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Avifauna and its interactions with the plants at Botanical Survey of India, Arid Zone Regional Centre, Jodhpur, Rajasthan, India

Introduction

Birds feed on nectar, fruits, plants, seeds, fishes, flesh, insects and various small animals, including other birds (Frank, 1995). Some migratory birds utilise the proteins stored in their bodies as additional energy during migration (Phil, 2000). Many bird species migrate annually over miles and across continents to avoid seasonal temperature changes, for adequate food sources and for breeding. Birds communicate mainly using visual and audio signals and few of these calls are so pleasant. Many birds maintains their own territory during the breeding season to protect their chicks and food sources. The greatest threat to birds can be the result of multiple factors, such as in particular habitat loss and degradation (Norris, 2002), overhunting, accidental mortality (collisions with man-made structures, mainly glass and unintentional vehicle collisions) (Brothers, 1991), chemical pollution (Wurster, 1965, Sanderfoot, Holloway, 2017), competition and predation from invasive species (Blackburn, 2004) and climate change (Tylor, Kumar, 2016).

The range of "functions and services" of ecosystems depends in large part on the overall level and state of biodiversity (Hooper et al., 2012; Pasari et al., 2013; Tilman et al., 2014; Lefcheck, Duffy, 2015). According to research on biodiversity in natural and semi-natural areas, biodiversity in cities and urban areas has received increasing attention in recent years (Farinha-Marques et al., 2011; Muller, Kamada, 2011; Elmqvist et al., 2013; Murgui, Hedblom, 2017; Rega-Brodsky et al., 2022). Aronson et al. (2014)

stated, 10,052 bird species were recognised worldwide, among them 2,041 (20%) occur in our cities. Due to urbanisation, land conversions, expansion of cities and agriculture, mechanisation of agriculture many birds lost their original habitats moved far beyond their natural niches (Jupiter et al., 2014; Urban, 2015; Taylor, Kumar, 2016). Arigela et al. (2020, 2021) studied the botanical choices of Baya Weaver (*Ploceus philippinus* L.) from southern India and favourite wild grass species of Scaly-breasted Munia (*Lonchura punctulate* L.) in southern Indian states. These studies have shown beneficial and life-sustaining elements for birds that are part of conservation measure.

In urban ecosystems, it is very important to measure bird reproduction and survival. Direct measurement of reproduction should be supplemented with many indirect measurements (e.g. ratio of juveniles to adults, predation rates on artificial nests) in order to increase the accuracy of monitoring. Important limiting factors, such as nesting predators, brood parasites, and most importantly, the availability and sources of food and nesting sites should be investigated (Donnelly, Marzluff, 2004). To understand how birds respond to different urban patterns (e.g. land use intensity, building aggregation and land use heterogeneity) at the urban/suburban or suburban/wildland interface, this type of monitoring is essential. Here, native bird communities are relatively intact, and managing developmental patterns to maintain rather than replace native communities makes sense. This work needs to be done in both habitat reserves and built-up areas so that we can use the entire landscape to preserve biodiversity (Rastandeh et al., 2018). The highly developed cities in arid biome support higher bird diversity than the natural habitat (Filloy et al., 2019).

Botanical gardens were established to protect the plant diversity for the well-being of people and the planet. Though the primary aim is to protect the plants, sometimes these gardens may acts as 'Other Effective area-based Conservation Measures' (OECMs) to attract and facilitate the favourable breeding environments for several migratory and indigenous birds. The dispersed resources of the urban environment can influence plant and animal species richness and the interactions among these species (Corral et al., 2020). The birds will also plays a great role to protect the plants form different pests and insect attacks and also act as pollinators and seed dispersal agents. Floristic inventories and exploration of fauna is essential to initiate the conservation efforts in particular landscapes as the flora and fauna are interdependent (Arigela et al., 2022).

The aim of the research undertaken here was to document the relationship between permanently or periodically resident birds that found shelter in the Botanical Survey of India, Arid Zone Regional Centre Campus, and the plants growing there. This problem is of particular importance for the biodiversity of birds in the aspect of maintaining green niches with plants in urban areas.

