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Birds of Karachi University and Dow University of health sciences campuses, Karachi: With notes on their feeding habit

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Abstract
The avifaunal survey of the campuses of the University of Karachi (K.U.) and Dow University of Health Sciences (D.U.H.S.) is based on long term of observations (1996-2015, K.U. and 2008-2015 D.U.H.S.). The purpose of presenting a comprehensive list is to document the avifauna of the two selected sites and to bring awareness among scientists, naturalists and bird lovers regarding the dwindling population of birds at the two university campuses and the need for conservation and preservation of natural vegetation and the associated avifauna. Both the campuses have a variety of planted and some naturally growing trees and also have large or small patches of semi-natural, vegetation. At K.U. campus there are several small ponds in the gardens of the departments. The birds were recorded on a weekly basis using binoculars for about 4 h a day. Identification was based on standard field guides and manuals. A total of 49 bird species were recorded, belonging to 12 orders and 27 families. With the exception of a few game birds, observations were taken on their feeding behavior which also reflects the association between plant species and the bird species. Whereas all 49 species occurred on the Karachi University campus, only 40 species were recorded from the Dow University of Health Sciences campus. Suggestions are given for the conservation of the avifauna at the two selected sites.

Keywords: Avifauna, diet of birds, Dow University of Health Sciences Campus, Karachi University Campus

1. Introduction
Bird populations of an area are of great significance from the standpoint of food-webs and owing to being outstanding indicator of a healthy ecosystem. The class Aves that includes birds, an exclusively distinct and successful clade, comprises of an estimated 10,417 species worldwide [1]. The bird fauna of both India and Pakistan has been extensively studied [2, 3]. Long-term surveys have reported approximately 778 species of birds from Pakistan [3]. People enjoy looking at birds, in particular their beauty of form, color of plumage, their flights and movements, their nests and sweetness of their songs. Many people keep one or more species of birds as pets. Birds are a significant component of the ecosystems and are often regarded as indicator species of inhabited areas [4]. Urbanization and industrialization both present specific challenges to conservation biologists. Undoubtedly, urban expansion results in the conversion of crop- lands, grasslands, and forested areas into built-up environments on a large scale [5], little is known regarding the impact of urbanization on ecosystems, communities, and species populations [6,7] . Population of birds and their diversity indicates the extent of urbanization and pollution in both terrestrial and aquatic ecosystems [8, 9]. Birds also play an important role in the dispersal of seeds (endozoochory) and provide the means of release of plant genetic variability into new habitats. A number of migratory birds enter the territory of Pakistan in winter and settle at the coast or interior water bodies of Sindh and Baluchistan. They are important from several viewpoints. Migratory birds can carry a wide range of viral, bacterial, fungal and protozoan zoonotic agents, either they are diseased or being seemingly healthy or carriers, and hosts of infected vectors [10]. Given their ability to fly freely and cover long distances during annual migrations, migratory birds potentially play a key role in the epidemiology of human-associated zoonoses [11].

The University of Karachi was established by an act of Pakistan parliament in June, 1951. The present campus, to which the University shifted in 1959, is spread over 1279 acres of land, situated 12 Km away from the city center.

There are over 52 departments and 19 research institutes/ centers, which are imparting education to more than 24,000 students. About 20 departments (or institutes) have been built since 1980's which obviously has resulted in considerable depletion of the area of natural vegetation and thereby bird populations and diversity. Dow University of Health Sciences (D.U.H.S.) campus is situated at about 1.5 kilometer away from Karachi University (K.U.) towards east at Gulzar-e-Hijri, SUPARCO Road. It is somewhat smaller campus compared to University of Karachi. However, it has a number of small gardens and patches of semi-natural vegetation as well as small groves of native and introduced trees that provide habitats to a variety of bird species. Since D.U.H.S. is built on the former Ojha Sanatorium (established 1942), it has some old trees and natural vegetation, adjacent wilderness or un-built area was also included for the D.U.H.S. campus.

The principal object of this study is to provide a list of bird species of both Karachi University and Dow University of Health Sciences campuses as well as to present notes on their feeding habit. This paper also relates to a certain extent the association between bird species with the specific plant species on which they may be dependent for their food or shelter.

