

Studies on avian diversity and behavioral ecology on a single host tree *Ficus benghalensis* in Nagpur, India

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Abstract: The present study reports the recorded observations of several bird species visiting the *Ficus beneghalensis* with a major focus on territorial intra-specific interactions, sharing of livestock, foraging habits and population assessment of the avian species dependent on a single host tree in an urbanized settlement in Nagpur, Maharashtra. A total of 849 individuals of six different frugivorous species were reported to visit the host tree during the study duration, along with it the temporal and seasonal variations in the avian population were studied over a period of seven months including both the major fruiting seasons of the tree. The feeding habitat, social interactions and territorial defence of a female Asian koel were the major focus of the study. The study examines the territorial distribution amongst avian species with respect to a single host tree and focuses on the evolutionary aspects of niche occupation in the survival of a species.

I. INTRODUCTION

A. Biodiversity in Nagpur.

Nagpur city is located in the Deccan plateau range in the state of Maharashtra at an altitude of 310.5 metres above sea level, with a human population ranging from 28 to 30 lakhs. The city has a tropical climate with temperatures ranging from the highest 48°C to the lowest 4°C with an annual rainfall of around 1000mm. The eastern part of the city is heavily industrialized and the city has three inland lakes and some minor reservoirs. Nagpur city also holds the title of one of the greenest cities in the country. Several academic campuses like NEERI, VNIT and well-protected natural places like Gorewada lake, Seminary Hills, Ambazari nature reserve, and Botanical Garden contribute to the greenery and ecological balance of the city. The city is also surrounded by several forest reserves on the outskirts more than 70kms from the core region of the city. The city reports frequent visits from migrated and local bird species of many families and orders.

A previous report on the avifauna diversity of the city lists a total of 284 species sighted in the region and in total more than 180 species are claimed to be resident species of the city [1]. Similar studies from regional sightings of different locations of Wadi, LIT campus, reports 28 and 62 species of birds respectively [2,3]. Report from studies on the avian population of urban habitat in the Raj Bhavan area of the city reports the presence of 154 bird species spread across 121 acres land and also highlights the increase of avian flora in the region [4] Studies on avifaunal biodiversity of wetlands in Futala and Gandhisagar lake reports 34 species each on different locations [5, 6]. The Gorewada International Bio-Park, in the city, also identifies 190 bird species belonging to 17 different orders [7].

B. Ficus tree.

The *Ficus beneghalensis*, also known by its Indian name, the Banyan tree is one of the largest and oldest trees to be recorded, the tree belongs to the Moraceae family and there are over 60 different species of the Ficus genus previously reported. The tree is considered a sacred tree throughout the Indian subcontinent in the Hindu culture and holds a documented record of the ancient Indian scriptures [8].

In modern science, the tree is reported to have several metabolites of pharmacological activity belonging to antibacterial, antioxidant, antidiabetic, analgesic and anti-helmentic classes. These include ketones, flavonoids, sterols, terpenoids and esters distributed in different parts of the plant. Quercetin-3-galactoside, 5,7,3, trimethoxy leucodelphinidin 3-O- α -L-Rhamnoside, β -sisterol, psoralen, peroxide radicals are amongst the key phytochemicals of medicinal use [9, 10].

F. benghalensis are colossal trees with an average height of 30m and 200m in diameters, they are one of the largest in terms of their spread, with the oldest recorded age of some trees more than 350 years. The tree is epiphytic and has aerial roots, the leaves are obtuse, elliptical with a leathery covering and are around 10-40cm with lateral veins of 5-7cm, the fig fruits grow in the leaf axis, and are sessile, usually found in pairs with an average diameter of 1.5 to 2cm, and grow from orange to red as they mature [8, 11].

C. Dependency of avian species on *F. benghalensis* in urban habitat. Associated with the agaonid wasps and being an evergreen perennial tree *F. benghalensis* bores fruit throughout the year and attracts frugivores mainly during its fruiting seasons and it is least visited in the months of December and January with House Crow and Common Myna being regular visitors all around the year while other were seasonal visitors [12]. Major species visiting tree varies depending on the season, location availability of food and species richness.

