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Plant-Avian Frugivory in the Urban Ecosystem of Delhi

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ABSTRACT

Plant-frugivore interactions are important ecological processes that play a vital role in maintaining the dynamics of the ecosystem. Birds are very important frugivores and very little is known about the plant-avian interaction matrix in the urban ecosystems of India. The present study endeavours to understand and document the plant–avian frugivory interactions in the human-dominated green spaces which is a mosaic of selectively planted exotic and native tree species in Delhi. A total of thirty avian frugivore species were recorded feeding on twenty-two focal tree species using phyto-centric approach. Characteristic traits of fruits like fruit diameter, colour and type and their interacting avian species were studied based on their fruit handling behaviour. The highest number of avian frugivore species were observed on native *Ficus* tree species in urban Delhi ecosystem, thereby providing evident proof of being an important food resource for avian disperser communities. The study suggests to introduce more native fig tree species in the city plantations to enhance and sustain the avian diversity in the novel fragmented urban ecosystems.

***Key words**: Urban ecosystem, Delhi, Phyto-centric approach*

Introduction

Seed dispersal is the most important dynamic process in the life history of plants as it promotes smooth gene flow within and among plant populations. Expansion implies dispersal of immobile plants species as they require some mechanism to disperse their diaspores to new habitable areas (van der Pijl, 1982). Successful dissemination of seeds involve a variety of biotic and abiotic dispersal factors (Jordano *et al.*, 2007). Dispersal of seeds by frugivores is one of the ancient ecological processes that has driven global plant evolution and diversification. It allows plants to reduce competition among kin and to colonize new, suitable habitats. Among biotic dispersers, birds play a very crucial role in the seed dispersal process in many tropical and temperate ecosystems as they feed on fleshy fruits and deposit (via excretion or regurgitation) the seeds away from the parent plant (Herrera, 1995; Jordano and Schupp, 2000; Whelan *et al.*, 2008). In tropical and subtropical Asia, 65% to 90% of woody plant species are dispersed by vertebrates, with birds dispersing maximum species of plant species (Corlett, 2011; Datta and Rawat, 2008 and Ganesh and Davidar, 2001). Various factors, like fruit crop size, fruiting phenology, and the fruit's size, structure, scent and chemical composition of pulp, seed size and texture

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influence how fruit species are utilized by frugivores (Howe and Miriti, 2004) while the body size, gape size, mass of frugivore birds are used as the characteristics of feeding patterns (Zhang *et al.*, 2022).

Urbanization is one of the most important threats to biodiversity and one of the key causes of local species extinction (McKinney, 2006). Urban green spaces like parks, gardens, avenues within cities and towns are examples of unique ecosystems that have developed as a result of the coexistence of novel species mixtures and environmental conditions (Baiser *et al.*, 2012; Cruz *et al.*, 2013; Hobbs *et al.*, 2006; McKinney, 2006). Avenue trees that are commonly exotic, are planted on roadsides, parks and gardens, face anthropogenic selective pressures which include fragmentation, degradation of habitat and defaunation in urban areas increasing the vulnerability of interactions involving homogenization of urban avian frugivores by generalist mediated seed dissemination. (Gelmi-Candusso and Hämäläinen, 2019; McConkey and O'Farrill, 2016; Ruxton and Schaefer, 2012; Stanley and Arceo-Gomez, 2020). As a result, urbanisation is anticipated to have a major impact on the abundance and characteristics of frugivores, which will have important repercussions for the success of introduced and native plant populations in urban settings (Stanley and Arceo-Gomez, 2020). Various animals adapt and evolve alongside with the changes in urban green spaces. Together, these organisms create unique, intriguing urban habitats that are required to be investigated thoroughly in order to understand the novel urban ecosystem.

In Asia, India is an important contributor to the current global urban explosion in cities. Increased urbanization has created challenges for management of natural areas within cities (Nagendra *et al.*, 2013). Delhi being one of the world's largest cities is not an exception. However, biotic interactions in particular the plant-frugivore interaction urban ecosystems are negligibly studied and documented in India. Investigating interactions and their complexity helps to comprehend about ecological and evolutionary processes in the anthropocentric landscapes (Bascompte and Jordano, 2007; Ings *et al.*, 2009; Strauss and Irwin, 2004; Vittoz and Engler, 2007). The present study aims to identify the plant – avian interaction in the fruiting tree species in the urbanized centre of Delhi providea baseline data towards understanding of novel dispersal dynamics of important tree species in the urban green spaces.