2. Materials and Methods

The avifaunal survey of the campuses of the University of Karachi (K.U.) and Dow University of Health Science (D.U.H.S.) is based on a long term of observations (1992-2015, Karachi University campus. and 2008-2015 Dow University of Health sciences campus). Both Karachi University and Dow University campuses have a variety of planted and some naturally growing trees and in addition possess natural, though partially disturbed vegetation. The planted trees include *Azadirachta indica, Delonix regia*, *Peltophorum pterocarpum* (*syn. P. roxburghii*), *Polyalthia longifolia*, *Cassia fistula*, *Albizia julibrissin*, *A.lebbeck Tamarindus indica, Eucalyptus* spp., *Erythrina suberosa, Moringa oleifera*, *Ficus religiosa*, *F. virens, F. benghalensis, Pithecellobium dulce, Morus alba, Mangifera indica, Psidium guajava, Manilkara zapota, Aegle marmelos, Dalbergia sissoo, Leucaena leucocephala, Terminalia catapa, Mimusops elengi, Plumeria obtusa, Alstonia scholaris, Cordia subestena*, *Casuarina equisetifolia, Guaiacum officinale, Millingtonia hortensis, Roystonia regia, Cocos nucifera, Phoenix dactylifera*, etc. In addition, there are also trees of wild species including *Prosopis cineraria*, *P. juliflora*, *P. glandulosa*, *Parkinsonia aculeata, Zizyphus mauritania, Vachellia nilotica* (syn. *Acacia nilotica*), *Thespisia pupulnea*, *Cordia myxa*, *Cordia gharaf*. A number of flowering climbers (cultivated) are also common, they include *Bougainvillea glabra*, *Jasminum grandiflorum*, *Quisqualis indica*, *Ipomoea reticulata*, *Tecoma* sp. Some of the above mentioned tree species were not seen at the campus of Dow University of Health Sciences. It had slightly lesser number of tree species as well as density. Some shrubs are often used for building hedges including *Clerodendrum inerme*, *Dodonaea viscosa* and *Carissa carandas*. These often provide nesting sites for small birds. There were substantially greater number of live trees and their variety in the residential area and the Nursery of the K.U. campus. The trees usually provide nesting sites for birds and also supply them with fruits and seeds. Neem tree (*Azadirachta indica*) which appears to be a predominant tree at K.U. campus is known to attract many birds[12]. Evergreen trees, dense shrubs and small trees in between Departments, roadsides, vacant lots and at the periphery of campus often play a key role as roosting sites. Dense shrubs (e.g., *Carissa carandas*, *Dodonaea viscosa* and *Clerodendrum inerme*, (all three cultivated but common as hedge plants) and small trees, e.g., *Parkinsonia aculeata*, *Thevetia peruviana* (the latter is regarded as poisonous, but it is harmless to some birds when they use it for their diet) are important to song birds. Additionally, the semi-natural vegetation includes numerous grasses, herbs and shrubs. These provide food as well as shelter to a number of small birds. There are several ponds within the gardens of various departments or Institutes at K.U. and also artificial seasonal small ponds are produced because of rains or damaged water supply lines that retain water for several months. Water birds are attracted to these artificial aquatic habitats but leave when the water recedes. The birds were recorded on a weekly basis using binoculars for about 4 h a day, 7-9 am and 5-7 pm. In addition birds were surveyed at least twice a year at 5:30-6:30 a.m. when calls or chirping of many birds can be heard. The birds were identified using field guides as well as standard books on birds of Pakistan (or the subcontinent) [2, 3, 13, 14, 15, 16, 17]. In addition, observations were taken on the feeding habit of birds. As far as possible scientific names of plants (that provide edibles to birds) are given. Plant nomenclature follows [18]. In addition, animal species (mostly insects) are also consumed by birds, since they are too many and often difficult to identify, their identity is restricted to their major groups. Some interesting observations regarding diet have been made by researchers on certain birds (e.g., game birds), therefore, these are included whenever deemed necessary.

2. Results and Discussion

In all 49 bird species were recorded on an overall basis from Karachi University and Dow University campuses. For each bird scientific name is given along with the common name (vernacular name is also give where possible). In addition, locality (viz, Karachi University and or Dow University of Health Sciences campuses), family and order to which the bird belongs are given. Locality is followed by notes on dietary habit and sometimes other interesting relevant information.

Following bird species were recorded during the survey among various Orders and Families.

Order Columbiformes

Family Columbidae

3.1. *Streptopelia tranquebarica* (Hermann, 1804)

3.1.1. Common name: Little Brown Dove (vernacular: fakhta)

3.1.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.1.3. Diet and feeding: Feeds on seeds of grasses and herbs including *Panicum antidotale*, *Paspalum* sp.., *Chloris barbata*, *Dactyloctinium* spp, *Cenchrus setigerus, C. ciliaris*, *Rhynchosia minima*, *Tephrosia strigosa*, *Senna holosericea, S. italica* , etc., as well as seeds of cultivated crops, including rice and maize, buds and young leaves.

3.2. *Streptopelia senegalensis* (Linnaeus, 1766)

3.2.1. Common name: laughing dove

3.2.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.2.3. Diet and feeding: The diet of laughing doves consists of grass, fallen seeds of *Rhynchosia minima*, *Tephrosia* spp, *Indigofera cordifolia, I. linifolia, I. hochstetteri*, *Senna holosericea*, *Cleome* spp., *Amaranthus viridis*, *Digera muricata*, etc. other grains, and small ground insects (such as termites and beetles).

