ANIMAL - PLANT

INTERACTION



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ANIMAL-PLANT INTERACTION

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Dedications to Nature Lovers



ABOUT THE BOOK

Animal-plant interaction is an important factor in maintaining the ecological balance and shows a variety of positive and negative associations. The interactions provide plants with benefits of mainly pollination, seed dispersal, and nutrient cycling and animals get the reward of nectar, food, and shelter. Due to urbanization and other anthropogenic activities, we are losing these important links and going close to the end of the world. The book “Animal-Plant Interaction” brings attention to animals and their interaction with plants. The book contains 5 chapters on the role of *Ficus* in bird diversity conservation, the role of Cicada in the forest ecosystem, the role of Miyawaki plantation in the establishment of animal-plant interaction, host plants of spittlebug, and the role of *Flueggea leucopyrus* in the restoration of bird diversity in the urban areas. This book covers the basics of animal-plant interaction and hopefully, it will be useful for students, researchers, intellectuals, and readers.

BACKGROUND

Ambika Prasad Research Foundation in association with many organizations of India is working on different aspects of life, livelihood, and indigenous communities. We focus on the interrelationships among them to achieve sustainability in nature. In this aspect, animal-plant interaction is an important component of our ecosystem. They are critically important in several ecological services and processes like seed dispersal, pollination, and the maintenance of community structure in forests and grasslands. The interaction is also important in tribal, rural, and urban areas. Particularly, we study the relationship between plants and birds, insects, and self-medication. The interdependence of plants and animals on each other helps in nutrient recycling and maintains the balance in the food chain and food web of an ecosystem. Due to urbanization, globalization, climate change, and other natural and man-made negative activities, the interactions are breaking down, leading to an imbalance in the ecosystem that impacts every aspect of biotic and abiotic components. Therefore, before the extinction of the relationship and mutualism, we should focus on interaction to find out the gaps and do research to make strategies for healthy animal-plant interaction.

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Chapter 1
Role of *Ficus* species in bird conservation

Summary

The deteriorating condition of the world calls for its conservation, or else there will be no world at the end of the day. Anthropogenic activities are largely responsible for the negative impacts on the flora, fauna, and environment. The vast changes in climatic conditions, habitat loss, and food scarcity have led to the extinction of some of the most valuable species in the world. The bird population is greatly affected by the drastic changes in the environment, which may lead to an imbalance in other ecological activities that hamper the cycle of life. Keeping the importance of birds in mind for the maintenance of ecological balance, the study was conducted to document the bird-plant interaction and the ways to conserve birds. A mutual interrelation between birds and trees plays an important role in bird conservation.

Background

The world is now in such a condition that every species on Earth is negatively impacted by the ill changes in the ecosystem. Due to global warming and climate change, it is becoming less and less feasible for animals and other species to survive (Shivanna 2022). The avian population is the most affected among the animals. The heat and unavailability of food are the major causes of the decline in bird population or extinction (Dutta 2017; Richard et al. 2021). Especially in summer, there is less availability of water, and urbanization has left no trees for birds to make nests or obtain food. For example, before urban sprawl, there was a good population of house sparrows, but they vanished from the neighbourhood quite some time ago. This occurred because of their habitat loss and the unavailability of food and nesting trees. Now, house sparrows can be seen due to the application of some conservation strategies, like hanging straw huts with grains and water in almost every house. Birds are important for the maintenance of ecological balance (Mariyappan et al. 2023). They act as biocontrol agents by feeding the pests that may cause

damage to crops and helping in the pollination and dispersal of seeds (Mahendiran and Azeez 2018; Kiran 2022). If there are no birds, then there will be no dispersal of seeds, there will be no new plants, and lastly, there will be no Earth to construct more buildings and survive. Knowing the graveness of the situation, there is an urgent need for the conservation of birds (Das et al. 2023) in turn conserving plants and Mother Earth. To do this, there must be knowledge of the relationship between birds and plants (Chupp and Battaglia 2016). This is a mutual relationship from which both birds and plants benefit (Sharma et al. 2023). Many birds make their home on trees, especially *Ficus* species, for food and nesting shelter, but they also pollinate and help in the dispersal of seeds. Every little thing is responsible for the balance of the ecological food web, like when a certain wasp confuses the flower of *Ficus* as its partner and pollinates the flower instead (Bain et al. 2015). This makes the availability of *Ficus* species easy, and the fruits of some *Ficus* species are available throughout the year for birds' consumption. The accessibility of year-round food and shelter resources for *Ficus* species is also responsible for a diverse variety of frugivorous and insect-eating bird visits. Birds commonly visit three Ficus species, namely *Ficus benghalensis*, *Ficus religiosa*, and *Ficus racemosa* (Devi et al. 2022). Some Ficus spp. are responsible for food, fodder, and medicine. F. benghalensis and F. religiosa are considered sacred trees by Hindus and Buddhists (Wilson and Wilson 2013).

During several projects of APRF, Odisha, India, authors observed the perching behavior of birds on specific tree species that belong to the genus *Ficus.* The associated birds are recorded in the morning (6 AM-9 AM) and evening (3.30 PM- 5 PM). Birds were identified using the published literature (Grimmett et al. 2011) and plants were identified by Dr. Sanjeet Kumar.

Table 1: Birds associated with *Ficus* species

Common Birds	Associated *Ficus* species	For food	For nesting
Alexandrine parakeet	*Ficus benghalensis*	✓	
Asian koel	*Ficus benghalensis* and *Ficus religiosa*	✓	
Asian openbill	*Ficus benghalensis*		✓
Asian pied starling	*Ficus benghalensis* and *Ficus religiosa*	✓	✓
Bank myna	*Ficus benghalensis* and *Ficus religiosa*	✓	✓
Black-hooded oriole	*Ficus benghalensis*, *Ficus religiosa* and *Ficus racemosa*	✓	✓
Brahminy starling	*Ficus benghalensis*	✓	
Brown-headed barbet	*Ficus benghalensis*, *Ficus religiosa* and *Ficus racemosa*	✓	
Cattle egret	*Ficus benghalensis*		✓
Common myna	*Ficus benghalensis* and *Ficus religiosa*	✓	✓
Coppersmith barbet	*Ficus benghalensis* and *Ficus religiosa*	✓	
Darter	*Ficus benghalensis*		✓
Eurasian collared dove	*Ficus benghalensis*, *Ficus religiosa* and *Ficus racemosa*	✓	✓
Golden oriole	*Ficus benghalensis*, *Ficus religiosa* and *Ficus racemosa*	✓	✓
Great egret	*Ficus benghalensis*		✓
Grey heron	*Ficus benghalensis*		✓
Hill myna	*Ficus benghalensis*, *Ficus religiosa* and *Ficus racemosa*	✓	
House crow	*Ficus benghalensis* and *Ficus religiosa*		✓

Indian grey hornbill	*Ficus benghalensis*, *Ficus religiosa* and *Ficus racemosa*	✓	✓
Jungle myna	*Ficus benghalensis*, *Ficus religiosa* and *Ficus racemosa*	✓	
Laughing dove	*Ficus benghalensis*, *Ficus religiosa* and *Ficus racemosa*	✓	✓
Little Cormorant	*Ficus benghalensis*		✓
Malabar pied hornbill	*Ficus benghalensis*		✓
Red-vented bulbul	*Ficus benghalensis* and *Ficus religiosa*	✓	✓
Red-whiskered bulbul	*Ficus benghalensis* and *Ficus religiosa*	✓	✓
Rose-ringed parakeet	*Ficus benghalensis*	✓	
Rosy starling	*Ficus benghalensis*	✓	
Rufous treepie	*Ficus benghalensis*	✓	✓
Spotted dove	*Ficus benghalensis*, *Ficus religiosa* and *Ficus racemosa*	✓	✓
Yellow-footed green pigeon	*Ficus benghalensis*, *Ficus religiosa* and *Ficus racemosa*	✓	✓

The present study revealed around 22 bird species get their food from different *Ficus* species, 21 bird species build nests on *Ficus* trees and 13 bird species consider *Ficus* trees for both food and nesting. Among various types of *Ficus* species, birds are commonly observed in mainly three species which are *Ficus benghalensis*, *Ficus religiosa*, and *Ficus racemosa*. Details are listed in Table 1, and illustrated in Plate 1 & Figure 1-2. Pradana et al. (2018) found 14 bird species on *Ficus benjamina* where most of the species were insectivores and 2 species were frugivores.