Materials and Methods

Study site

Delhi covers an area of 1483 sq. km and lies in a humid subtropical climate having a hot summer with temperature reaching up to 46 ºC from May to July and a cold winter from November to February

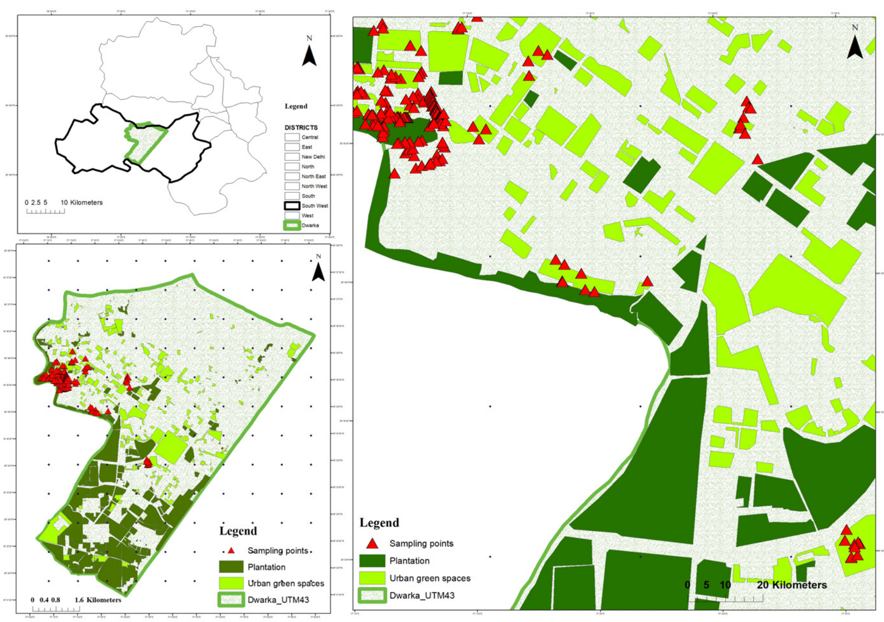

Fig. 1. Map of Dwarka sub-city (green) in south-west Delhi District highlighting sampling points (red).

(Krishen, 2007) with an average annual rainfall of 60 cm from August to September. It comprises of 18,000 parks and gardens in about 80 sq.km at various locations (Delhi Society of Parks and Gardens, 2023). The present study was undertaken from January 2021 to December 2022. The seed dispersal pattern was studied in the urban green spaces of human-dominated landscape of Delhi in Dwarka (28° 32′ to 28° 38′ North and 77° 0′ to 78° 8′ East) region in the south-west district of Delhi (Delhi Development Authority, 2023). This region is recent urban extension that has a complex pattern of urbanization with mosaic of green spaces, avenue trees and concrete buildings. Remnants of natural vegetation comprises of 'thorn forest' still persist among the green spaces of this region (Krishen, 2007). The other important feature of the study area is the Najafgarh drain, a significant man-made feature and surrounding agricultural lands, provides a suitable habitat for a variety of bird species in this region. Numerous fleshy fruit tree species planted in parks, gardens and avenues attracts many avian frugivores.

Methodology

A total of 22 focal tree species were selected on the basis of their dominance in avenues, parks and gardens. The phenology and fruiting period of these tree species were noted from Maheshwari (1963) and Krishen (2007) and recorded visually in the study area. The avian frugivores interacting with the selected focal tree species were directly observed through extended tree watches in the field following phyto-centric approach (Jordano, 2016). Data on avian visitors and fruit handling technique was obtained through tree watches (Bollen *et al.,* 2004). Tree watches were done early morning between 0600 hrs. and 0900 hrs and evening between 1630 hrs to 1800 hrs during summers and 0700 hrs. to 1000 hrs. in the morning and 1600 hrs to 1700 hrs in winters from a hideout that was set up about 15-20 meters away using Nikon Action EX (8 X 40) binoculars. No observations were made on windy, foggy and rainy days.

Avian frugivore species were observed and identified using manual of Grimmett *et al*., 2012. Plant-avian interactions were photographed using Sony alpha 600 digital camera. Frugivores were also observed and categorized according to their feeding guild as chiefly frugivore, omnivore, granivore and insectivorous. Gape width and mass for each avian frugivore was recorded using secondary data. Avian frugivores were observed and photographed using Sony alpha 600 camera and categorized on the basis of fruit handling behavior as gulpers, mashers and peckers (Levey, 1987). Avian frugivores were also given codes as provided in Table 2.

