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STUDIES ON THE FLORA AND AVIFAUNA ASSOCIATED WITH THE KARACHI WESTERN BACKWATERS MANGROVE FOREST

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ABSTRACT

The Karachi Western Backwaters lie behind the sandy stretch of the Sandspit and Hawkes Bay beaches. Sea water enters the lagoon via Manora Channel, while the Lyari River falls on the eastern-northeastern side of the lagoon. Mangrove forest exists on 400 to 500 hectares of the swamps in the lagoon, traversed by a main channel and its branches. This forest is an important wintering ground for a large number of migratory birds coming from Siberia, Central Asia, Europe, and Pakistan's own high altitude cold areas.
A thorough study of the flora, vegetation, and the Avifauna associated with this mangrove forest was done for the first time. Complete inventories of plant species and bird species were prepared, while the bird populations were monthly monitored for six years from 2005 to 2010. A total of 58 plant species were recorded that were present in four types of microhabitats, ranging from the coastal wet and saline soil to the intertidal zone in the mangrove swamps (including the sole mangrove species *Avicennia marina*) to somewhat higher dry sandy and rocky land around the mangrove ecosystem. The total recorded bird species were 96, out of which 58 were migratory and 38 were resident species. Over the study years both the number of bird species and total number of individuals continued to decrease. By the end of the study, 14 migratory birds totally disappeared. These were in addition to those 25 migratory species that were not found altogether in the present study but were reported in a previous work shortly before the commencement of the present study. This trend indicates that this area is fast becoming unfavourable for the migratory bird species. The possible causes include pollution, continually increasing anthropogenic disturbances and increasing human presence in the area. This important ecosystem is in dire need of immediate conservation measures.

Key-words: Avifauna, backwater, Mangrove forest, Sandspit, Hawks Bay.

INTRODUCTION

A backwater is a part of a river in which there is little or no current; if a river flows into a lake or sea, this is the region in which the lower flux of water permitted at the mouth causes the water to backup. In the presence of tide action, fresh and salt water may become mixed to form an estuarine environment (http://en.wikipedia.org/Backwater_(river).

Lagoons being partially enclosed water bodies do not have as strong wave action as in the open sea. Coastal lagoons tend to accumulate sediments from inflowing rivers, from runoff from the shores of the lagoon, and from the sediments carried into the lagoon through inlets by the tide (http://en.wikipedia.org/wiki/Lagoon). Such environment in the tropical and subtropical regions favours the establishment of mangrove forests.

Mangroves are one of the three most productive ecosystems on Earth along with coral reefs and rain forests; they provide food, shelter, breeding grounds, and refuge to a number of economically and ecologically important marine species and also serve as bird sanctuaries (Holguin *et al.*,. 2006).

The Karachi Backwaters, lying behind the sand spit of the Sandspit and Hawkes Bay beaches support rich growth of mangrove forest which is formed by a single mangrove species *Avicennia marina.* The backwaters of Karachi are divided into the Eastern backwaters and the Western backwaters by the Chinna Creek (Map-1). The western backwaters include the Manora Channel which serves as the inlet for the lagoon as well as entrance for the Karachi harbor, the Lyari River estuary at the eastern-northeastern margin of the western backwaters, and the water channels, mud-flats, and mangrove forests lying in-between the sandy strip along Arabian Sea and the mainland. The mainland area surrounding the mangrove ecosystem is somewhat higher, dry, rocky and sandy land, presenting a microhabitat totally different from that of the mangrove swamps. Information on the flora of the study area is almost non-existent despite the fact that plants have the pivotal role in any ecosystem. The only detailed work available is that of Rashid and Abbas (2011) who reported 47 plant species belonging to 19 families from the area.

The health of mangrove ecosystem can be assessed by detailed studies on different physical parameters and indicator organisms. Mangrove trees themselves occupy the central importance in the ecosystem, supporting most of the other organisms. Among various organisms, birds are considered as highly effective biodiversity indicator mainly because they are well-known and have a resonance and connection with people and their lives (Gregory and

Strien, 2010). The common occurrence of birds in a mangrove community is a useful indicator of system's health (Holguin *et al*. 2006).

Few studies are available on the avifauna of the Backwaters mangroves despite the fact that birds are the most prominent component of the mangrove fauna almost everywhere in the world. Khanum and Ahmed (1988) reported 34 species from the Karachi coast including the Backwaters. Theirs was a 4-month study from July to October 1985 and the 34 species included 12 resident and 22 migratory species; though the time was not suitable for the migratory species observations as their numbers usually peak in the month of December (personal observation). Ghalib and Hasnain (1997) reported 75 species of aquatic birds from the Clifton beach of Karachi. The comparatively more detailed work is that of Durranee *et al*. (2008) on the Western Backwaters mangroves avifauna, spanning over five years from January 2000 to December 2004, i.e. concluding before the start of the present study. They recorded 114 species, 78 of which were migratory and 36 resident. However, they did not record the number of individuals or the abundance of various species of birds.

The study area covered by the western backwaters of Sandspit / Hawkes Bay measures about 500 hectares. Mangrove forest on 300 ha is in good condition and 100 ha is degraded forest. The creek system is one of the most important areas for wintering, passage and summering shorebirds in Pakistan, and also supports significant numbers of cormorants, flamingoes, ducks, gulls, and terns.

MATERIALS AND METHODS

The study site is located behind the Sandspit / Hawkes Bay beach (24º 50' N, 66º 56' E) in Western Backwaters mangrove area. Nine spots were selected for birds' observations along the main channel (Fig. 1) and its branches (Map-1).

1. Flora and vegetation

The whole study area was surveyed in different seasons and a list of all available plant species was prepared. Various ecological characteristics of the species including their microhabitat preferences were noted down.

The flora associated with mangroves and that present away from mangroves on higher grounds was also noted down.

The life forms were determined by the criteria given by Raunkiaer (1934).

