International Research Journal of Environmental Sciences ISSN 2319–1414
Vol. **9(4),** 74-79, October **(2020)** *Int. Res. J. Environmental Sci.*

Case Study

Diversity and importance of the genus *Ficus* L. from an urban forest: The case study of Fergusson College Campus, Pune, India

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Available online at: www.isca.in, www.isca.me
Received 9th April 2020, revised 17th September 2020, accepted 10th October 2020

Abstract

Urban forests are composed of diversified tree species ranging from invasive to indigenous ones. Ficus species in an urban environment plays a massive role in providing various ecosystem services. Earlier studies in pristine forest ecosystems have already proved the importance of Ficus trees in nature. Most frugivorous avian and chiropteran species depend on the fleshy fig fruits as they provide them with a balanced diet. A diversified group of animal ranging from aves (domestic pigeons, parrots, koel and many more) to an advanced class of mammals (frugivorous bats, insectivorous bats, squirrels, mongoose and many more) depend on the substantial numbers of Ficus species population for nourishment supply and habitation (nesting, settling, roosting, perching and many more) in an urban forest. Ficus benghalensis has recorded the most visitors by chiropterans and avian species in the current study. The present work throws light on the diversity of Ficus species from an urban surrounding and their interactions with animals. Hence, this data will prove to be instrumental in selecting plant species for afforestation drives in a city, which will boost the conservation of urban biodiversity.

Keywords: Ficus diversity, urban forest, urban biodiversity, animal interaction, Pune.

Introduction

The urban forests have always defined as a collection of trees that grow within a city, town, urban, or suburban areas[1]. Defining urban forests as a "collection of trees" has decreased the biodiversity value of it since people keep planting invasive species during plantation drives in developing countries to increase the greenery in their town[2].A stable urban forest in a neighbourhood is vital to understand the kind of biodiversity it supports. However, in many Indian suburbs, the diversity of trees remains undocumented, which creates a void in the action plan to safeguard urban floral and faunal species.

Thus, documentation of species becomes an essential factor in today's world of science.

Fergusson College campus has a vast biodiversity profile, which has been investigated in the past few instances. The range of fauna which includes 90 spiders (28 families), 93 butterflies (6 families), five amphibia (3 families), 26 reptiles (9 families), 137 birds (52 families) and 19 mammals (13 families) species[3-5]. Apart from fauna, the campus also holds 437 species of plants[6]. After IISc Bangalore, the Fergusson college campus nurtures the second largest campus in terms of floristic biodiversity[7].

The entire campus biodiversity is supported by the urban forest patch. It increases the value of the 109 acres college campus in terms of environment and leisure activities.

The forest is comprised of many tree species out of which *Ficus* genera are present in quite good numbers. Many ecologists and environmentalists consider *Ficus* species as "keystone species," which holds the different components of an ecosystem together[8]. Individual *Ficus* species, nevertheless, are not equally vital for all fig consumers and pantropically, there are various guilds of *Ficus* species that distinctly attract subgroups of the regional frugivore wildlife[8]. *Ficus* species, both cultivated and natural ones, are phytodiverse and plentiful in a large number of tropical cities and are very crucial for urban wildlife. These urban *Ficus* associations are of reasonable interest as they conveniently allow us to look at the natural associations between an entire *Ficus* flora and an entire frugivorous group[9, 10]. The intention of the study is not only to recognize diversification of *Ficus* species in the urban campus but also to look into the relationships with the diversified animal groups.

Methodology

Fergusson College (Latitude: 18.5235°N, Longitude: 73.8376° E) is located at the heart of the bustling Pune city of Maharashtra. The campus comprises of a hill covered with trees, continued with trees present on ground level too. This entire patch of 72 acres was surveyed to understand the biodiversity of the campus. Inventorying plant species from the campus started in 2015 and studying the relationships between floral and faunal components of the campus started in 2018. The entire work was carried between February 2017 and March 2020. The

inventorization of plants was done through point count methodology, and digital pictures were clicked to establish the relation of plant and animal. The activities of birds were documented between 7.00am to 10.30am daily. Mist nets were tied to trees both below and above their own canopies adjacent to the fruiting part of the trees which helped in confirming the official visit of bats. Other animals also stopped at *Ficus* trees for various purposes such as nestling, resting and predation.