Ripe fruits were collected and photographed in the field from beneath the fruiting tree species in the field. Photographs of ripe fruits were also taken in the lab using a stereomicroscope MZ12.5. Fruit color namely black-purple, brown, red, green, yellow and orange (Willson and Thompson, 1982; Wheelwright and Janson, 1985), and fruit type (Shivanna and Tandon, 2014) were observed and recorded. Diameters of fruits were also measured using digital vernier caliper. Maximum of 50 samples of each fruit

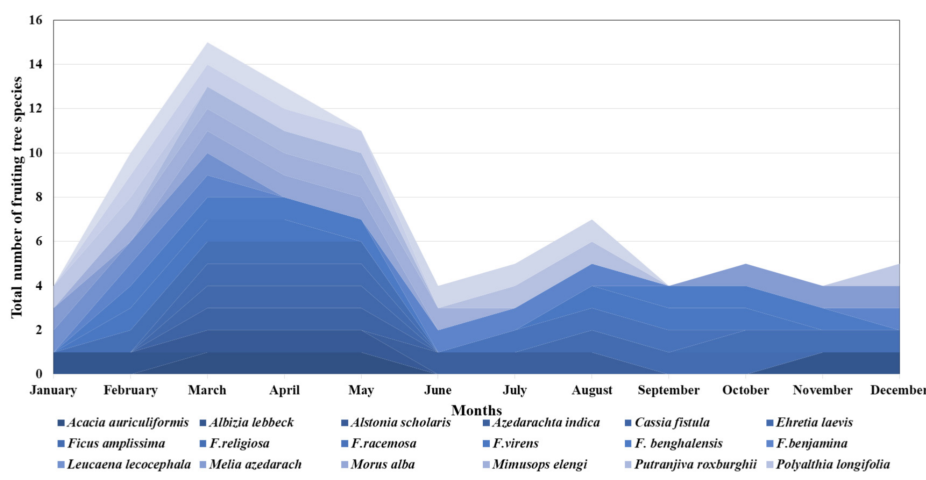

Fig. 2. Fruiting phenology of the focal tree species

species were taken for measurement. Data collected from the field were analysed using MS-Excel and IBM SPSS Statistics version 21.

Results

Focal tree species phenologyand composition

Fruiting period of 22 focal tree species belonging to 17 genera of 12 families were observed which peak in the month of March (15 species). It was observed that fruits of Moraceae flushed twice in a year asynchronously (Fig. 2). Among 22 tree species, 4 tree species namely *Acacia auriculiformis*, *Leucaena leucocephala*, *Azadirachta indica* and *Morus alba* are exotic (Table 1).

Feeding guild and dietary composition of avian frugivores

A total of 30 species of avian frugivores were observed foraging on the focal fruit-bearing tree species. Maximum avian frugivores (67%) were Passeriformes and common myna was found to feed on 12(54%) fruiting tree species, while red-vented

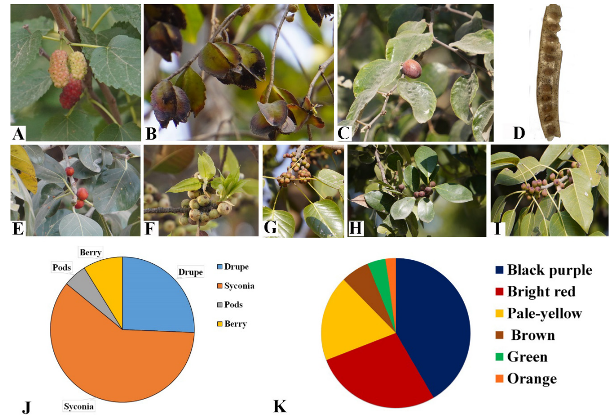

Fig. 3. Fruit types and colour handled by avian frugivores (A) Berry fruit type of *Morus alba*, Drupe of (B) *Terminalia arjuna* and (C) *Ziziphus auritiana* (D) Pod of *Leucaena leucocephala* Syconia (figs) of (E) *F. benghalensis* (F) *F. virens* (G) *F.religiosa* (H) —*F.benjamina* (I) *F. amplissima*; Pie chart showing proportion of (J) fruit types and (K) fruit colour spectra handled by all the avian frugivore species in the study area

Table 1. Focal tree species (Kew science. Plants of the World Online. 2017, March) and their fruit traits observed in the study area

