments of plants, including flowers, pollen, nectar, leaves, and fruits. Bats which feed on fruits are called frugivores and they are generally abundant in secondary forests due to the high production of fruits plants characteristic of these ecosystems.

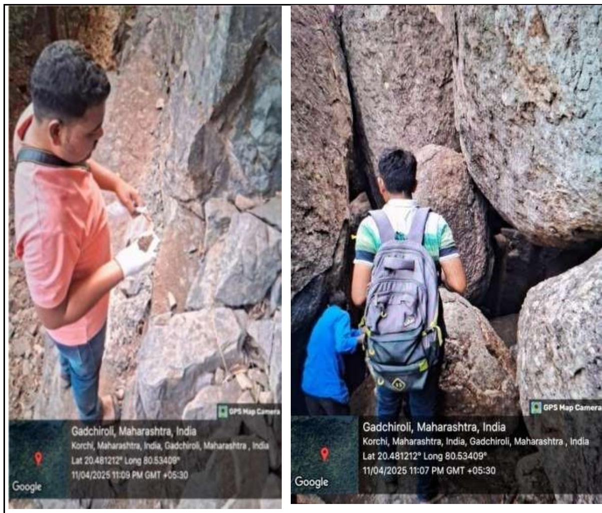
Bats have since long played crucial role in several fields. They play a key role in agriculture. They are major benefactors to crop pollination and seed dispersal. They are also excellent ecological indicators of good quality of Habitat. Their presence in the caves has a modifying impact on the cave ecosystem that was since long unknown. Bats mark their presence by physical alteration of rocks which they cling to with their claws, chemical alterations due to the large amounts of urine they generate which corrosive and gaseous alteration by breathing, leading to significant production of CO2. which claws, chemical alteration's due to the large amounts of urine they generate which corrosive, leading to urban significant production carbon dioxide (CO_2). Foraging behavior has an important role in evolutionarybiology and ecology since it is a major determinant of survival, growth and reproductive success (Kramer, 2001). Diet choice and diet selection of animals are fundamental to understand the interactions between animals and their habitats. The studyof chiropteran foraging activity presents inherent difficulties owing in part to limitations preventing direct observations of their crepuscular and nocturnal foraging habits (Kunz, 1973). Megachiroptera or flying foxes are known to feed on at least 188 plant genera in 16 families in Asia and Africa (Marshall, 1983). Around the world at least 289 plant species, producing more than 448 economically valuable goods, rely on fruit bats to some degree for their pollination and seeddispersal (Fujita, et al., 1991). The suborder Megachiroptera consists of the larger fruit and nectar-feeding bats, the only frugivorous family represents in

India is Pteropodidae (Bates, and Harrison, 1997). Frugivorous bats consume large fruits such as breadfruit (Artocarpus: Moraceae), mangoes (Mangifera: Anacardiaceae) and papaya (Carica: Caricaceae). Ecomorphological studies predict that the foraging behaviour of a bat species should relate to its wing morphology and echolocation call designs (Norberg, and Rayner, 1987; Brigham, et al., 1997; Ratcliffe, andDawson, 2003; Stoffberg, and Jacobs, 2004). In turn, this should allow us to determine likely foraging strategies and habitats for a particular species (Norberg, and Rayner, 1987). Wing morphology of the insectivorous bats plays a key role in constraining and allowing for specific foraging behaviours governed by maneuverability and sometimes, the ability to hover. Finding food requires efficient flight and flight costs increase with body size so bats may have had selective pressures over time to minimize their mass (Dumont, et al., 2005). The sub-order Microchiroptera comprises a large and diverse group of smaller bats, most of which feed on insects, although some feed on vertebrates (Megadermatidae), blood (Desmodontinae) and fish (Vespertilionidae) (Strahan, 1983; Churchill, 1998). 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 pestcontrolling agents (Murphy, 1993; Whitaker, 1993; Tuttle, 1995). The most common insect orders consumed by bats are Coleoptera, Lepidoptera, Diptera, Hymenoptera and Isoptera (Verts, et al., 1999; Pavey, et al., 2001; Ezhilmathi, 2010). It is rather easier because most bats do not eat many different kinds of insects at one time. Thus, a single stomach of faecal pellet often contains one to four kinds of insect reflecting their successful feeding. Insects may be caught in flight or taken from vegetation, the ground or water surfaces in a foraging style referred to as gleaning. Bats select foraging sites based on some combination of prey abundance and physical attributes of the site such asproximity to suitable roosts, wind speed accessibility and navigability (Grindal, 1996). There was no comprehensive study on foraging behavior of the bats of eastern Maharashtra. Therefore, the present study was aimed to investigate the foraging behaviour of the bats of eastern Maharashtra.

Materials and Methods:

Sampling:

Samples are collected by using hand gloves and plastic bags. Dropping were collected from the roosting site over October 2023 to March 2024.Faecal pellets collected for insect prey were properly labelled and preserved in 70% alcohol and analysed microscopically using the method described by Whitaker. The remaining pellets were kept at -15^0c for further nutritional analysis.



Site:1

Site:2

Site.1: Tipagadh caves, Korchi taluka, Gadchiroli; Site.2: Bhavargadh Cave, Dhanora taluka, Gadchiroli.

Prey analysis of guano:

The pellets were soaked in a Petri dish containing

70% alcohol and teased apart individually using fine needles under microscope.

Each pellet was searched for partially digested insect part (fruits seed, wings, antenna and mouth parts, leg) and were identified using the standard keys given in entomological guide books and papers focused on bat diets. The percentage volume and percentage frequency of the foods consumed for each Bat were calculated for the entire study period by using the following formulae given by Whitaker (1998).

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

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

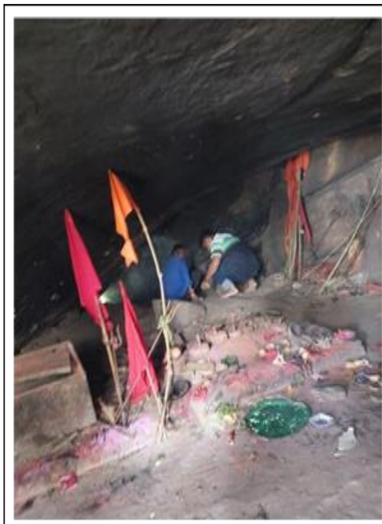
The prey items were categorized into four classes: Basic food (>20%), Constant food (5-20%), Supplementary food (1-5%) and Chance food (<1%) as described byVerzhutski and Ramanujan (2002).

Study area:

Studies are mainly conducted in Korchi taluka, Dhanora taluka of Gadchiroli region.