Results and discussion

A total of 9 species (Table-1) belonging to the genus Ficus was found to be thriving in the forest patch. Out of which, *Ficus benghalensis* L. is abundant with a population of 47. The other *Ficus* species have only one individual left in the campus. *Ficus benghalensis* is an evergreen tree, grows enormously, upto 30m in tree height, having numerous aerial roots that have the potential to grow into different trunks so that the mother tree can go on growing laterally in an ad infinitum way; a single *F. benghalensis* can spread extensively. The leaves are tough, whole, oval or elliptic, 30-40cm in length with noticeable veins arranged laterally. The fruits are 1-2cm in width, devoid of stalks, present in sets at leaf axils, and once ripe, fruit color changes to bright red[11]. *Ficus religiosa* L. is a massive deciduous species with an insipid trunk frequently seeming corrugated on account of the abundant roots which have united with the trunk. The leaves are rubbery 5-7 inches in length by 2-4 inches in width, ovate or somewhat rounded, stalked at the tip, and at the base, it is relatively heart-shaped, or on many occasions, it may be rounded. The flowers are tiny, which are then contained by the receptacle, which eventually grows into a fig type of fruit[11]. *Ficus infectoria* Willd is an enormous stifling tree species with an expanding tree canopy. The airborne roots generally cape about the central trunk as an alternative to developing props. The foliage is 9-18cm in length and 2-5cm in width, consisting of an ashen coloured mid-rib. The stipules generally measure lesser than 1cm in length. The fruits are figs which are pea-sized, occurring in duos, and greenish to tan in colour with numerous spots. This tree is an attractive shade-providing tree when new leaves varying from purple to bright red appear from March-April[12]. *Ficus benjamina* L. is an evergreen member of Moraceae family, innate to South and Southeast countries of Asia. In natural conditions, it grows up to 25-30 m with elegantly drooping subsets of branches and features lustrous foliage which is 5-12cm in length, ovoid with a pointy tip. It bears minutely sized red coloured fruits as figs, which are a favorite foodstuff of severalfowls[13,14]. *Ficus maclellandii* King (also well-known as Banana Leaf Fig Tree) has a "pleasing to the eye" experience and it is also an evergreen species of tree. The leaves are saber-shaped, growing upto 3-10 inches in length, young leaves emerge as red but matures into dark olive green and grows to be leathery as texture. They hang down graciously from the plant. The tree's crown is uncluttered and lop-sided. The fruits are stalked to the trunk and are minutely sized in nature[15]. *Ficus microcarpa* L. f. is an evergreen species of tree, which can grow upto a height of 15 m, has a rounded compact crown, planegrey bark, any kind of injury leads to oozing out of milky latex, and elongated, thin, hanging airborne roots. The tree's leaves are simple, alternately arranged, sturdy, deep silkyjade, elliptic to rhombus-shaped, 5-6 inches long, with shortly jagged, corrugated tips. The flowers are miniscule, unisexual, plentiful, concealed within the receptacle that grows into a fig which is plumpy, a dedicated receptacle that matures into a compound fruit, whitish-green, developing to yellow-dark red when ripened, stalkless, present in sets at foliage axils with a size of around 1cm in extent[13,16]. *Ficus amplissima* Sm. is an enormous semi-deciduous or evergreen tree species with an extensively increasing crown measuring more than 10m. It can develop up to a stature of 25-26m in natural environments and has a compact spread of above-ground roots, which are commonly enveloped around the upper part of the woody stem. The foliage surface is without hairs and is mainly coriaceous. The fruits are stalkless, axillary, depressed sphere in shape, minute and light bottle green firstly, matures into dull red to purple on becoming fully grown[13,17]. *Ficus racemosa* L. is a large tree species with few or no airborne roots. The leaves are shaped in the form of elliptic to oblong-elliptic, simple, consisting of 2 stipules, small hairs, linear to deltoid in shape, deciduous. The specie's inflorescence is of hypanthodium type. The tree's flowers have three kinds of florets; staminate florets are diandrous, sessile, located adjacent to the opening of the receptacles; gall florets are gender neuter florets that consists of a long stalk and are situated between the staminate and pistillate flowers; pistillate florets are sub-sessile, plentiful and smaller in size than the male florets. The fruits are figs that are fleshy and whose colours vary from dull orangeish-red to bright red[11,18]. *Ficus elastica* Roxb. ex Hornem. is a tall tree growing up to 30-40 m in height and proliferates rapidly in size[19]. Their leaves are elliptically shaped, large in size, acute, marvellous, coriaceous, bearing large stipules, caduceus, scales of buds vary between pinkish to yellow, and parallelly arranged lateral veins are present. This tree also sports an inflorescence, which is of hypanthodium in nature[13]. The male flowers consist of 3 sepals and a single stamen; gall florets have three sepals with a short style; female ones also consist of 3 sepals with a superior ovary, style is short in size, and stigma is generally club-shaped in nature. At the same time, fruits are globose in shape and turn bright red on maturing[19].