Family	Tree species	Fruit type	Fruit colour	Fruit diameter (mm)	Nativity
Annonaceae	*Polyalthia longifolia* (Sonn.) Benth. & Hook.f. ex Thwaites	Drupe	Black-purple	12.79	Native
Apocynaceae	*Alstonia scholaris* (L.) R.Br.	Pod	Brown	3.13	Native
Boraginaceae	*Ehretia laevis* Roxb.	Drupe	Orange	5.25	Native
Combretaceae	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Drupe	Brown	22.94	Native
Fabaceae	*Acacia auriculiformis* A. Cunn. ex Benth.	Pod	Green	3.94	Exotic
	Albizia lebbeck (L.) Benth.	Pod	Brown	6.36	Native
	Cassia fistula L.	Pod	Brown	19.98	Native
	Leucaena leucocephala (Lam.) de Wit	Pod	Brown	6.57	Exotic
Meliaceae	*Azadirachta indica* A.Juss.	Drupe	Pale-Yellow	10.89	Exotic
Moraceae	*Ficus amplissima* Sm.	Syconia	Black-purple	13.36	Native
	Ficus religiosa Forssk.	Syconia	Black-purple	10.93	Native
	Ficus racemosa L.	Syconia	Red	28.58	Native
	Ficus virens Aiton	Syconia	Pale –yellow	20.52	Native
	Ficus benghalensis L.	Syconia	Red	13.09	Native
	Ficus benjamina L.	Syconia	Black purple	8.05	Native
	Morus alba L.	Berry	Black-purple	10.5	Exotic
Meliaceae	*Melia azedarach* L.	Drupe	Pale-Yellow	14.13	Native
Myrtaceae	*Syzygium cumini* (L.) Skeels	Drupe	Black-purple	12.68	Native
Putranjivaceae	*Putranjiva roxburghii* Wall.	Drupe	Green	11.63	Native
Phyllanthaceae	*Phyllanthus emblica* L.	Drupe	Green	36.4	Native
Rhamnaceae	*Ziziphus mauritiana* Lam.	Drupe	Red	9.91	Native
Sapotaceae	*Mimusops elengi* L.	Berry	Orange	12.07	Native

bulbul consumed 11(50%) fruit species. About 57.66% of avian species consuming fruits were omnivorous while only 33% were chiefly frugivorous. Alexandrine parakeets, brown-headed barbet, copper-smith barbet, golden oriole, Indian gray hornbill, red-vented bulbul, red whiskered bulbul, rose-ringed parakeet and yellow footed green pigeon were chiefly frugivorous species while common myna, followed by Asian koel, house crow, Indian white eye and rufous tree pie were observed as omnivores that relied on fruiting tree species. Only 10% granivores were observed to be feeding on fruiting tree species. Asian koelwas also observed handling 11 fruiting tree species.

Most of the avian frugivores were observed to consume fruits of *Ficus religiosa* followed by *F.benghalensis, F. virens, Morus alba, F. benjamina* and *F. amplissima* (Fig. 5). Fig-eating birds were found to have feeding guilds ranging from almost completely insectivorous (common tailor bird, red-breasted fly-catcher) to entirely frugivorous (yellow-footed green pigeon, rose-ringed parakeets, alexandrine parakeets). Among all avian frugivores, passerines were observed to handle maximum fig tree species.

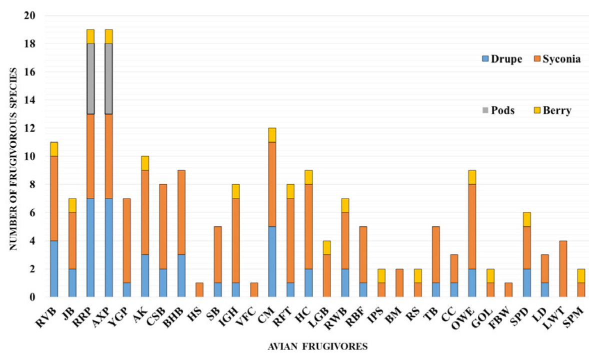

Fig. 4. Frequency distribution of all fruit types handled by each frugivore species

Rose-ringed parakeets and Alexandrine parakeets consumed a maximum of 19(86%) out of 22 fruiting tree species. Among non- fig species, fruits of *Morus alba* were handled maximum by frugivore species. Surprisingly no avian frugivore was observed on *Mimusops elengi*. (Fig. 5B). Yellow-footed green pigeon, Coppersmith barbet and brown headed barbet were observed to feed on *Ficus* species.