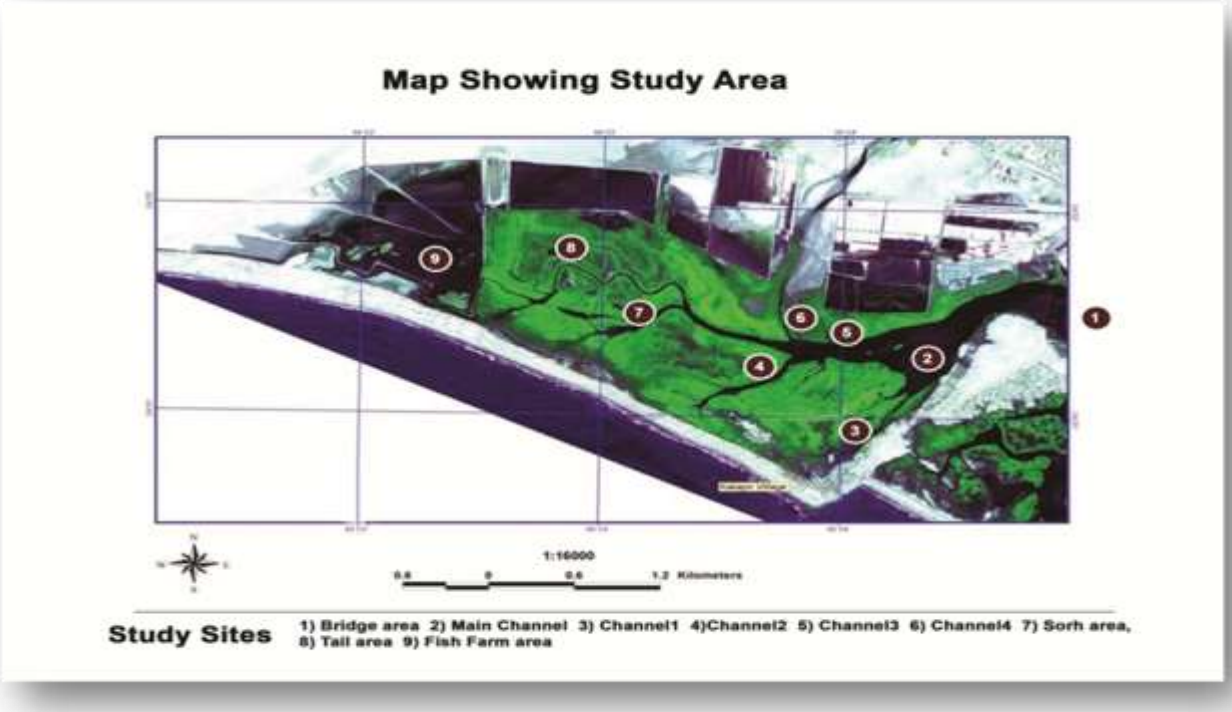

Fig.1. A view of main channel at high tide.

Fig.2. Birds feeding on mud-flats at ebb tide.

2. Avifauna

In avifauna all the species of birds were observed which are normally found. The detailed observations of birds in the study area were taken on monthly basis in the current research study.

Visits were always made during the ebb tides (the period between high tide and low tide) so that maximum part of the intertidal area may be examined (Fig. 2). The study area was surveyed for the birds' estimation, in total; one full day visit per month was scheduled. In this way 12 visits were conducted for the total counts.

Field binocular with specifications of 10X50 were used. Telescope was used for species identification for greater distances than binoculars. The telescope which was utilized in bird species identification had specifications of 20X to 60X. Due to its heavy weight it was mounted on a tripod to avoid vibration during the observation.

A spotting scope mounted on a tripod was employed for counting and identification of birds. When the area was large and the birds were scattered, then counting and identification of birds was done for nearly every 100 meters. Care was always taken not to disturb the birds so that they might not fly elsewhere resulting in double counts.

OBSERVATIONS AND RESULTS

1. Flora and Vegetation

In the present study the plant biodiversity of backwaters was found as total 58 species (47 dicots and 11 monocots) belonging to 22 families (20 dicots and 2 monocots) and 45 genera of which 36 were dicots and 9 were monocots (Fig. 3). Among families Poaceae was the largest family (9 species) followed by Papilionaceae, Chenopodiaceae and Amaranthaceae (5 species each) on second rank while Euphorbiaceae was the third largest family with 4 species (Fig. 4).

Among genera *Euphorbia* was the largest genus with 4 species, *Heliotropium* was the second largest genus with 3 species and *Amaranthus*, *Launaea*, *Senna*, *Cleome*, *Abutilon*, *Indigofera*, *Cyperus* and *Dactyloctenium* were on third position with 2 species in each genus (Fig. 5). These larger families and genera contributed 48.27% and 36.20% of the flora of the study area respectively (Table - 1).

Regarding the Habit of the plants, herbs (25) were the largest habit category in the study area followed by grasses (Fig. 6). Regarding life forms, Chamaephyte was the largest life-form (24) followed by Therophytes (16) and Phanerophytes on 3rd position with 9 species (Fig. 7). The complete checklist of plants with their life-forms, habit, and other information is provided in Table 2.

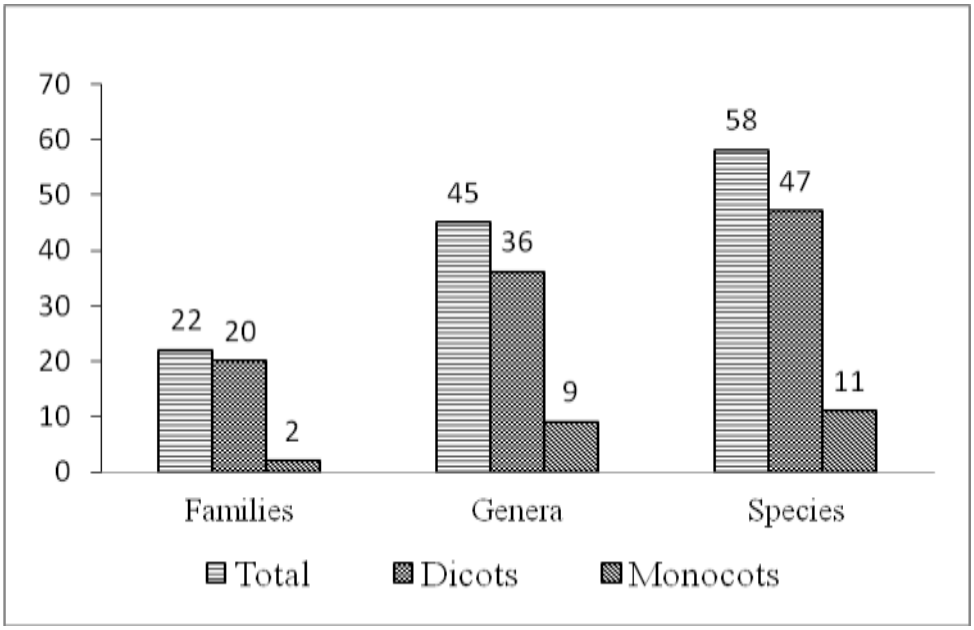

Fig. 3. Number of Plant families, genera and species in the study area.

The plant species of the study area occurred in four kinds of microhabitats. The most abundant and prominent kind of vegetation are the mangrove forests formed by a single mangrove species *Avicennia marina* in the inter-tidal zone. In addition to *Avicennia*, four more halophytic species occurred almost in the inter-tidal zone in close proximity of mangroves. Another 19 halophytes occurred somewhat away from mangroves on moist saline soil, some on the sandy stretch towards the main sea coast, e.g. *Lotus garcinii*, *Indigofera argentea*, *Astragalus fatmensis* and *Polycarpaea spicata*, etc. The raised land away from mangroves was dry rocky or sandy and apparently non-saline or with very low salinity. Twenty plant species (non-halophytes) occurred in this microhabitat. The fourth

microhabitat was the vicinity of cultivated places, like lawns and flower beds along various buildings and open spaces recently disturbed by human activity. Thirteen species occurred in this kind of microhabitat, these were also mostly non-halophytes (Fig. 8, and Appendix-I). Though quite a few species occurred in more than one type of microhabitats, but the above mentioned distribution refers to their more preferred microhabitat. However, the alien invasive species *Prosopis juliflora* was present in almost every kind of microhabitats, even among *Avicennia* stands in the intertidal zone.