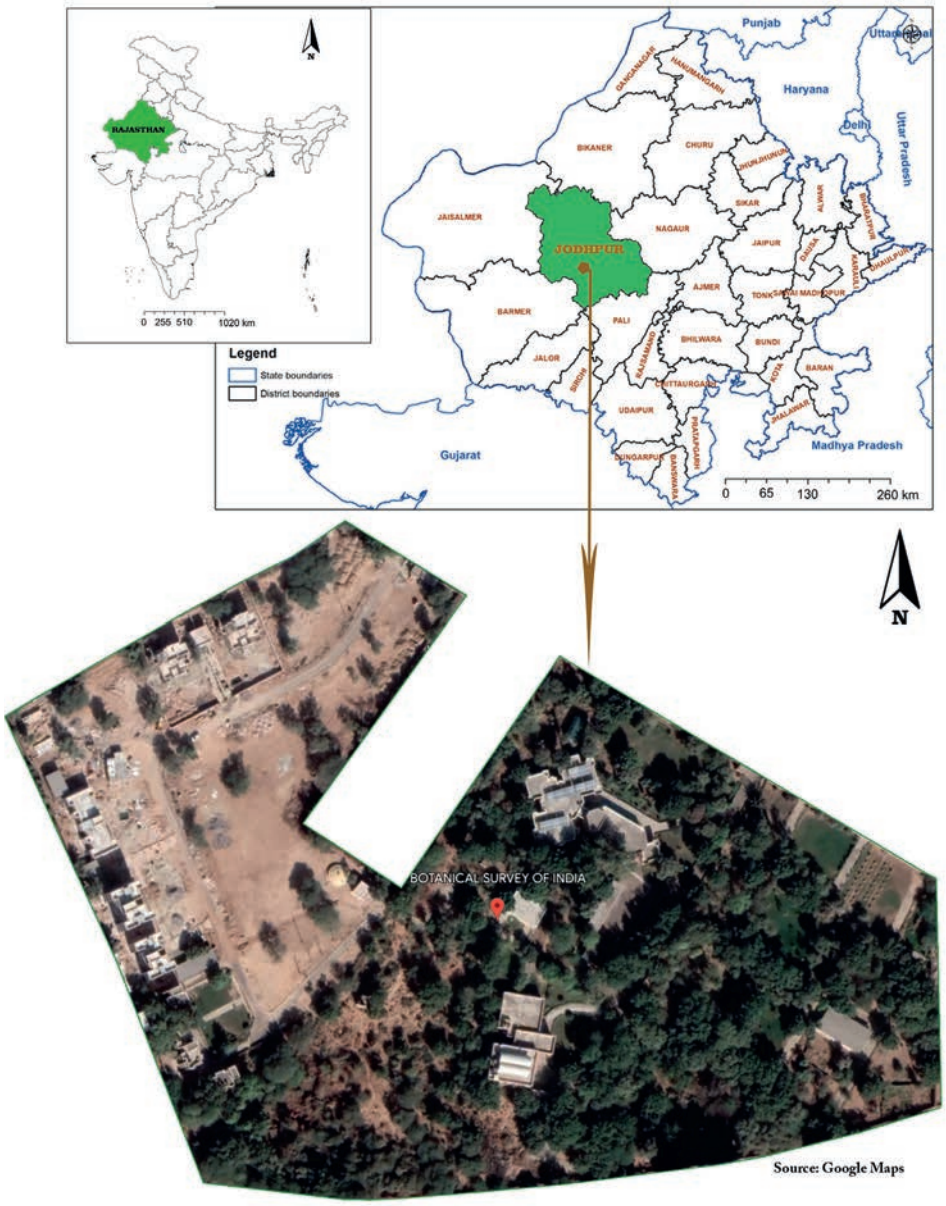

Fig. 1. Study area – Botanical Survey of India, Arid Zone Regional Centre Campus, Jodhpur, Rajasthan

Study area, materials and methods

Botanical Survey of India (BSI), Arid Zone Regional Centre Campus (AZRC) was established in 1972 and it has about 5.66 hectares eco-friendly campus at Jodhpur, Ra-

jasthan, India which is an extreme arid region of the Thar Desert of India (Fig. 1). The AZRC possess more than 250 plants species, including a seasonal weeds in different sections like Aquatic plants division, Medicinal plants sections, Cactus garden, Grass section, Pomology section and EET plants section, of which about 120 plants are trees and shrubs. High and low extreme temperatures, uncertain rainfall and dryness is the characteristic climate in the garden. Winter lasts from November to March followed by summer from April to June. The temperature varies from 49o C in summer to 1o C in winter. South-west monsoon season lasts from July to mid-September with the average rainfall of 360 mm.

Studies of birds and their interactions with plants were carried out in the AZRC garden from November 2022 to April 2023 and at that time photos were taken. Based on bird calls (sounds) and their appearance at forage sites and flight in the campus, birds were located and photographed. A few nocturnal birds were located based on their calls and droppings at roosting places in the garden. Nikon 5300 with Nikkor 200–500 lens and Panasonic FZ–28 digital cameras were used to capture the birds. Observations of birds, their interactions with plants were made in the morning, afternoon and evening, based on their activity. The photographed birds were identified based on literature (Ali, 1987, 2002; Grewal, 2016; Grimmett, 2016) and with the help of Expert determinations.

Botanical nomenclature and system of classification was used according to APG-IV, WFO (https://wfoplantlist.org/plant-list/) and zoological one according to Linnaean Taxonomy and IOC World Bird List Version 13.1.

Results

During the investigation, a total of 55 birds were recorded from the BSI, AZRC campus (Tab. 1 – Appendix 1, Fig. 3–8 – Appendix 2). Based on the food preferences of the recorded birds, the largest group, as many as 20 species, was considered insectivorous, 10 as omnivorous and predatory, while only 1 species was classified as nectarivores (Fig. 2A). There are the most residents (this kind of birds appear throughout the year in the campus and replicate their progenies) in this group and the least internal migrants from adjacent areas and Indian states (Fig. 2B).

The largest group here are representatives of the families Accipitridae Vigros (7 species) and Columbidae Leech (5 species). As many as 20 families were represented here by only 1 species (Tab. 1 – Appendix 1). The frequently occurring birds are Asian Gree Bee-eater, Brahminy Starling, Eurasian Collared Dove, House Crow, Grey Francolin, Indian Silverbill, Large Gray Babbler, Purple Sunbird, Rock Pigeon, Red Collared Dove and Rose-ringed Parakeet.