Fruit characters and its effects on avian assemblage

Fruit type, colour, and diameter were also determined for the selected focal fruiting tree species (Table 1). Four types of fruits were observed, which included: Syconia (Figs) (*Ficus amplissima, F. benjamina, F. benghalensis, F. racemosa, F. religiosa* and *F. virens)*, drupes (*Azadirachta indica, Ehretia laevis, Melia azedarach, Phyllanthus emblica, Polyalthania longifolia Putranjiva roxburghii, Syzygium cumini, Terminalia arjuna, Ziziphus mauritiana*)berries (*Mimusops elengi, Morus alba*) and pods(*Acacia auriculiformis, Albizia lebbeck, Alstonia scholaris, Cassia fistula, Leucaena leucocephala*). Maximum frugivore species were found to be feeding on syconia, followed by drupe, berry and pods (Fig. 3 and 4). Syconia (figs) were consumed by all frugivorous species found in the study area. Drupes were consumed maximum by alexandrine parakeet and rose-ringed parakeet followed byred-vented bulbul. Woody fibrous drupe of *Treminalia arjuna*, *Polyalthia longifolia,*

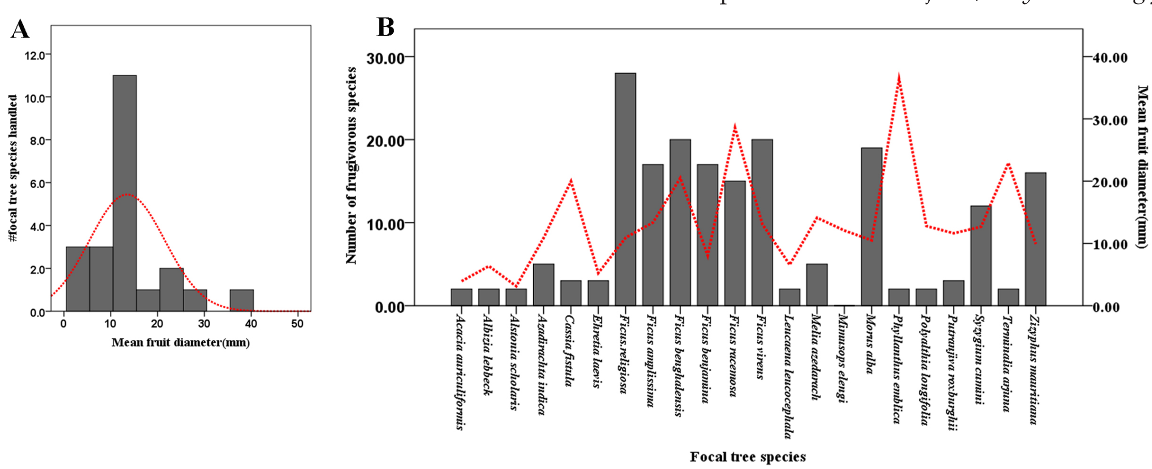

Fig. 5(A). Mean fruit diameter handled by avian frugivore **(B)** Frequency of avian frugivore species handling fruits species, along with their respective fruit diameter

Table 2. Avian frugivore species, their IUCN status along with their observed feeding guild, gape width and mass