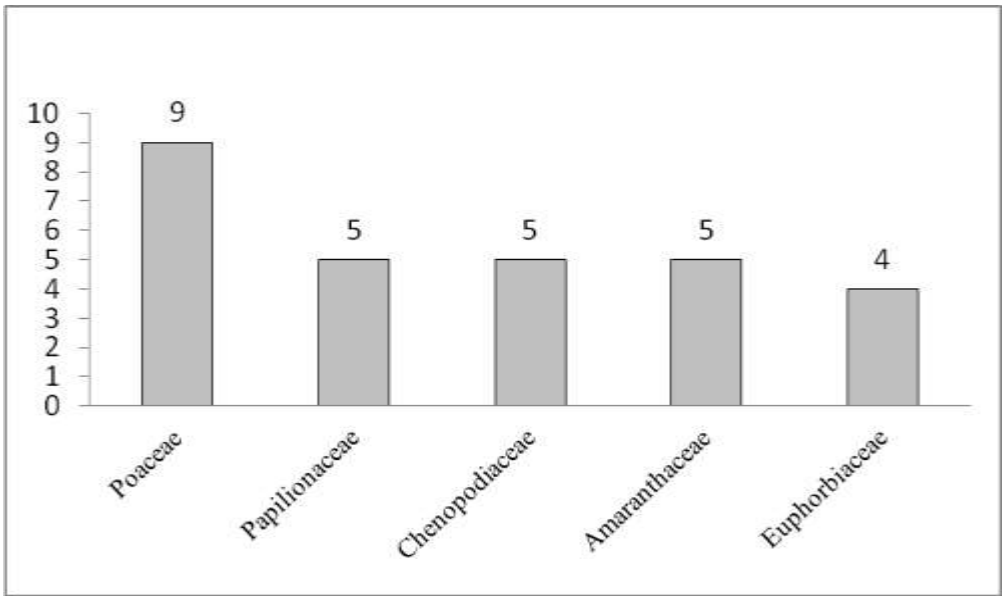

Fig. 4. The largest, 2nd largest and 3rd largest (with reference to the number of species) plant family of the study area.

Table 1. Larger plant families and larger genera of the study area.

Families	Number of species	Genera	Number of species
Amaranthaceae	5	*Amaranthus*	2
Chenopodiaceae	5	*Launaea*	2
Euphorbiaceae	4	*Heliotropium*	3
Papilionaceae	5	*Senna*	2
Poaceae	9	*Cleome*	2
		Euphorbia	4
		Abutilon	2
		Indigofera	2
		Cyperus	2
		Dactyloctenium	2
Total:	28 (48.27%)		23 (39.65%)

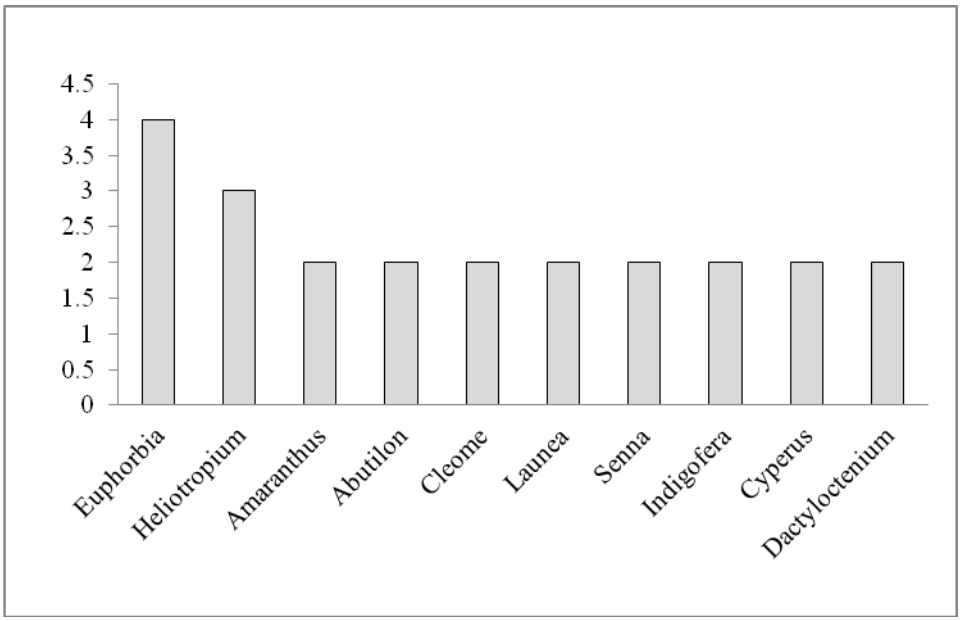

Fig. 5. The largest, 2nd largest and 3rd largest plant genera of the study area.

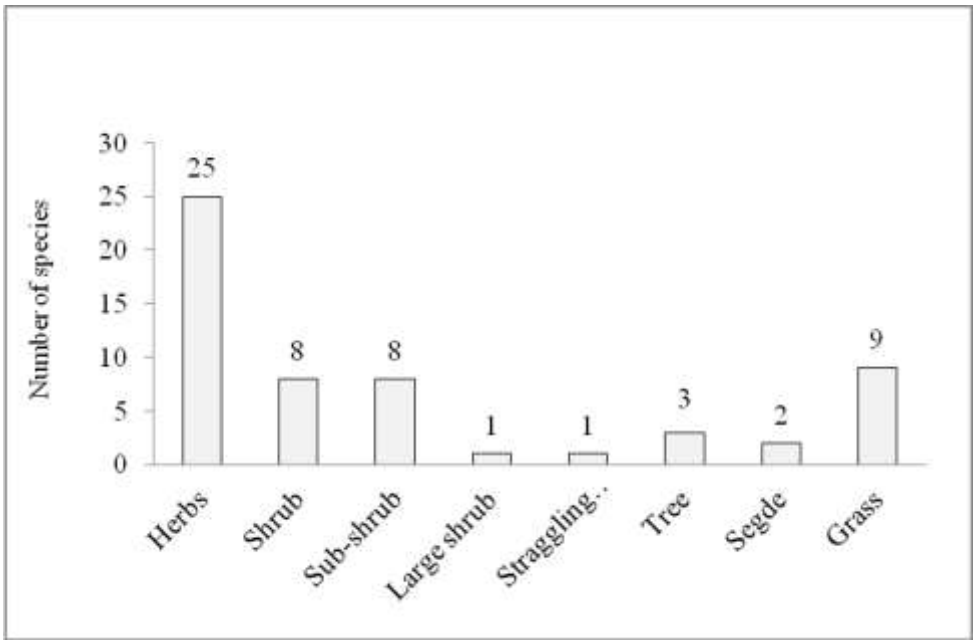

Fig. 6. Habit distribution of plant species in the study area.

Avicennia marina was the only tree species in the study area, all others were shrubs or herbs. Though *Prosopis juliflora* also becomes a tree with age, but the individuals found in the study period were all large shrubs.