In the analysed area, interactions of birds with 75 species of plants, representing 34 families were recorded (Tab. 2 – Appendix 1). Most of these plants belong to the

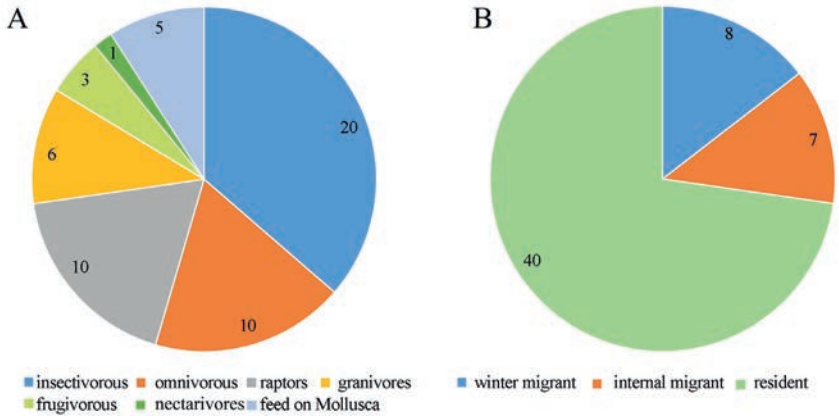

Fig. 2. The comparison of the number of species representing different types of diets (A) and the number of resident and migrants (B) among birds recorded in the Botanical Survey of India, Arid Zone Regional Centre Campus

Fabaceae Lindl. (14 species) and Poaceae (R. Br.) Barnh. (6 species) families. During the observations, it was found that these plants provide various types of benefits to the birds living on this area (Fig. 9–13). Most plants are a source of insects that are part of the birds' diet (birds were observed feeding on 65 plants of this type) and a shelter or nesting place (25 species) – Fig. 9.

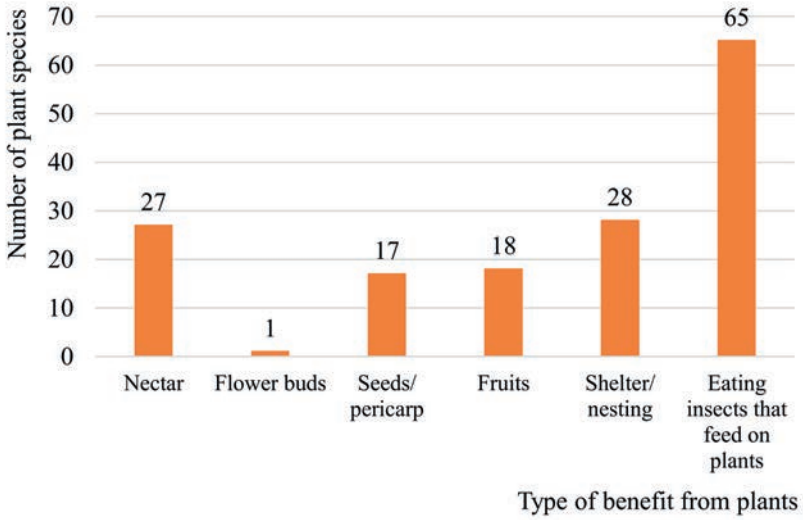

Fig. 9. The comparison of the types of benefits offered to birds by the some plants growing in the Botanical Survey of India, Arid Zone Regional Centre Campus

One of the plant species – *Balanites roxburghii* – is the source of edible flower buds. Some plant species offer birds as many as 4 types of different benefits, e.g. *Azadirachta indica*, *Commiphora wightii*, *Ehretia acuminata*, *Gmelina arborea* and *Pongamia pinnata* (Tab. 2 – Appendix 1).

Discussion

In the upper layer of the vegetation cover of the Arid Zone Regional Center Campus (AZRC), the most common plant species are: *Ailanthus excels*, *Azadirachta indica*, *Balanites roxburghii*, *Capparis decidua*, *Cocculus hirsutus*, *Dichrostachys cinerea*, *Gmelina arborea*, *Holoptelea integrifolia*, *Ipomoea pes-tigridis*, *Prosopis cineraria*, *Salvadora oleoides*, *S. persica*, *Senegalia senegal*, *Tecomella undulata*, *Vachellia tortilis* and *Ziziphus mauritiana* (Tab. 2 – Appendix 1). This diversified upper story vegetation of AZRC creates a microhabitat (niche) and shelter for birds. The frugivorous birds are zoochoric seed dispersal agents for these plant species in the Jodhpur urban areas. Birds can be particularly effective at dispersing seeds over longer distances and into suitable habitats. The movement of birds may be crucial in allowing plant progeny to avoid greater disease pressure in the vicinity of their parental individuals. Many bird behaviors also allow for targeted dispersal of plants to specific habitats where seedlings have a better chance of developing, whether by burying seeds or dropping consumed seeds with fertilising droppings (Blanco et al. 2015; Brønnvik, von Wettberg, 2019).

Common species in the undergrowth of the analysed area are: *Abutilon indicum*, *Acrachne racemosa*, *Achyranthus aspera*, *Aerva persica*, *Aloe vera*, *Amaranthus spinosus*, *Barleria prionitis*, *Blepharis scindica*, *Calotropis procera*, *Cenchrus ciliaris*, *C. setigerus*, *Crotalaria medicaginea*, *Dactylactenium scindicum*, *Dicliptera paniculata*, *Diplocyclos palmatus*, *Echinops echinatus*, *Euphorbia caducifolia*, *Euphorbia hirta*, *Heliotropium europaeum*, *Heliotropium zeylanicum*, *Justicia procumbens*, *Pavonia odorata*, *Physalis angulata*, *Polygala erioptera*, *Pupalia lappacea*, *Sida rhombifolia*, *Tephrosia purpurea*, *Trichodesma zeylanicum*, *Cyanthillium albicans*, *C. cinereum*, *Zygophyllum indicum* and *Ziziphus numularia* (Tab. 2 – Appendix 1). These plants form an excellent forage and nesting sites for the ground birds like Grey Francolin, Indian Thick-knee and Lapwings and others (Tab. 1 – Appendix 1). Among these plants are fruiting plants and plants with small seeds, which are beneficial to birds. Availability of food and safe nesting places are the most important elements necessary for the functioning of different bird populations, especially in urbanised conditions (Donnelly, Marzluff, 2004).