Order	Family	Avian species	Avian species code	Common name	IUCN status*	Body mass (g)	Gape width (mm)	Feeding guild
Buceroti formes	Bucerotidae	*Ocyceros birostris*	IGH	Indian gray hornbill	LC	375	58.29	Frugivore
Columbi formes	Columbidae	*Spilopeliasene galensis*	LD	Laughing dove	LC	80	9	Granivore
		Spilopeliachinensis	SPD	Spotted dove	LC	163	8.6	Granivore
		Treron phoenicopterus	YGP	Yellow-footed green pigeon	LC	230	12	Frugivore
Cuculi formes	Cuculidae	*Eudynamys scolopaceus*	AK	Asian Koel	LC	222	19.8	Omnivore
Passeri formes	Cisticolidae	*Orthotomussutorius*	TB	Common tailor bird	LC	8	5.6	Insectivore
	Corvidae	*Corvus splendens*	HC	House crow	LC	255	19	Omnivore
		Dendrocittavagabunda	RFT	Rufous treepie	LC	110	14.5	Omnivore
	Estrildidae	*Lonchurapunctulata*	SBM	Scaly breasted munia	LC	13	8	Omnivore
	Leiothrichidae	*Argyastriata*	JB	Jungle babbler	LC	70	11.6	Omnivore
		Argyamalcolmi	LGB	Large gray babbler	LC	115	13	Omnivore
	Muscicapidae	*Ficedulaparva*	RBF	Red-breasted flycatcher	LC	10	5	Insectivore
		Eumyiasthalassinus	VFC	Verditor flycatcher	LC	17	9	Omnivore
	Nectariniidae	*Cinnyrisasiaticus*	SB	Purple sunbird	LC	9	4.9	Nectarivore
	Oriolidae	*Orioluskundoo*	GOL	Indian Golden oriole	LC	75	11.2	Frugivore
	Passeridae	*Passer domesticus*	HS	House sparrow	LC	28	9.329	Granivore
	Phyllosco pidae	*Phylloscopus collybita*	CC	Common chiffchaff	LC	11.5	5.4	Insectivore
	Pycnonotidae	*Pycnonotus cafer*	RVB	Red-vented bublbul	LC	47.5	10.6	Frugivore
		Pycnonotus jocosus	RWB	Red whiskered bulbul	LC	27.5	8.8	Frugivore
	Sturnidae	*Gracupica contra*	IPS	Indian pied starling	LC	86	12	Omnivore
		Acridotheres ginginianus	BM	Bank myna	LC	70	20	Omnivore
		Acridotheres tristis	CM	Common myna	LC	112.5	10.5	Omnivore
		Pastor roseus	RS	Rosy starling	LC	74.5	9.6	Insectivore
	Sylviidae	*Currucacurruca*	LWT	Lesser white throat	LC	10	5.4	Insectivore
	Zosteropidae	*Zosterops palpebrosus*	OWE	Indian white eye	LC	12	7.14	Omnivore
Piciformes	Megalaimidae	*Psilopogon zeylanicus*	BHB	Brown headed barbet	LC	110	18	Frugivore
		Psilopogon haemacephalus	CSB	Coppersmith barbet	LC	40	13	Frugivore
	Picidae	*Dinopiumbenghalense*	BRF	Black-rumped Flameback	LC	107	17	Omnivore
Psittaci formes	Psittaculidae	*Psittacula eupatria*	AXP	Alexandrine parakeet	NT	230	25	Frugivore
		Psittacula krameri	RRP	Rose ringed parakeet	LC	125	14.6	Frugivore

(Note: *LC: Least concern, NT: Near threatened; Birds name follow Grimmett *et al*., 2012 and body mass and gape width were sourced from Balasubramanian,1996; Naniwadekar *et al.,* 2019; Gopal *et al*., 2020; Tobias *et al*., 2022; Partasasmita *et al*., 2018) berry of *Phyllanthus emblica* and pods of *Acacia auriculiformis, Albizia lebbeck, Alstonia scholaris, Leucaena leucocephala* were only predated by alexandrine parakeet androse-ringed parakeet for its seed, while fruits of *Ficus* species were crushed in the bills and small seeds were ingested along with pulp (Fig. 4).

A high proportion of black-purple colored fruits followed by bright red observed belonged to Moraceae family except *F. virens* which are pale-yellow colored. Maximum fruits handled by frugivores were of black-purple color followed by bright-red. Least number of fruits handled were of orange color (Fig. 4).

Fruit diameter were highly variable and ranged from 36 mm *(Phyllanthus emblica)* to 4 mm *(Ehretia laevis)* (Fig. 2B). Fruit choices and handling behaviour of avian frugivores were also influenced by the fruit diameter and gape size of avian frugivores. Maximum proportion (50%) of fruits handled by the frugivores ranged from 10-15 mm.77% of fruits with diameter ≤ 15 mm were handled by frugivores (Fig. 6). Gape width of frugivores varied from 5.4 mm to 54.29 mm (Table 2) and mean fruit diameter was found to be positively correlated with the gape width (r_s = 0.40397, p (2-tailed) = 0.02683.) and body mass of the frugivore (r_s = 0.42817, p (2-tailed) = 0.01825). However, there was no correlation between the mean fruit diameter and number frugivore species visiting the focal tree species (r_s = 0.173, p (2-tailed) = 0.221) (Fig. 6).

Fruit handling behaviour

The frugivores in the study area comprised 47% obligatory peckers, 30% obligatory gulpers, 17% peckers and gulpers and only 7% mashers (Fig.7). House crow, rufous tree pie, jungle babbler, Indian white eye, common tailor bird were observed to be the major peckers in the study area. Red vented bulbul, red whiskered bulbul, common myna, were observed to swallow small sized fruits while pecked the pulp of large sized fruit. They were observed pecking on fruits of *Ficus benghalensis*, *Meliaazedarach* and *Syzygium cumini* while gulping the complete fruits of *F. religiosa, F.amplissima, F. benjamina, F.virens* and *Morus alba*. Indian gray hornbill, yellow-footed green pigeon, Asian koel, coppersmith barbet and brown headed barbet were observed as major gulpers in the study area. They swallowed the complete fruit irrespective of the fruit diameter due to their large gape size. Onlyalexandrine parakeets and rose-ringed parakeets mashed the fruits externally in their bills and were much less gape-limited, therefore were observed to consume maximum fruit species in the study area (Fig. 4).

