



Analyzing the Diurnal Activity and Foraging Behavior of Three- Striped Palm Squirrel (*Funambulus palmarum*) at Isabella Thoburn College, Lucknow, Uttar Pradesh

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ABSTRACT

Funambulus palmarum is the scientific name for the squirrel. These rodents are members of the *Sciuridae* family. Despite the fact that there are over 40 different kinds of squirrels in India and about 280 different species worldwide, there are only four subspecies of Indian palm squirrels. They have different activities during the day and then a period of inactivity during the night. They are diurnal. Being omnivores, squirrels exhibit a diverse array of dietary preferences and feeding techniques. The study was conducted at Isabella Thoburn College from December 1, 2023, until March 15, 2024. To conduct the survey, the Focal sampling approach was used. The findings demonstrate that the squirrels exhibited bimodal patterns of diurnal activity, with two separate peaks occurring in the morning and the evening and quite busy during the month of February. The squirrels' strong preference for human-provided food over native plants and insects explains their audacity or willingness to take risks. It was common practice to gnaw food as a feeding technique. It was discovered that squirrels could adjust to the resources at hand regardless of the seasonal variations.

Keywords: Diurnal activity, dietary preferences, squirrel, seasonal variations, Focal sampling

INTRODUCTION

The squirrel's Latin name, *Funambulus*, meaning "the tightrope walker," perfectly captures its agility. Palm trees are mentioned in the term *palmarum*. This species of squirrel is sometimes known as the three-striped palm squirrel. Because of its stripes, the Indian Palm Squirrel resembles a huge chipmunk quite a bit. However, it should be highlighted that chipmunks are a separate species.

Despite the fact that there are over 40 different kinds of squirrels in India and about 280 different species worldwide, there are only four subspecies of Indian palm squirrels. They use leaves, twigs, and other plant materials to build their nests. Approximately 25 metres above the ground, they construct their nest. The babies use the twigs and leaves from the nest as bedding, Thurston and Brittingham (1997).

Because they are opportunistic, palm squirrels can choose from a wide range of foods. Being omnivores, they consume both plant and animal matter in addition to fungi and insects. When their numbers increase in a particular location, they eat animal waste such as tree barks, Brittingham and Thurston (1997). The strongest indicators of an animal's diurnal activity are its behaviours during the day and its state of inactivity at night. Lima (1998). Comprehending the daily activity pattern of an animal is essential to comprehending its response to changes in the climate, McCain and King (2014). During the day, squirrels forage for food and rely on human-provided food from urban parks, homes, and bird feeders (Magris and Gurnell, 2002; Reher et al., 2016). Thus, if supplemental food is a significant source of food for squirrels, urban residents can be informed on what foods to provide squirrels so they can eat a varied and well-balanced diet, Shuttleworth (2000).

The primary goal of the research was to observe, comprehend, and evaluate the eating habits, dietary preferences, and diurnal activity rhythm of three-striped palm squirrels (*Funambulus palmarum*).