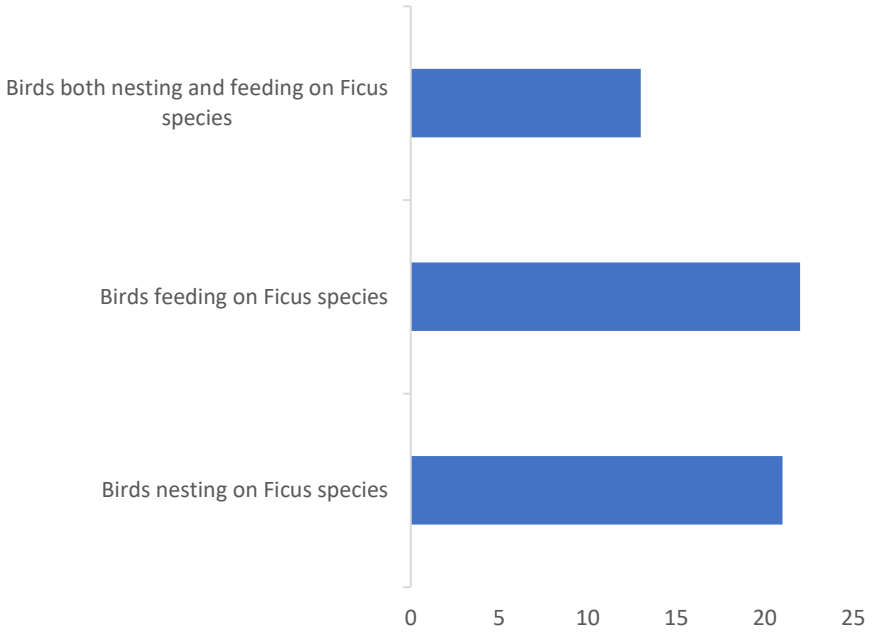


Figure 1: Role of *Ficus* species in bird conservation



Figure 2: Fruits of *Ficus benghalensis*

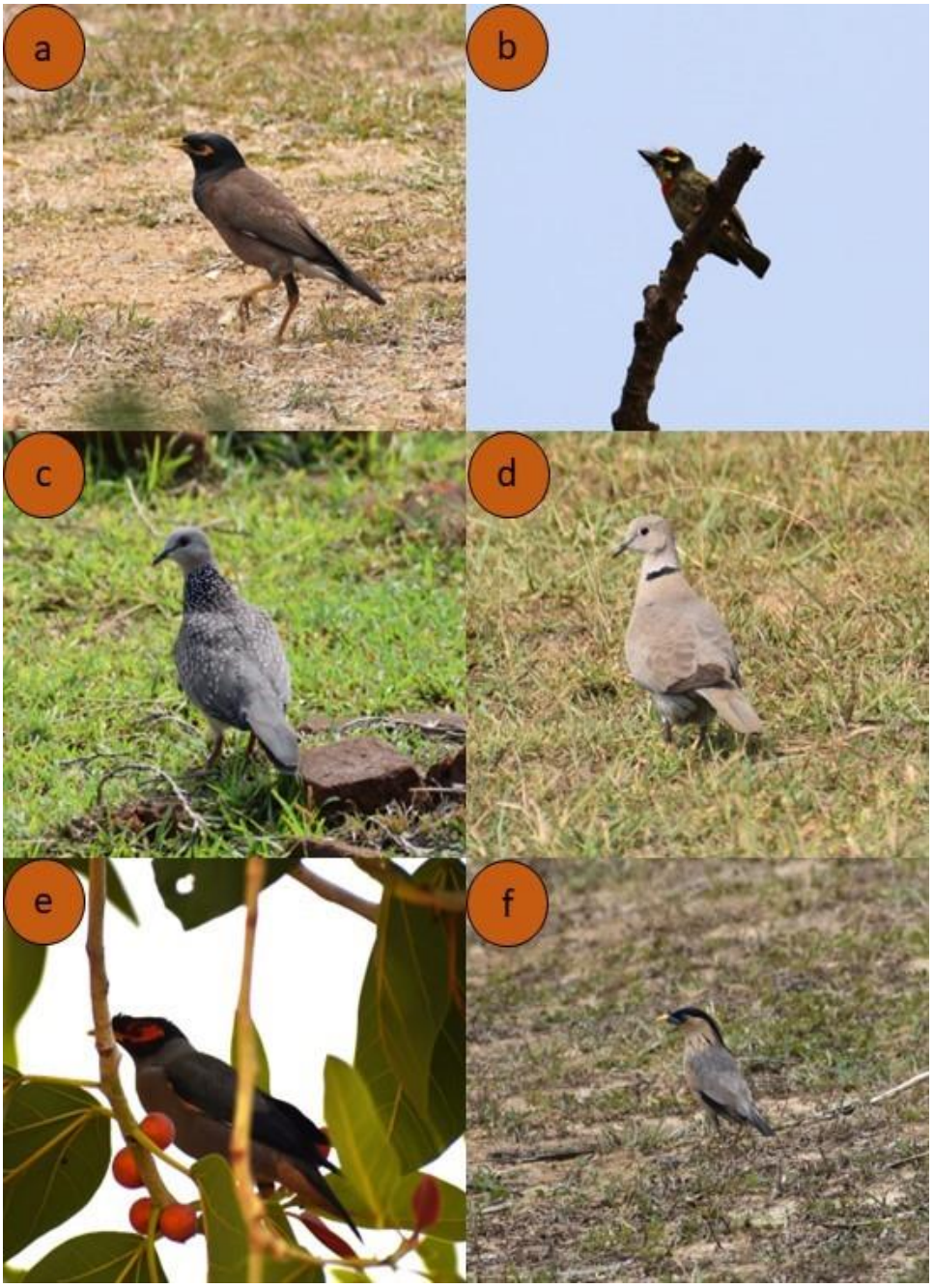


Plate 1: Some common birds associated with *Ficus* species; a) Common myna, b) Coppersmith barbet, c) Spotted dove, d) Eurasian collared dove, e) Bank myna, f) Brahminy starling

In 2018, Kaur and Kumar reported 51 species of birds belonging to 14 orders on 6 indigenous trees, of which 31 species are found on the Peepal tree. Hendrayana et al. (2022) reported 43 bird species belonging to 21 families on observation of three *Ficus* species. Of these, 28 species were found on *Ficus benjamina*, 20 species on *F. sinuata*, and 19 species on *F. kurzii*. Rawal et al. in the year 2022 reported that 3 common fig species were surveyed for visitation of birds across 3 sites in Delhi, India, and found that 106 trees were visited by 29 bird species, which included 7 obligate frugivores.

Concluding remarks

The study concludes that the mutual interaction between birds and *Ficus* species is important not only for the bird population but also for the maintenance of the plant population and directly helps in ecological balance. So, to conserve the avifaunal population, there is a need to conserve the plants associated with them for food and nesting especially *Ficus* species. Therefore, *Ficus* species play a very significant role in bird conservation.



Chapter 2
Role of Cicada Inside the Forest

Summary

Cicadas are the representative of a healthy forest. They are known to produce loud buzzing calls inside the forest to attract the females who make clicking sounds when they are ready to mate. They are sap-sucking insects, that totally depend on plants for food throughout their life starting from newly hatched nymphs to adults. Plants also benefit from the cicadas as they defoliate the tree trunks, aerate the soil, improve infiltration of water into the ground, and provide nutrients to the soil after death which helps with the plant growth. The interaction between cicadas and the forest ecosystem is years old process that makes the soil fertile and increases the longevity of the forest. They are the nutritious food of various predators and play an important role in the food web of the forest ecosystem. Keeping the importance of the cicadas in mind, the present survey was carried out to list out the host plants and predators of cicadas to showcase the plant-cicada-predator relationship.

Background

Cicadas are large insects often noticed due to the loud calls produced by them for courtship as mating songs (Figure 1). They are the indicators of a healthy forest ecosystem. They are the insects belonging to the order Hemiptera, which are considered true bugs. Cicadas, along with other smaller jumping bugs like leafhoppers, treehoppers, planthoppers, and spittlebugs, belong to the suborder Auchenorrhyncha. The superfamily Cicadoidea is divided into 2 families, namely the Tettigarctidae with 2 species, and the Cicadidae with more than 3000 species (Marshall et al. 2018). There are 2 types of cicadas based on their emergence from the underground. One is the annual cicada that is visible every year, and the other is the periodic cicada that remains underground for the majority of its lifespan and emerges only after a predictable period of time, i.e., after 13 or 17 years, depending on the species and location (Toivonen and Fromhage 2020). They are herbivores as they suck xylem sap from tree roots

as nymphs as well as from branches and twigs as adults, but when they are young, they sometimes rely on grasses and other small plants for nutrition (Huang et al. 2023). The lifecycle of cicadas has 3 stages which are eggs, nymphs, and adults. The male cicadas produce loud mating calls to attract the females (Hou et al. 2022). After mating, the female lays eggs by cutting slits into the bark of a twig (Lehnert et al. 2019). Sometimes, the overlaying of eggs may affect the trees; small trees may wilt, and large trees may lose some small branches. Both the male and female cicadas die within weeks of their arrival in the soil. The dead bodies are decomposed by microorganisms and some nematodes, which increases the nutrient mineralization of the soil. When the eggs hatch, the nymphs drop to the ground and start to burrow into the soil for food and shelter. Cicadas live underground as nymphs for the majority of their lifespan, and in the final nymphal instar stage, they construct a tunnel to exit out to the surface (Yang 2006). After their emergence from the ground, the cicadas moult for the last time on a nearby tree, and the abandoned exoskeletons remain clinging to the bark of trees (Song et al. 2019). After the mass emergence of the cicadas from the soil, plant growth may suffer due to heavy feeding by the large nymphs. In the period of the mass availability of cicadas, the adults are often preyed upon by birds, bats, wasps, mantises, spiders, etc. (Koenig et al. 2011). Therefore, cicadas have developed some methods to escape predators. Large cicadas fly rapidly to evade if they are disturbed, while others are well-camouflaged as their colour matches tree bark, making their sighting very difficult, and some species act dead when threatened. Thus, cicadas act as an integral element that balances the forest ecosystem and helps in maintaining a healthy forest.