2. Avifauna

In the six years' inventorying and monitoring work on the avifauna of the study area during 2005 and 2010, a total of 96 species were recorded **(**Table 3) with a cumulative count of 121902 individuals (Tables 4).

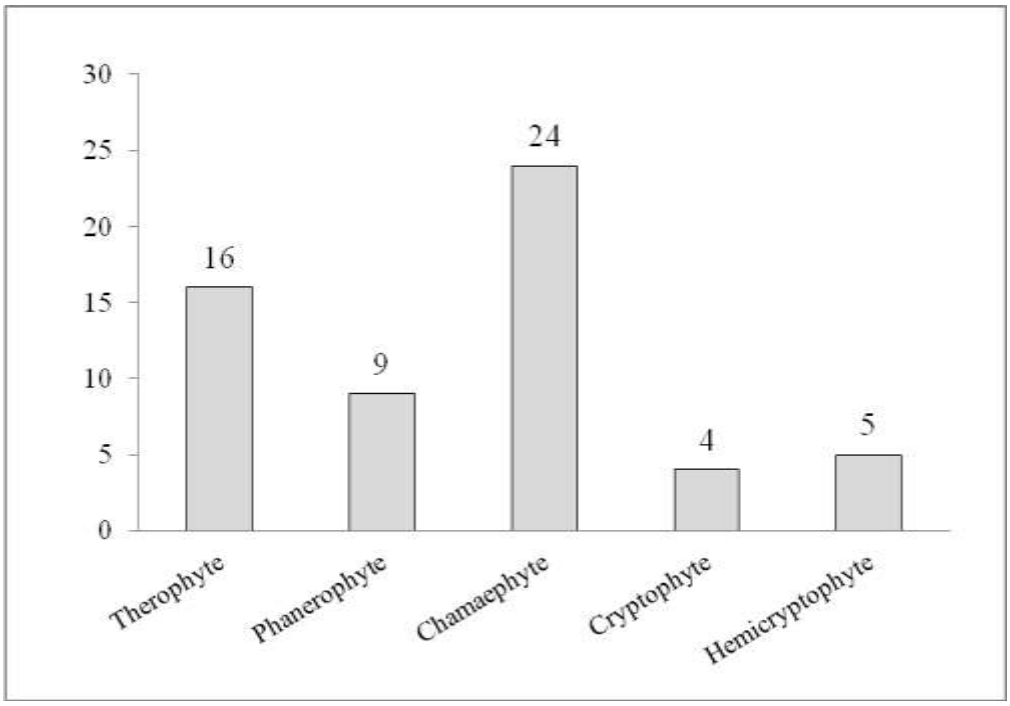

Fig. 7. Distribution of Life-forms in the study area.

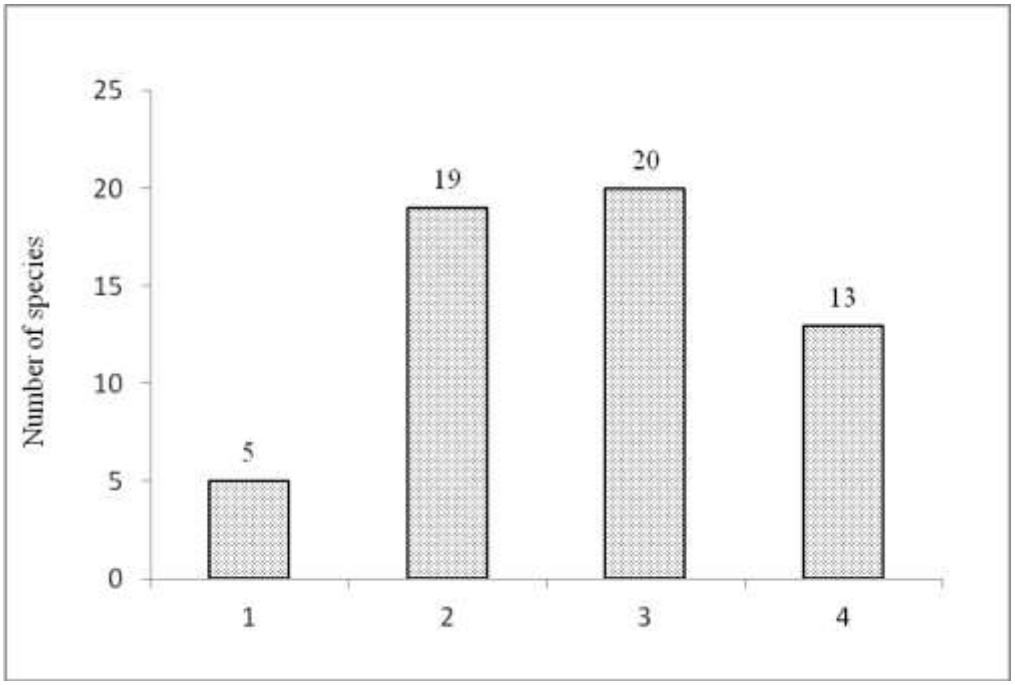

Fig. 8. Plant species occurring in different microhabitats.
1-Intertidal zone and close proximity of mangroves,
2 - Moist saline soil somewhat away from mangroves,
3 - Higher, dry rocky or sandy land,
4 - Proximity of cultivated places

Table 2. List of plant species with their life-forms and Habit.