STUDY AREA

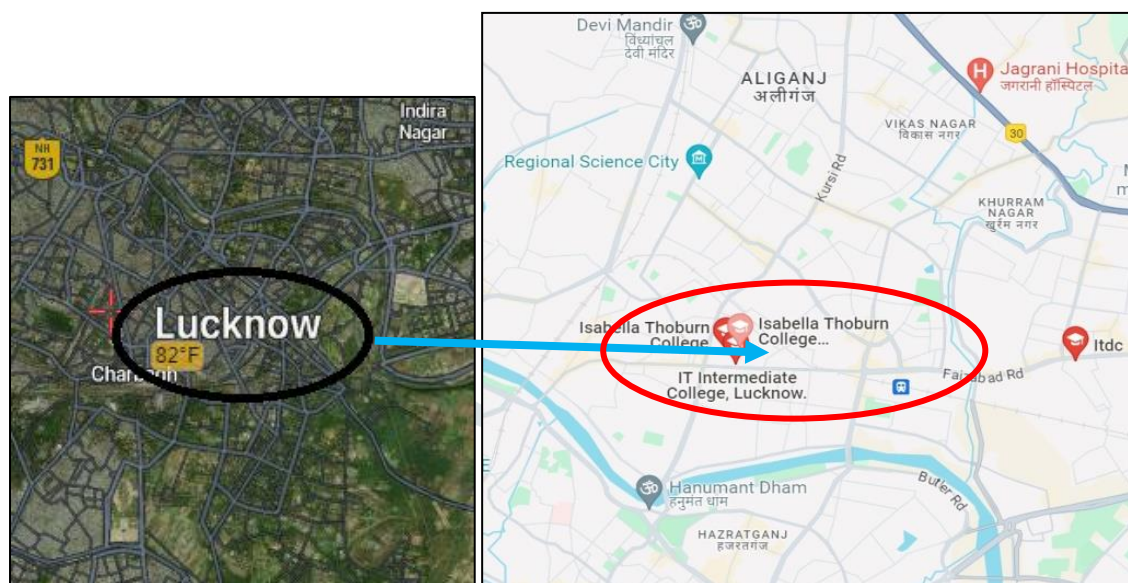
Isabella Thoburn College, Lucknow is a women's college in Lucknow, India, named for Isabella Thoburn, who founded it and was the first American woman to sail as a Methodist Episcopal Church missionary in India in 1869. When the college opened in 1870, there were just six female students enrolled. The college is currently connected to the University of Lucknow. On the Chand Bagh site, it has constructed buildings since the 1920s, including lecture halls, student residences, labs, and a library.

Selected sites for study

To conduct the short-term study, three different sites where the squirrel population can be maximum were selected to estimate the squirrel population in the campus of Isabella Thoburn College. Selection of these sites was totally based upon the availability of food and water, along with its foraging trees. Presence of *Ficus* species like banyan (*Ficus benghalensis*) and peepal (*Ficus religiosa*), along with some fruit-bearing trees such as mango, guava, and tamarind was the first category of the site selection. All three sites offered a good habitat with a healthy environment for their survival. Thus, three distinct sites in the Isabella Thoburn College campus were chosen with the study period divided into three phases: **Phase 1 (15th December 2021 to 14th January 2024), Phase 2 (16th January to 14th February 2024) and Phase 3 (16th February to 15th March)**, which is said to be the winter season in North India. In all 3 phases, Interval of 2 hours at 3 different Time shifts from 7 a.m. to 9 a.m., 11 a.m. to 1 p.m., and 3 p.m. to 5 p.m. was conducted.

Selected sites for study are:

1. Department of Zoology
2. Hostel mess area
3. Canteen area



(Source: satellites.pro) **Map 1: Satellite Map of Isabella Thoburn College**

MATERIALS AND METHODS**Plan of Field Work**

The study was carried out from 1st December 2023 to 15th March 2024 in Isabella Thoburn College at three different sample areas which include Department of Zoology, Mess area, and Canteen area. The study period was divided into three phases- Phase-1 (15th December 2021 to 14th January 2024), Phase-2 (16th January to 14th February 2024) and Phase-3 (16th February to 15th March) which corresponds to the seasons such as winter, late winter and spring. The study area was separated into three time zones that is morning (7a.m. - 9a.m.), afternoon (11a.m. to 1p.m.), and evening (3p.m.-5p.m.). The survey was conducted using a Focal Sampling Method.

Method of Study**Focal Animal Sampling**

Focal animal sampling is a method for observing and recording an animal's behaviour over a specific period of time. The researcher selects an individual to focus on and records all of their activities, or simply those of interest. The individual might be picked at random or according to certain characteristics such as age, gender, or reproductive status. The researcher records the animal's behaviour at certain intervals.

Focal animal sampling is more comprehensive than other sampling methods and can yield information on individual behaviours. However, it can be impractical, and some behaviour may be overlooked since sampling does not catch everything that occurs in real time. Scan sampling is an alternative to focused sampling in which a group of animals' behaviours are recorded at regular intervals.