During current studies, a number of interactions between various species of birds and plants were observed. For example, *Ziziphus mauritiana* and *Z. numularia* are the most favourite plant for the White eared Bulbul and Red-vented Bulbul in the winter. Purple Sunbirds swig the nectar of *Aloe vera* (Fig. 12 – Appendix 2), *Calotropis procera*

(Fig. 13 – Appendix 2), *Ougeinia oojeinensis* and *Tecomella undulata* flowers. They maintain the territory and chase the other small birds (Fig. 10 – Appendix 2). Common Tailorbirds, Lesser Whitethroat and White-eared Bulbuls are also gulp the nectar of the *T. undulata* flowers (Fig. 10 – Appendix 2). In the contrast, Asian Koels, Brahminy Starlings, Large Gray Babblers, Red-vented Bulbul and White-eared Bulbul feed on the fruits of *Azadirachta indica*, *Bergera koenigii*, *Cordia dichotoma*, *Ficus religiosa* (Fig. 13 – Appendix 2), *Salavadora persica* (Fig. 11 – Appendix 2), *Santalum album* and *Withania somnifera*. Eurasian Collared Dove, Red Collard Dove and Laughing Doves roost in the night on *Vachellia tortilis* and *Prosopis juliflora*, to escape from jungle cat and other predators. Green Bee-eaters and House Crows prefer mostly *Azadirachta indica* (Neem Tree) to roost. Barn Owl prefers *A. indica* and *Prosopis cineraria* to roosting and foraging garden rats. Shikra and Big Gray Babbler chase barn owls when they spot it during the day.

Large Gray Bablers make nests on *Prosopis cineraria* from January to February. Lesser Whitethroats are preferring to search the insects on *Capparis decidua*, *Prosopis cineraria* and *P. juliflora* and they maintain the territory. Indian Silverbill flocks eat the caryopsis of *Acrachne racemosa*, *Cenchrus ciliaris*, *C. setigerus*, *Cynodon dactylon*, *Dactylactenium scindicum* (Fig. 11 – Appendix 2), and prefer *Balanites roxburghii*, *Euphorbia cauducifolia*, and *Prosopis cineraria* for nest building and roosting. Indian peafowls eat the fruits and Lesser Whitethroat, Purple Sunbird and Red Vented Bulbuls feed on the flower buds of *Balanites roxburghii*. Rose-ringed Parakeets feed on flower buds of *Agave americana* and on fruits of *Azadirachta indica* (Fig. 13 – Appendix 2), *Vachellia tortilis, Cocculus hirsutus* (Fig. 10 – Appendix 2)*, Commiphora wightii, Moringa concanensis, Pongamia pinnata* (Fig. 13 – Appendix 2)*, Prosopis cineraria* (Fig. 12 – Appendix 2), *Prosopis juliflora* and *Salvadora persica* (Fig. 11 – Appendix 2). Brahminy Starling, Lesser Whitethroat (Fig. 12 – Appendix 2), Red vented Bulbul, White-eared Bulbul also feast on the fruits of *Cocculus hirsutus* (Fig. 10 – Appendix 2). Brahminy Starling and House Sparrow also glean the aril and insects on *Vachellia tortilis*. Black Redstart roost on *Cryptostegia grandiflora* and catches the flies under the *Senegalia senegal* plants. White-browed Fantail mainly searches for the insects under *Dichrostachys cinerea* and *Prosopis cineraria* plants. Black-rumped Flameback Woodpecker bores the stems of *Ailanthis excelsa* and *Azadirachta indica* for larvae and other insects. Eventually these birds protect the plants from the insect attacks.

Over the course of the research, other interesting observations were also recorded. For example, White-throated Kingfisher preys on skinks and garden lizards and Indian Pond-Heron feeds on larvae, frogs and skinks. Shikra is a common bird of prey in the AZRC that preys mainly on the five-banded palm squirrel and Rock Pigeon chicks. Other raptors like Black Eagle, Black Kite, Egyptian Vulture, Long legged Buzzard, Oriental Honey-Buzzard and Short-toed Snake-Eagle have been recorded in the AZRC (Tab. 1 – Appendix 1). The plants existing in the AZRC campus such as *Azadirachta*

indica, *Barleria prionitis*, *Capparis decidua*, *Ehretia acuminata*, *Euphorbia caducifolia*, *Gmelina arborea*, *Ougeinia oojeinensis*, *Prosopis cineraria*, *Millettia peguensis*, *Moringa concanensis*, *M. olifera*, *Sapindus trifoliatus*, *Tecomella undulata* and *Vitex negundo*, are the good sources of nectar for honey bees (Tab. 2 – Appendix 1). The huge beehives in the AZRC attract the Oriental Honey-Buzzards. Migratory birds such as Blyth's Reed Warbler, Common Chiffchaff, Lesser Whitethroat, Eurasian Scops-Owl, Gray Wagtail, Greater Whitethroat and Red-breasted Flycatcher are recorded in the AZRC, Jodhpur (Tab. 1 – Appendix 1; Fig. 2B).

Threatened plants such as *Commiphora wightii*, *C. stocksiana*, *Dalbergia latifolia* and *Tecomella undulata* are protected in the garden by the Botanical Survey of India authorities. Red-breasted Flycatcher is gleaning and perching these plants. The Indian endemic tree species *Pterocarpus marsupium* subsp. *acuminatus* and *Syzygium salicifolium* are also protected in the AZRC, Garden (Tab. 2 – Appendix 1). Shikra makes the nest on *Azadirachta indica* and *Eucalyptus camaldulensis*. The Greater Coucal builds the nests on bushy *Dendrocalamus strictus* and *Balanites roxburghii*. Grey Francolins with chicks nest under bushy *Euphorbia caducifolia* spurges to escape predators and other reptiles. This explains the necessity for the presence of other plants in the habitat that perform the functions of the ecosystem, apart from fodder plants (Jupiter et al., 2014; Rastandeh et al., 2018).