S. No F/Spp.	Name of families (No of genera/No. of spp.)	Name of Genus (No. of spp.)	Name of Plant species	Habit	Life Forms
1/1	Aizoaceae (1/1)	*Aizoon* (1)	*Aizoon canariense* L.	Herb	Therophyte
2/2	Amaranthaceae (4/5)	*Aerva* (1)	*Aerva javanica* (Burm. f.) Juss. ex J.A. Schultes	Shrub	Phanerophyte
3		*Alternanthera* (1)	*Alternanthera sessilis* (L.) DC.	Herb	Chamaephyte
4		*Amaranthus* (2)	*Amaranthus graecizans* L.	Herb	Therophyte
5			*Amaranthus viridis* L.	Herb	Therophyte
6		*Digera* (1)	*Digera muricata* (L.) Mart.	Herb	Therophyte
3/7	Asclepiadaceae (1/1)	*Calotropis* (1)	*Calotropis procera* R. Br.	Shrub	Phanerophyte
4/8	Asteraceae (1/2)	*Launaea* (2)	*Launaea procumbens* (Roxb.) Amin.	Herb	Chamaephyte
9			*Launaea resedifolia* (L.) Kuntze	Herb	Chamaephyte
5/10	Avicenniaceae (1/1)	*Avicennia* (1)	*Avicennia marina* (Forssk.) Vierh.	Tree	Phanerophyte
6/11	Boraginaceae (1/3)	*Heliotropium* (3)	*Heliotropium crispum* Desf.	Subshrub	Chamaephyte
12			*Heliotropium ophioglossum* Stocks ex Boiss.	Subshrub	Chamaephyte
13			*Heliotropium strigosum* Willd.	Herb	Chamaephyte
7/14	Caesalpiniaceae (1/2)	*Senna* (2)	*Senna holosericea* (Fresen.) Greuter	Subshrub	Chamaephyte
15			*Senna italica* Mill.	Subshrub	Chamaephyte
8/16	Capparidaceae (2/3)	*Capparis* (1)	*Capparis cartilaginea* Decne.	Straggling shrub	Chamaephyte
17		*Cleome* (2)	*Cleome brachycarpa* Vahl. ex DC.	Herb	Chamaephyte
18			*Cleome viscosa* L.	Herb	Therophyte
9/19	Caryophyllaceae (1/1)	*Polycarpaea* (1)	*Polycarpaea spicata* Wight & Arn.	Herb	Therophyte
10/20	Chenopodiaceae (5/5)	*Arthrocnemum* (1)	*Arthrocnemum macrostachyum* (Moric.) C. Koch	Shrub	Chamaephyte
21		*Atriplex* (1)	*Atriplex stocksii* Boiss.	Subshrub	Chamaephyte
22		*Chenopodium* (1)	*Chenopodium murale* L.	Herb	Therophyte
23		*Salsola* (1)	*Salsola imbricata* Forssk.	Shrub	Phanerophyte
24		*Suaeda* (1)	*Suaeda fruticosa* Forssk. ex J. F. Gmelin	Shrub	Chamaephyte
11/25	Convolvulaceae (3/3)	*Convolvulus* (1)	*Convolvulus glomeratus* Choisy	Herb	Chamaephyte
26		*Cressa* (1)	*Cressa cretica* L.	Herb	Therophyte
27		*Ipomoea* (1)	*Ipomoea pes-caprae* (L.) R. Br.	Herb	Chamaephyte
12/28	Euphorbiaceae (1/4)	*Euphorbia* (4)	*Euphorbia caducifolia* Haines	Shrub	Phanerophyte
29			*Euphorbia clarkeana* Hook. f.	Herb	Therophyte
30			*Euphorbia hirta* L.	Herb	Chamaephyte
31			*Euphorbia serpens* Kunth in Humb.	Herb	Chamaephyte
13/32	Malvaceae (2/3)	*Abutilon* (2)	*Abutilon fruticosum* Guill.& Perr.	Shrub	Chamaephyte
33			*Abutilon indicum* (L.) Sweet	Large Shrub	Phanerophyte
34		*Sida* (1)	*Sida ovata* Forssk.	Subshrub	Chamaephyte
14/35	Mimosaceae (1/1)	*Prosopis* (1)	*Prosopis juliflora* (Swartz) DC.	Large Shrub	Phanerophyte
15/36	Molluginaceae (1/1)	*Glinus* (1)	*Glinus lotoides* L.	Herb	Chamaephyte
16/37	Orobanchaceae (1/1)	*Cistanche* (1)	*Cistanche tubulosa* Willd.	Herb	Cryptophyte
17/38	Papilionaceae (4/5)	*Astragalus* (1)	*Astragalus fatmensis* Hochst. ex Blatter	Herb	Therophyte

39		*Indigofera* (2)	*Indigofera argentea*	Herb	Chamaephyte
40			*Indigofera oblongifolia* Forsk.	Shrub	Phanerophyte
41		*Lotus* (1)	*Lotus garcinii* DC.	Herb	Therophyte
42		*Tephrosia* (1)	*Tephrosia uniflora* Blatter & Hallberg	Herb	Therophyte
18/41	Plumbaginaceae (1/1)	*Limonium* (1)	*Limonium stocksii* (Boiss.) O. Kuntze	Subshrub	Chamaephyte
19/42	Tamaricaceae (1/1)	*Tamarix* (1)	*Tamarix alii* Qaiser	Large shrub	Phanerophyte
20/43	Zygophyllaceae (3/3)	*Fagonia* (1)	*Fagonia indica* Burm.f.	Shrub	Chamaephyte
46		*Tribulus* (1)	*Tribulus terrestris* L.	Herb	Therophyte
47		*Zygophyllum* (1)	*Zygophyllum simplex* L.	Herb	Therophyte
21/48	Cyperaceae (1/2)	*Cyperus* (2)	*Cyperus longus* L.	Sedge	Cryptophyte
49			*Cyperus rotundus* L.	Sedge	Cryptophyte
22/50	Poaceae (8/9)	*Aeluropus* (1)	*Aeluropus lagopoides* (L.) Trin. ex Thw.	Grass	Cryptophyte
51		*Cynodon* (1)	*Cynodon dactylon* (L.) Pers.	Grass	Hemicryptophyte
52		*Dactyloctenium* (2)	*Dactyloctenium aegyptium* (L.) Willd.	Grass	Therophyte
53			*Dactyloctenium aristatum* Link	Grass	Therophyte
54		*Halopyrum* (1)	*Halopyrum mucronatum* (L.) Stafp	Grass	Hemicryptophyte
55		*Leptothrium* (1)	*Leptothrium senegalense* (Kunth) Clayton	Grass	Hemicryptophyte
56		*Setaria* (1)	*Setaria verticillata* (L.) P. Beauv.	Grass	Therophyte
57		*Sporobolus* (1)	*Sporobolus arabicus* Boiss.	Grass	Hemicryptophyte
58		*Urochondra* (1)	*Urochondra setulosa* (Trin.) C.E. Hubb.	Grass	Hemicryptophyte

Taxonomy

The recorded 96 species belonged to 64 genera in 32 families and ten orders (Fig. 9). The largest order *Passeriformes* consisted of 12 families, second largest order *Charadriiformes* consisted of 6 families and third largest order *Coraciiformes* consisted of 4 families, while orders *Falconiiformes, Pelecaniformes,* and *Ciconiiformes* consisted of 2 families each. The largest family was *Scolopocidae* which contained 16 species; all these species were migratory (winter visitors). The second largest family was *Ardeaidae* with 10 species most of which were resident species with two winter visitors. The third largest family *Sternidae* contained eight species, five of which were winter visitors and three residents (Fig. 10). These three larger families, contributed 35.41% of the total species in the study area from 2005-2010.

Table 3. Taxonomic break-up and occurrence of bird species observed in the study area during 2005 – 2010.

Order	Families	Species	Common name	Occurrence
Chardriiformes	Recurvirostridae	*1. Himantopus himantopus*	Black Winged Stilt	Common
		2. Recurvirostra avosetta	Avocet	Uncertain
	Charadriidae	*3. Charadrius alexandrinus*	Kentish Plover	Less common
		4. Charadrius dubius	Little Ringed Plover	Less common
		5. Charadrius hiaticula	Common Ringed Plover	Less common
		6. Charadrius leschenaultii	Greater Sand Plover	Common
		7. Charadrius mongolus	Lesser Sand Plover / Mongolian Plover	Common
		8. Pluvialis squatarola	Grey Plover	Less common
		9. Vanellus indicus	Red wattled Lapwing	Most common