Morphology

Cicadas are identified due to the presence of prominent compound eyes set wide apart, short antennae, and membranous front wings. The body of the cicada is divided into the head, thorax, and abdomen. They have 3 small ocelli on top of the head in a triangle between the 2 large eyes, which distinguishes cicadas from other members of the order Hemiptera. They have red, white, yellow, or blue eyes, and their body colour can be black, brown, or green. The mouthparts form a long and sharp rostrum that they insert into the plant to feed (Reiter et al. 2023). The thorax is divided into 3 segments which consist of the wing muscles. Cicadas have 2 pairs of membranous wings that may be hyaline, cloudy, or pigmented. The wing venation varies between species, which helps in their identification. The abdomen is segmented, and the last few segments have reproductive organs. In females, the abdomen terminates with a large, saw-edged ovipositor, which is used to scrape the bark of trees for laying eggs. In males, the abdomen is hollow and used as a resonating chamber to produce loud sounds. Their call is especially loud due to the rapid buckling and unbuckling of drum-like timbals (Hou et al. 2022).

Peculiar findings

Cicadas are not good fliers; they may bump into something when they try to fly due to their irregular wing shape and larger body size. Thus, they are often seen perched on the bark of trees, sucking tree sap. Even when humans are nearby, they pass by them and cannot see the cicadas due to their higher perch and camouflage with the tree barks. The wings of the cicada are transparent and appear rainbow-colored. The surface of the forewing is hydrophobic in nature and repels water due to the presence of minute waxy cones and blunt spikes. The spikes have

the ability to tear apart the bacterial membrane, which makes the surface of the wing a biomaterial first of its kind that can kill the bacteria (Qu et al. 2023). In ancient human culture, the exoskeletons of cicadas were used as hair or clothing accessories, being lightweight and having hook-like legs. The shells are used in traditional Chinese medicines. Cicadas have been used as money, in folklore, to forecast weather, to provide songs, and for myths around the world. For example, in Chinese tradition, they symbolize rebirth and immortality due to their periodic emergence (https://en.wikipedia.org).

Role in the nutrient cycle

Cicadas either have a long lifecycle of 13 or 17 years or may emerge from the ground every year. In the nymphal stage, cicadas aerate the soil by making burrows underground in search of root sap to feed. They also improve the water filtration system in the soil. The cicadas have high protein content which makes them nutritious for their predators. While laying eggs and also for food, cicadas prune the mature trees encouraging plant growth. But in just a few weeks of emergence, the cicadas die after mating and laying eggs. After death, the body parts of cicadas are decomposed by bacteria and other invertebrates in the soil which stimulates nutrient mineralization in the soil. The presence of carcasses of adult cicadas increases the population of consumers in the soil food web which enhances the decomposition rate of plant litter due to intense feeding by microbial detritivores and predatory soil fauna, increasing the soil nutrient concentrations (Setala et al. 2022). The cicadas are an essential component of the forest ecosystem and are also considered indicators of healthy forests. Therefore, there is a need to protect the plants in the forest for the conservation of cicadas as well as other faunal species.

A field survey was conducted in the Mayurbhanj district of Odisha state to sight and document cicadas and list the host plants and predators of cicadas from July to August in 2023. The photographs of cicadas, their host plants, and predators were taken. Cicadas and their predators were identified through the literature study and the host plants were identified by Dr. Sanjeet Kumar.

From the survey conducted in the study area 10 host plants of cicada were documented and listed in Table 1. Among the 10 host plants, it was noticed that 2 species belonged to the family Phyllanthaceae, and 1 species each belonged to the family Combretaceae, family Leguminaceae, family Malvaceae, family Burseraceae, family Anacardiaceae, family Dilleniaceae, family Ebenaceae, and family Dipterocarpaceae. During the study, the predators of cicadas and their host plants were documented and listed in Table 2. Bats and squirrels were only found on trees; robber flies were only found in shrubs; birds, mantises, and raccoons were found in trees and shrubs; snakes, spiders, and wasps were found in trees, shrubs, and herbs; and frogs were found near the water bodies. So, the specific host plants of the predators should be conserved to maintain the healthy prey-predator population.

Table 1: Host plants of Cicada

Plant name	Local name	Family	Bark character
Anogeissus latifolia	Dhaura	Combretaceae	Whitish or pale grey in color and exfoliating in thin flakes.
Baccaurea ramiflora	Rajkoli	Phyllanthaceae	Pale grey in color and branchlets hispid or tomentose.
Bauhinia semla	Amthi	Leguminaceae	Dark brown in color and

			branchlets glabrascent.
Bombax ceiba	Simili	Malvaceae	Greyish or ash-colored and broad-based conical prickles on its lower trunk.
Boswellia serrata	Salia	Burseraceae	Grey in color, smooth, and peeling off in thin flakes.
Bridelia retusa	Kasi	Phyllanthaceae	Grey to dark brown in color with longitudinal cracks, and conical thorns present on the trunk when young.
Buchanania cochinchinensis	Chara	Anacardiaceae	Dark grey or black in color, rough and young branches silky tomentose.
Dillenia aurea	Bada rai	Dilleniaceae	Thick and pale brown in color.
Diospyros melanoxylon	Kendu	Ebenaceae	Black or dark ashy in color with vertical and horizontal cracks and branchlets fulvous-tomentose.
Shorea robusta	Sal	Dipterocarpaceae	Grey-brown in color and vertically fissured.

Table 2: Predators of cicadas and their host plants

	Predators	Host plants of predators	Remarks
Cicada	Bats	Trees	Specific host trees of bats should be conserved.
	Birds (Flycatchers, etc.)	Trees and shrubs	Specific host plants of birds should be conserved.
	Frogs	Near water bodies	Water bodies inside the forest should be conserved.
	Mantises	Trees and shrubs	Specific host plants of mantises should be conserved.
	Raccoons	Trees and shrubs	Specific host plants of raccoons should be conserved.
	Robber flies	Shrubs	Grasslands should be conserved.
	Snakes	Trees, shrubs, and herbs	The habitat of snakes should be conserved.
	Spiders	Trees, shrubs, and herbs	The host plants of spiders should be conserved.
	Squirrels	Trees	Specific host trees of squirrels should be conserved.
	Wasps	Trees, shrubs, and herbs	The host plants of wasps should be conserved.

In 2008, Flory and Mattingly made a block design establishing a plantation of three native and three exotic plant species in Indiana, USA which are common to the forests where cicadas generally occur, and noticed that cicada oviposition damage did not reduce the performance of native or exotic host plants just showed branch death and breakage.