Discussion

The avian frugivore assemblage in the urban landscape of Delhi is typically complex since it is a novel ecosystem with maximum number of tree species are selectively planted. But due to lower number of dispersal studies in urban landscapes in India, there is a need to study these plant-frugivore interactions.

Fruit traits

A total of 30 species of avian frugivores were observed in the Dwarka sub city of South-West Delhi handling diverse variety of fruits. Our investigation revealed the significance of fruit traits like fruit diameter (Howe and Estrabook, 1977), type (Wenny and Levey, 1998) and color (Wheelwright and Janson, 1985) that are responsible for attracting avian dispersers in the novel landscape.

Fruit size play a significant role in fruit selection of avian frugivores (Howe and Estabrook, 1977;

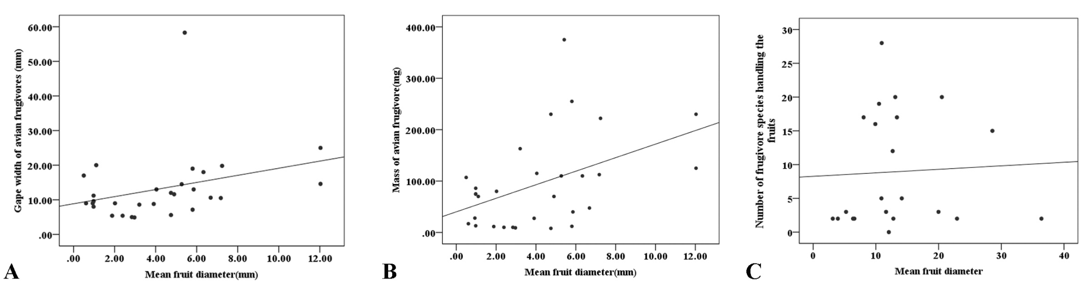

Fig.6(A). Correlation between gape width of frugivore and mean fruit diameter **(B)** Correlation between body mass of avian frugivores and the mean fruit diameter **(C)** Correlation between number of frugivore species handling the fruits and mean fruit diameter in the study area

Leighton and Leighton, 1983). It is important for a frugivore to adapt, for efficient handling of fruits.Our results showing the maximum handling of fruits with diameter ≤ 15 mm is supported by the optimum foraging theory where medium sized fruits were chosen over small and large sized fruits for acquiring high energy with lowest efforts (Wheelwright, 1985). Medium-sized fruits are often easier for birds to handle and manipulate as compared to large fruits as they are small enough to be consumed by smaller bird species, but also attractive enough to larger bird species like Indian gray hornbill, yellow footed green pigeon to be transported over longer distances. Similar results were also reported in the study from Sriharikota where avian fruits were generally small (≤ 10 mm) in diameter (David *et al.,* 2011). This shows that efficient handling of a given fruit is determined by the fruit size relative to the body size of avian frugivore, specifically the gape width and body mass in the mutualistic frugivory networks.

It was found that as the gape size of birds increased, the number of fruit species handled also increased. Positive correlation between gape widths and fruit diameter have also been reported earlier ((Bender *et al.*, 2018; Naniwadekar *et al*., 2019; Palacio *et al*., 2016; Stevenson *et al.,* 2005; Wheelwright, 1985). All the frugivorous species observed in the present study with large gape size were legitimate seed disperser as they swallowed the complete fruit and dropped the seeds away from the parent plants. Asian koel proves to be a legitimate seed disperser as it swallowed a wide array of fruit species in the urban green spaces due to its large gape size. For successful dissemination of seeds away from the parent plant, fruits produced should be of size that can be swallowed by the maximum frugivorous community. However, it is important to note that the relationship between gape size and fruit diameter is not always straight forward. Other factors, such as the shape and texture of the fruit, can also influence a bird's ability to consume it. Additionally, some bird species may be able to manipulate larger fruits to make them easier to consume, using techniques such as pecking or breaking the fruit into smaller pieces. It is evident from our observations that synanthropic species like common myna and red-vented bulbul handled fruits depending on the fruit diameter; fruits with diameter greater than the gape size were pecked while fruits with smaller diameter were swallowed.