Estimating the population abundance of three-striped palm squirrel

A time-area survey (Goodrum, 1940) was performed to determine the richness and quantity of three-striped palm squirrel (*F. palmarum*) in each zone. This approach is often used for surveying tree squirrels. Three sample locations (35 m apart) were chosen at random in each zone, and all squirrels seen at each point were watched and tallied for 40 minutes. The number of squirrels reported at each of the eight sampling locations in a zone was averaged. The population size in each zone was approximated using the methodology shown below.

$$N = \frac{A \sum x}{n \Delta \pi r^2}$$

Where, N = Population abundance

A = Area of zone

$\sum x$ = Number of squirrels seen

n = Total number of points sampled in a zone

Δ = average sample effort in terms of portion of circle observed

r = average radial distance between two points in a zone

The daily activities of three-striped palm squirrel

The squirrel's diurnal activities, such as climbing and crawling, as well as foraging methods such as food preferences, handling time (measured in minutes with a timer), caching, and rapid food intake, were all recorded. Focal animal sampling (Altman, 1974) was employed to examine diurnal activities, which entails watching an animal for a set sample period and documenting all of its behaviours.

Food preferences and feeding tactics of the three-striped palm squirrel

Feeding and Food Preferences was investigated by placing supplementary food such as peanuts, dried red chillies, and cooked rice on the ground at a distance of 4 meters from the observer to record meal choices without direct human interaction.

RESULT AND DISCUSSION

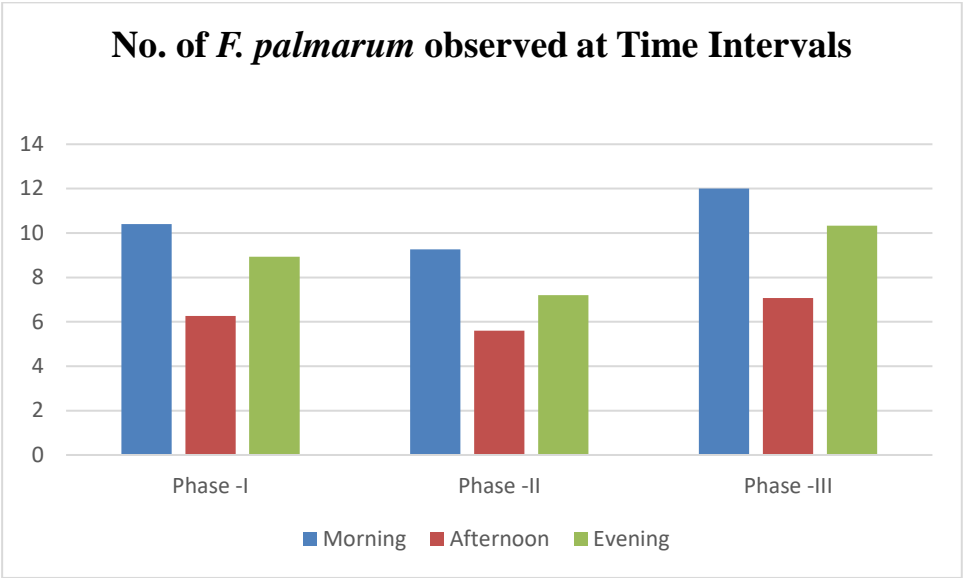
The distribution, diurnal activities, and foraging methods of three-striped palm squirrel (*Funambulus palmarum*) were recorded and statistically examined at three distinct sampling sites in Isabella Thoburn College, Lucknow, Uttar Pradesh, India.

Population abundance of *F. palmarum* estimated using a time-area survey (Goodrum, 1940) from 15th December 2023 to 15th March 2024.

The Population Abundance of three-striped palm squirrel (*F. palmarum*) was estimated at 3 distinct time intervals: morning (between 7 a.m. - 9 a.m.), afternoon (between 11 a.m. - 1 p.m.) and evening (between 3 p.m. - 5 p.m.).