Figure 1: Cicada consuming plant sap

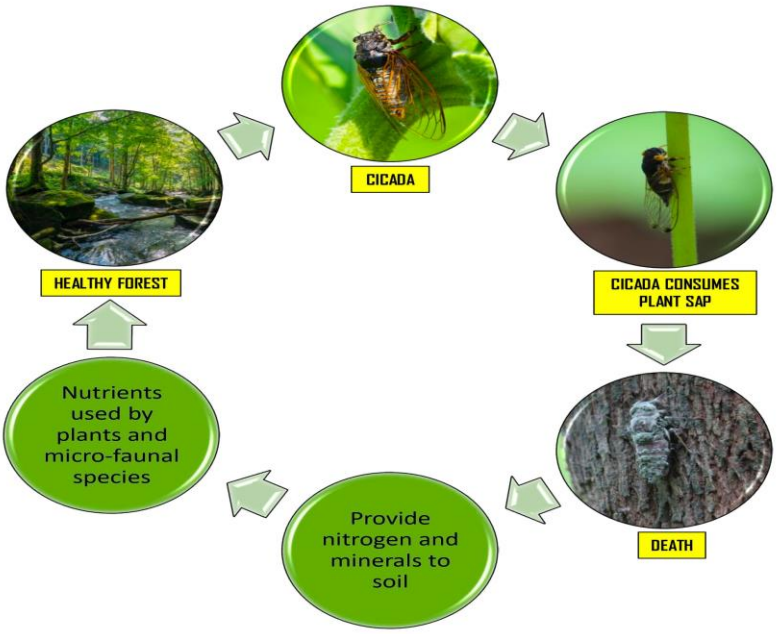


Figure 2: Role of Cicada in nutrient cycling inside the forest

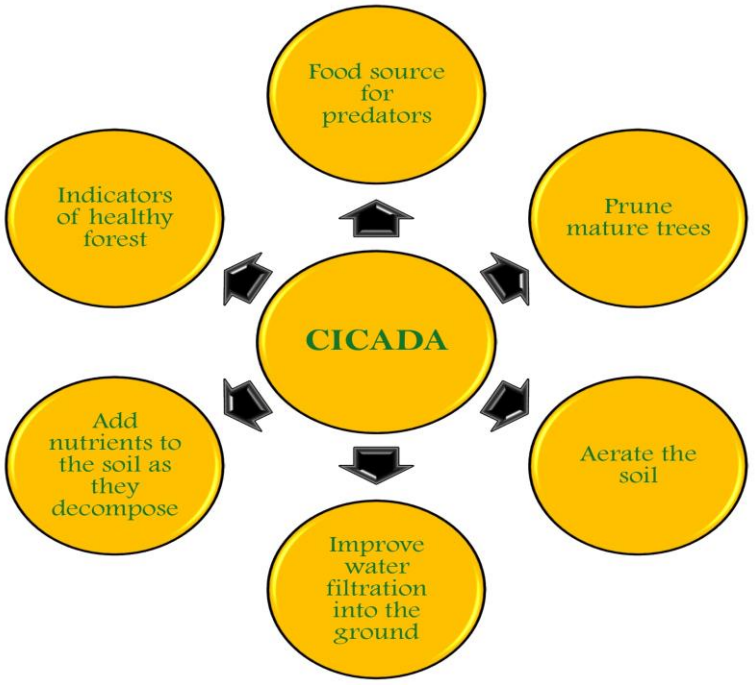


Figure 3: Uses of Cicada inside forest ecosystem

In 2020, a literature survey was performed which enumerated 106 species of birds belonging to 13 orders, and comprising 20 of the 33 passerine families that were found to consume cicadas within the limits of the Western Palearctic. Adult cicadas were hunted by some predators like cuckoos, owls, bee-eaters, crows, shrikes, flycatchers, sparrows, starlings, etc. and nymphs were consumed by some passerines, owls, and herons in the Western Palearctic region.

Concluding remarks

From the results of the survey, it was concluded that cicadas play a major role in the balance and maintenance of the forest. They are found on the host plants for feeding the xylem sap as well as trimming the bark of trees which helps in the growth of trees and removal of injured or dead parts. They are also a food source for various predators and play an important role in food webs and the detritivore cycle providing nitrogen and other nutrients to the soil (Figure 2). Cicadas are herbivores and depend on plants for food which reduces the growth and reproduction of plants increasing the competition among plant communities and changing its composition. Insect-plant interactions play an influential role in the structure and composition of plant communities in the forest ecosystem (Figure 3). The nymphs help in aerating the soil making it fertile for plant growth. Therefore, cicadas are an essential component of the forest ecosystem and keep the forest healthy. Thus, there is a need for the conservation of the host plants to protect the cicadas and maintain the predator population in turn keeps the forest ecosystem in equilibrium.

Chapter 3
Role of Miyawaki plantation in the establishment of plant-animal relationship

Summary

Climate change and other environmental changes induced by natural or anthropogenic activities have severe negative impacts on biodiversity. In the contemporary situation, the cases of loss of forest cover and, a decline in floral and faunal diversity have been increasing day by day all over the world. To conserve biodiversity and repair the damage caused to the environment, several researchers are developing techniques to solve the issue. One of the popular methods for the conservation of the bio-wealth and increasing the forest cover is the Miyawaki plantation. The Miyawaki plantation technique is helpful for the development of a mini-forest on a piece of degraded land quickly to increase carbon sequestration and decrease the amount of carbon dioxide in the environment. Keeping this in mind, the present survey was conducted in the Miyawaki plantation of Badampahar range for assessment of the development of the mini-forest and enumerated 32 local plant species, 20 bird species, 23 butterfly species, 7 moth species, and 5 dragonfly species.

Background

The establishment of floral and faunal species is an important aspect of ecological balance. Due to anthropogenic activities and natural calamities, the environment is already disturbed. Global researchers are working on restoring habitats and forming forests along with the extension of forest cover to repair the damage to the environment and biodiversity loss. In different methods of repair, the Miyawaki plantation is quite popular in the 21st century. Miyawaki plantation was first started by Akira Miyawaki, a Japanese forester and botanist who specialized in plant ecology, seeds, and natural forests (Miyawaki 2004). He was a specialist in natural vegetation restoration of degraded land. The Miyawaki technique was used to convert degraded barren land into a healthy mini-forest within a short period of time. In the Miyawaki plantation method, local plant species are

planted by making 4-5 pits in 1 square meter area. Organic compost and vermicompost are added into the pits and 18-month-old saplings are planted and watered continuously for a year. Within 2-3 years tremendous growth is observed and the close plantation of saplings causes competition between the plants to grow faster into dense forests. Keeping this in view, an attempt has been made to study the biodiversity at the 2-year-old Miyawaki plantation in the Badampahar range, Rairangpur Forest Division, Odisha, India. In the present study, the authors showed the interrelationship among the flora and fauna in the Miyawaki plantation.

A survey was conducted in August-September, 2023 at Miyawaki plantation (Figure 1), Badampahar range, Rairangpur Forest Division, Odisha. The plants were enumerated (Table 1) and identified by Dr. Sanjeet Kumar along with their associated birds, butterflies, moths, and dragonflies. All the enumerated flora and fauna were tabulated in the result section.

From the survey conducted in Miyawaki forest in the study area, 32 plant species, 20 bird species, 23 butterfly species, 7 moth species, and 5 dragonfly species were enumerated. From the enumerated floral species, 32 species belonged to 20 different families of which 30 plant species were trees, one herb species, and one shrub species. Among the 20 bird species enumerated, 7 bird species were found on trees; 4 species on both trees and shrubs; 3 species on trees, shrubs, and grasses; 3 species on trees and grasses; 1 species in grasses and 2 species in shrubs and grasses. All the 23 butterfly species enumerated were found in shrubs, herbs, and grasses. The 7 enumerated moths were also found in shrubs, herbs, and grasses. 5 dragonflies were also enumerated and found in the grasses.

Table 1: Plants used for afforestation under the Miyawaki method

Name	Local name	Family	Habit
Aegle marmelos	Bela	Rutaceae	Tree
Albizia lebbeck	Dhala siriso	Mimosaceae	Tree
Andrographis paniculata	Bhuinimbo	Acanthaceae	Herb
Artocarpus heterophyllus	Panasa	Moraceae	Tree
Azadirachta indica	Limba	Meliaceae	Tree
Bambusa arundinacea	Baunsa	Poaceae	Shrub
Bauhinia purpurea	Kuler saga	Caesalpiniaceae	Tree
Bombax ceiba	Simili	Bombacaceae	Tree
Cassia fistula	Sunari	Caesalpiniaceae	Tree
Dalbergia latifolia	Pahadi sissoo	Fabaceae	Tree
Dalbergia sissoo	Bali sissoo	Fabaceae	Tree
Ficus benghalensis	Bara	Moraceae	Tree
Ficus racemosa	Dimiri	Moraceae	Tree
Ficus religiosa	Osto	Moraceae	Tree
Gmelina arborea	Gambhari	Verbenaceae	Tree
Holoptelea integrifolia	Charla	Ulmaceae	Tree
Holarrhena antidysenterica	Kurei	Apocynaceae	Tree
Madhuca longifolia	Mahula	Sapotaceae	Tree
Mangifera indica	Amba	Anacardiaceae	Tree
Millettia pinnata	Karanja	Fabaceae	Tree
Mimusops elengi	Boula	Sapotaceae	Tree
Phyllanthus emblica	Amla	Euphorbiaceae	Tree
Pterocarpus marsupium	Piasal	Fabaceae	Tree
Saraca asoca	Ashok	Fabaceae	Tree
Schleichera oleosa	Kusum	Sapindaceae	Tree
Shorea robusta	Sal	Dipterocarpaceae	Tree
Spondias pinnata	Ambada	Anacardiaceae	Tree
Syzygium cumini	Jamun	Myrtaceae	Tree
Terminalia arjuna	Arjuna	Combretaceae	Tree
Terminalia bellirica	Bahada	Combretaceae	Tree
Terminalia chebula	Harida	Combretaceae	Tree
Ziziphus mauritiana	Barokoli	Rhamnaceae	Tree