3.3. *Columba livia* Gmelin JF, 1789
3.3.1. Common name: Blue Rock Pigeon (Vernacular: Kaboter)

3.3.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.3.3. Diet and feeding: Mostly grains and seeds, particularly seeds of grasses like *Panicum antidotale*, *P.turgidum, Chloris barbata*, *Brachiaria ramosa, Dactyloctinium* spp*, Sorghum* spp.(cultivated at homes and gardens), *Cenchrus* spp. *Rhynchosia minima*, *Tephrosia* spp, *Amaranthus viridis*, *Digera muricata*, etc.
Order Passeriformes
Family Corvidae

3.4. *Corvus splendens* Vieillot, 1817
3.4.1. Common name: Sindh House Crow (vernacular: kauwa)

3.4.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.4.3. Diet and feeding: It is an omnivore bird. Feeds on small reptiles, insects, small invertebrates, eggs, nestlings, grains, fruits and vegetables, bones of chicken and other left-over food of human beings. Sometimes crushed animals lying on roads and streets. Thus, it is often named as the urban scavenger.

3.5. *Dendrocitta vagabunda* (Latham, 1790)
3.5.1. Common name: Rufous treepie
3.5.2. Locality: Karachi University campus
3.5.3. Diet and feeding: More or less same as above
Family Passeridae

3.6. *Passer domesticus* (Linnaeus, 1758)
3.6.1. Common name: House sparrow; (vernacular: Ghar ghayya)

3.6.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.6.3. Diet and feeding: House Sparrows have a mainly vegetarian diet, feeding particularly seeds of weeds and grasses including *Brachiaria ramosa, Chloris barbata*, *Cenchrus setigerus*, *C. pennisetiformis*, *Dichanthium annulatum*, or waste grain or small pieces of bread, left over rice dishes of human beings. It seems that the population of *Passer domesticus* is declining.

3.7. *Passer pyrrhonotus* Blyth, 1845
3.7.1. Common name: Sind sparrow
3.7.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.7.3. Diet and feeding: Sind sparrow feeds mainly on the seeds of grasses and other plants such as *Panicum* spp., *Paspalum distichum, Dactyloctenium* spp*., Digitaria nodosa, Dichanthium annulatum,* etc. In addition, it often feeds on caterpillars.
Family Alaudidae

3.8. *Alauda arvensis* Linnaeus, 1758
3.8.1. Common name: Eurasian Skylark, Sky Lark, Skylark
3.8.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.8.3. Diet and feeding: Small invertebrates and seeds of grasses and herbs, also other plant material. Basically, insectivorous in breeding season and vegetarian in winter
Family Hirundinidae

3.9. *Hirundo rustica* (Linnaeus, 1758)
3.9.1. Common name: Barn Swallow, Swallow (vernacular: ababeel),

3.9.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.9.3. Diet and feeding: This bird is an aerial insectivore, including other swallow species and the unrelated swifts. Diet varies within and between years and sites, depending on local availability of insects. More than 80 insect families have been recorded in its diet [19].
Family Motacillidae

3.10. *Motacilla alba* (Linnaeus, 1758)
3.10.1. Common name: white wagtail
3.10. 2. Locality: Karachi University and Dow University of Health Sciences campuses

3.10.3. Diet and feeding: The actual composition of the diet of white wagtails varies by location and also probably by year, but terrestrial and aquatic insects and other small invertebrates form the major part of the diet. These include a variety of beetles, dragonflies, small snails, spiders, worms, crustaceans, to maggots found in carcasses and, most importantly, flies in the order Diptera. The white wagtail is somewhat unusual in the parts of its range where it is non-migratory as it is an insectivorous bird that continues to feed on insects during the winter (most other insectivorous birds in temperate climates migrate or switch to more vegetable matter). Often it is seen in lawns and patches of grasses during winter where it searches for insects. There is a variety of patterning of colours (black, white, grey).

3.11. *Motacilla flava* (Linnaeus, 1758)
3.11.1. Common name: western yellow wagtail
3.11.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.11.3. Diet and feeding: Diet includes a wide variety of terrestrial and aquatic invertebrates mostly various types of insects; also some plant material, especially seeds.
Family Laniidae

3.12. *Lanius vittatus* (Valenciennes, 1826)
3.12. 1. Common name: Bay-backed Shrike
3.12. 2. Locality: Karachi University and Dow University of Health Sciences campuses

3.12. 3. Diet and feeding: The bird is basically insectivorous. It feeds more or less exclusively on insects that comprise mainly of Coleoptera (beetles) and Orthoptera (grasshoppers, crickets), also Lepidoptera (moths and butterflies), Neuroptera (net-winged insects), Diptera (true flies, one pair of wings) and Hymenoptera (flies with two pairs of membranous wings).