	Scolopacidae	*10. Actitis hypoleucos / Tringa hypoleucos*	Common Sandpiper	Common
		11. Calidris alba	Sanderling	Less number
		12. Calidris alpina	Dunlin	Less common
		13. Calidris canutus	Red Knot	Less common
		14. Calidris minuta	Little Stint	Less common
		15. Gallinago gallinago	Common Snipe	Less common
		16. Limosa lapponica	Bartailed Godwit	Regular
		17. Limosa limosa	Black Tailed Godwit	Regular
		18. Numenius phaeopus	Whimbrel	Common
		19. Numenius arquata	Eurasian Curlew	Common
		20. Phalaropus lobatus	Phalarope	Less common
		21. Tringa erythropus	Spotted Red Shank	Less common
		22. Tringa ochropus	Green Sandpiper	Regular
		23. Tringa stagnatilis	Marsh Sandpiper	Less common
		24. Tringa totanus	Common Red Shank	Common
		25. Xenus cinereus	Terek Sandpiper	Less common
	Laridae	*26. Larus argentatus*	Herring Gull	Common
		27. Larus fuscus	Lesser Black head Gull	Common
		28. Larus ridibundus	Black Headed Gull	Common
		29. Laruss brunnicephalus	Brown Headed Gull	Regular
	Sternidae	*30. Chlidonias hybridus*	Whiskered Tern	Less common
		31. Gelochelidon nilotica	Gull Billed Tern	Common
		32. Hydroprogne caspia	Caspian Tern	Regular
		33. Sterna acuticauda	Black Bellied Tern	Regular
		34. Sterna aurantia	River Tern	Less common
		35. Sterna hirundo	Common Tern	Regular
		36. Strenula albifrons	Little Tern	Regular
		37. Thalasseus sandvicensis	Sandwich Tern	Common
	Haematopodidae	*38. Haematopus ostralegus*	Eurasian Oystercatcher	Less Common / rare
	Accipitridae	*39. Accipiter badius*	Shikra	Less common
Falconiformes		*40. Circus aeruginosus*	Marsh Harrier	Frequent regular
		41. Milvus migrans	Common Kite	Less common
		42. Haliastur indus	Brahaminy Kite	Less common
	Pandionidae	*43. Pandion haliaetus*	Osprey	Less common
Pelecaniformes	Phalacrocoracidae	*44. Phalacrocorax niger*	Little Cormorant	Common
		45. Phalacrocorax carbo	Large Cormorant	Common
		46.Phalacrocorax fuscicollis	Indian Cormorant / Indian Shag	Less common
	Pelecanidae	*47.Pelecanus erythrorhynchos*	White Pelican	Very rare
		48. Pelecanus crispus	Dalmatian Pelican	Very rare
Ciconiiformes	Ardeidae	*49. Ardea alba*	Great Large Egret	Common
		50. Ardea cinerea	Grey Heron	Less common

		51. Ardea intermedia / Mesophoyx intermedia	Median Egret	Common
		52. Ardea purpurea	Purple Heron	Threatened
		53. Ardeola grayii	Pond Heron	Common
		54. Bubulcus ibis	Cattle Egret	Very rare
		55. Butorides striatus	Little Heron	Very rare
		56. Egretta gularis	Western Reef Heron	Common
		57. Egretta garzetta	Little Egret	Common
		58. Nycticorax nyticorax	Black Crowned Night Heron	Rare
	Threskiornithidae	*59. Plegadis falcinellus*	Glossy Ibis	Rare
		60. Platalea leucorodia	Eurasian Spoon Bill	Less common
Phoenicopteriformes	Phoenicopteridae	*61. Phoenicopterus ruber*	Greater Flamingo	Common
Anseriformes	Anatidae	*62. Tadorna tadorna*	Common Shelduck	Common
		63. Aythya fuligula	Tufted Duck	Moderate regular
		64. Anas acuata	Pintail	Less number
		65. Aythya ferina	Pochard	Regular less number
Coraciiformes	Alcedinidae	*66. Alcedo atthis*	Small King Fisher	Less common
	Halyonidae	*67. Halcyon smyrnensis*	White breasted King Fisher	Less common
	Cerylidae	*68. Ceryle rudis*	Pied King Fishers	Less common
	Meropidae	*69. Merops orientalis*	Small Bee Eater	Common
		70. Merops superciliosus	Large Bee Eater	Less common
Passeriformes	Laniidae	*71. Lanius exubitor*	Great Grey Shrike	Less common
		72. Lanius vittatus	Bay Backed Shrike	Regular
	Cisticolidae	*73. Orthotomus sutorius*	Tailor Bird	Common
	Acrocephalus	*74Acrocephalus arundinaceus*	Great Warbler	Common
	Nectariniidae	*75. Cinnyris asiaticus / Nectarinia asiatica*	Purple Sunbird	Common
	Muscicapidae	*76. Saxicoloides fulicatus*	Indian Robin	Common
	Zosteropidae	*77. Zosterops palpebrosus*	Oriental White Eye	Common
	Aludidae	*78. Galerida cristata*	Crested Lark	Less common
		79. Clandrella raytal	Sand Lark	Rare
		80. Ammomanes deserti	Desert Finch Lark	Less common
	Pycnonotidae	*81. Pycnonotus cafer*	Red Vented Bulbul	Common
		82. Pycnonotus leucotis	White Eared Bulbul	Common
	Sturnidae	*83. Sturnus roseus*	Rosy Pastor	Common
	Hirundinidae	*84. Hirunda rustica*	Barn Swallow	Predominant
		85. Raparia diluta	Pale Martin	Predominant
	Motacillidae	*86. Motacilla flava*	Yellow Wagtail	Abundant
		87. Motacilla alba	White Wagtail	Less common
		88. Motacilla cinerea	Grey Wagtail	Less common
	Corvidae	*89. Corvus splendens*	House Crow	Common
	Passeridae	*90. Passer domesticus*	House Sparrow	Common

Columbiforms	Columbidae	*91. Columba palumbus*	Wood Pigeon	Wanderer
		92. Spilopelia senegalensis	Laughing Dove / Little Brown Dove	Common
		93. Streptopelia decaocto	Eurasian Collared Dove	Common
		94. Streptopelia tranquebarica	Red Turtle /Collared Dove	Less common
Podicipediformes	Podicipedidae	*95. Podiceps cristatus*	Crested Grebe	Common
		96. Podiceps nigricollis	Black Necked Grebe	Common

Table 4. Month-wise numbers of individuals of bird species recorded in the present study.