Common threats to the birds at BSI, AZRC are gregarious populations of House crows, Rock pigeons, Domestic cats and Stray dogs. House crows and Asian Koels steal the eggs of Eurasian Collared Dove, Rock Pigeons and Red Collared-Doves. They also raise Red-wattled Lapwings chicks. Wild cats are also a threat to birds, but they control Rock Pigeon populations and maintain ecological balance as they are part of the ecosystem. Spectacled Cobra, Monitor Lizard and Mongoose swallow the eggs of ground birds and Rock Pigeons. Monitoring these permanent threats is essential for the functioning of bird populations in the area (Donnelly, Marzluff, 2004; Rastandeh et al., 2018; Corral et al., 2020). Due to urban infra development and real estate, original habitats of the birds shrink and AZRC is one of the suitable habitats for many birds.

Conclusions

The study area is valuable in terms of biodiversity of bird species that found shelter here in urbanised conditions. At the same time, it is a place with rare floristic elements, which are a very important component of the bird habitat, as they offer different types of benefits for birds. The number of interactions of birds and plants observed here proves the need to protect this place. We strongly suggest Jodhpur Urban development authorities and social forestry departments to plant more indigenous plants like *Dichrostachys cinerea*, *Prosopis cineraria*, *Salvadora oleoides*, *S. persica*, *Senegalia senegal*, *Tecomella undulata*,

Ziziphus mauritiana and *Z. numularia* along with the Neem trees, to conserve and enhance the urban biodiversity, and to avoid the Dieback disease attack on Neem, which is vigorous in Andhra Pradesh, Karnataka and Telangana states of India. We also suggest these authorities not to consider the *Conocarpus lancifolius* for avenue plantations in the Jodhpur urban areas. The introduced alien tree *C. lancifolius* shows allelopathic effect on the growth of indigenous plant species. Jodhpur city is prone to dust storms in summer and pollen of this alien tree triggers respiratory problems when these pollen dust is added into the environment.

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Conflict of interest

The authors declare no conflict of interest related to this article.

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Appendix 1

Tab. 1. Birds occur at Botanical Survey of India, Arid Zone Regional Centre, Jodhpur; Nutrition: Fr – frugivorous, Ins – insectivorous, Omn – omnivorous, Rap – raptors, Moll – feed on Mollusca, Rept – feed on reptiles, Ne – Nectar, Gr – Grains, Fl – Flower buds

Succ. No.	Scientific name	Common Name	Type of occurrence	Family	Type of Diet
1.	*Prinia socialis* Sykes	Ashy Prinia	Resident bird	Cisticolidae	Ins
2.	*Merops orientalis* Latham	Asian Green Bee-eater	Resident bird	Meropidae	Ins
3.	*Eudynamys scolopaceus* Linnaeus	Asian Koel	Resident bird	Cuculidae	Omn
4.	*Acridotheres ginginianus* Latham	Bank Myna	Internal migrant	Sturnidae	Omn
5.	*Tyto alba* Scopoli	Barn Owl	Resident bird	Tytonidae	Rap
6.	*Dicrurus macrocercus* Vieillot	Black Drongo	Resident bird	Dicruridae	Ins
7.	*Ictinaetus malaiensis* Temminck	Black Eagle	Resident bird	Accipitridae	Rap
8.	*Milvus migrans* Boddaert	Black Kite	Resident bird	Accipitridae	Rap
9.	*Phoenicurus ochruros* Gmelin, SG	Black Redstart	Winter migrant	Muscicapidae	Ins
10.	*Dinopium benghalense* Linnaeus)	Black-rumped Flameback	Resident bird	Picidae	Ins, (Fr)
11.	*Acrocephalus dumetorum* Blyth	Blyth's Reed Warbler	Winter migrant	Acrocephalidae	Ins
12.	*Sturnia pagodarum* Gmelin, JF	Brahminy Starling	Resident bird	Sturnidae	Omn
13.	*Bubulcus ibis* Linnaeus	Cattle Egret	Resident bird	Ardeidae	Ins, Moll, Rept, Fish
14.	*Phylloscopus collybita* Vieillot	Common Chiffchaff	Winter migrant	Phylloscopidae	Ins
15.	*Acridotheres tristis* Linnaeus	Common Myna	Resident bird	Sturnidae	Omn
16.	*Orthotomus sutorius* Pennant	Common Tailorbird	Resident bird	Cisticolidae	Ins
17.	*Tephrodornis pondicerianus* Gmelin, JF	Common Woodshrike	Internal migrant	Vangidae	Ins
18.	*Psilopogon haemacephalus* Müller, PLS	Coppersmith Barbet	Resident bird	Megalaimidae	Fr, (Ins)
19.	*Neophron percnopterus* Linnaeus	Egyptian Vulture	Resident bird	Accipitridae	Rap
20.	*Streptopelia decaocto* Frivaldszky	Eurasian Collared Dove	Resident bird	Columbidae	Gr (Ins)
21.	*Otus scops* Linnaeus	Eurasian Scops-Owl	Migrant	Strigidae	Rap