Satellite view of Study area

Site. 1. Tipagadh **Site. 2. Bhavargadh**

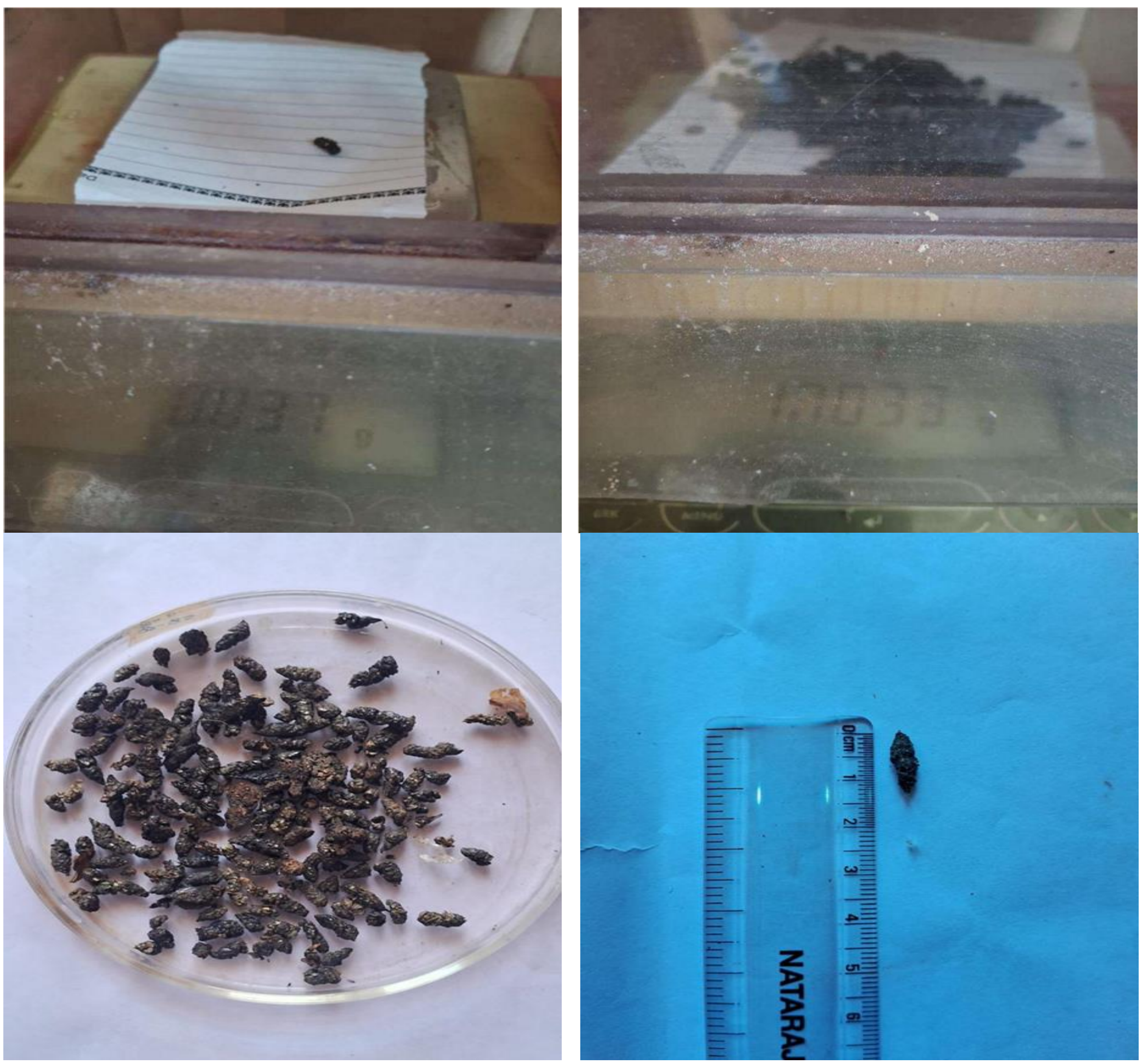


Species found in study area-

<u>*Rhinopoma hardwickii* (lesser mouse-tailed bat)</u>

<u>Observations:</u>

A) Weight of Guano

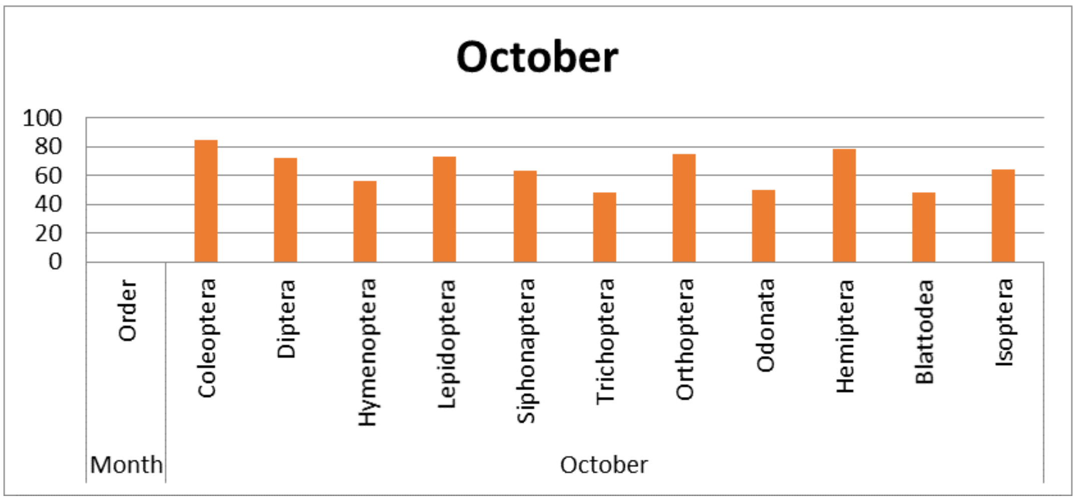


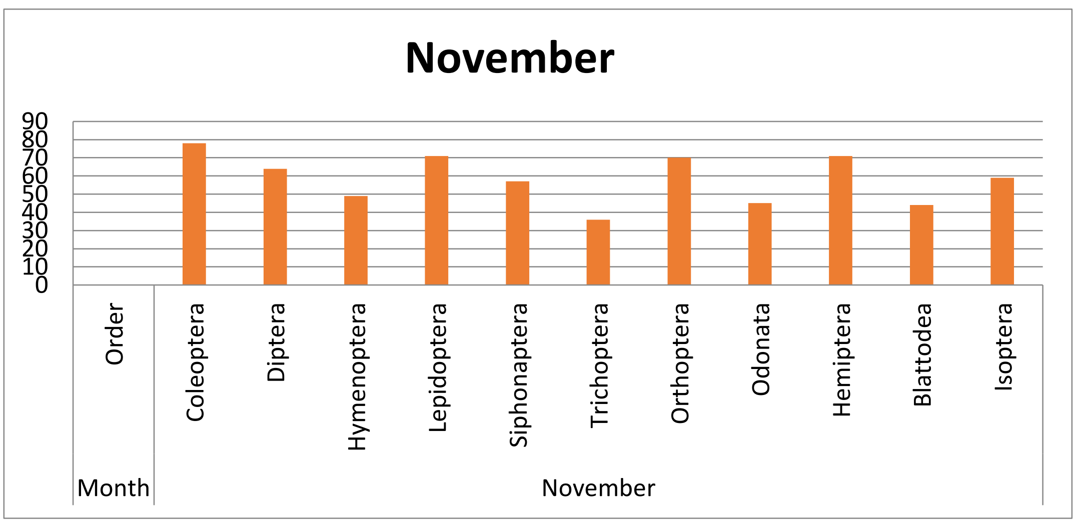
B) Remains of insects

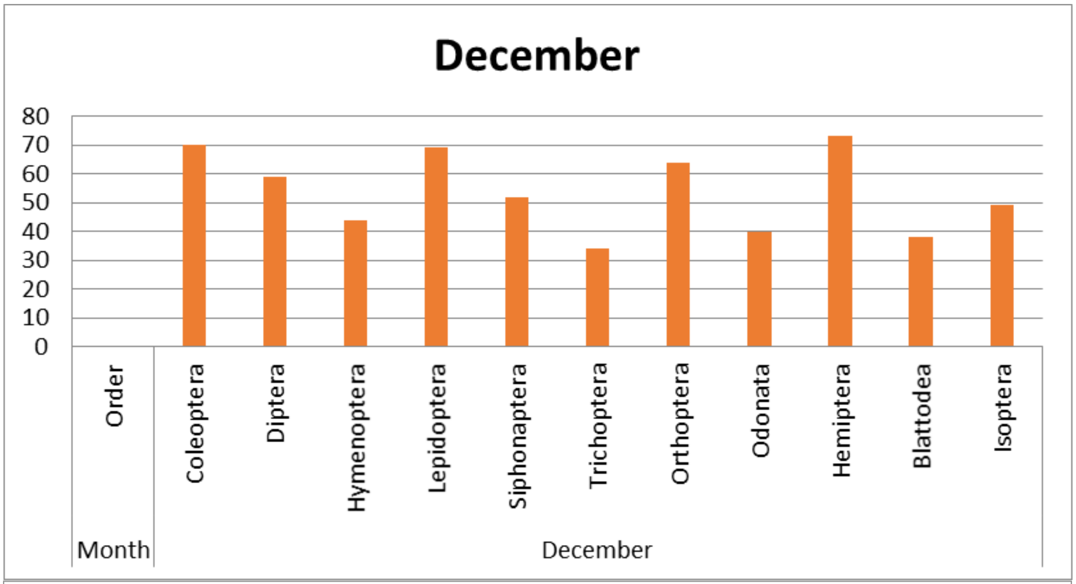
Morphological Observation of Bat Guano:

Sr. No.	characteristics	Morphological Observation
1.	Size	Varies, but generally small, ranging from about 1.4cm to 0.8mm length.
2.	Shape	Cylindrical or pellet-shaped, similar to grain of rice.
3.	Colour	Dark brown or black, but can turn lighter as they dry and age.
4.	Texture	Dry and crumbly, easily crumbling into a fine powder when crushed.
5.	Weight	Bat guano is relatively light, the weight would depend on the size, in given sample weight about 37mg to 62mg. Dry weight of faecal pellet is about 20 to 35mg and wet pellet is about 37 to 62 mg.