3.13. ***Lanius meridionalis*** **Temminck, 1820**
3.13.1. Common name: Southern grey shrike
3.13.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.13.3. Diet and feeding: Diet comprises of arthropods (mostly large insects) and small vertebrates (reptiles, small mammals and birds).
Family Sturnidae

3.14. ***Acridotheres ginginianus*** **(Latham, 1790)**
3.14.1. Common name: Bank Myna
3.14.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.14. 3. Diet and feeding: Omnivorous, diet incorporating animal food, fruit, seeds, and food waste discarded by humans. Animal food includes frog tadpoles,

3.15. ***Acridotheres tristis*** **Linnaeus, 1766**
3.15.1. Common name: common myna
3.15.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.15.3. Diet and feeding: The common myna is omnivorous. It feeds on insects, arachnids, crustaceans, reptiles, seeds (of grasses and weeds in the lawns), grain and fruits (*Azadirachta indica*) and discarded waste from human habitation. It forages on the ground among grasses (lawns) for insects, and especially for grasshoppers (such as *Acrida exaltata*), from which its generic name *Acridotheres* is derived. It is particularly active at the time of cowdung-manuring of lawns to pick up insects.

3.16. ***Sturnus roseus*** **(Linnaeus, 1758)**
3.16.1. Common name: rosy starling
3.16.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.16.3. Diet and feeding: feeds on a wider range of fruits including those of *Ficus* spp. Flocks of this bird are seen feeding on the fruits of *Ficus* in the canopy as well as fallen fruits on the ground. The diet includes seeds and nectar as well.
Family Pycnonotidae

3.17. ***Pycnonotus cafer*** **(Linnaeus, 1766)**
3.17.1. Common name: Red vented bulbul ;(vern. bululbul)
3.17.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.17.3. Diet and feeding: Feeds on small fruits e.g., *Salvadora persica*, *S. oleoides*, *Morus alba*, *Carissa carandas. Solanum nigrum, Ficus* sp. Red-vented bulbuls also feed on petals of flowers, nectar, insects and occasionally geckos. They have also been seen feeding on the leaves of *Medicago sativa*. Usually seen perching on neem (*Azadirachta indica*, *Ficus virens*, *Ficus religiosa*, *Guaiacum officinale*, *Mangifera indica* (mango), *Cassia fistula*, etc

3.18. ***Pycnonotus leucogenys*** **(Gray, JE, 1835)**
3.18.1. Common name: White cheeked bulbul (or Himalayan bulbul); (vern: bulbul)

3.18.2. Locality: Karachi University and Dow University of Heath Sciences campuses

3.18.3. Diet and feeding: This bulbul eats insects and other small invertebrates. The diet also includes berries and other fruits, e.g., *Salvadora persica*, *S. oleoides*, *Azadirachta indica*, *Carissa carandas*, *Morus alba, Grewia tenax* and a variety of buds and seeds. Often perches on *Mangifera indica* (mango), *Delonix regia*, *Prosopis juliflora*, *P. glandulosa, P. cineraria, Salvadora persica*, *Grewia tenax, Guaiacum officinale, Peltophorum pterocarpum*, *Azadirachta indica*, etc.
Family Nectariniidae

3.19. ***Cinnyris asiaticus*** **(Latham, 1790)**
3.19.1. Common name: purple sunbird
3.19. 2. Locality: Karachi University and Dow University of health Sciences campuses

3.19.3. Diet and feeding: Small insects, and spiders (Araneae); nectar of *Moringa oleifera* flowers but also occasionally other fruits or nectar (e.g. *Cassia fistula*, *Vachellia nilotica* (syn. *Acacia nilotica*), *Thevetia peruviana* (generally considered poisonous to vertebrates. However, a few bird species are known to feed on this plant species without any harmful effects. The authors have observed the sunbird foraging on it.). Sometimes forages on small berries (*Salvadora persica*). Forages usually singly. Often seen perching or feeding on *Moringa oleifera* (drumstick) which appears to be its favourite tree. Some trees of *M. oleifera* have been planted in recent years in the garden of the Institute of Environmental Studies by the first author in an attempt to increase the population of sunbird.
Family Phylloscopidae

3.20. ***Phylloscopus collybita*** **(Vieillot, 1817)**
3.20.1. Common name: chiffchaff
3.20.2. Locality: Karachi University and Dow University of health Sciences campuses

3.20.3. Diet and feeding: Depends on the availability of the fruits, seeds and blossoms
Family Estrildidae

3.21. ***Estrilda amandava*** **(Linnaeus, 1758)**
3.21.1. Common name: red avadavat, red munia
3.21.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.21.3. Diet and feeding: Small grass seeds (*Cenchrus* spp. *Paspalum distichum*, *Dactyloctinium* spp., *Chloris barbata*); occasionally insects, including termites (Isoptera). Clings to stems to feed on ripening grass seeds.