Figure 1: A Miyawaki plantation in study area

Table 2: Faunal diversity after 2 years of plantation

Common name	Scientific name	Associated plants (Habit)
Birds		
Alexandrine parakeet	*Psittacula eupatria*	Trees
Asian koel	*Eudynamys scolopaceus*	Trees
Black drongo	*Dicrurus macrocercus*	Trees and shrubs
Black-hooded oriole	*Oriolus xanthornus*	Trees
Common myna	*Acridotheres tristis*	Trees, shrubs, and grasses
Coppersmith barbet	*Psilopogon haemacephalus*	Trees
Eurasian collared dove	*Streptopelia decaocto*	Trees and grasses
Green bee-eater	*Merops orientalis*	Trees and shrubs
Indian robin	*Copsychus fulicatus*	Grasses
Jungle babbler	*Argya striata*	Trees, shrubs, and grasses
Laughing dove	*Spilopelia senegalensis*	Trees and grasses
Long-tailed shrike	*Lanius schach*	Trees
Oriental magpie-robin	*Copsychus saularis*	Trees, shrubs, and grasses
Plain prinia	*Prinia inornata*	Shrubs and grasses
Purple-rumped sunbird	*Leptocoma zeylonica*	Trees and shrubs
Red-vented bulbul	*Pycnonotus cafer*	Trees and shrubs
Rose-ringed parakeet	*Psittacula krameri*	Trees
Rufous treepie	*Dendrocitta vagabunda*	Trees
Scaly-breasted munia	*Lonchura punctulata*	Shrubs and grasses
Spotted dove	*Spilopelia chinensis*	Trees and grasses

Butterflies		
Blue pansy	*Junonia orithya*	Shrubs, herbs and grasses
Blue tiger	*Tirumala limniace*	Shrubs, herbs and grasses
Chocolate pansy	*Junonia iphita*	Shrubs, herbs and grasses
Common castor	*Ariadne merione*	Shrubs, herbs and grasses
Common crow	*Euploea core*	Shrubs, herbs and grasses
Common emigrant	*Catopsilia pomona*	Shrubs, herbs and grasses
Common five-ring	*Ypthima baldus*	Shrubs, herbs and grasses
Common grass yellow	*Eurema hecabe*	Shrubs, herbs and grasses
Common palmfly	*Elymnias hypermnestra*	Shrubs, herbs and grasses
Common pierrot	*Castalius rosimon*	Shrubs, herbs and grasses
Common silverline	*Cigaritis vulcanus*	Shrubs, herbs and grasses
Danaid eggfly	*Hypolimnas misippus*	Shrubs, herbs and grasses
Dark brand bush brown	*Mycalesis mineus*	Shrubs, herbs and grasses
Great eggfly	*Hypolimnas bolina*	Shrubs, herbs and grasses
Indian palm bob	*Suastus gremius*	Shrubs, herbs and grasses
Lemon pansy	*Junonia lemonias*	Shrubs, herbs and grasses
Lime butterfly	*Papilio demoleus*	Shrubs, herbs and grasses
Peacock pansy	*Junonia almana*	Shrubs, herbs and grasses
Plain tiger	*Danaus chrysippus*	Shrubs, herbs and grasses
Sahyadri yamfly	*Loxura atymnus atymnus*	Shrubs, herbs and grasses
Small branded swift	*Pelopidas mathias*	Shrubs, herbs and grasses
Striped tiger	*Danaus genutia*	Shrubs, herbs and grasses
Tawny coster	*Acraea terpsicore*	Shrubs, herbs and grasses
Moths		
Beet webworm moth	*Spoladea recurvalis*	Shrubs, herbs and grasses
Brown-striped semi-looper	*Mocis undata*	Shrubs, herbs and grasses
Castor hairy caterpillar	*Euproctis lunata*	Shrubs, herbs and grasses
Greenish silk-moth	*Trilocha varians*	Shrubs, herbs and grasses
Straw dot	*Rivula sericealis*	Shrubs, herbs and grasses
Triangular-striped moth	*Chalciope mygdon*	Shrubs, herbs and grasses
White-marked tussock moth	*Orgyia leucostigma*	Shrubs, herbs and grasses
Dragonflies and damselflies		
Ground skimmer	*Diplacodes trivialis*	Grasses
Green marsh hawk	*Orthetrum sabina*	Grasses
Long-legged marsh glider	*Trithemis pallidinervis*	Grasses
Common picture wing	*Rhyothemis variegata*	Grasses
Ruddy meadow skimmer	*Neurothemis intermedia*	Grasses

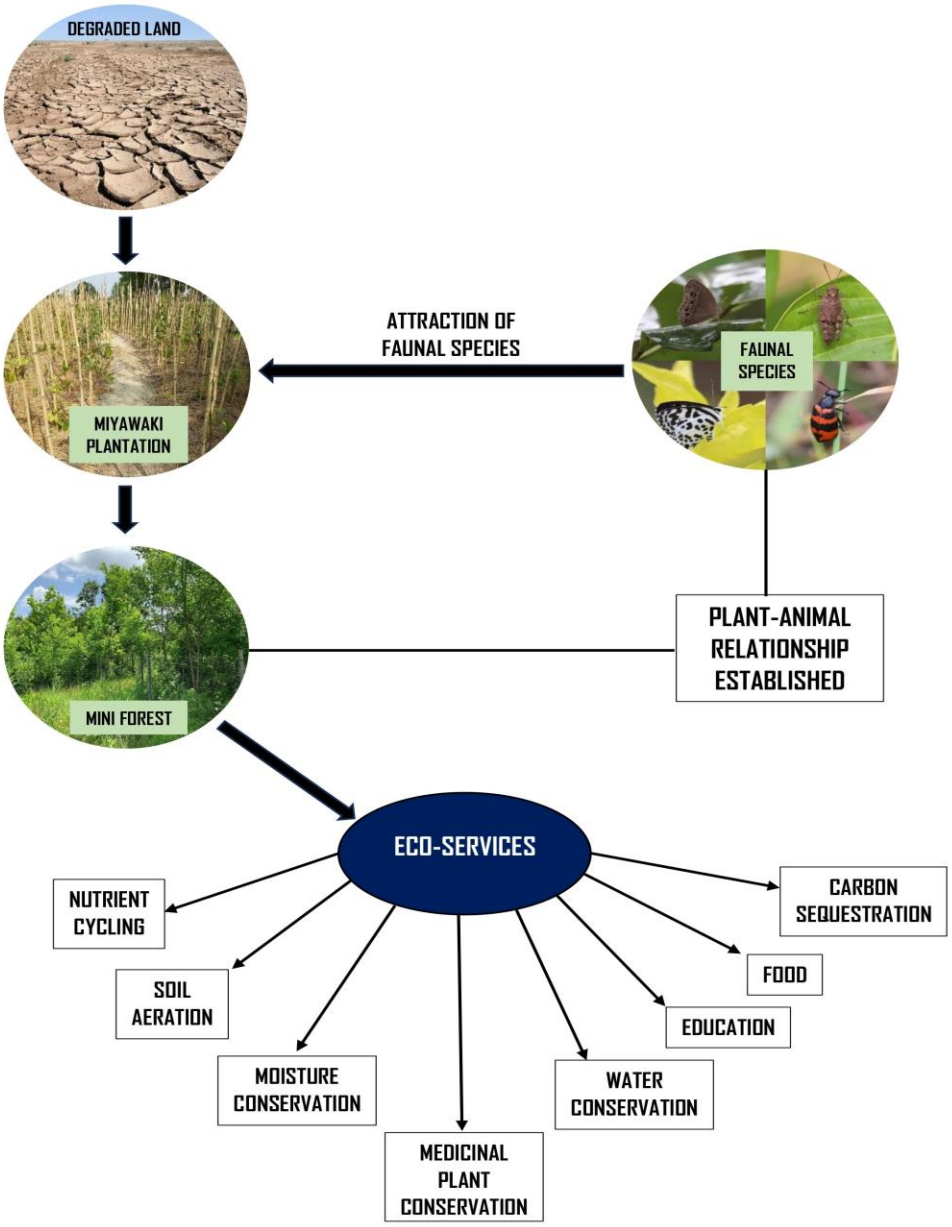


Figure 2: Model for plant-animal interaction in Miyawaki plantation in Badampahar range

Egerer and Suda (2023) worked with 16 students and the local municipality of Munich, Germany to create "tiny forests" using the concept of the 1970s restoration work of Akira Miyawaki in

the urban areas for urban greening, transdisciplinary communication, and engagement with the community members. In 2023, Deepalakshmi and Umadevi developed a Miyawaki forest in the college premises of Tamil Nadu by planting 109 saplings of 16 varieties of species and analyzing the soil parameters before and after sapling growth. They proved that the interaction between soil microbes and soil nutrients has helped the growth of the Miyawaki forest to create a healthy environment.