Avian fauna on *F. Benghalensis* is affected mainly by no. of fruiting trees, weather and seasonal variation [13]. Another factor influencing avian diversity includes the presence of a wetland, it provides appropriate habitat for birds for nesting, roosting and breeding. Many previous studies reported many residential species in the surrounding region of Nagpur [6, 7], and observations from [24] suggest that the Ficus tree has a major role in the dependency of these avian species in this urban habitat. On the whole, these data suggest that Nagpur is rich in avian diversity due to the presence of all essentials for nesting, feeding, protection against predators, suitable weather and wetlands. This also indicates that such a high population of birds will have to compete for limited food availability that varies largely from season to season.

II. MATERIALS AND METHODS

This report is based on individual observations made through a terrace about 5m far facing the upper branches of the tree. Observations were noted daily throughout the fruiting season of the tree from September to April. To report the frequency of the fruiting bar and verify our hypothesis about the variation in the avian community and their dependency on the fig fruits, observations were recorded following the fruiting bar of the tree, the branch that bores the maximum number of fruits at any given time. The observations were recorded for a *Ficus benghalensis* tree, with an average height of 15 to 20m and are supposed to be more than two hundred years located at a community park in the urban vicinity of Nagpur city at GPS coordinates 21.116909,79.067685. The park also hosts trees like Pimpal and Banyan among other local species for which the observations were not made.

Sample data was recorded for two-time intervals, 6:00 am to 8:00 am and 4:00 pm to 6:00 pm and the obtained data for the number of individuals of each species visiting the tree per month was calculated considering the average of the data obtained for each specific species along with random observations made throughout the day. Species richness was calculated with Margalef's index and variation in frugivory activities of bird species was calculated on the temporal and seasonal scale. The independent two-tailed t-test was statistically calculated to assess the hypothesis for population variation in the two fruiting seasons. Behavioral interactions amongst the species and foraging habits were recorded and tabulated. Identification of birds was done with the help of information given by Ali. The fruit samples falling on the ground as a result of winds and the feeding habits of these birds were collected for assessment and photographic documentation. The supported pictures were taken from a cell phone (Nokia 6) with a low-resolution camera of 5 megapixels and an F-stop value of f/2.0.

Table I -Checklist of birds observed during the study duration.

Common name	Scientific name	Family
Yellow footed green pigeon	<i>Treronphoenicoptera</i>	Columbidae
Common Tailorbird	<i>Orhtotomussutorius</i>	Cisticolidae
Red-vented Bulbul	<i>Pycnonotuscafer</i>	Pycnonotidae
Coppersmith Barbet	<i>Megalaimahaemacephala</i>	Megalaimidae
Asian Koel	<i>Eudynamysscolopacea</i>	Cuculidae
Eurasian Golden Oriole	<i>Oriolusorioluskundoo</i>	Oriolidae
Common Myna	<i>Acridotheres trististristis</i>	Sturnidae
Purple Sunbird	<i>Nectarinia asiatica</i>	Nectariniidae

III. OBSERVATIONS and RESULTS:

a. Species Distribution

The data obtained for the total number of individuals of avian species visiting the host tree during fruiting seasons shows a total of seven different frugivores entirely dependent on the tree, whereas occasional visits made by Common Myna, Black Drongo and Asian Green Bea-eater were not considered. Coppersmith Barbet and Red-vented Bulbul were found to be the most dominant species in terms of number of individuals [14]. Out of the seven species, it was observed that birds of smaller size were densely distributed on the outer core or external fruiting tier of the tree, whereas the Asian koel and Yellow-footed Green Pigeon, comparatively larger than other birds would mostly occupy the inner core/internal fruiting tier of the tree and upper branches of the tree respectively. Fig 1. represents a pie chart with the approximate area of the foraging tier of the tree occupied by the dominant species.