Squirrels were counted for 40 minutes, stopping at each sample point. In all 3 phases the population abundance was observed during the morning and evening hours. The record was minimum in the afternoon hours. Due to their crepuscular nature, squirrels are most active during dawn and twilight. They can evade predators and yet have enough light to seek for food because to this habit. They could also be more active during the colder hours of the day in order to control their body temperature. The average number of squirrels in each phase was determined and calculated as Mean \pm Standard Deviation ($\bar{x} \pm SD$). The population abundance of *F. palmarum* was estimated using a time-area survey (Goodrum, 1940). The population of *F. palmarum* was observed to be maximum in phase 3 as compared to Phase 2 and 1.

Table 1: Population Abundance of <i>F. palmarum</i>				
Population abundance of <i>F. palmarum</i> in different Time Intervals				
		Phase 1	Phase 2	Phase 3
Average no. of squirrels observed ($\bar{x} \pm SD$)		8.53 \pm 2.17	7.36 \pm 2.24	9.8 \pm 2.51
Population abundance (%) $N = \frac{A \sum x}{n \Delta \pi r^2}$		50.88%	45.0%	60.0%

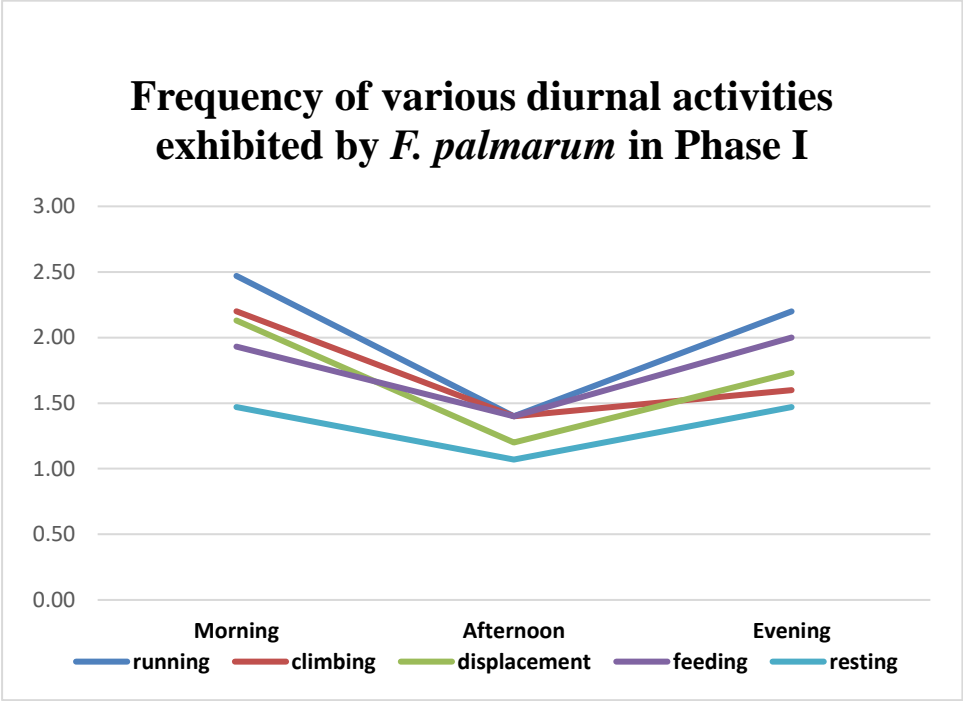


Graph-1: Number of *F. palmarum* observed at different Time Intervals

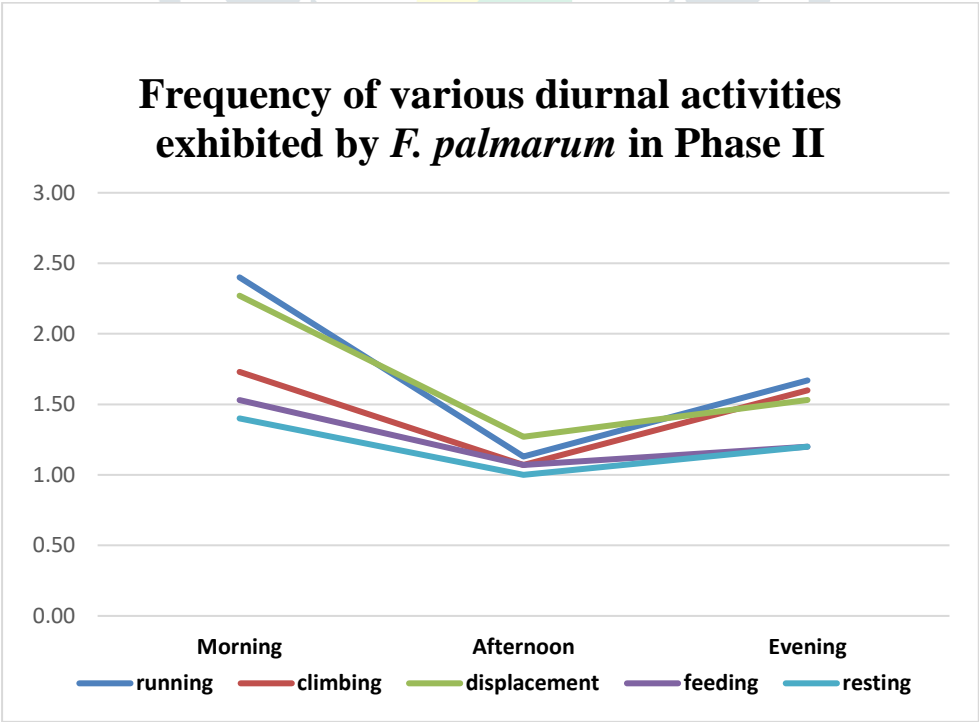
Table 2: Defining the daily activities and the average daily activities of <i>F. palmarum</i> in all the 3 phases.				
Diurnal Activities	Description of the Activity	Phase 1	Phase 2	Phase 3
Running	Running on the tree branches, ground, and power lines	2.02	1.73	2.42
Climbing	Climbing the tree, buildings	1.73	1.47	2.04
Displacement	Jumping from one place to the other	1.69	1.69	1.49
Feeding	Eating and drinking	1.78	1.27	1.56
Resting	Body lies in contact with the ground, with eyes closed or Open	1.33	1.20	2.33

In the current investigation, two definite peaks in the daily activity frequency were seen in phase 1, in the early morning (between 7 a.m. to 9 a.m.) and evening (between 3 p.m. to 5 p.m.) for different times of observation at each phase. Two different times of the day saw the highest activity levels among the three-striped palm squirrels. It was discovered that the squirrels were less active in the afternoon. The animal displayed a longer morning activity period in phases two and three in comparison to the other two phases, while phase one's activity started earlier in the morning (at <a.m.), starting at 7 a.m. As a result, the squirrels demonstrated a bimodal pattern of frequency in their daytime activity Bordignon and Filho (2000). Previous research on squirrel foraging behaviour has revealed that peak foraging activity occurs in the morning after two hours from dawn and before two to five hours from dusk Halloran (1999).