1. Month wise Foraging habit of RhinopomaHarswickii Bat in Tipagadh bat cave in korchi taluka, Gadchiroli.






December
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Diptera
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Lepidoptera
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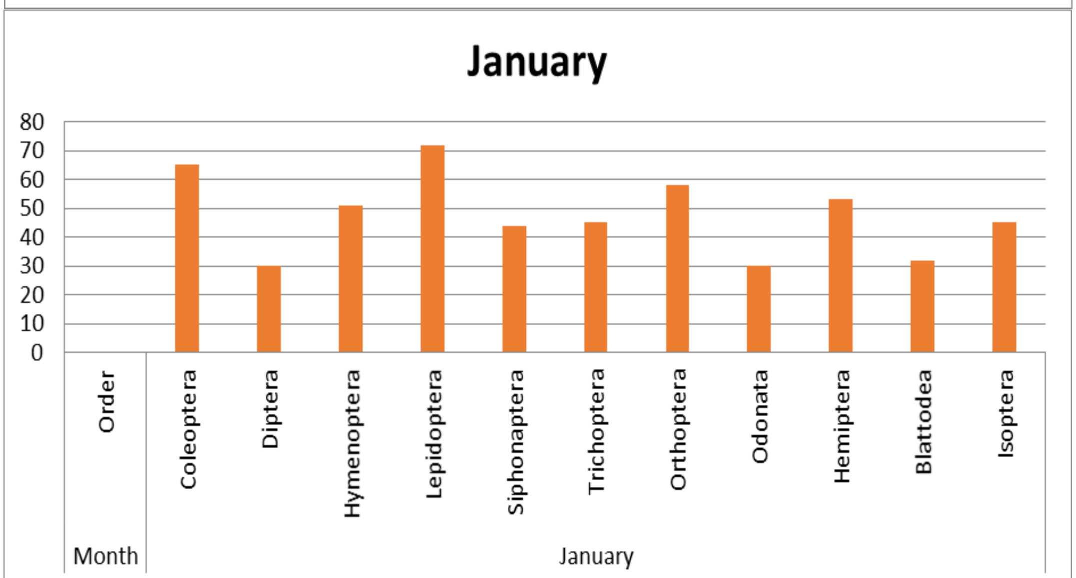
Trichoptera
Orthoptera