The relative study on the character of *Ficus* L. fig ingestion by the fowls and chiropterans (Table-2) exhibited that avesoutnumbered the chiropterans in respect to the diversity of species giving the trees a visit (Figure-1). Both frugivorous and insectivorous avian species occupy a significant part in seed dispersion when they endeavor to latch on to the arthropods. The seeds by means of gluey casing get caught to the mandible of the insectivorous fowls. When the avesscrubs its bill by forcefully scrapping it on a different tree's branch, those sticky seeds of fig eventually get transported to a novel substrate that backs the initial epiphytic development[21]. During the investigation period, *Ficus benghalensis* saw the most avian visitors trailed by *Ficus microcarpa*. These members of the

Moraceae family have adapted to urban microclimate employing seed dispersal through the production of an enormous amount of figs for summer time[22,23]. Thus, the importance of these *Ficus* genus to the bird community can be revealed by the diversity of avian visitors.

During the night, *Ficus* species are frequently visited by chiropterans. The current investigation showed *Ficus benghalensis* was the most visited tree by bats, trailing behind it is *Ficus religiosa.* Chiropterans being winged mammals hinge on energy-rich well-balanced nutritious fruits which are rich in amino acids, minerals, carbohydrates and fats. They bank solely on *Ficus* trees by nurturing on a mixture of fruits obtained from a diverse range of *Ficus* species[24]. Earlier studies throw light on their diet, which is contained with calcium that helps in sustaining cellular developments and lactation during the post reproduction stage[25,26]. Later on, studies also established that intake of fruits from diversified species of *Ficus* could offer bats all the nutritious compounds they need to survive[24] Hence, all these works resonate that frugivorous chiropteran species cannot subsist in the environment devoid of these fig species.

Table-1: The studied fig trees along with their phenology and fruit morphology.

Scientific Designation	Period of blooming	Morphology/Colour of fig (fruit)
Ficus benghalensis L.	April-June	Rounded in shape; bright red when matures.
Ficus religiosa L.	November-January	Soft; pinkish red to red; globose.
Ficus infectoria Willd.	November	Pinkish light red to purple with a soft outer texture.
Ficus benjamina L.	February-April	Light yellow to orange; rounded.
Ficus maclellandii King	September	Rounded; emerald green in early stage to orangish red when ripened.
Ficus microcarpa L. f.	August-September	Figs is light yellow to dark yellow in colour.
Ficus amplissima Sm.	September	RedPinkish fig; drupe.
Ficus racemosa L.	May-June	Light pinkish to red in colour; rounded.
Ficus elastica Roxb. ex Hornem.	November-January	Globose in shape; greenish yellow in early stage to red in mature form.

Table-2: Studied *Ficus* trees and their respective interactions with various animal groups.