22.	*Motacilla cinerea* Tunstall	Gray Wagtail	Winter migrant	Motacillidae	Moll, Ins
23.	*Centropus sinensis* Stephens	Greater Coucal	Resident bird	Cuculidae	Omn
24.	*Curruca communis* Latham	Greater Whitethroat	Winter migrant	Sylviidae	Ins, (Fl, Ne)
25.	*Ortygornis pondicerianus* Gmelin, JF	Grey Francolin	Resident bird	Phasianidae	Ins
26.	*Corvus splendens* Vieillot	House Crow	Resident bird	Corvidae	Omn
27.	*Passer domesticus* Linnaeus	House Sparrow	Resident bird	Passeridae	Gr (Ins)
28.	*Pavo cristatus* Linnaeus	Indian Peafowl	Resident bird	Phasianidae	Omn
29.	*Ardeola grayii* Sykes	Indian Pond-Heron	Resident bird	Ardeidae	Moll, Rept, Fish
30.	*Copsychus fulicatus* Linnaeus	Indian Robin	Resident bird	Muscicapidae	Ins
31.	*Euodice malabarica* Linnaeus	Indian Silverbill	Resident bird	Estrildidae	Gr (Ins)
32.	*Burhinus indicus* Salvadori	Indian Thick-knee	Resident bird	Burhinidae	Moll, Rept, Frog
33.	*Argya malcolmi* Sykes	Large Gray Babbler	Resident bird	Leiothrichidae	Omn
34.	*Spilopelia senegalensis* Linnaeus	Laughing Dove	Resident bird	Columbidae	Gr, (Ins)
35.	*Curruca curruca* Linnaeus	Lesser Whitethroat	Winter migrant	Sylviidae	Ins, (Fl, Fr)
36.	*Buteo rufinus* Cretzschmar	Long legged buzzard	Vagrant	Accipitridae	Rap
37.	*Lanius schach* Linnaeus	Long-tailed Shrike	Resident bird	Laniidae	Ins
38.	*Pernis ptilorhynchus* Temminck	Oriental Honey-buzzard	Internal migrant	Accipitridae	Rap
39.	*Prinia inornata* Sykes	Plain Prinia	Resident bird	Cisticolidae	Ins
40.	*Cinnyris asiaticus* Latham	Purple Sunbird	Resident bird	Nectariniidae	Nec, Fl, Fr, (Ins)
41.	*Streptopelia tranquebarica* Hermann)	Red Collared-Dove	Resident bird	Columbidae	Gr (Ins)
42.	*Ficedula parva* Bechstein	Red-breasted Flycatcher	Winter migrant	Muscicapidae	Ins
43.	*Pycnonotus cafer* Linnaeus	Red-vented Bulbul	Resident bird	Pycnonotidae	Omn
44.	*Vanellus indicus* Boddaert	Red-wattled Lapwing	Resident bird	Charadriidae	Moll, Rept, Frog
45.	*Columba livia* Gmelin, JF	Rock Pigeon	Resident bird	Columbidae	Gr, (Ins)
46.	*Psittacula krameri* Scopoli	Rose-ringed Parakeet	Resident bird	Psittaculidae	Fr
47.	*Accipiter badius* Gmelin, JF	Shikra	Resident bird	Accipitridae	Rap

48.	*Circaetus gallicus* Gmelin, JF	Short-toed Snake-Eagle	Internal migrant	Accipitridae	Rap
49.	*Athene brama* Temminck	Spotted Owlet	Resident bird	Strigidae	Rap
50.	*Phylloscopus griseolus* Blyth	Sulphur-bellied Warbler	Winter migrant	Phylloscopidae	Ins
51.	*Rhipidura aureola* Lesson, RP	White-browed Fantail	Resident bird	Rhipiduridae	Ins
52.	*Pycnonotus leucotis* Gould	White-eared Bulbul	Resident bird	Pycnonotidae	Omn
53.	*Halcyon smyrnensis* Linnaeus	White-throated Kingfisher	Resident bird	Alcedinidae	Moll, Rept, Fish
54.	*Hirundo smithii* Leach	Wire-tailed Swallow	Internal migrant	Hirundinidae	Ins
55.	*Treron phoenicopterus* Latham	Yellow-footed Green-Pigeon	Internal migrant	Columbidae	Fr

Tab. 2. Selected plant species used by birds inhabiting or migrating through the Botanical Survey of India, Arid Zone Regional Centre, Jodhpur ; X – indicates the type of benefit for birds

No.	Name of species	Family	Nectar	Flower buds	Seeds/ pericarp	Fruits	Shelter/ nesting	Eating insects that feed on plants
1.	*Barleria prionitis* L.	Acanthaceae	X				X	X
2.	*Blepharis scindica* Stocks ex T. Anderson	Acanthaceae	X					
3.	*Dicliptera paniculata* (Forssk.) I. Darbysh.	Acanthaceae	X					X
4.	*Justicia procumbens* L.	Acanthaceae	X					X
5.	*Achyranthes aspera* L.	Amaranthaceae						X
6.	*Aerva javanica* Juss.	Amaranthaceae						X
7.	*Amaranthus spinosus* L.	Amaranthaceae			X			X
8.	*Pupalia lappacea* (L.) Juss.	Amaranthaceae						X
9.	*Calotropis procera* (Aiton) Dryand.	Apocynaceae	X					X
10.	*Cryptostegia grandiflora* Roxb. ex R. Br.	Apocynaceae	X				X	X
11.	*Agave americana* L.	Asparagaceae		X				
12.	*Aloe vera* (L.) Burm.f.	Asphodelaceae	X					
13.	*Echinops echinatus* Roxb.	Asteraceae	X					X
14.	*Cyanthillium albicans* (DC.) H. Rob.	Asteraceae						X
15.	*Cyanthillium cinereum* (L.) H. Rob.	Asteraceae						X
16.	*Tecomella undulata* Seem	Bignoniaceae	X				X	X
17.	*Cordia dichotoma* G. Forst.	Boraginaceae	X			X		X
18.	*Ehretia acuminata* R. Br.	Boraginaceae	X			X	X	X
19.	*Heliotropium europaeum* L.	Boraginaceae	X					X
20.	*Heliotropium zeylanicum* Lam.	Boraginaceae	X					X
21.	*Trichodesma zeylanicum* (Burm.f.) R. Br.	Boraginaceae	X					X
22.	*Commiphora stocksiana* (Engl.) Engl.	Burseraceae					X	X
23.	*Commiphora wightii* (Arn.) Bhandari	Burseraceae			X	X	X	X
24.	*Capparis decidua* Edgew.	Capparaceae	X		X	X	X	X