Year	Number of Individuals of bird species												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2005	4015	5031	2603	1192	762	523	372	398	647	1874	2823	5231	25471
2006	3602	3990	2033	1004	609	406	349	415	665	1925	3185	4454	22637
2007	3076	2516	1429	713	1225	723	465	423	452	1488	3870	3938	20318
2008	2561	2841	1500	793	490	423	380	352	735	1403	2491	2989	16958
2009	2982	3152	1324	733	513	353	304	483	848	2020	4594	4056	21362
2010	1907	1993	2084	1095	704	532	539	563	734	1107	1672	2226	15156
Total	18143	19523	10973	5530	4303	2960	2409	2634	4081	9817	18635	22894	121902
Mean of 2005-2010 (six years)	3023.83	3253.83	1828.83	921.67	717.17	493.33	401.50	439.00	680.17	1636.17	3105.83	3815.67	

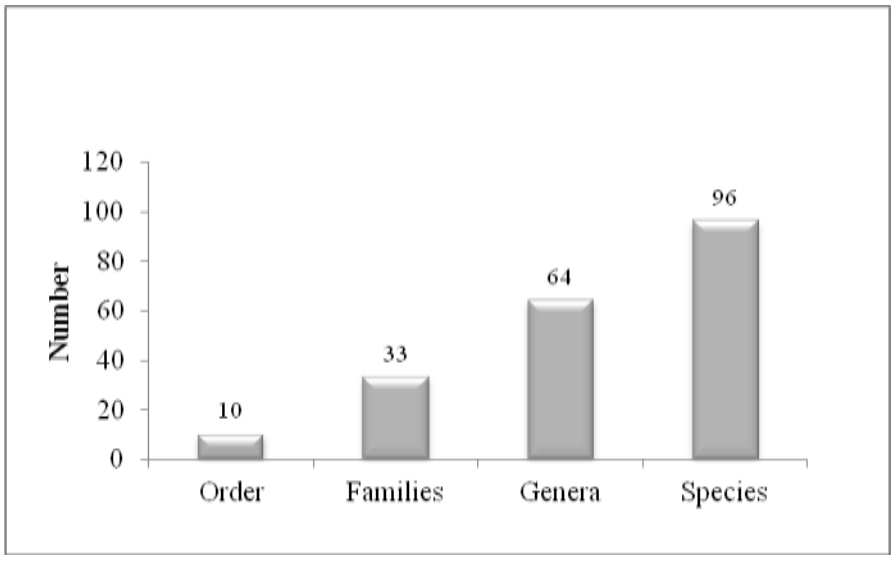

Fig. 9: Number of orders, families, genera and species of Avifauna recorded from study area during 2005-2010

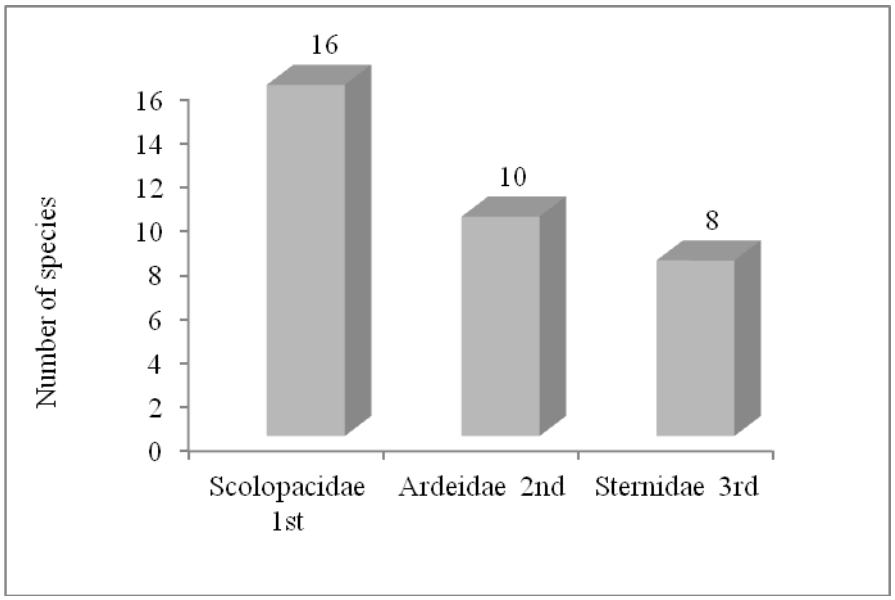

Fig. 10. The largest, 2nd largest and 3rd largest Avifauna families recorded from the study area during 2005-2010.

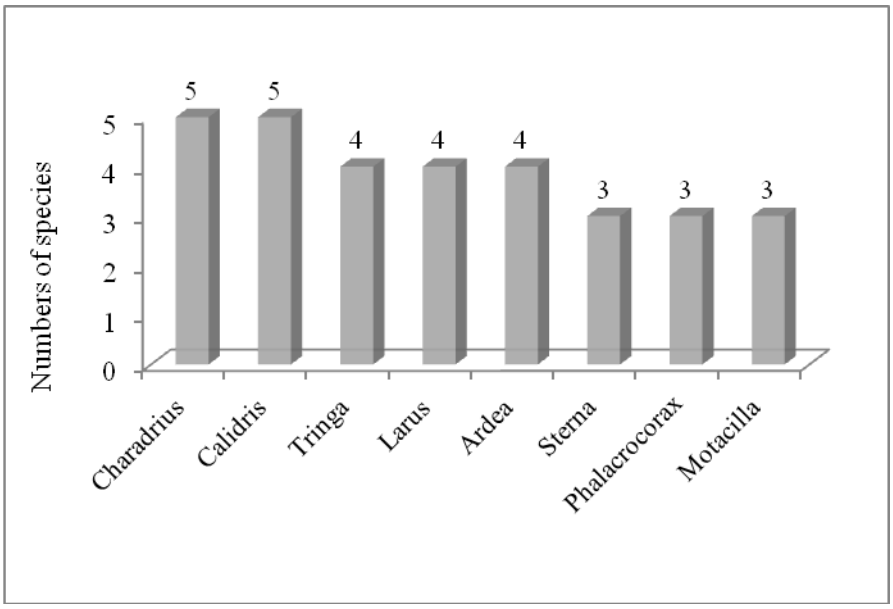

Fig. 11. Largest, 2nd largest and 3rd largest Avifauna genera of the study area recorded 2005-2010.

The birds' genera *Charadrius, Calidris, Tringa, Larus, Ardea, Sterna, Phalacrocorax,* and *Motacilla* contributed 32.29% of the total number of species in the study area. These eight genera were larger with 3 or more species per genus (Fig. 11), all other genera consisted of one or two species in the study area.

Population dynamics

The total number of recorded individuals varied in different months of the year that is, most of the species did not show an even distribution throughout the year. The highest counts were recorded in the month of December in

five of the six years of study, followed by February (four of the six years). The higher counts shifted in different years to January March, November, etc. however on the basis of six years' total, December showed the highest numbers of individuals followed by February and November **(**Table-4). On the other hand, with respect to the month of peak population for different species, most of the species showed their peak populations in the month of December, followed by February and January respectively. On average, 31.17 species showed their peak population in December, followed by February (18.67 species) and 12 species showed their peak population in January (Table – 5).

The total count of birds and total number of species were the highest in the first year of study, i.e. 2005 (Table – 4). In the next year the number of species was the same but the total count decreased, and in the subsequent years both the number of species and number of individuals continued to decrease; fourteen species had totally disappeared (all migratory), while several had greatly decreased populations by the end of the study.