Concluding remarks

From the present study, it was concluded that the Miyawaki plantation is a good method to develop a mini-forest out of degraded lands. The technique can be used in urban areas as the plantation can be done in a small patch of unused land. The growth of the Miyawaki plantation is very fast and can provide a good green cover. The plantation not only helps in carbon sequestration but also plays a major role in the conservation of some medicinal plants and smaller faunal species like invertebrates, insects, birds, small reptiles, etc., (Figure 2). Therefore, the Miyawaki plantation technique along with the protection of existing forests should be done all over the world to utilize degraded lands and conserve biodiversity.

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Chapter 4
Host plants of Spittlebug: a case study in Rourkela Forest Division, Odisha, India

Summary

Spittlebugs are generally known for the froth that they produce while feeding on plants. They are mainly found in herbs, shrubs, and grasses and they mostly prefer plants belonging to the families Asteraceae, Poaceae, and Rubiaceae. They pierce the stems and suck the xylem sap from the plants, but this is generally not harmful to plants. When the larval forms are huge in number, their feeding may cause stunted growth in plants, leaves to lose their shape, and branches to break up. They are not directly helpful to the plants but after death, they provide nutrients to the plants and indirectly benefit plants. They are food for many predators and form an important component in the food web creating a balance in the ecosystem. Hence, keeping the importance of spittlebugs and their association with plants, a survey was conducted in the study area to document spittlebugs and their relation with the host plants.

Background

Spittlebugs are small hopping insects that belong to the order Hemiptera in the suborder Auchenorrhyncha under the superfamily Cercopoidea. The superfamily comprises four families Aphrophoridae, Cercopidae, Clastopteridae, and Macherotidae (Dietrich 2009). The adult bugs are capable of jumping several times higher than their height and length and look like small frogs hence, they are also called froghoppers. These insects are called spittlebugs due to the appearance of froth on the herbs, grasses, shrubs, stems, and branches of some trees. The nymphs feed face down on the stem and the excess sap is excreted out the anus. The spittlebugs feed on the plant sap and the nymph surrounds themselves with foam which is a mixture of plant sap and glandular secretions that enhances the viscosity and stabilizes the foam to make them last longer. The mixture is forced out of the abdomen under pressure and as it is mixed with

air forming bubbles. The bug pulls the bubbles over its back to cover its body with foam. The adults also consume the plant sap and excrete out small droplets of excess water but not like the foam produced by the nymphs. The foam consists of carbohydrates, amino acids, proteins, and fatty acids and showed strong anti-bacterial activity against the bacterium, *Staphylococcus aureus* (Sahayaraj et al. 2021). Generally, insects feed on the phloem sap but the nymphs of froghoppers consume the dilute xylem sap flowing up from the roots. The spittlebug tends to feed on young and soft parts, so, when the plants grow. The nymphs move towards the leaves and can be found on the underside of the leaves. They can survive with only the sap diet due to the presence of two symbiotic bacteria in their gut that provide them with the essential amino acids. Also, legumes and other nitrogen-fixing plants have higher levels of amino acids, so, the bugs are often found feeding on them. The produced foam hides the nymphs from the predators, provides moisture so that the insects won't dry up, and insulates against heat and cold but reduces the photosynthetic capacity of plants (Tonelli et al. 2018). When the nymphs mature in 5-8 weeks, the adults move to nearby grassy areas, pastures, or areas with broadleaf weeds for feeding. The adults do not produce any foam. The females lay clusters of eggs in plant debris or in leaves and stems and there is only one generation per year. After hatching, they feed and grow, periodically molting by shedding their exoskeletons as all insects do and they go through five larval stages. Upon final moult, the insect turns a winged, mature adult and exits out of the spittle mass. The adult males and females' mate, and the female lays eggs inside the plant stems generally behind leaf sheaths or other protective plant material. The eggs live through the winter and then the cycle continues for the next generation. The spittle secretions are not harmful to the plants but large-scale feeding of

the nymphs may damage some parts of the plants (Villa et al. 2020). If the bugs are bothersome, then they can be removed from the plants during the nymphal stage by plucking them off with hands or by spraying the plants with garden hose. They are the vectors of a xylem-limited bacterium, *Xylella fastidiosa* which infected and caused the death of olive trees, grapevines, and several other crop plants in Northwestern Italy (Bodino et al. 2021). The natural predators of adult spittlebugs are birds, beetles, wasps, spiders, and some ants which play an important role in the biological control of these insect populations (Marin et al. 2020). The predators sometimes get tricked by the 2 black dots present in the tail end of froghoppers as eyes and this gives the bugs a chance to flee from the predators. Every species in nature has a certain role to play in the sustenance of the world. Likewise, the spittlebugs may help alleviate the fluid pressure in the xylem and phloem tissues of the plants by sucking out the sap in turn, making a protective covering around themselves against environmental stress and predation. However, the theory of decreasing fluid pressure in the tissues is not proved and the positive use of spittlebugs on plants is also not recorded so far. So, more work should be done on the spittlebugs to know their importance in the ecosystem other than being a part of the food web. The study is a splendid example of the plant-animal relationship and the interactions between them which are essential for the survival of both species with ease.

Morphology

Immature spittlebugs, the nymphs are mostly noticed because of the small foamy masses on the plants surrounding these bugs that resemble spittle hence, the name spittlebug. The tiny nymph is usually pale yellow, green, or tan, wingless, soft, elongated, plump-looking little bugs. The nymphs have large eyes on the sides of their heads. Adult bugs are 6-12 mm long, elongate, oval,

and usually dull coloured with prominent eyes. They have a head with front clypeus inflated, median ocelli absent, ocelli on the crown distant from the margin, pronotum extended to scutellar suture, body covered with fine setae, hind coxae conical, and male sub-genital plate present (Dietrich 2009). The tibia of each hind leg is without rows of setae and has 1 or 2 stout spines with a ring of spines at its outer end. The wing covers are held tent-like over their bodies and marked by spots, bands, or stripes. The back portion is often wider than the front, making them look like tiny frogs and good jumpers because of enlarged hind legs, so they are also called froghoppers.

During the floral diversity survey in Rourkela Forest Division, Odisha, we observed a unique froth-like structure on the stem of many herbs, shrubs, grasses, and seedlings of some tree species. We photographed and identified the presence of nymphs of the spittlebug inside the foam with the help of available literature. It was a very interesting piece of information so we enumerated the host species in the study area. We enumerated the plants and presented them here. From the survey conducted, 17 host plant species of spittlebug were enumerated which belong to 13 different families. Out of the enumerated 17 plant species, 13 plant species are herbs, 2 species are undershrub and 2 species are trees. From the 17 host plant species of spittlebug, 3 species belong to the family Asteraceae; 2 species each to families Poaceae and Rubiaceae; and 1 plant species each belongs to the families Acanthaceae, Amaranthaceae, Caesalpiniaceae, Capparaceae, Combretaceae, Mimosaceae, Onagraceae, Orchidaceae, Pedaliaceae and Rhamnaceae (Table 1; Figure 1-7). They are also the food of many birds, insects and spiders (Figure 8).

Table 1: Host plants of spittlebug

Common name	Local name	Scientific name	Family	Habit
Goat weed	Poksunga	*Ageratum conyzoides*	Asteraceae	Herb
Joy weed	Kolamsago	*Alternanthera sessilis*	Amaranthaceae	Herb
Creat	Bhuinimbo	*Andrographis paniculata*	Acanthaceae	Herb
Christmas bush	Phulgandhuri	*Chromolaena odorata*	Asteraceae	Undershrub
Wild-dog mustard	Banosorisho	*Cleome viscosa*	Capparaceae	Herb
Dhub grass	Duba ghasa	*Cynodon dactylon*	Poaceae	Herb
Commelina-leaf Habenaria	Debasundha	*Habenaria commelinifolia*	Orchidaceae	Herb
Water primrose	Jagal	*Ludwigia adscendens*	Onagraceae	Herb
Touch-me-not	Lajakuli	*Mimosa pudica*	Mimosaceae	Herb
Tropical girdle pod	Gothia gobi	*Mitracarpus villosus*	Rubiaceae	Herb
		Oplismenus burmannii	Poaceae	Herb
Coffee weed	Chakunda	*Senna occidentalis*	Caesalpiniaceae	Undershrub
Sesame	Rasi	*Sesamum indicum*	Pedaliaceae	Herb
Shaggy buttonweed	Solaganthi	*Spermacoce articularis*	Rubiaceae	Herb
White murdah	Arjuna seedling	*Terminalia arjuna*	Combretaceae	Tree
Mexican daisy	Bisalya karani	*Tridax procumbens*	Asteraceae	Herb
Common jujube	Barakuli	*Ziziphus mauritiana*	Rhamnaceae	Tree