Odonata
Hemiptera
Blattodea
Isoptera
Month
December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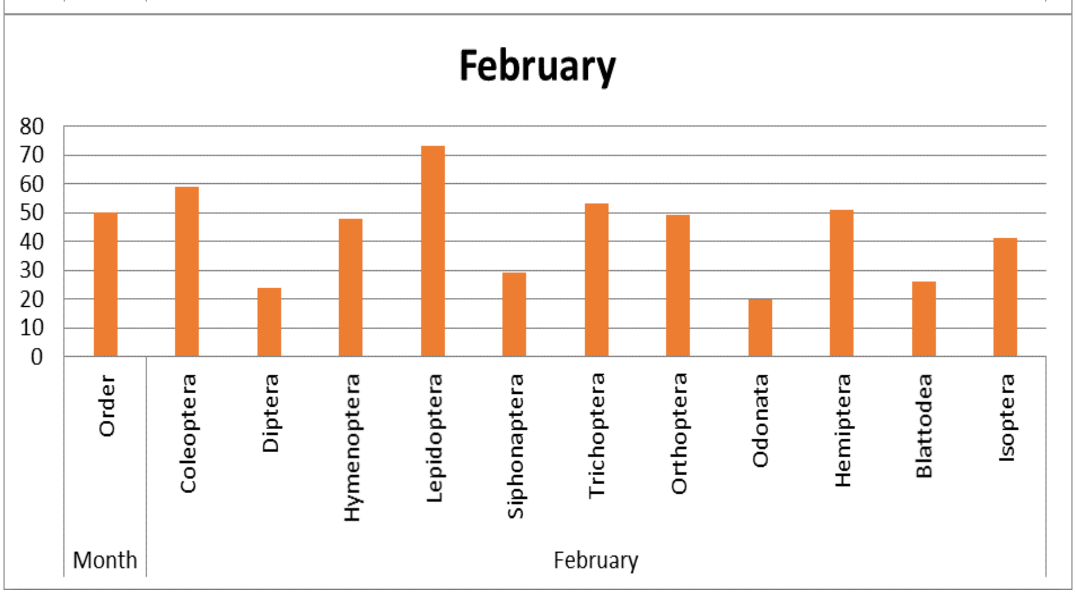
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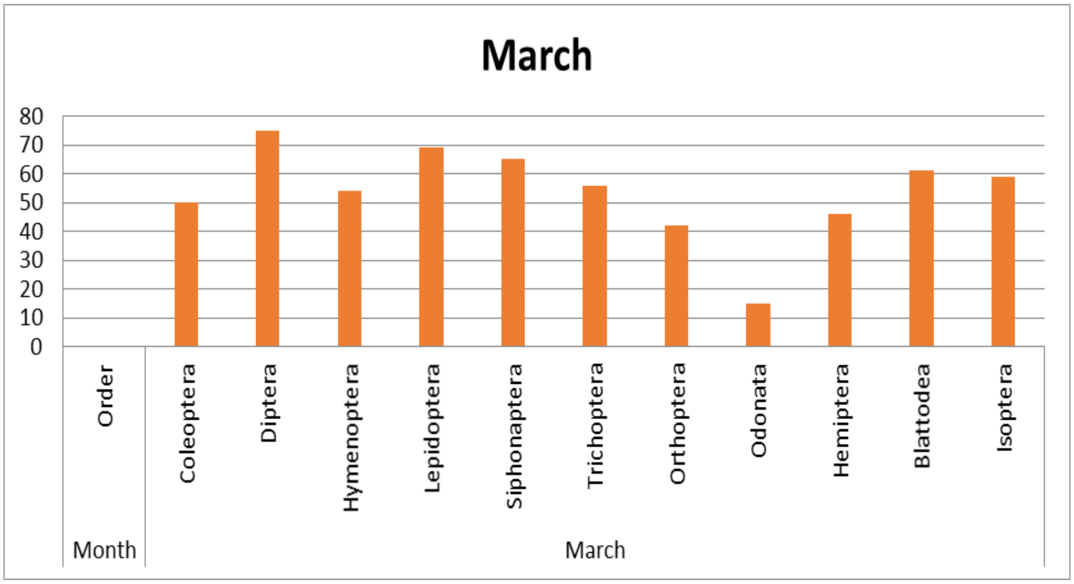
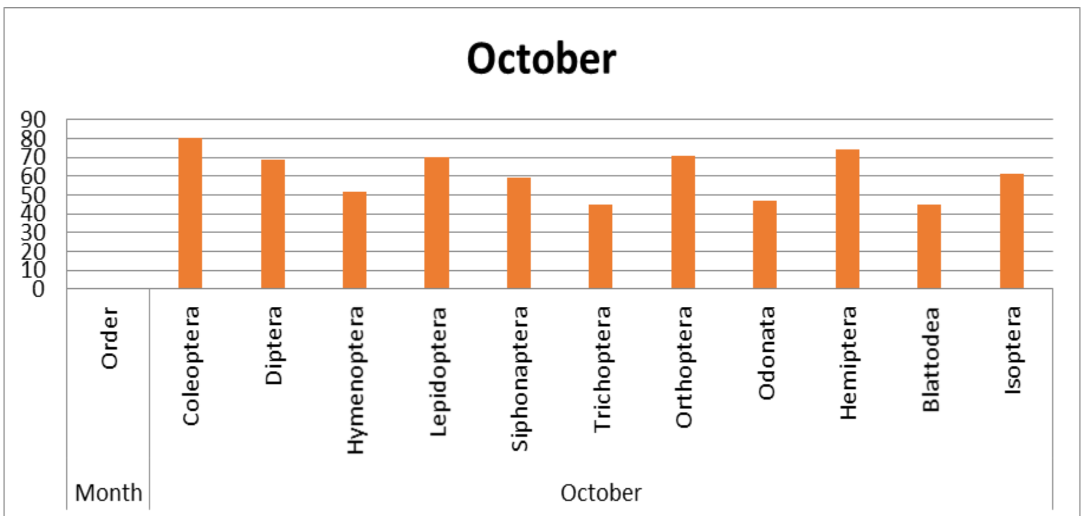
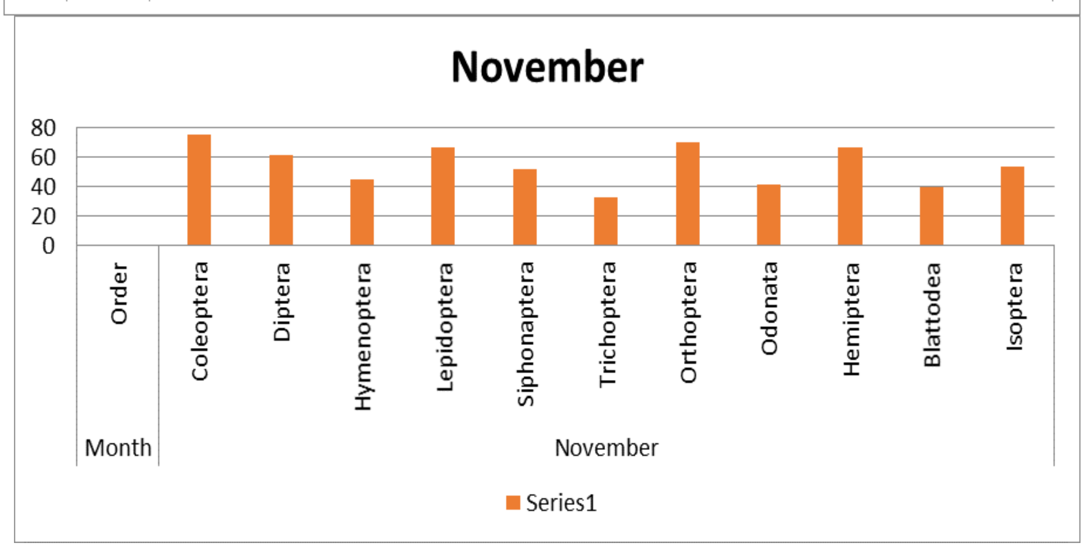
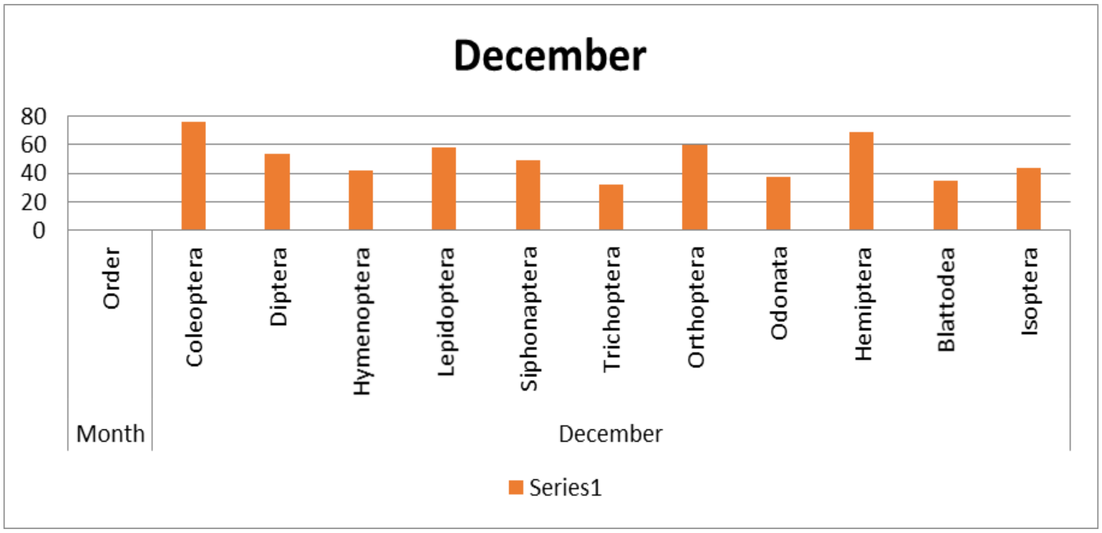