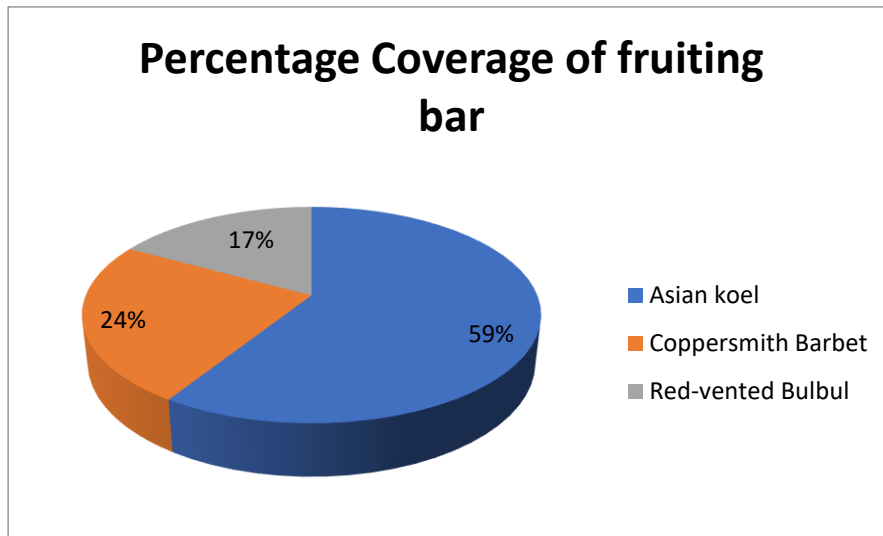


Fig 1. Percent Coverage of fruiting bar by three dominant species

b. Species Richness Inference

The species richness index is calculated following Margalef’s species richness index and was reported to be a higher index of 2.31 which implies a higher number of species for the existing ecological environment [15]. This data corroborates with the competitive exclusion principle (CEP) and thus indicates that the higher index is a result of the limited resources available and therefore follows the parameters of coexistence, however, the species would never result in exclusion since they violate many conditions and also due to the temporal variability, habitat diversity, seasonal changes despite the ecological niche overlap [16]. Table II reports the number of individuals of each species observed during the study duration.

Table II- Periodic species abundance of the major inhabitants.

CommonName→	Coppersmith Barbett	Yellow-footed Green Pigeon	Asian Koel	Red-vented Bulbul	Common Tailorbird
Month↓					
Septmeber	83	0	3	96	42
October	102	0	5	109	47
November	112	21	7	124	43
December	137	38	7	139	54
January	153	69	7	158	48
February	174	72	7	169	43
March	220	54	7	186	39
April	241	26	5	216	35

C. Seasonal Variation

Although the same fruiting tier or foraging habitat was assessed to check the difference in the avian population, a significant amount of variation was recorded in each of the species during the two fruiting seasons. The p-values from the independent two-tailed t-test for the avian population visiting the tree were calculated based on the two fruiting seasons for the dominant species feeding on the Ficus fruit. The values from Table III show a significant difference and reject the null hypothesis that refers to no significant difference in the avian population during the two seasons. The lower p-values obtained indicate that there is fierce competition for the same resources in the harsh summer season due to fruit preference in the avian population [17] thus indicating a higher species richness and contradicting the results obtained from similar studies in a cold climate [12]. The leafless or leaf maturation of the host plant from December to April correlates with the beginning of the summer fruiting season and thus explains the steep decline and increase in avian frugivory in the following season reported in Fig. 2 [13].

Table III - Seasonal variation of birds.

Common Name	p-value	Maximum number of individuals	
		Season 1	Season 2
Coppersmith Barbet	0.008779	147	241
Red-vented Bulbul	0.005956	139	216
Common Tailorbird	0.226018	54	48