Munoz et al. (2020) reported the first records of outbreaks of the Pine spittlebug from Puebla, Mexico which promoted the foliar fall of 2600 ha of forest. The systematic sampling revealed that the first three nymphal stages

feed on roots of 1 grass, 4 herbs, 1 shrub, and 2 trees. From the fourth instar, the insects feed on pine roots and when they are adults, they migrate to needles of young or mature pine trees to feed and reproduce. Bodino et al. (2020) described the host plant selection and exploitation by spittlebugs in 2 different Mediterranean regions of Italy likely the Apulia and Liguria olive groves during field surveys in 2016-18. They found that host plant association depended on the insect preference and ground cover floral composition. They also mentioned that the spittlebug population is low under warm and dry Mediterranean conditions. Liccardo et al. (2020) proposed a biological control model to manage the infection of the bacterium *Xylella fastidiosa* present in the vector *Philaenus spumaris*, a meadow spittlebug responsible for Olive Quick Decline Syndrome that has killed several olive trees in Southern Italy by using *Zelus renardii*, the natural predator of the bug. *Z. renardii* keeps the population of spittlebug in check which decreases the infection of the bacterium in olive trees. Xu et al. (2022) described a new genus *Nangamostethos* gen. nov. of the tribe Cosmoscartini from the Niubao Formation, the late Eocene of the central Tibetan Plateau, China. The new fossil represents one of the few fossils of Cercopidae species described from Asia and likely the *Nangamostethos* genus was extinct from the Tibetan Plateau due to regional aridification and an overturn of plant taxa in the late Paleogene.



Figure 1: Spittlebug on common grass



Figure 2: Spittlebug on *Tridax procumbens*



Figure 3: Spittlebug on *Habenaria commelinifolia*



Figure 4: Spittlebug on *Andrographis paniculata*



Figure 5: Spittlebug on *Mitracarpus villosus*



Figure 6: Spittlebug on *Alternanthera sessilis*



Figure 7: Spittlebug on *Ageratum conyzoides*

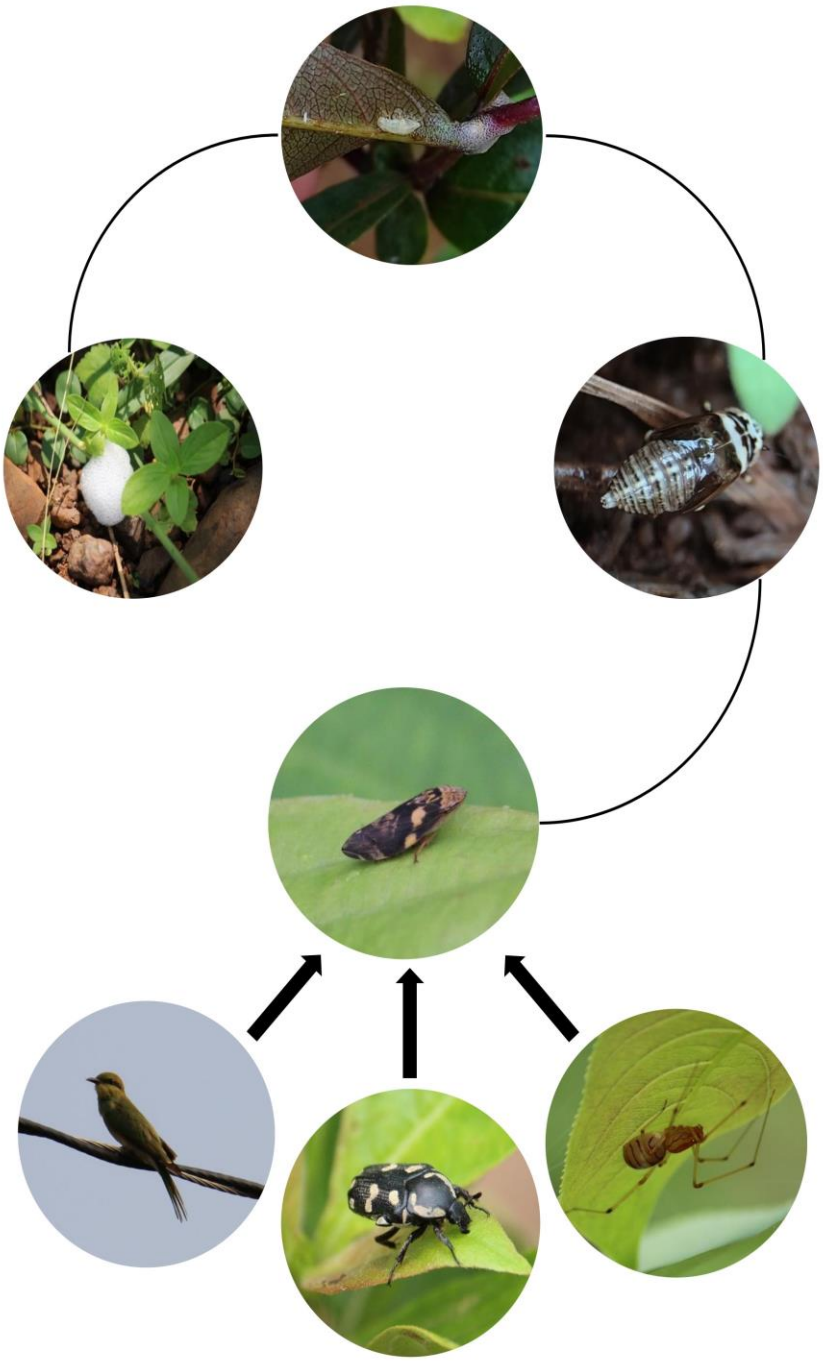


Figure 8: Spittlebugs are food of many birds, insects, and spiders

Concluding remarks

From the above study, it was concluded that plants and animals both play important roles in the functioning and balance of nature. Spittlebug helps the host plants relieve the excess water pressure in the tissues and vessels and plants provide food and shelter to the bugs. The feeding of nymphs in large populations may cause little harm to the plants such as wilting the feeding area, and breakage of young stems and branches, other than that there are no severe negative effects of bugs on plants. But the large populations of spittlebugs may become an issue for plants, then they can be removed physically by hand or with the help of a strong stream of hose water. Therefore, there is a need to conserve the host plants of spittlebugs to maintain the ecological balance.



Chapter 5
Flueggea leucopyrus: a useful shrub for restoration of urban bird diversity

Summary

Urbanization is a major cause of the decline in the bird population. It is an important concern to restore food plants especially shrubs in urban areas. In this context, the identification of such plants is a vital task. Keeping this in mind, the authors have surveyed the urban areas of Cuttack and found a shrub *Flueggea leucopyrus*. After periodic observation, it was noted that Red-vented bulbul, Brahminy starling, Asian pied starling, Yellow-eyed babbler, etc. consume the fruits of *F. leucopyrus*. The study recommends that the plantation of this plant is necessary to restore the bird population in urban areas.

Background

Birds are an important component of ecology, particularly in urban areas. They consume different types of fruits and help in self-afforestation through seed dispersal. Due to rapid urbanization, anthropogenic activities, and climate changes, the population of birds is declining. Birds depend on different types of plant species for food, nesting, and perching (Xu et al. 2022). Cities are extended yearly, and all trees and shrubs are cut down to make concrete jungles. Due to this continuous extension of concrete jungles, birds are not able to get food and shelter. Birds interacting with the flora have a mutualistic relationship as they both benefit from the association (Quintero et al. 2023). Birds feed on the nectar or fruit from the plants and the plants benefit by having birds carry out the major processes of survival which are pollination and seed dispersal (Hu et al. 2022). The birds are primary pollinators and seed dispersers in the world and ensure the future of the native plants for generations to come. Sometimes, the hard seed coats desiccate after passing through the gut of birds and then the seeds germinate to grow (Kleyheeg

et al. 2018). They are crucial for the proper balance of the ecosystem and are important species for biodiversity conservation. The insectivorous birds help in pest control and the scavenging birds like vultures keep the environment clean by feeding on the decomposing flesh of dead animals. The bird droppings, known as guano are rich in nitrogen and phosphorous and are utilized by plants to increase the growth and rate of photosynthesis. They are also helpful in the recycling of nutrients in the marine ecosystem by fertilizing the coral reefs and balancing the food chain and food web of an ecosystem (Grant et al. 2022). They protect important habitats like wetlands by predating on snails and periwinkles which could turn the wetlands into mudflats due to overgrazing (O'Neil et al. 2022). The birds are also important for the formation of new soil after their death as they are excellent mediums for transferring organic materials from their bodies to the soil which makes the soil richer. Some birds are considered keystone species as their presence or absence in an ecosystem affects the survival of other species mainly plants indirectly. Humans also benefit from the birds as they themselves and their eggs are an important food source. Nowadays, birdwatching is becoming one of the best recreational activities. As birds play many roles in the ecosystem, they are considered ecosystem engineers and they should be conserved (Filho and Faria 2017). The birds can be protected by protecting their habitat and conserving their host plants. As birds provide so many services, their healthy population will improve the well-being of the ecosystem. Keeping the importance of the availability of birds and their related plant species, an attempt has been made to document the birds consuming the fruits of *Flueggea leucopyrus*.