Scientific Nomenclature	Avian species	Chiropteran species	Tree users
Ficus benghalensis L.	*Dicrurusmacrocercus* (Drongo), *Terpsiphone paradise* (Fly catcher), *Pycnonotuscafer* (Red-vented bulbul), *Pycnonotusjocosus* (Red whiskered bulbul), *Eudynamysscolopaceus* (Asian Koel), *Acridotherestristis* (Myna), *Psittaculacolumboides* (Parakeet), *Oriolusoriolus* (Oriole), *Corvusmacrorhynchos* (Crow), *Cuculuscanorus* (Common Cukoo)	*Pteropusgiganteus*, *Cynopterusbrachyotis* (Lesserdog-faced fruit bat), *Cynopterussphinx* (Short nosed fruit bat), *Rousetusleschenaulti*, (Fruits bat); *Hipposiderosspeoris* (Schneider's leaf nosed bat), *Hipposiderosater* (Dusky leafnosed bat), *Megadermalyra* (Indian false vampire), *Myortishorsfieldi* (Horse fields mouse eared bat)	*Herpestes edwardsi* (Common Indian Mongoose), House sparrow (*Passe r domesticus*)
Ficus religiosa L.	*Chalcophapsindica* (Emerald dove) *Eudynamysscolopaceus* (Asian Koel)	*Cynopterusbrachyotis* (Lesser dog-faced fruit bat), *Cynopterussphinx* (Short nosed fruit bat), *Rousetusleschenaulti*, (Fruits bat), *Hipposiderosspeoris* (Schneider's leaf-nosed-bat), *Hipposiderosater* (Duskyleafnosed bat), *Megadermalyra*(Indian false vampire)	*Milvusmigrans* (Black Kite)
Ficus infectoria Willd.	*Meropsorientalis* (Small bee eater), *Dendrocittavagabunda* (Indian treepie), *Pycnonotuscafer* (Red-vented bulbul),	*Pipestrellusdormer* (Dormer's bat), *Rhinolophusrousii* (Rufoushorshoe shaped)	*Paradoxurus hermaphroditus* (Common

	Pycnonotusjocosus (Red whiskered bulbul) Spotted dove (*Streptopelia chinensis*)		palmcivet), *Herpestesedwardsi* (CommonIndianMongoose)
Ficus benjamina L.	*Columba liviadomestica* (Domestic Pigeon), *Sturnus vulgaris* (Common starling), *Turdusmerula* (Common black bird), *Psittaculakrameri* (Rose ringed parakeet), *Cuculuscanorus* (Common Cukoo)	Not Available	Not Available
Ficus maclellandii King	*Psittaculakrameri* (Rose ringed parakeet), *Sturnus vulgaris* (Common starling), *Cuculuscanorus* (Common Cukoo), *Acridotherestristis* (Myna), *Eudynamysscolopaceus* (Asian Koel)	*Pipestrellus dormer* (Dormer's bat), *Megadermalyra* (Indian false vampire), *Megadermaspasma* (Lesser false vampire bat)	*Herpestes edwardsi (Common Indian Mongoose)*
Ficus microcarpa L. f.	*Pycnonotuscafer* (Red vented bulbul), *Pycnonotusjocosus* (Red whiskeredbulbul), *Corvusmacrorhynchos* (Crow), *Columba liviadomestica* (Domestic Pigeon), *Chalcophapsindica* (Emerald dove), *Acridotherestristis* (Myna), *Dendrocittavagabunda* (Indian treepie),	*Cynopterusbrachyotis (Lesser dog-faced fruit bat), Cynopterussphinx (Short nosed fruit bat)*	*Funambuluspalmarum* (Common palm squirrel)
Ficus amplissima Sm.	*Meropsorientalis* (Small bee eater), *Dendrocittavagabunda* (Indian treepie) *Psittaculacolumboides* (Parakeet), *Oriolusoriolus* (Oriole) *Acridotherestristis* (Myna),	*Cynopterusbrachyotis (Lesserdog-faced fruit bat), Cynopterussphinx (Short nosed fruit bat)*	*Funambuluspalmarum*(Common palm squirrel)
Ficus racemosa L.	*Dendrocittavagabunda* (Indian treepie), *Psittaculacolumboides* (Parakeet) *Acridotherestristis* (Myna), *Pycnonotuscafer* (Red-vented bulbul), *Pycnonotusjocosus* (Red-whiskered bulbul)	*Pteropusmedius* (Indian Flying Fox) *Cynopterusbrachyotis* (Lesser dog-faced fruit bat), *Cynopterussphinx* (Short nosed fruit bat), *Rousetusleschenaulti*, (Fruits bat) *Hipposiderosspeoris* (Schneider's leaf nosed bat)	*Acridotherestristis* (Myna), *Funambuluspalmarum* (Common palm squirrel)
Ficus elastica Roxb. exHornem.	*Columba liviadomestica* (Domestic Pigeon), *Pycnonotuscafer* (Red-vented bulbul), *Pycnonotusjocosus* (Red-whiskered bulbul), *Eudynamysscolopaceus* (Asian Koel)	*Megadermaspasma* (Lesser false vampire bat) *Pipestrellusdormer* (Dormer's bat), *Rhinolophusrousii* (Rufoushorshoe shaped)	*Funambuluspalmarum* (Common palm squirrel), *Sturnus vulgaris* (Common starling)