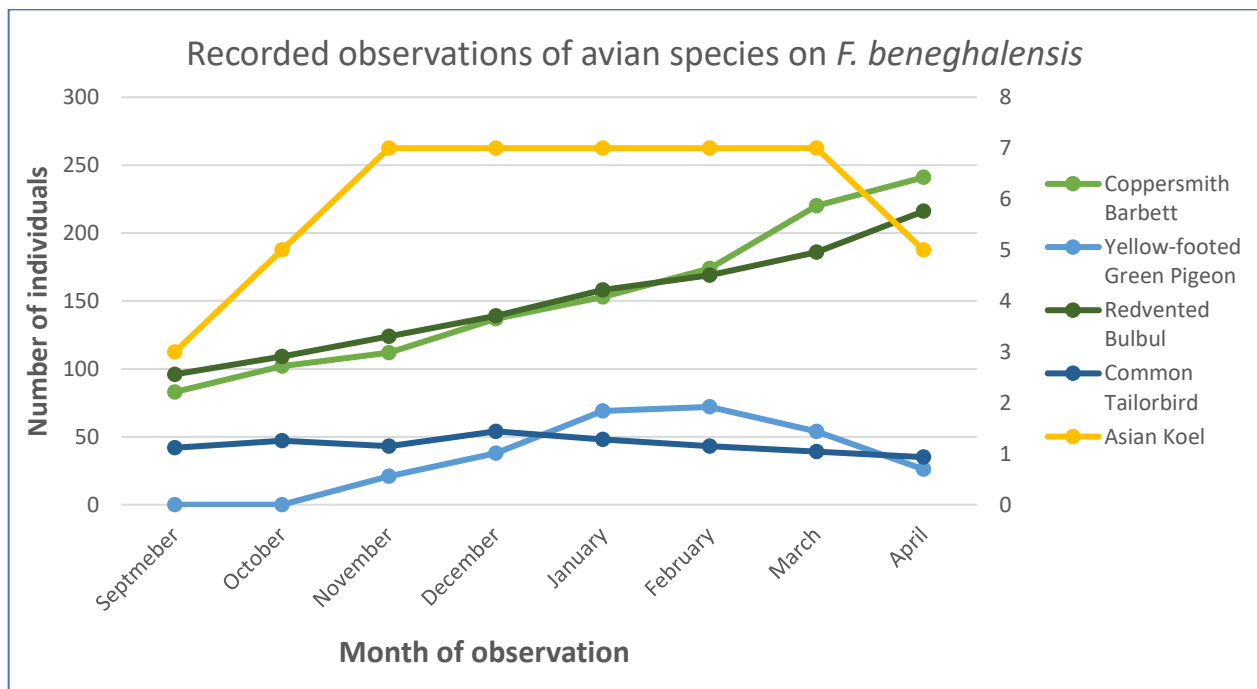


Fig 2. Variation in abundance of species during different seasons.

d. Temporal Variation

From many previous reports that had recorded higher activity in the morning feeding sessions, our data slightly contradicts the records in terms of smaller birds that are most active during the early afternoon period from 12 pm to 3 pm [18]. The Fig. 3 graph represents the average mean values of the population taken together from the data and was plotted against three durations during which the feeding session of the population from each species would last for around two hours. The data from our study represents a temporal variation pattern that is highly synchronous to similar studies on fruiting trees carried out in forest ecosystems [19].

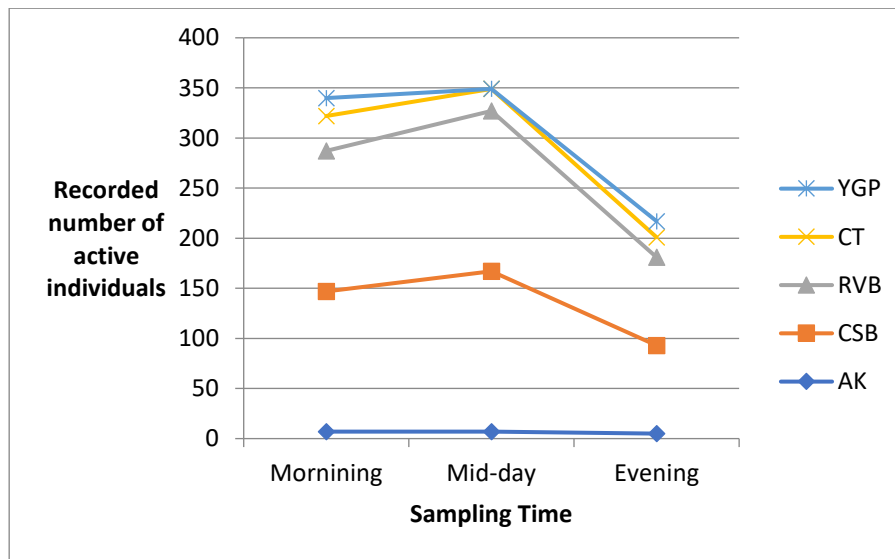


Fig 3- Visual representation of species abundance on tree during day time. Legends used represent, YGP – Yellow-footed green pigeon, CT – Common tailorbird, RVB – Red-vented bulbul, CSB – Coppersmith barbett, AK – Asian koel.