25.	*Ipomoea pes-tigridis* L.	Convolvulaceae	X				X
26.	*Diplocyclos palmatus* (L.) C. Jeffrey	Cucurbitaceae			X		X
27.	*Euphorbia caducifolia* Haines	Euphorbiaceae				X	
28.	*Euphorbia hirta* L.	Euphorbiaceae					X
29.	*Vachellia tortilis* (Forssk.) Galasso & Banfi	Fabaceae		X		X	X
30.	*Butea monosperma* (Lam.) Kuntze	Fabaceae	X				X
31.	*Crotalaria medicaginea* Lam.	Fabaceae		X	X		X
32.	*Dalbergia latifolia* Roxb.	Fabaceae	X			X	X
33.	*Dalbergia sissoo* Roxb. ex DC.	Faceacae	X			X	X
34.	*Dichrostachys cinerea* (L.) Wight & Arn.	Fabaceae				X	X
35.	*Millettia peguensis* Ali	Fabaceae	X			X	X
36.	*Ougeinia oojeinensis* (Roxb.) Hochr.	Fabaceae	X				X
37.	*Prosopis cineraria* (L.) Druce	Fabaceae		X		X	X
38.	*Pongamia pinnata* (L.) Pierre	Fabaceae	X		X	X	X
39.	*Prosopis juliflora* (Sw.) DC.	Fabaceae			X	X	X
40.	*Pterocarpus marsupium* subsp. *acuminatus* (Prain) Thoth.	Fabaceae				X	X
41.	*Senegalia senegal* (L.) Britton	Fabaceae			X		X
42.	*Tephrosia purpurea* (L.) Pers.	Fabaceae					X
43.	*Gmelina arborea* Roxb.	Lamiaceae	X		X	X	X
44.	*Vitex negundo* L.	Lamiaceae	X			X	X
45.	*Abutilon indicum* (L.) Sweet	Malvaceae					X
46.	*Pavonia zeylanica* (L.) Cav.	Malvaceae					X
47.	*Sida rhombifolia* L.	Malvaceae					X
48.	*Azadirachta indica* A. Juss.	Meliaceae	X		X	X	X
49.	*Cocculus hirsutus* (L.) W. Theob.	Menispermaceae		X			
50.	*Ficus religiosa* L.	Moraceae			X		X

51.	*Moringa concanensis* Nimmo	Moringaceae	X		X			X
52.	*Moringa oleifera* Lam.	Moringaceae	X		X			X
53.	*Eucalyptus camaldulensis* Dehnh.	Myrtaceae					X	
54.	*Syzygium salicifolium* J. Graham	Mytraceae				X	X	X
55.	*Acrachne racemosa* (B. Heyne ex Roth) Ohwi	Poaceae			X			X
56.	*Cenchrus ciliaris* L.	Poaceae			X			X
57.	*Cenchrus setiger* Vahl	Poaceae			X			X
58.	*Cynodon dactylon* (L.) Pers.	Poaceae			X			X
59.	*Dactyloctenium scindicum* Boiss.	Poaceae			X			
60.	*Dendrocalamus strictus* Nees	Poaceae					X	X
61.	*Polygala erioptera* DC.	Polygalaceae			X			X
62.	*Ziziphus mauritiana* Lam.	Rhamnaceae				X		X
63.	*Ziziphus nummularia* (Burm.f.) Wight & Arn.	Rhamnaceae			X			
64.	*Aegle marmelos* (L.) Corrêa	Rutaceae	X				X	X
65.	*Bergera koenigii* L.	Rutaceae				X	X	X
66.	*Salvadora oleoides* Decne.	Salvadoraceae				X		X
67.	*Salvadora persica* L.	Salvadoraceae			X	X		X
68.	*Santalum album* L.	Santalaceae				X		X
69.	*Sapindus trifoliatus L.*	Sapindaceae					X	X
70.	*Ailanthus excelsa* Roxb.	Simaroubaceae						X
71.	*Physalis angulata* L.	Solanaceae				X		X
72.	*Withania somnifera* (L.) Dunal	Solanaceae				X		
73.	*Holoptelea integrifolia* (Roxb.) Planch.	Ulmaceae					X	X
74.	*Balanites roxburghii* Planch.	Zygophyllaceae		X			X	X
75.	*Zygophyllum indicum* (Burm.f.) Christenh. & Byng	Zygophyllaceae						X

Fig. 3. A. Ashy Prinia, B. Asian Koel female, C. Black Drongo, D. Black Kite, E. Blyth's Reed Warbler, F. Brahminy Starling, G. Common Chiffchaff, H. Common Myna (Photo. Ravi Kiran Arigela)

Fig. 4. A. Cattle Egret, B. Coppersmith Barbet, C. Greater Coucal, D. Egyptian Vulture, E. Eurasian Scops-Owl, F. Great Whitethroat, G. Asian Green Bee-eater, H. Grey Francolin (Photo. Ravi Kiran Arigela)

Fig. 5. A. Gray Wagtail, B. House Sparrow, C. Indian Peafowl, D. Indian Robin, E. Indian Silverbill, F. Large Gray Babbler, G. Laughing Dove, H. Long legged Buzzard (Photo. Ravi Kiran Arigela)