3.22. ***Lonchura punctulata*** **(Linnaeus, 1758)**
3.22.1. Common name: scaly-breasted munia or spotted munia

3.22.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.22.3. Diet and feeding: The scaly-breasted munia feeds mainly on seeds but also eats small berries such as those of *Salvadora oleoides*, *S. persica*, *Lantana camara,* seeds of grasses such as *Digitaia nodosa*, *Chloris barbata*, *Desmostacya bipinnata*, *Cenchrus setigerus*, *Dichanthium annulatum*, are consumed. Though the bill is suited for crushing small grains, they may also feed on algae,

3.23. ***Amandava amandava*** **(Linnaeus, 1758)**
3.23.1. Common name: red avadavat, red munia or strawberry finch

3.23.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.23.3. Diet and feeding: They feed mainly on grass seeds (*Chloris barbata*, *Paspalum* sp., *Paspalidium* spp., *Panicum antidotale*) but also take insects such as termites whenever available.
Family Dicruridae

3.24. *Dicrurus macrocercus* Vieillot, 1817
3.24.1. Common name: Black drongo
3.24.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.24.3. Diet and feeding: Black drongos feed mainly on insects such as grasshoppers, cicadas, termites, wasps, bees, ants, moths, beetles and dragonflies. The species of the insects were not identified. It becomes more active after sunset near lights where the flying insects are attracted and found in large number.
Family Muscicapidae

3.25. ***Phoenicurus ochruros*** **(Gmelin, SG, 1774)**
3.25.1. Common name: black redstart
3.25.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.25.3. Diet and feeding: Invertebrates and berries, switching their proportions considerably. Invertebrates in diet include grasshoppers, earwigs, bugs, cockroaches. Berries (fruits) include those of *Salvadora persica*, *Grewia tenax, Lantana camara*, *Morus alba*, etc.

3.26. *Copsychus fulicatus* (Linnaeus, 1766)
3.26.1. Common name: Indian robin (vernacular: shama)
3.26.2. Locality: Karachi University and Dow University of Health Sciences Campuses

3.26.3. Diet and feeding: They are mainly insectivorous but often forage on vertebrates including frogs and lizards. They are particularly active in evening and capture insects attracted to light.
Family Leiothrichidae

3.27. *Turdoides striata* (Dumont, 1823)
3.27.1. Common name: jungle babbler
3.27.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.27.3. Diet and feeding: jungle babbler feed mainly on insects, but also eats grains, nectar and berries. They are often seen on trees of *Ficus virens, Ficus religiosa, Ficus beghalensis*, and shrubs of *Salvadora persica*, *Carissa carandas, Lantana camara*, etc. They are usually seen in flocks of seven, hence locally they are called as seven sisters.
Order Galliformes
Family Phasianidae

3.28. *Coturnix coturnix* (Linnaeus, 1758)
3.28.1. Common name: white wagtail
3.28.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.28.3. Diet and feeding: Commonly feeds on seeds and insects on the ground among the swards of grasses.

3.29. *Francolinus pondicerianus* (Gmelin, JF, 1789)
3.29.1. Common name: grey partridge (francolin): (vernacular: bhora teeter)

3.29.2. Locality: Karachi University campus
3.29.3. Diet and feeding: The bird is omnivorous. The examination of the crops of grey francolin disclosed 33 species of plants (seeds) and 7 orders of insects were identified *Citrullus colocynthis*, *Echinochloa colonum*, *Celosia* sp. *Cyperus rotundus, Gynandropsis gynandra*, *Farsetia jacquemonti, Indigofera* spp. and *Launaea procumbens.* All these plant species occur more or less commonly on K.U. campus. Among the insect groups included in the diet belong to Coleoptera, Lepidoptera (butterflies and moths), Orthoptera (grasshoppers), Homoptera (bugs) and Diptera (flies) [20].

3.30. *Francolinus francolinus* (Linnaeus, 1766)
3.30.1. Common name: black partridge (francolin); (vernacular: kala teeter)

3.30.2. Locality: Karachi University campus
3.30.3. Diet and feeding: This bird is also omnivorous. A total of 19 different genera of plants (seeds) and 4 orders (having 12 species) of insects were found in the crops of the bird investigated. Insects are consumed throughout the year although plants make the bulk of the diet. Seeds of a number of plant species were recorded including those of mustard (*Brassica campestris*), wild pea (*Lathyrus sativus*), *Abutilon* spp., *Rhynchosia minima*, *Setaria* spp., *Dactyloctinium scindicum*, *D. aegyptium*, *Eriochloa* sp., *Launaea procumbens*, *Solanum nigrum,* etc. Most of these plant species are present on K.U. campus. Among the insects Diptera, Hymenoptera, Coleoptera, Araneae are commonly consumed by black francolin [20].
Order Coraciiformes
Family Upupidae