e. Foraging Habits

Different foraging habits and the number of fruits consumed by the individuals of the avian species were reported in Table III - Seasonal variation of birds. The foraging habit or mode of consumption of fruits largely depends on the size of the individual bird species. As it was observed larger birds like the Indian Golden Oriole, Asian koel, and Yellow-footed Green Pigeon would prefer to directly consume the whole fruit and smaller birds like Coppersmith Barbet and Red-vented Bulbul would eat the fruits in bits and pieces. Much smaller birds like the Common Tailorbird and Purple Sunbird were observed feeding upon the leftovers of fruits eaten by larger birds. Studies on the fruiting phenology of *Ficus* explains the low observations recorded in tropical climate region in December and November [20].

f. Inter and Intra-species interactions

The intra-species interactions were recorded mostly in the four dominant species feeding on the *Ficus* plant and competing for its resources. The three males of the Asian koel family and the two females were frequently observed with aggressive behavior towards smaller birds visiting their foraging niche, although each member had a separate distinct ecological niche all the members would visit each other and show similar aggressive behaviors like high pitch vocalization, attacking other birds were observed [21, 22]. The females of the Koel family were very aggressive as compared to the males when it comes to territorial defence. A single female was reportedly seen engaged in territorial defence for two hours in the afternoon during the peak summer fruiting season. The significant data from Table II- Periodic species abundance of the major inhabitants, support this aggressive behavior with the substantial increase in the number of avian populations competing for the same resources in the harsh summer climate. This behavior also explains the economics of territorial defence in the avian intraspecific territorial system [23]. Minor incidents were reported between the Red-vented Bulbul and Coppersmith Barbet but taken together tackling both the species together, especially during the peak afternoon time of their activity was a huge challenge for the Asian Koel.

IV. CONCLUSION

Nagpur city located in the plateau region of India has recorded an avian fauna diversity of 284 species the rich diversity is attracted by inland lakes and minor reserves within the city. *Ficus benghalensis* one of the important fruiting trees of the subcontinent bears fruits throughout the year and offers a larger foraging tier to many frugivores in urban habitats by providing food and shelter. Considering the urban habitat of the region and frequent human intervention a higher species diversity was observed for a single tree. Although with significantly less number of individuals the Asian koel species accounts for a large foraging tier of the fruiting tree amongst the other dominant species. Redvented bulbul and Coppersmith barbett avian population is reportedly higher and characterized by similar foraging habits and similar size has a fierce competition amongst them to get the maximum benefits. The reported inter and intra-species interactions amongst the frugivores clearly show the dominance of the Asian koel species and being the larger as compared to others it intimidates other smaller birds and defends its territory aggressively. The avian community stringently follows the territorial distribution and each species utilizes the resources equally sharing the same ecological niche. In total the

overall health of the ecosystem is well-maintained and suggests that the avian population can thrive competitively even in the growing urban habitats if supported by native trees that would provide food and shelter to the community.

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BIOGRAPHY

The first author of the paper is currently working as a Research Associate at Biopol Biosciences, Bangalore Bioinnovation Centre, Bengaluru, India. He has master's degree in Biotechnology and his research interests lies in the field of molecular biology, microbiology and protein biochemistry. Although a biotechnologist, he is an avid birdwatcher and therefore through his daily observations compiled the data to produce the paper. The second author is currently pursuing her master's in Biotechnology and her research interests lies in bioinformatics, cell biology and molecular biology.

Additional pictures for references.



(a)



(b)



(c)



(d)

Fig 1. (a) Coppersmith Barbett (b) Indian Golden Oriole (c) Ficus fruits (d) Yellow-footed green pigeon