Fruit color has also been the most extensively studied fruit trait, owing to the fact that various avian frugivores perceive different colors, and this has played a crucial role in determining the evolutionary selection of plant species. (Hill *et al.,* 2021). Maximum fruits of black-purple followed by red color were handled by the frugivores in the present study. However, unripe green fruits of only *Ficussp.* were observed to be handled at the same time. This shows adaptation become an opportunistic frugivore is in process but reasons are still not clear (Snow, 1971). Fruits with dark color and high contrast against the foliage indicate the ripening and maturity of fruits giving feeding cues for avian species (Wheelwright and Janson, 1985). Similar results were obtained in the study conducted in Point Calimere Wildlife Sanctuary in South India, red followed by black coloured fruits were preferred by avian frugivores (Balasubramanian and Maheswaran, 2003). However, according to Kamruzzaman and Asmat (2008), dominant fruit color choices made by avian frugivores are red, green and yellow respectively.

Among all fruit types, present study confirmed that maximum frugivores were attracted by syconia (fig) tree species. The ease with which figs were handled by diverse assemblages of avian frugivores ranging from small passerine birds like Indian white eye, red-vented bulbul to medium and large-bodied birds like yellow-footed green pigeon, barbets, Indian grey hornbill, parakeets, the crow contribute to the unique role that *Ficus* plays in frugivore survival in the urban landscape of Delhi. In the present study *F. religiosa* and *F. benghalensis* attracted maximum frugivore species. Soft flesh of figs can be penetrated by the bills of birds that are unable to swallow the whole fruit. These urban fig communities easily thrive in the urban areas like sides of buildings and stones and play a very important role in maintaining its avian frugivore diversity thereby providing us an opportunity to look at the relationships between an entire fig flora and an entire frugivore fauna (Harrison, 2005; Lambert and Marshall, 1991; Leighton, 1983; Milton *et al*.,1982; Shanahan *et al*., 2001; Sreekar *et al*., 2010; Terborgh, 1986).Therefore, figs *(Ficus spp*.) are considered to be keystone plant resources for many tropical forests such as those in Panama (Korine *et al*., 2000), South Africa (Bleher *et al.,* 2003), Peninsular Malaya (Lambert and Marshall 1991), India (Kannan and James, 1999), and Indonesia (Leighton and Leighton, 1983).

Frugivore Assemblage

Frugivore assemblage in the urban landscape of Delhi is typically complex. Frugivores of passeriformes order belonging to family Sturnidae, Pycnonotidae and Corvidae were predominant frugivores in the human dominated landscape of Delhi. Earlier studies have also shown that members of the Sturnidae family, members of Pycnonotida family like red-vented bulbul and red-whiskered bulbul are very important frugivores in the human dominated landscape of subtropical Asia (Balasbramanian, 1996; Corlett, 1998; David *et al*., 2011; Levey, 1987). These trends are also confirmed in the subtropical forests in Hong Kong (Corlett, 1998) and Yakushima Island (Noma and Yumoto, 1997). These results confirm that small to medium sized birds are more common frugivores in the urban disturbed landscape as they are more resilient and adapted to high level disturbances (Blanco *et al.,* 2019).

Rose-ringed and alexandrine parakeets were also found to be opportunistic frugivores as they handled maximum number of native and exotic fruiting tree species and predated on almost all fruit types found in the study area. They predated on pods of *Acacia auriculiformis Albizia lebbeck, Alistonia scholaris, Cassia fistula* and *Lecaena leucocephala.* Fruits of *Alistonia scholaris* planted along the avenues are reported to be dispersed by wind but we observed that their fruits were predated by parakeets. This shows thatthey are experimenting and developing new dynamics with the fruiting tree species to evolve and better adapt to the novel plant mixture in urban green spaces. However, besides being a frugivore it is a seed predator, and therefore can be categorized as dyszoochorous species since they destroy the seeds and causes immense damage to the fruits (Rasmussen and Anderton, 2005).

This study provided a first ever baseline record of plant-avian frugivore interactions in the human-dominated landscape of South-west Delhi that are comparable to those at other study locations in Southeast Asia. Our study suggests that fruit consumption by avian frugivores is highly influenced by fruit colour, size and type. Fruit handling behaviour of avian frugivores determine the effective dispersal of seeds. Fig tree species attracted all the avian frugivore species observed and can be considered as the keystone species due to the fruit availability and being soft and fleshy made it easily accessible for all avian frugivores irrespective of their gape size. Therefore, the study of plant-frugivore mutualistic interactions and their consequences for individual plant fitness has become crucial for understanding ecological systems which are novel in fragmented urban habitats (Bronstein *et al*., 2006; Valiente Banuet *et al*., 2014).

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