2. Month wise Foraging habit of *Rhinopoma Hradwickii*bat present in the Bhavargadh Cave in Dhanora taluka, Gadchiroli.



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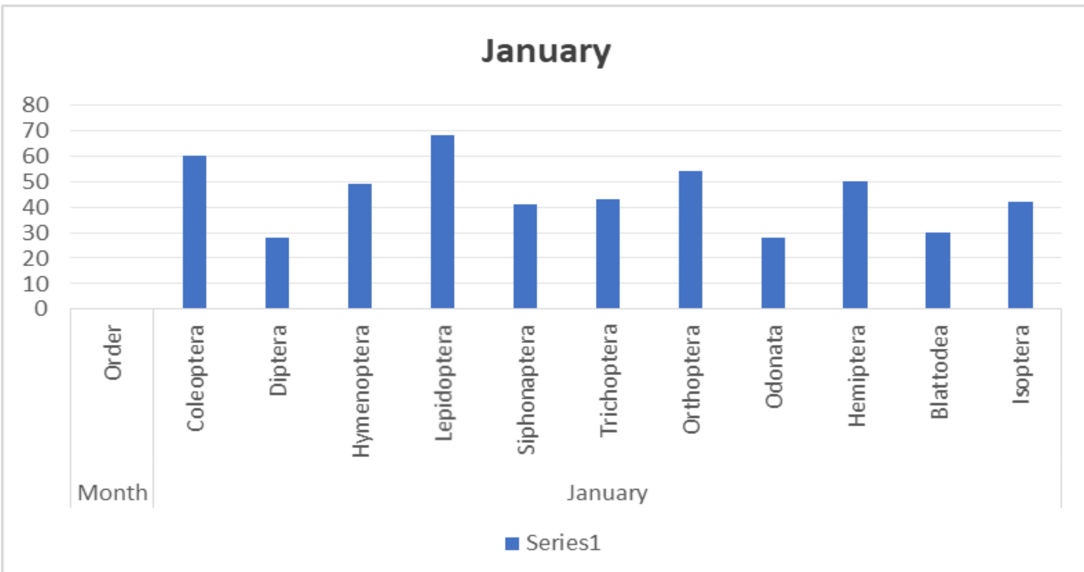
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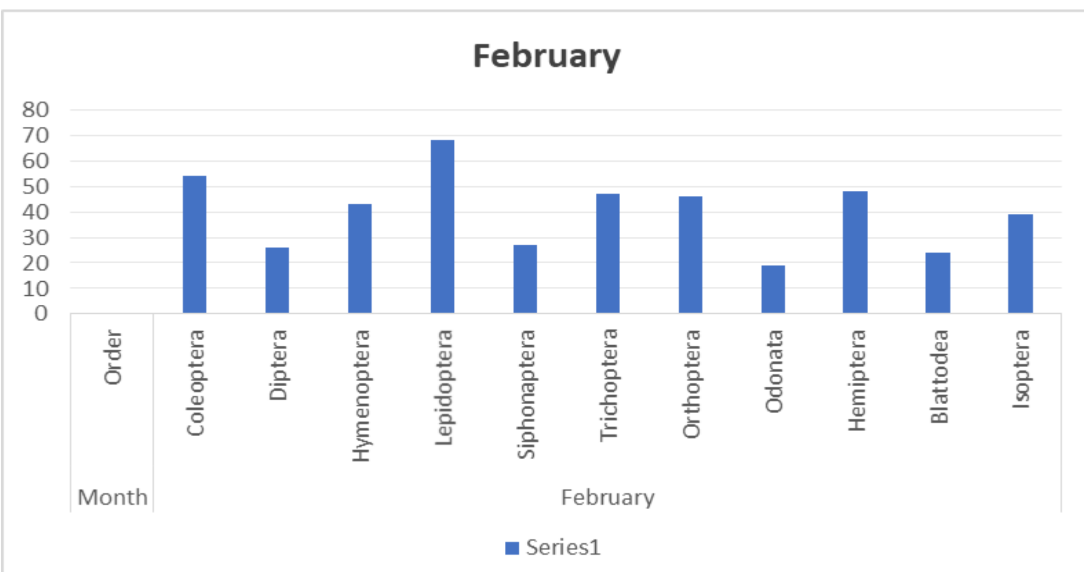
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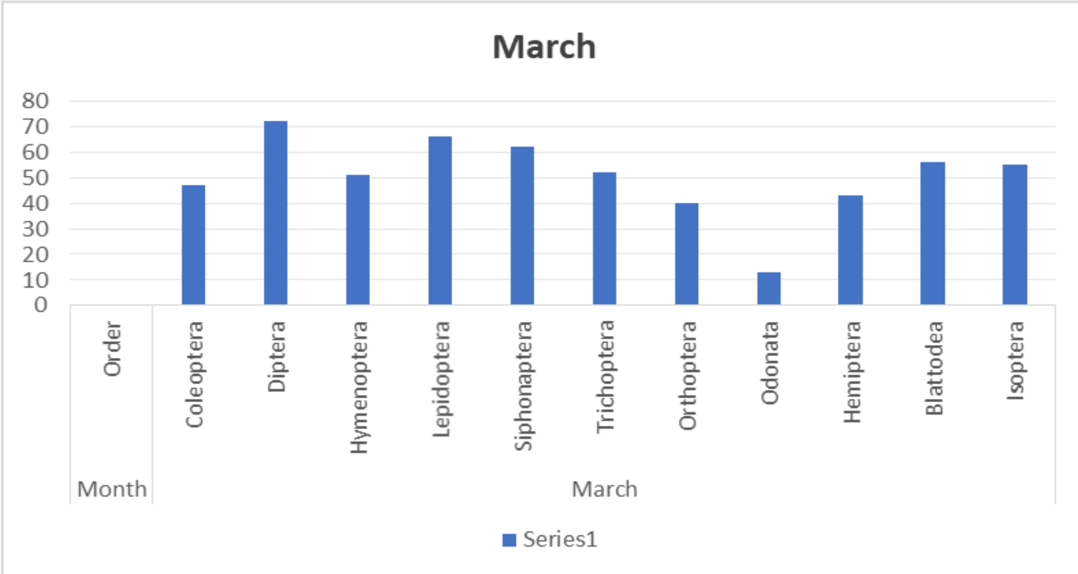