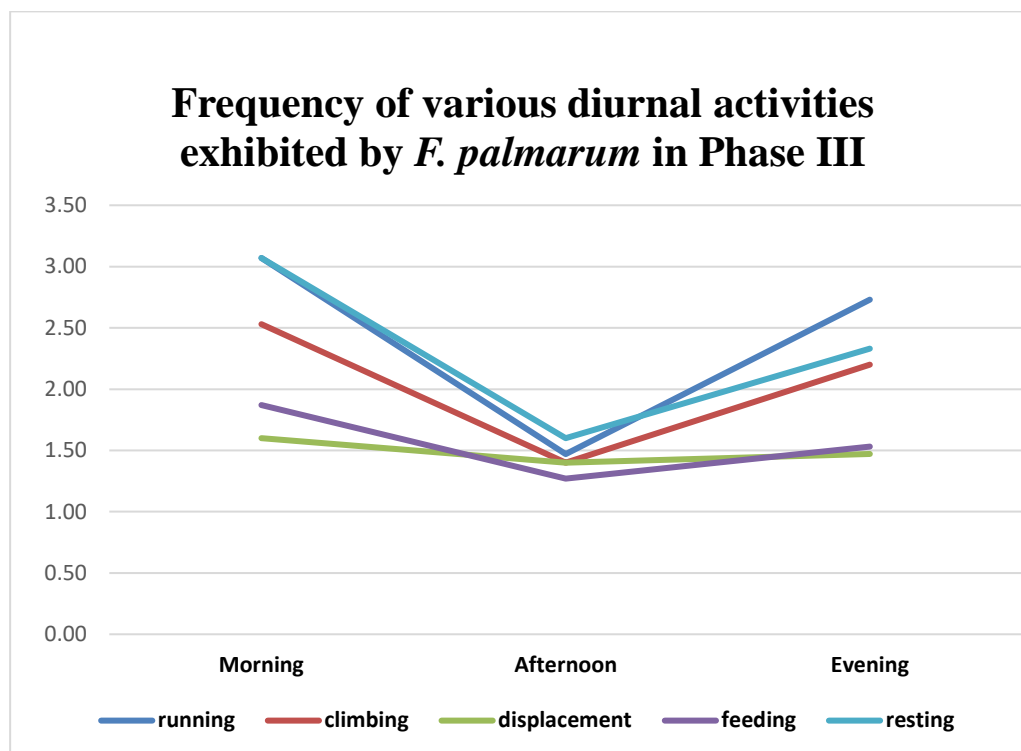
This bimodal activity might be attributed to the fact that the temperature is reasonable in the morning and evening. To avoid being exposed to severe heat, squirrels avoid foraging in the afternoon Bryce (2001). Squirrels are less active in the afternoon to avoid the peak temperatures of the day Tonkin (1983). Because Phase 1 coincided to the month of February which is the winter season in India, there was a delay in dawn and a dip in temperature, which may have influenced the squirrels' behaviour in the morning.



Graph-2: Frequency of various diurnal activities exhibited by *F. palmarum* in Phase 1



Graph-3: Frequencies of various diurnal activities exhibited by *F. palmarum* in Phase II



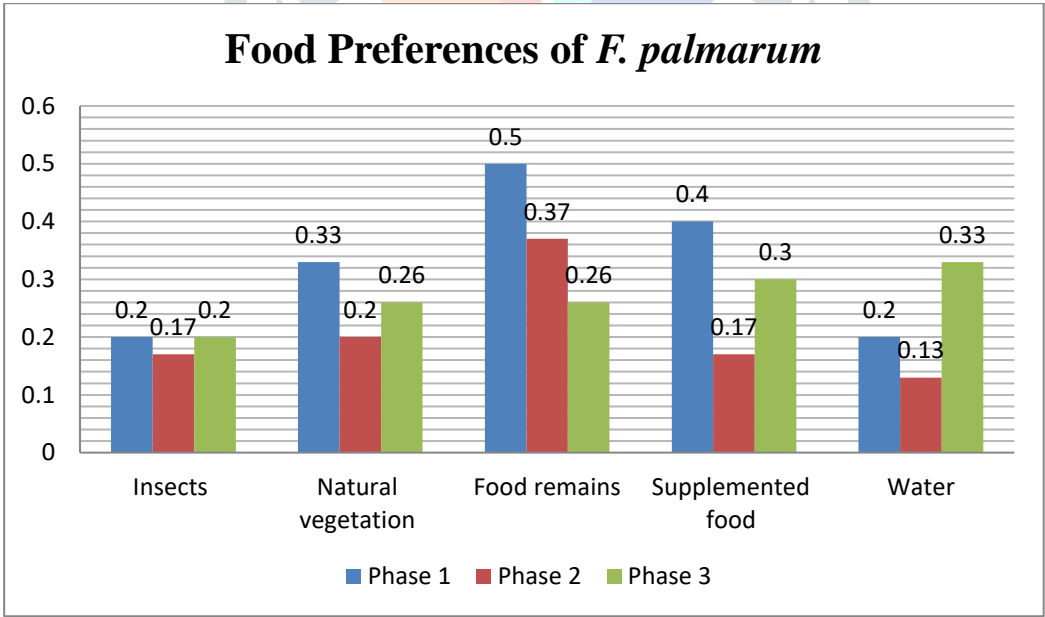
Graph-4: Frequency of various diurnal activities exhibited by *F. palmarum* in Phase III