Morphology

Flueggea leucopyrus is an erect shrub 1.5-4m tall with branches cylindrical or obtusely angular when young and gray in color.

Final branchlets are spine-tipped, cylindrical, and rigid. Leaf stalks are 2-8 mm and grooved. Leaf blade is elliptic, obovate, or round, papery to thinly leathery. Leaf margin is not toothed and the tip is rounded. Inflorescence cymose and cymes arise from leaf axils or at leafless nodes. Flowers are tiny and yellowish in color. Male flowers with pedicels long and slender, 5 sepals, obovate, concave, 4-5 stamens, petals absent, disk of 3-5 claws alternating with stamens, rudimentary ovary present, trifid. Female flowers with angular pedicels, 1-5 sepals, disk saucer-shaped and sometimes thickened, ovary 3-locular, bifid. Fruit a capsule, globose, berrylike, and whitish in color when ripe (Figure 1). Flowering period is from April to July. Fruiting period is from May to October.

A survey was carried out in the year 2023 (January 2023-August 2023) at the Mahanadi River area, Cuttack, Odisha. The observation was made in the morning and evening every weekend and occasionally in the afternoon. The birds consuming the fruits of the plant were noted down and tabulated. The birds were identified by using the book "Birds of the Indian Subcontinent". The plant was identified by Dr. Sanjeet Kumar and his team.

From the survey conducted in the study area, 15 different bird species belonging to 12 genera and 9 different families were observed to consume the fruits of the *Flueggea leucopyrus* plant and enumerated in tabular form. From the 15 enumerated bird species, 5 bird species were seen feeding on the fruits during the morning (Figure 2), 4 bird species in the evening, 1 bird species during both morning and evening and 5 bird species were seen feeding fruits throughout the day. Out of the 15 documented bird species, 5 bird species belonged to the family Sturnidae, 2 bird species each to the families Megalaimidae and Pycnonotidae, and 1 bird species each to the families Estrilidae, Leiothrichidae,

Muscicapidae, Oriolidae, Paradoxornithidae, and Passeridae (Table 1).

Table 1: List of birds consuming fruits of *Flueggea leucopyrus*

Scientific name	Common name	Family	Time of visiting
Acridotheres fuscus	Jungle myna	Sturnidae	Evening
Acridotheres tristis	Common myna	Sturnidae	Evening
Argya striata	Jungle babbler	Leiothrichidae	Evening
Chrysomma sinense	Yellow-eyed babbler	Paradoxornithidae	Throughout the day
Copstchus saularis	Oriental magpie-robin	Muscicapidae	Throughout the day
Gracupica contra	Asian pied starling	Sturnidae	Throughout the day
Lonchura punctulata	Scaly-breasted munia	Estrilididae	Morning
Oriolus xanthornus	Black-hooded oriole	Oriolidae	Morning
Passer domesticus indicus	House sparrow	Passeridae	Morning & evening
Pastor roseus	Rosy starling	Sturnidae	Morning
Psilopogon haemacephalus indicus	Coppersmith barbet	Megalaimidae	Morning
Psilopogon zeylanicus	Brown-headed barbet	Megalaimidae	Morning
Pycnonotus cafer	Red-vented bulbul	Pycnonotidae	Throughout the day
Pycnonotus jocosus	Red-whiskered bulbul	Pycnonotidae	Throughout the day
Sturnia pagodarum	Brahminy starling	Sturnidae	Evening

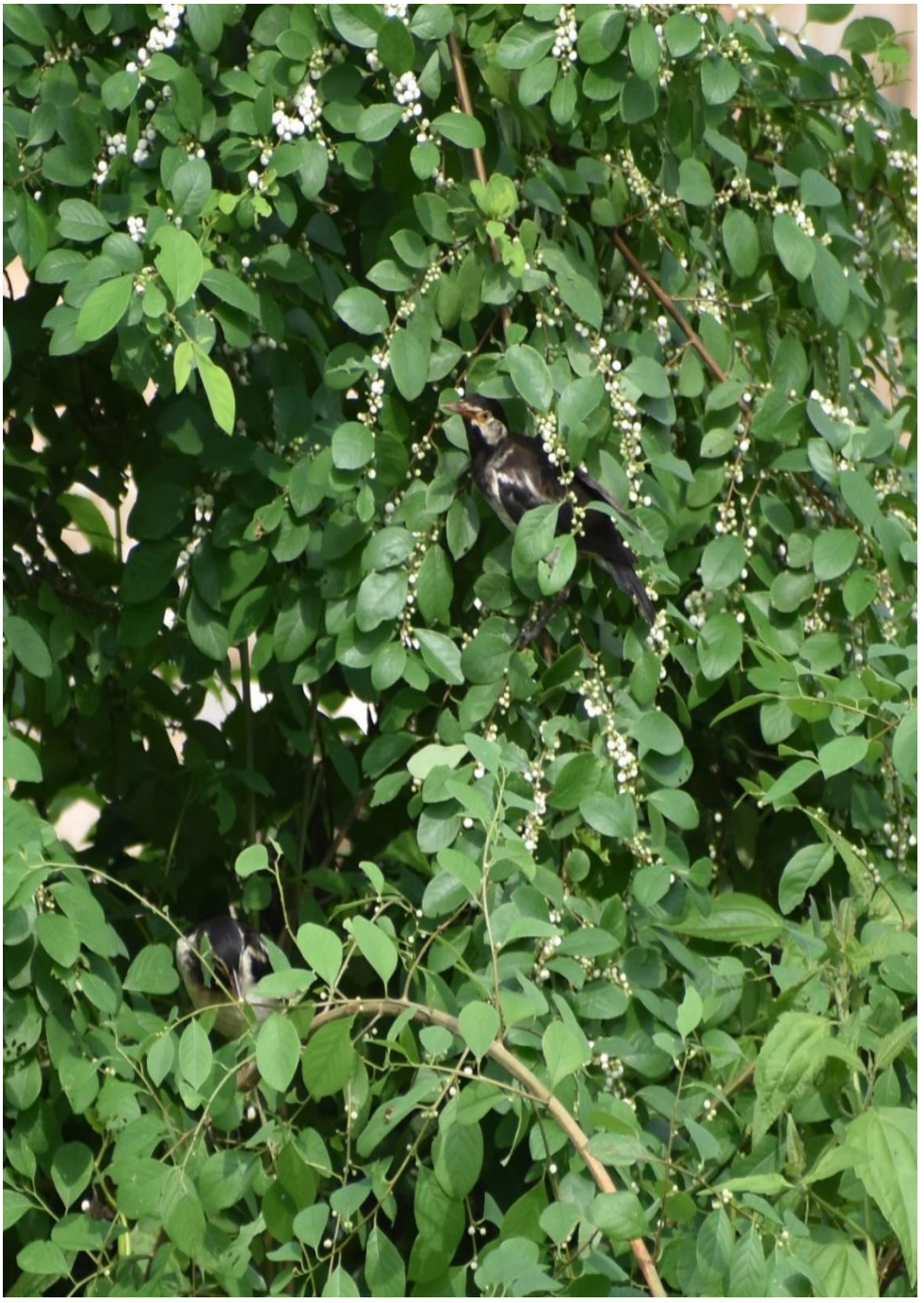


Figure 1: Asian pied starling feeding on fruits of *Flueggea leucopyrus*



Figure 2: Red-whiskered bulbul consuming fruits of *Flueggea leucopyrus*

David et al. (2015) recorded 34 bird species from 17 families and 12 mammal species from 11 families eating fruits in Sriharikota (Andhra Pradesh) and Point Calimere (Tamil Nadu). They found that house crow, large-billed crow, spotted dove, lesser white throat, and orange-headed thrush, specifically fed on the fruits of *Flueggea leucopyrus* in Sriharikota. Ramaswami et al. (2019)

explored the effects of the fruiting of invasive plants like *Lantana camara* on the native fruiting plants *Erythroxylum mongynum* and *Flueggea leucopyrus* on the visit and fruit removal by birds. They found 13 bird species visiting and feeding on the fruits of both the native plants irrespective of the presence of the invasive plant species.

Concluding remarks

From the survey conducted it was concluded that bird-plant interaction plays a major role in the functioning and balance of the ecosystem. Birds play an important role in pollination and seed dispersal hence increasing the plant population and plants provide the birds with food and shelter. Nowadays, the plant population in cities is decreasing because of the decline in the bird population due to urbanization, pollution, anthropogenic activities, and climate change. The study shows and proves the interdependence of both plants and animals on each other for their survival. Therefore, birds are essential for the maintenance of an ecosystem and to protect them, there should be conservation and plantation of plants in the urban areas.

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