3.31. *Upupa epops* Linnaeus, 1758
3.31.1. Common name: Hoopoe; vernacular: Hoodhood
3.31.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.31.3. Diet and feeding: Diet of the hoopoe mostly comprises of insects, but small reptiles, frogs and plant material e.g., seeds are also consumed. Common insects that

form its diet are: crickets, locusts, beetles, earwigs, ant-lions, bugs and ants.
Family Meropidae

3.32. *Merops orientotalis* Latham 1801
3.32.1. Common name: green bee-eater; (Vernacular: harial)
3.32.2. Locality: Karachi University campus
3.32.3. Diet and feeding: The green bee-eater feeds on flying insects and can sometimes be nuisance to bee-keepers.
Family Coraciidae

3.33. *Coracias benghalensis* (Linnaeus, 1758)
3.33.1. Common name: Indian roller (Vernacular: neelcunt)
3.33.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.33.3. Diet and feeding: Feeds on large arthropods and small vertebrates: grasshoppers, crickets, earwigs, mantises, bugs, termites, beetles, moths, wasps, ants. Insect larvae are also the usual items of the diet.
Family Alcedinidae

3.34. *Halcyon smyrenensis* (Linnaeus, 1758)
3.34.1. Common name: White-throated Kingfisher
3.34.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.34.3. Diet and feeding: Its diet includes a wide variety of prey. Among the insects mole-crickets (*Gryllotalpa*), crickets and grasshoppers (Locustidae, Tettigidae) are consumed.

3.35. *Alcedo atthis* (Linnaeus, 1758)
3.35.1. Common name: common kingfisher
3.35.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.35.3. Diet and feeding: It forages on small fish, tadpoles, water beetles and their larva and other aquatic insects.
Order Accipitriformes
Family Accipitridae

3.36. *Milvus migrans* (Boddaert, 1783)
3.36.1. Common name: black kite (vern. Cheel)
3.36.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.36.3. Diet and feeding: Diet An extremely versatile feeder, it takes carrions as well as live birds, mammals, fish, lizards

3.37. *Circaetus gallicus* (Gmelin, JF, 1788)
3.37.1. Common name: Short-toed Snake-eagle
3.37.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.37.3. Diet and feeding: Specializes in reptiles, particularly snakes

3.38. *Circus aeruginosus* (Linnaeus, 1758)
3.38.1. Common name: Western Marsh-harrier
3.38.2. Locality: Karachi University and Dow University of Health Science campuses

3.38.3. Diet and feeding: Great opportunist lacks specialization; the diet comprises of a very wide range of prey, varying with local availability. They prefer small to medium-sized birds.

3.39. *Accipiter badius* (Gmelin, JF, 1788)
3.39.1. Common name: shikra
3.39.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.39.3. Diet and feeding: Usually they feed on rodents (*Nesokia indica*, *Rattus rattus*, *Bandicota begalensis*), squirrels, shrews, small birds, small reptiles such as lizards or small snakes and insects. They prey birds try to avoid the raptor using various techniques. They also feed on termites, and small bats. Rarely, they feed on carrions.
Order Pelecaniformes
Family Ardeidae

3.40. *Egretta garzetta* (Linnaeus, 1766)
3.40.1. Common name: little egret
3.40.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.40.3. Diet and feeding: Their diet is mainly fish, but amphibians and small reptiles are also consumed.

3.41. *Bubulcus ibis* (Linnaeus, 1758)
3.41.1. Common name: cattle egret
3.41.2. Locality: Karachi University campus
3.41.3. Diet and feeding: The diet includes crickets, grasshoppers, beetles, moths, flies, and other small invertebrates; also sometimes small vertebrates.

3.42. *Ardeola grayii* (Sykes, 1832)
3.42.1. Common name: Indian pond heron or paddybird
3.42.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.42.3. Diet and feeding: The diet of the Indian pond-heron includes small fish, frogs, tadpoles, other invertebrates, etc.
Order Charadriiformes
Family Charadriidae

3.43. *Vanellus indicus* (Boddaert, 1783)
3.43.1. Common name: red-wattled lapwing
3.43.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.43.3. Diet and feeding: The diet of the lapwing includes a variety of insects, spiders and other invertebrates.
Order Psittaciformes
Family Psittaculidae

3.44. *Psittacula krameri* (Scopoli, 1769)
3.44.1. Common name: rose-ringed parakeet
3.44.2. Locality: Karachi University and Dow University of Health Sciences campuses