Food Preferences of three-striped palm squirrel (*F. palmarum*)

The Optimal Foraging Theory model MacArthur and Pianka (1966) illustrates how the most favourable strategy is chosen by the forager through natural selection. It asserts that natural selection supports foraging methods that optimize the intake of energy and nutrients from food, as well as the costs (challenges) of seeking for and getting food, such as energy expenditure, food amount, and predation. This has an impact on the organism's fitness, pace of adaptation to the environment, and reproductive success. Throughout the three periods, the three-striped palm squirrels favoured supplemental food such as cooked rice, red chillies, and groundnuts above other meal kinds. In Phases 1 and 2, the squirrels practiced scavenging more, feeding on food remnants from discarded plastic bags and dustbins. The squirrels also grazed on natural plants, and neem tree blooms. The squirrels dined on a variety of insects, including *Oecophylla sp.* (Asian weaver ant) on trees and Pholcidae sp. (Cellar spider) under leaves. The high temperature in phase 3 enhanced the three-striped palm squirrels' water requirements. Based on Optimal Foraging Theory the squirrels choose the most advantageous mode of foraging depending on the food sources that were available in each phase. Every day, the community members offered supplemental food such as cooked rice and red chillies at the same location. As a result, this decreases energy expenditure and search time for food, while increasing the quantity and quality of food ingested (greater benefit and lower cost). Urban squirrels are more inclined than wild squirrels to explore urban settings and graze for human resources. This is because squirrels in urban areas have gotten accustomed to human presence and have learned that humans offer fewer predatory threats. Thus, squirrels rely on people for food and shelter. Urban squirrels are more daring because they contact with humans on a regular basis and are viewed as opportunists. The choice for supplemental food (peanuts, red chillies, rice) offered as part of the study suggests squirrels' boldness or risk-taking behaviour, as well as their lack of fear of humans.

Although additional food sources were accessible in Phase 2, squirrels chose human resources because they were more readily available. This demonstrates the habituation of urban squirrels (urban adapters) to human presence, as well as their reliance on humans and man-made food sources. The pace of scavenging is determined by a number of parameters, including meteorological conditions, deposition, the amount of remains, the length of time food remains are exposed to sunlight, and the rate of decomposition Byard (2002). As a result of the moderate weather conditions (minimal sun exposure time), food remains decomposed at a slower rate in Phases 1 and 2.

Table-3: Food Preferences of <i>F. palmarum</i>			
Types of food	Rate of Food Preferences in <i>F. palmarum</i>		
	Phase 1	Phase 2	Phase 3
Insects (Ants, Spiders)	0.2	0.17	0.2
Natural vegetation (Fruits, flowers, leaves)	0.33	0.2	0.26
Food remains	0.5	0.37	0.26
Supplemented food (Cooked rice, red chillies, Groundnuts, Mountain knot grass)	0.4	0.17	0.3
Water	0.2	0.13	0.33



Graph-5: Food Preferences of *F. palmarum*

CONCLUSION

According to previous research, three-striped palm squirrels *F. palmarum* engage in a variety of activities in the morning and evening. The frequency of observed behaviours varied with the seasons (phases). The squirrels' highest activity time matched with that of people in the morning and evening. Squirrels adapted to the available food supplies in each season, preferring items with low search and handling time but high

nutritional content. Palm squirrels were well-adapted to human-provided meals rather than eating on natural flora and insects. As urban adapters, they rely on people for basic resources such as shelter and food. So, squirrels occupy human settings, where their essential needs for survival are met.

Squirrels also nibble on telephone lines, burrow in holes in gardens and infiltrate houses via fissures to cache or establish nests. Squirrels are known to contain parasites including tularemia and ringworm, which are easily transferred to people Baldwin (2015). Because they are so extensively scattered, eradicating them from urban and suburban environments is extremely difficult. These squirrels' reliance on human environments will continue to rise as urbanization progresses, and the squirrel may eventually become a problem.

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