Calculations:

1) Identification Of Insect Residues (100gm of sample of bat guano):

$$\text{Percentage Volume}(\%) = \frac{37mg}{2703} \times 100$$

$$= 1.37\%$$

$$\text{Percentage Frequency}(\%) = \frac{600}{2703} \times 100$$

$$= 22.20\%$$

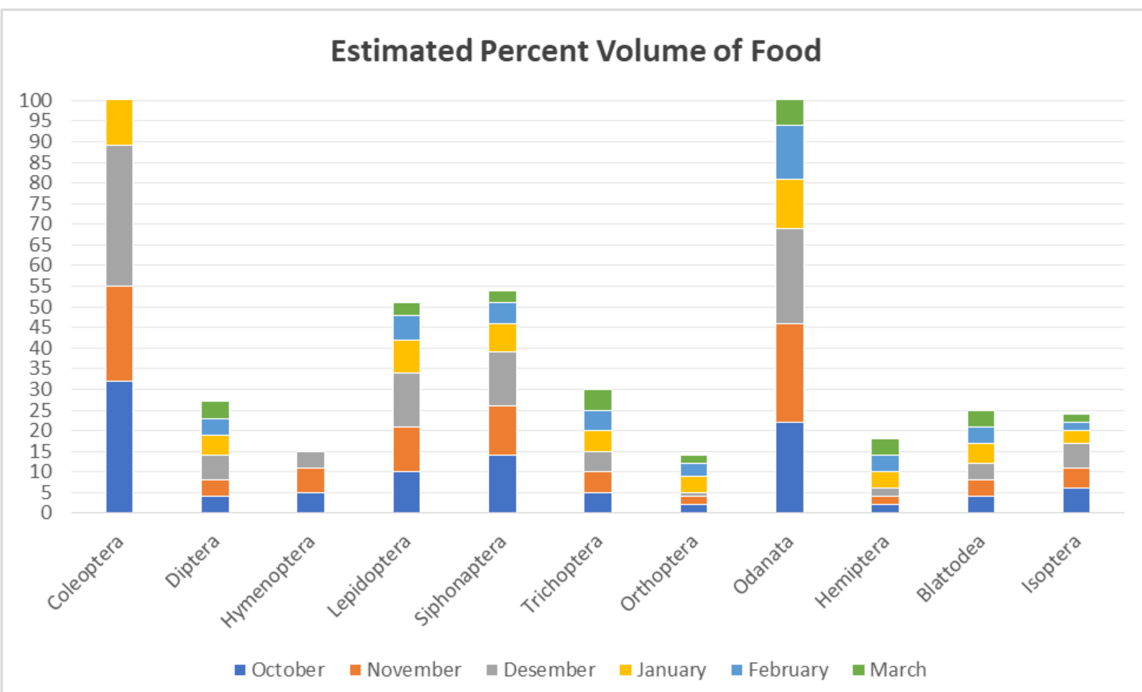

Figure no. 1: Estimated percent volume of food of *Rhinopoma Hardwickii* Bat from Tipagadh Cave in Korchi taluka, Gadchiroli, based on guano analysis.