Fig. 6. A. Long-tailed Shrike, B. Lesser Whitethroat, C. Plain Prinia, D. Lesser Goldenbacked Woodpecker, E. Red Collared-Dove, F. Red-vented Bulbul, G. Red-breasted Flycatcher, H. Red-wattled Lapwing (Photo. Ravi Kiran Arigela)

Fig. 7. A. Rose-ringed Parakeet, B. Shikra, C. White-browed Fantail, D. Common Tailorbird, E. Indian Thick-knee, F. White-eared Bulbul, G. White-throated Kingfisher, H. Spotted Owlet (Photo. Ravi Kiran Arigela)

Fig. 8. A. Barn Owl, B. Oriental Honey-buzzard, C. Common Woodshrike, D. Yellow-footed Green-Pigeon, E. Short-toed Snake-Eagle, F. Eurasian Collared Dove, G. Black Redstart female, H. Sulphur-bellied Warbler (Photo. Ravi Kiran Arigela)

Fig. 10. Plant-Bird interactions: A. Lesser Whitethroat, B. Red-vented Bulbul, C. Common Tailorbird, D. Purple Sinbird, E. White-eared Bulbul are swigging the nectar of *Tecomella undulata* Seem flowers, F. Purple Sinbird slurping the nectar of *Aloe vera* flowers, G, H. Red-vented Bulbul and Rose-ringed Parakeet gulping the *Cocculus hirsutus* (L.) W. Theob. fruits (Photo. Ravi Kiran Arigela)

Fig. 11. Plant-Bird interactions: A. Rose-ringed Parakeet, B. Red-vented Bulbul, C. Large Gray Babbler, D. White-eared Bulbul, E. Brahminy Starling, F. Asian Koel male are swallowing the fruits of *Salvadora persica* L.G. Rose-ringed Parakeet feasting the fruits of *Vachellia tortilis* (Forssk.) Galasso & Banfi, H. Indian Silverbill feeding on the caryopsis of *Cenchrus ciliaris* L. (Photo. Ravi Kiran Arigela)

Fig. 12. Plant-Bird interactions: A, B. Red vented Bulbul swigging the fruits and flower buds of *Withania somnifera* (L.) Dunal and *Balanites roxburghii* Planch., C, D. Lesser Whitethroat feeding on *Cocculus hirsutus* (L.) W. Theob. and *Balanites roxburghii*, E, F. Rose-ringed Parakeet feasting the fruits of *Prosopis cineraria* (L.) Druce and *Commiphora wightii* (Arn.) Bhandari, G. Brahminy Starling feeding on *Vachellia tortilis*, H. Purple Sunbird is feeding on the *Balanites roxburghii* (Photo. Ravi Kiran Arigela)

Fig. 13. Plant-Bird interactions: A, B, C, D. Purple Sunbird swigging the nectar of *Gmelina arborea* Roxb., *Calotrpis procera* (Aiton) Dryand., *Dalbergia sissoo* Roxb. ex DC. and *Butea monosperma* (Lam.) Kuntze, E, F. Rose-ringed Parakeet feeding on the fruits of *Azadirachta indica* and *Pongamia pinnata*, G. White-eared Bulbul swallowing the figs of *Ficus religiosa* L., H. House Sparrow gleaning the insects on *Vachellia tortilis* (Forssk.) Galasso & Banfi (Photo. Ravi Kiran Arigela)

Abstract

Observations of plant-bird interactions at the Botanical Survey of India (BSI), Arid Zone Regional Centre (AZRC) in Jodhpur campus have been supported by photographic evidence. A total of 55 species of birds have been recorded here, including winter migratory birds (8), internal migratory birds (7) and sedentary birds (40). In the analysed area, interactions of birds with 75 species of plants, representing 34 families, were recorded (most of these plants belong to the families Fabaceae and Poaceae). During the observation, it was found that these plants brought various benefits to the birds living in the area. Most plants are a source of insects that are part of the diet of birds and a shelter or nesting site. These observations allowed for the formulation of conclusions regarding the importance of urban gardens and native plant species for the preservation of biodiversity in urbanised conditions.

Keywords: biodiversity, birds, urban environment, habitat, migration, pollinators, seed dispersal

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Awifauna i jej interakcje z roślinami w Botanical Survey of India, Arid Zone Regional Centre, Jodhpur, Radżastan, Indie

Streszczenie

Obserwacje oddziaływań między roślinami a ptakami w Botanical Survey of India (BSI), Arid Zone Regional Center (AZRC) w kampusie Jodhpur zostały poparte dowodami fotograficznymi. Zarejestrowano tu łącznie 55 gatunków ptaków, w tym migrujące zimą (8), migrujące wewnętrzne (7) i ptaki osiadłe (40). Na analizowanym obszarze odnotowano oddziaływania ptaków z 75 gatunkami roślin, reprezentującymi 34 rodzin (większość z tych roślin należy do rodzin Fabaceae i Poaceae). W trakcie obserwacji stwierdzono, że rośliny te przynoszą różnego rodzaju korzyści ptakom żyjącym na tym terenie. Większość roślin jest źródłem owadów wchodzących w skład diety ptaków oraz schronieniem lub miejscem gniazdowania. Obserwacje te pozwoliły na sformowanie wniosków dotyczących znaczenia ogrodów miejskich i rodzimych gatunków roślin dla zachowania różnorodności biologicznej w warunkach zurbanizowanych.

Słowa kluczowe: różnorodność biologiczna, ptaki, środowisko miejskie, siedlisko, migracja, zapylacze, rozsiewanie nasion

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