3.44.3. Diet and feeding: Usually feeds on buds, fruits, vegetables, nuts, berries, and seeds. One of its favorite foods seems to be guava (*Psidium guajava*). On K.U. campus many residential houses have guava trees that provide the parakeet its food. Also it eats ripe mangos (*Mangifera indica*) which are also common. Also it feeds on the seeds of *Prosopis*

juliflora and *Vachellia nilotica* (syn. *Acacia nilotica*), though controversy exists regarding the name of genus). Under this tree can be seen many fallen green fruits without seeds as they are consumed by parakeets. Often they can be seen eating seeds from the fruits on the trees.
Order Cuculiformes
Family Cuculidae

3.45. *Eudynamys scolopacea* (Linnaeus, 1758)
3.45.1. Common name: Asian Koel; Vern. Koel
3.45.2. Locality: Karachi University Campus and Dow University of Health Sciences campus

3.45.3. Diet and feeding: Koel is a very vocal bird during the breeding season (March to August). It feeds on a number of fruits including *Azadirachta indica*, *Carissa carandas*, *Morus alba*, *Syzygium cumini* (Java plum), *Pithecellobium dulce* (vern. Jungle jalebee).
Order: Strigiformes
Family: Tytonidae

3.46. ***Tyto alba* (Sibley and Monroe 1990, 1993)**
3.46.1. Common name: Barn owl
3.46.2. Locality: Karachi University campus
3.46.3. Diet and feeding: Most prey is terrestrial but bats and birds are also consumed; also rats/mice (*Milardia meltada*, *Rattus rattus*, *Tatera indica*, *Nesokia indica*, *Bandicota begalensis*), lizards, amphibians and various insects are included in the diet. For details of the prey items consumed by *Tyto alba,* please refer to an article by [21].

3.47. *Athene brama* (Temminck, 1821)
3.47.1. Common name: Spotted owlet
3.47.2. Locality: Karachi University campus
3.47.3. Diet and feeding: It is a carnivorous raptor and its food consists of rodents, birds, reptiles, amphibians, annelids and arthropods [19, 22, 23]. On K.U. campus many ponds or ditches are present which provide good habitat for frogs. They can provide the owl ample amount of food. Often it is seen roosting on *Cordia myxa* trees.
Order Pteroclidiformes
Family Pteroclididae

3.48. *Pterocles exustus* (Temminck, 1825)
3.48.1. Common name: Sandgrouse
3.48.2. Locality: Karachi University campus
3.48.3. Diet and feeding: Examination of crops of this bird did not reveal any insects. Seeds of the following species were recorded from the crops: *Alysicarpus* sp., *Amaranthus viridis*, *A. polygamous*, *Crotalaria burhia*, *Cyamopsis tetragonoloba*, *Euphorbia* spp., *Gynandropsis gynandra*, *Heliotropium strigosum*, *Indigofera linifolia*, *I. cordifolia*, *Panicum antidotale*, *Panicum turgidum*, *Tephrosia strigosa*, *Tephrosia* sp., etc. [20]. All those species reported in the sequel occur more or less commonly on the K.U. campus particularly after rains. It is noteworthy that in the study of [20], some bird samples were obtained from K.U. campus.
Order Piciformes
Family Picidae

3.49. ***Dipnopium benghalensis* (Linnaeus, 1758)**
3.49.1. Common name: Golenbacked woodpecker (vern. Khat berhai)
3.49.2. Locality: Karachi University campus
3.49.3. Diet and feeding: They feed from a variety of places including the ground up to the canopy of trees. Their principal diet includes insects, particularly beetle larvae that they pick up from under the bark. Also feed on termites; sometimes they feed on nectar. In recent years their feeding habit has evolved and they have adapted to urban developed habitats making use of artificial constructions, fallen fruits on the ground and even human leftovers.