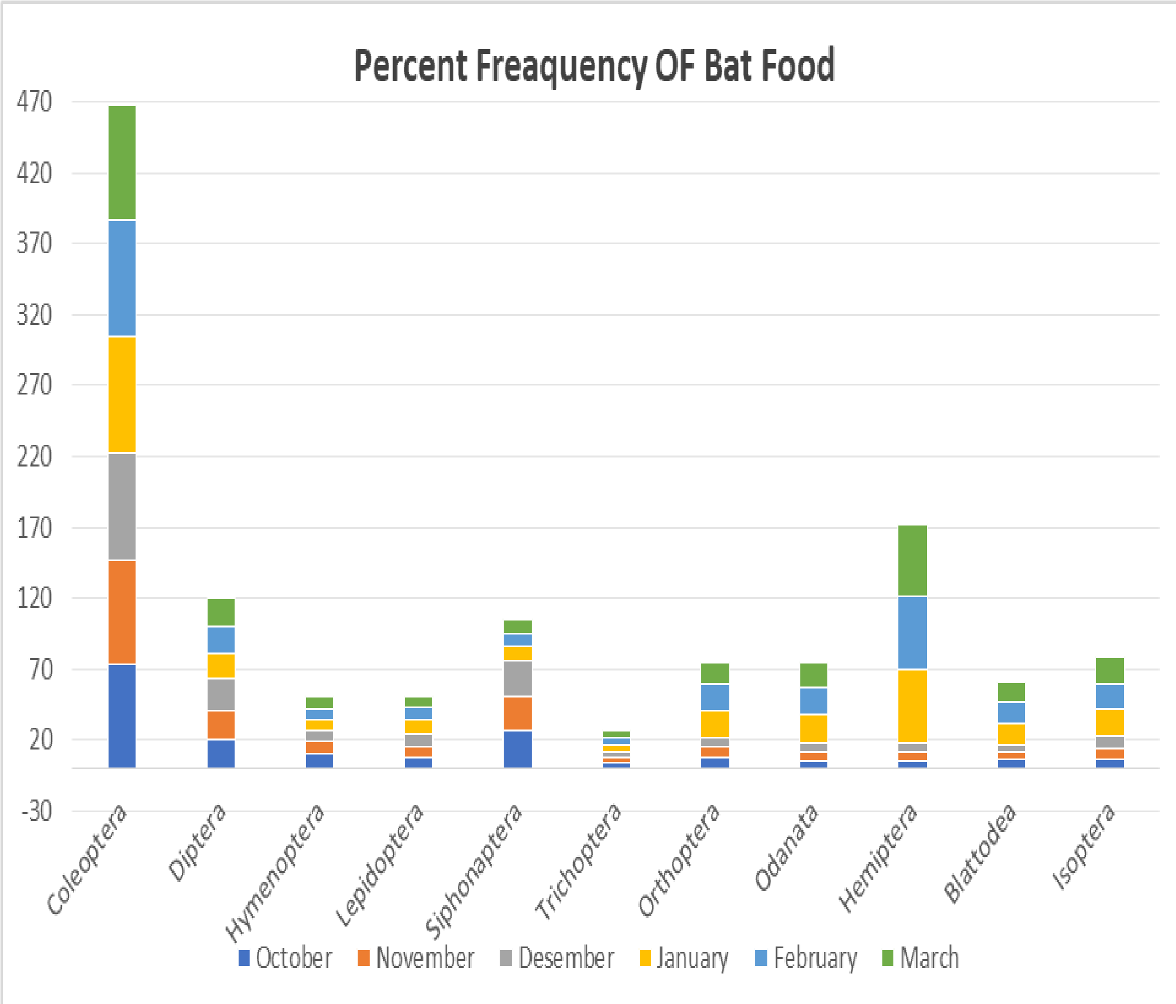

Figure no. 2. Estimated percent frequency of food *Rhinopoma Hardwickiifrom* Tipagadh caves, Korchi taluka, Gadchiroli, based on guano analysis.

2) Identification of insects residues (100 gm of sample of bat guano)

$$\text{Percentage Volume}(\%) = \frac{32mg}{3125} \times 100$$

$=1.024\%$

$$\text{Percentage Frequency}(\%) = \frac{600}{3125} \times 100$$

$=19.2\%$

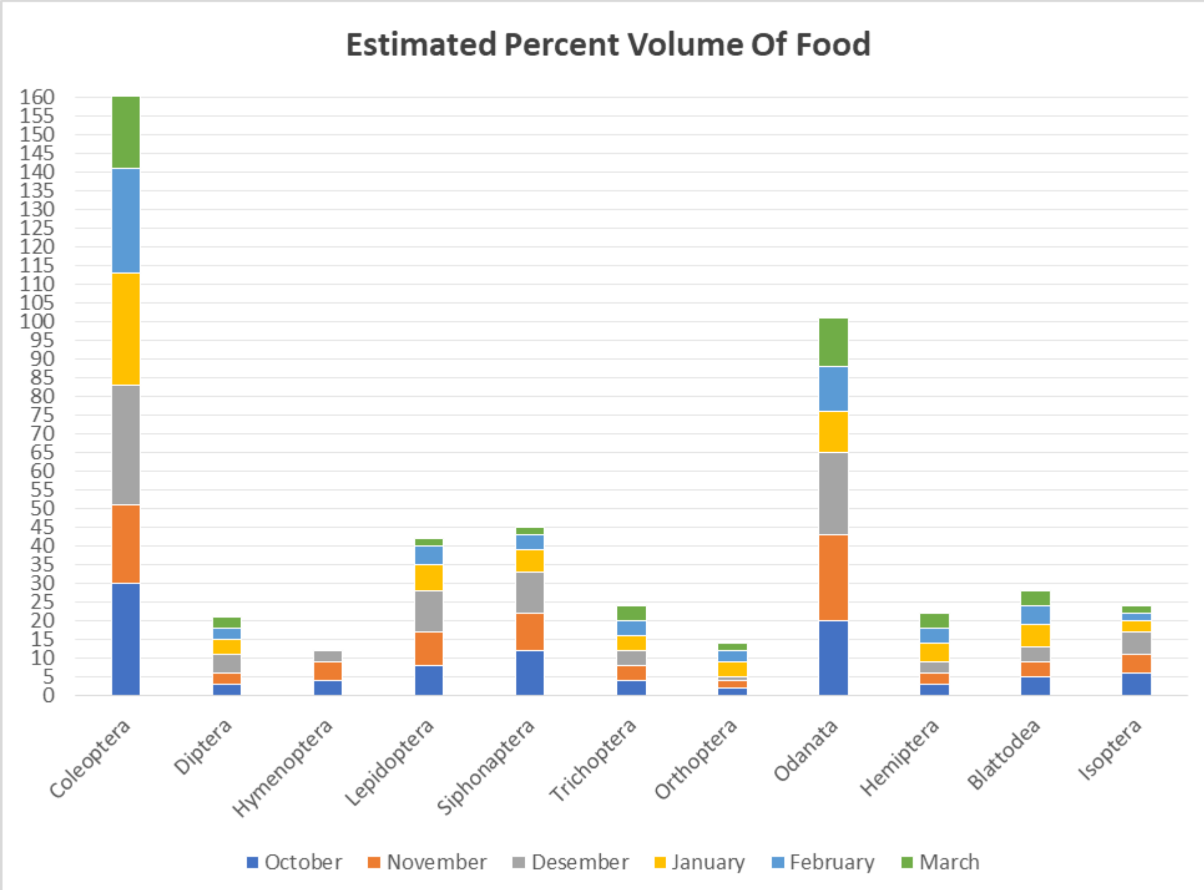

Figure no. 3. Estimated percent volume of food of *Rhinopoma Hardwickii* Bat from Bhavargadh Cave in Dhanora taluka, Gadchiroli, based on guano analysis.