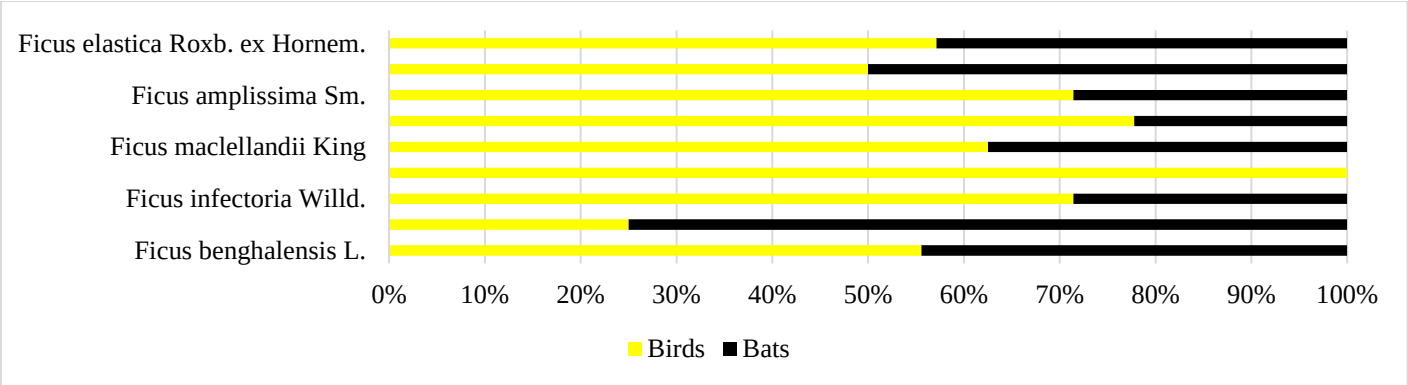

Figure-1: Percentage interaction of avian and chiropteran species with the studied *Ficus* trees.

Conclusion

The current study defines the role of *Ficus* trees in an urban forest with scientific evidence. It also throws light on the need of diversification of *Ficus* species in an urban environment. These figs trees mainly play a massive role in the sustenance of these particular surroundings. Apart from it, it majorly plays a role in the fields of carbon sequestration, oxygen production and pollution elimination. This study paves the path for understanding the cost-benefit structure related to the ecosystem services provided by these *Ficus* species in an urban environment. Similar kind of studies are useful in development of a roadmap for a forestation of degraded urban areas in a better way by focusing on the biodiversity and ecological implications. More similar studies should be carried out in different environments to understand the role of figs trees in a forest-dwelling at a structured urban environment.

Acknowledgement

The authors are wholeheartedly thankful to all the volunteers involved during this study period. We also express our gratefulness to Dr R.G. Pardeshi, Principal of Fergusson College, Pune for his steadfast support and inspiration.

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