4. Discussion and Conclusion

The number of bird species varied across the university campuses. In general, where the teaching departments are built too congested i.e. in the centre of the university, the bird diversity is low. Peripheral areas of both the campuses showed highest number of bird species as these areas held most complex vegetation with trees, shrubs, tall grasses (*Phragmites karka*) and herbs. This accords well with the findings of [24]. The number of bird species recorded from K.U. campus is much higher (49 species) than that of Dow University of Health Sciences (40 species). The major reasons for this difference in avifaunal diversity are 1) greater area of Karachi University (with greater number of plant communities and more complex vegetation types) than that of D.U.H.S., 2) greater habitat diversity at K.U., that is, vacant lots, old-field, cultivated fields (experimental fields), a large nursery, roadsides, ponds, etc., 3) greater number of plant species such as grasses, herbs, shrubs and trees, i.e., greater species richness of plants.. The plants supply birds with fruits and seeds as well as nesting sites, in particular trees and sometimes shrubs (or bushes) also provide nesting sites for small birds. Tree cover has been used as a predictive variable in bird richness in urban parks [25, 26]. For about last 25 years, several new departments have been built in K.U. campus. For the purpose of construction, large patches of vegetation have been cleared. As a consequence habitat fragmentation has resulted. As pointed out earlier, bird diversity at K.U. campus in particular and Karachi city in general is declining principally as a result of habitat fragmentation [27, 28]. One important consequence of habitat fragmentation is that the dispersal of seeds is considerably hindered which causes local extinction of plant species. Often birds are specific with respect to their diet. Thus the bird species populations in various communities are likely to dwindle as their food becomes scarce. If this trend continues, it would result in local extinction of many bird species that are particularly dependent on food derived from naturally growing plant species. However, some studies [29, 30, 31, 32] suggest that certain birds (e.g., sunbird) are capable of adapting their feeding preferences to the available food and nesting sites in city landscapes (or built-up area), potentially as a response to loss of their natural habitat caused by reduction of green areas. Given the ability of some bird species to adapt to urban habitats both phenotypically and genetically, it is debatable whether such environments can attain greater levels of biodiversity, at least locally. Small patches of vegetation are often cleared or bulldozed on the campuses in the name of cleaning the campus. This practice should be immediately stopped. At many sites the cleared land becomes occupied by *Prosopis juliflora* which is an invading introduced species from South America [33]. Moreover, it has great allelopathic potential and eventually reduces plant species diversity by suppressing other wild plant species growing in the vicinity

and becomes the predominant species of the community and eventually forms a more or less pure population. It is a source of food for only a limited number of animal species and a few birds. Obviously, this would reduce the bird diversity because of suppression of grasses that provide most of the birds their diet and the nesting material. The results of the survey over the time span suggest a loss of species richness and consequently functional diversity; hence most likely indicate a decline in ecosystem function, with decreasing green areas within the campus and increasing built-up of concrete structures in the increasingly urban surrounding of the campus landscape matrix. A number of studies have been conducted that attempt to disclose the influence of the extent and duration of urbanization on bird populations [34, 35, 36, 37, 38]. The studies demonstrated that 1) species composition alters in an area as it becomes urbanized, 2) with the exception of one study, they confirm that the number of species decline with increasing urbanization, and. 3) all studies concur that the abundance of birds increases with urbanization. The Dow University of Health Sciences campus is relatively new but it is built on a former Ojha Sanatorium complex which was fairly large. Therefore, there are patches of semi-natural vegetation still intact to which are associated bird communities. However, total bird assemblages are smaller than that of K.U. campus because of lower overall area and greater number of plant communities (habitats) at K.U. compared to that at D.U.H.S. campus.

Birds occupy many trophic levels, from mid-level consumers to top predators. Similar to other native organisms, birds help maintain sustainable population levels of their prey and predator species and after their death their carrions serve as food for raptors. Birds are also important from the standpoint of plant reproduction by serving either as pollinators or as seed dispersers. Birds also provide critical resources for their many host-specific parasites adapted for living on birds. Owing to a significant role that birds play in maintaining ecosystems and supporting biodiversity, many seek and advocate their protection to manage biological threats and efficiently protect the environment [39]. Sufficient amount of natural vegetation including tall and medium–sized trees and a multi-layered vegetation structure including shrubs, herbs and grasses should be component of the composition in order to maintain high bird species diversity in urban green areas such as university campuses. The positive relationship between bird species number and vegetation structure emphasizes the importance of green space containing trees , tall and small grasses and developed shrub layer (or a hedgerow) i.e., vegetation structure is an overwhelmingly important component for maintaining high bird species diversity in urban green spaces such as university campuses. Characteristics of the vegetation structure are also important factors for birds in recognizing their environment in urban areas [40, 41]. To protect, maintain and restore functional green infrastructures in urban landscapes it is suggested that compaction should be practiced with ample amount and quality of green spaces in between buildings. Such zoning has been advocated for forest landscapes [42] but could also be applied in urban landscapes. Both landscape level and green-area characteristics are essential for an efficient design and management of urban areas with respect to bird species richness. It is noteworthy that moderate levels of development increase resource availability for some birds by way of plantation of some plants. Such a pattern has been observed which is also detectable at a much larger scale [37]. However, without adequate knowledge of the significance of matrix structure, evaluation of bird–habitat relationships may be misleading [43] for better management, one important recommendation is to preserve both large and small patches of urban green in the campuses so as to maintain bird species diversity and richness and the overall connectivity in between patches [44]. Furthermore, such patches of green areas should be preferably heterogeneous with respect to their vegetation structure (thickness and mixture of trees and shrubs).and they should be left undisturbed. In addition, water pots should be placed for thirsty birds. The water pots can also be placed at regular intervals along roadsides beneath the trees so that they can be filled when the trees are watered. In addition, sugar water feeders can also be placed in university gardens to attract nectarivorous birds. The recommendations provided can elevate the biodiversity at the two university campuses under study but may be applied to other universities located in the city and its suburbs as well as the new universities to be built in the Sindh province.

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