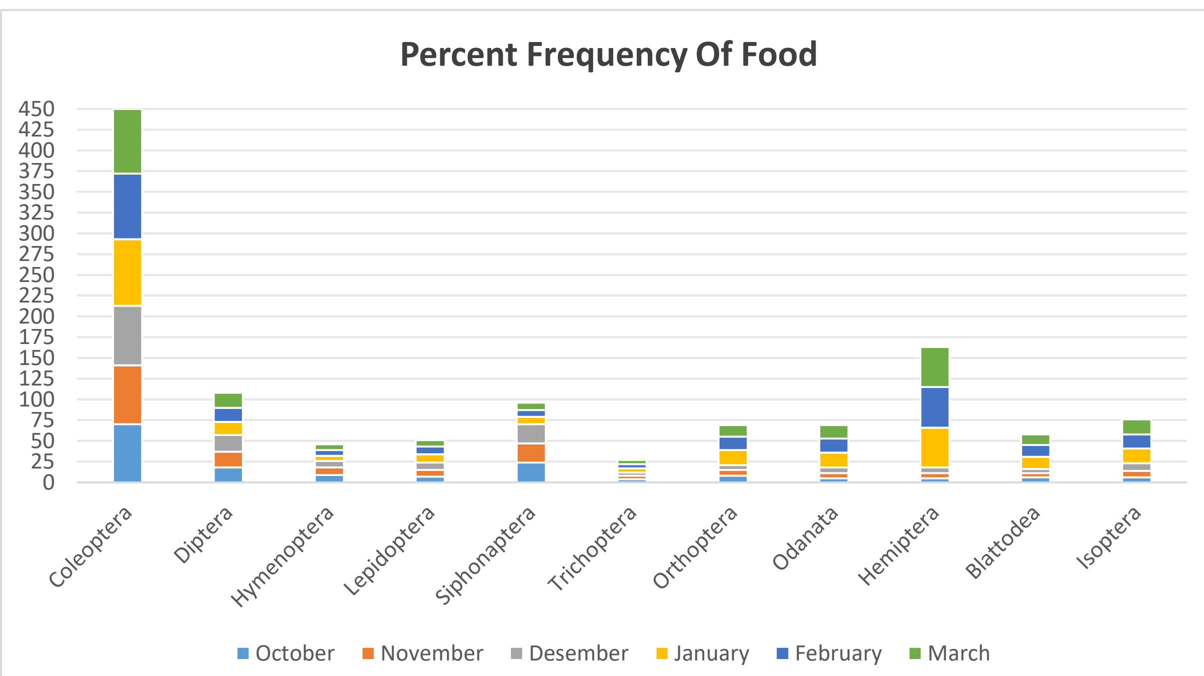

Figure no. 4: Estimated percent frequency of food *RhinopomaHardwickii*from Bhavargadh Caves, Dhanora Taluka, Gadchiroli, based on guano analysis.

	Basic food (>20%)	**Constant food (5-20%)**	**Supplementary Food(1-5%)**	**Chance food (<1%)**
Site.1. Tipagadh Caves	Coleoptera, Odonata	Lepidoptera, Siphonaptera	Diptera, Hymenoptera, Trichoptera, Isoptera, Blattodea	Orthoptera, Hemiptera
Site.2. Bhavargadh Cave	Coleoptera, Odonata	Lepidoptera, Siphonaptera	Blattodea, Isoptera,	Hemiptera, Hymenoptera, Diptera, Orthoptera, Trichoptera

Result:

Faecal pellets are collected form two different sites, Tipagadh caves in korchi taluka and Bhavargadh cave in Dhanora taluka. Were analysed for prey, the faecal pellets collected were blackish brown and 1.4 to 0.8mm long. The pellets were soft when they contained only insect's parts and hair but were very sticky, dirty and comparatively hard to tease apart when they contained invertebrate parts and total of 11 insects orders were identified in both sites Tipagdh cave and Bhavargadh cave.

In Tipagadh cave during the month of october Coleoptera and odonata formed the basic food, Lepidoptera, Siphonaptera and inertebrates formed the constant food. Diptera, OrBlattodea,Trichoptera, Isoptera and Hymenoptera formed the supplementary food. During the month of November Coleoptera and odonata formed the basic food, Hemiptera and Lepidoptera formed the constant food, Orthoptera and Diptera formed the supplementary food and Trichoptera and Hymenoptera formed the chance food. During the month of December Coleoptera and invertebrates formed the basic food. Hemiptera, Lepidoptera and Trichoptera formed the constant food. Blattodea, Diptera, Odonata and Hymenoptera formed the supplementary food and Orthoptera, Isoptera and Siphonaptera formed the chance food (fig.1). During the month of january Coleoptera, Odonata formed the basic food, Lepidoptera, Siphonaptera and Blattodea formed the constant food. Isoptera, Diptera, Hemiptera and Orthoptera formed the supplementary food, Trichoptera and Hymenoptera formed the chance food. During the month of February Coleoptera formed the basic food, Odonata formed the constant food, Lepidoptera, Siphonaptera, Blattodea, Diptera, Trichoptera and Orthoptera formed the supplementary food, Isoptera, Hemiptera and Hymenoptera formed the chance food. During the month of March Coleptera formed the basic food, Odonat formed the constant food, Blattodea,Isoptera, Diptera and Hymenoptera formed supplementary food, Orthoptera, Trichoptera and Hemiptera formed the chance food. Figure.2 explain that of all the major dietary items Coleoptera insects were consumed more by bates throughout the year.

Discussion:

The present study on the foraging habits and physical characterization of bat guano from two cave sites in Gadchiroli district—Tipagadh cave in Korchi taluka and Bhavargadh cave in Dhanora taluka—provides valuable insights into the dietary preferences and ecological roles of the cave-dwelling bat species *Rhinopomahardwickii*. The analysis of bat guano revealed a diverse insect prey base, with eleven insect orders identified across both sites, indicating a broad dietary spectrum that reflects the bats' opportunistic feeding behavior and adaptability to available prey in their habitats.

The predominance of Coleoptera (beetles) and Odonata (dragonflies and damselflies) as basic food items in certain months suggests these insects are abundant and accessible in the bats' foraging habitats during those periods. Lepidoptera (moths and butterflies), Hemiptera (true bugs), and Siphonaptera (fleas) were frequently consumed as constant food sources, while other insect orders such as Diptera (flies), Blattodea (cockroaches), Trichoptera (caddisflies), Isoptera (termites), Hymenoptera (ants, bees, wasps), and Orthoptera (grasshoppers, crickets) were supplementary or chance foods depending on the month and site. This variation in diet composition aligns with the known insectivorous nature of *Rhinopomahardwickii* and highlights their role as natural pest controllers, consuming a wide range of agricultural and forest insect pests.

The physical characteristics of the guano—color, texture, and consistency—also correlated with the dietary content. Guano containing primarily insect parts was softer and easier to dissect, whereas guano with more invertebrate fragments was sticky and harder. This observation supports previous findings that the physical state of bat guano can reflect its nutritional and compositional makeup.

The study further emphasizes the ecological importance of bats in maintaining insect population balance and contributing to nutrient cycling through guano deposition. Bat guano serves as a rich organic fertilizer, supporting diverse cave-dwelling organisms and enhancing soil fertility in surrounding ecosystems. The presence of guano-dependent species in caves underscores the bats' indirect influence on cave biodiversity and ecosystem functioning.

Moreover, the foraging behavior of bats, influenced by wing morphology and echolocation, allows them to exploit various microhabitats effectively, which is evident from the diversity of prey detected. This adaptability is crucial for their survival and reproductive success, especially in the seasonal and habitat-specific contexts of the Gadchiroli region.

Conclusion:

This research provides comprehensive insights into the foraging ecology of *Rhinopomahardwickii* in the Gadchiroli region, demonstrating their broad and seasonally variable insectivorous diet. The identification of 11 insect orders in their guano underscores their adaptability and ecological importance in controlling insect populations, including agricultural pests.

The physical characterization of guano complements dietary analysis, offering a practical, non-invasive method for studying bat feeding habits. The findings emphasize the bats' dual ecological role: regulating insect populations and enriching cave and surrounding ecosystems through guano deposition.

Conservation of bat habitats in Gadchiroli is crucial to maintain these ecosystem services. Future research could focus on detailed seasonal foraging patterns, impacts of environmental changes on diet, and the potential application of guano as an organic fertilizer in sustainable agriculture. This study reinforces the importance of bats in ecosystem health and advocates for their protection and habitat management.

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