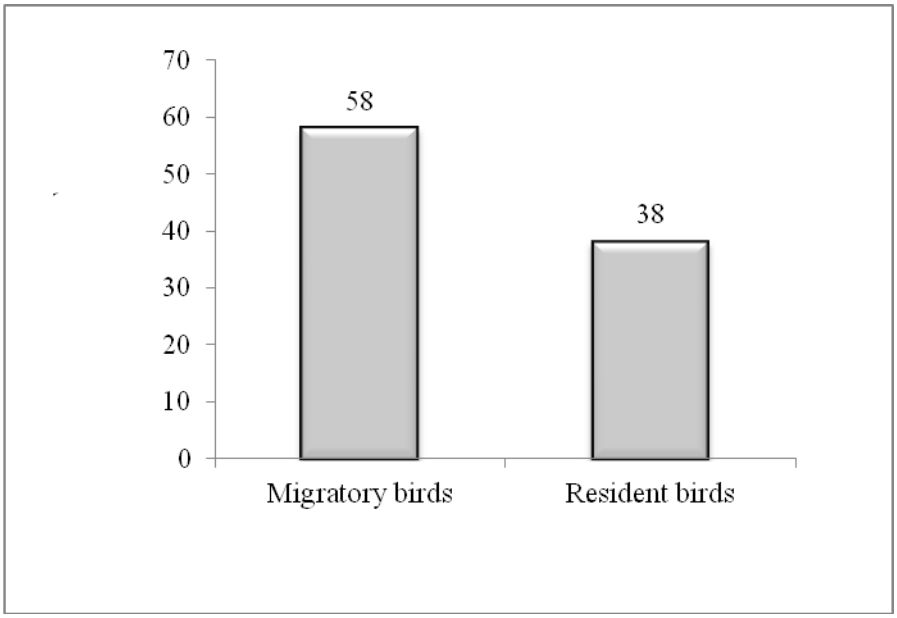

Fig. 12. Frequencies of Migratory and Resident birds in study area during 2005-2010.

Table 5. Month-wise number of bird species showing their peak population of year.

Year	Number of bird species											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	8	33	6	3	2	3	1	1	4	8	7	35
2006	10	23	4	5	0	3	1	3	2	7	7	46
2007	16	8	3	3	6	1	3	3	4	7	21	23
2008	10	19	6	9	1	2	2	2	3	2	4	37
2009	15	13	3	6	2	2	2	1	2	4	18	24
2010	13	16	13	3	1	2	4	4	3	2	3	22
Mean of 2005-2010 (six years)	12.00	18.67	5.83	4.83	2.00	2.17	2.17	2.33	3.00	5.00	10.00	31.17

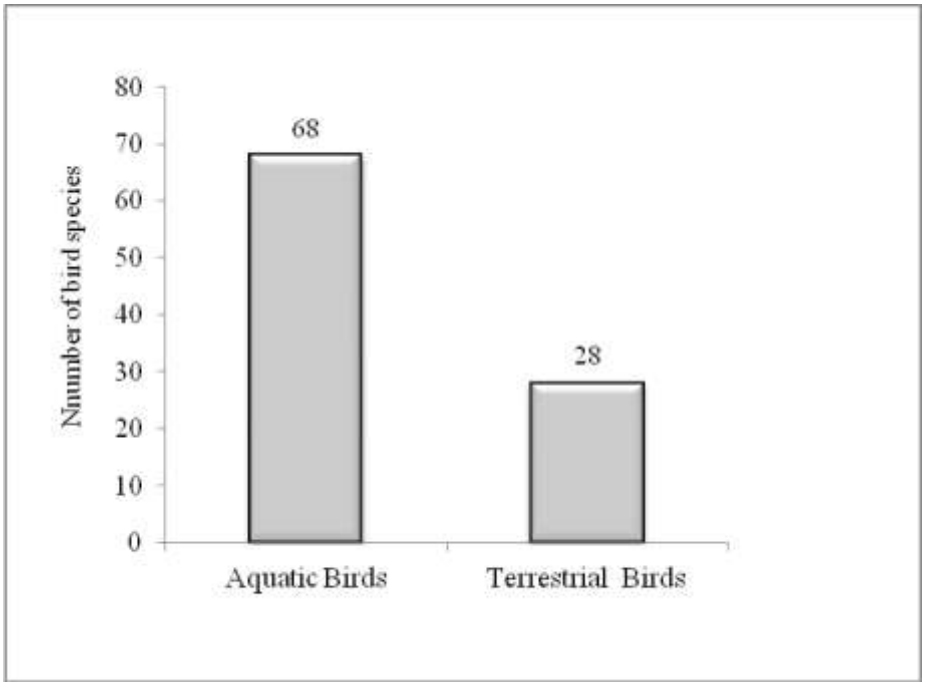

Fig. 13. Frequencies of aquatic and terrestrial species in the total species of birds recorded in study area during study period 2005-2010.

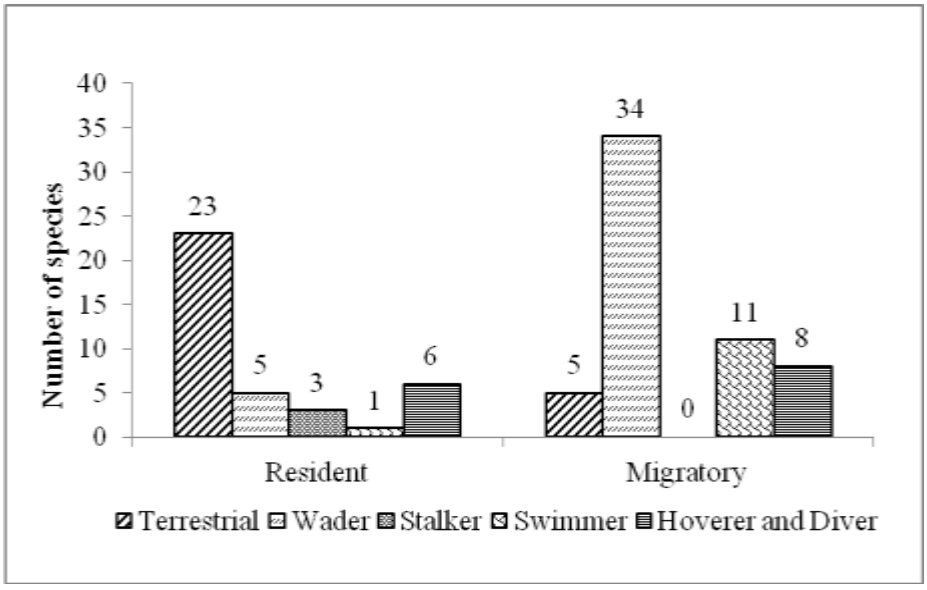

Fig. 14. Frequencies of various habit categories among the resident and migratory bird species of the study area.

Resident and migratory species

The migratory species mostly come from the Central Asia, Siberia, and Europe to escape the harsh winters of their native lands. Some short distance migratory species come from the high altitude colder areas of Pakistan. The migratory birds usually start coming from September – October and start returning to their homelands from February.

The sample contained 58 migratory and 38 resident bird species (Fig. 12). Overall, there were 68 aquatic and 28 terrestrial species among the total of 96 species (Fig. 13). The resident species had more terrestrial species (23) than in the migratory species (only 5 terrestrial species); while the number of wader species was the highest (34) among migratory aquatics and hoverer – diver species among resident aquatics were more than other aquatic categories of residents (Fig. 14).

Appendix - I

a) Species in intertidal zone and close proximity of Mangrove 1. *Avicennia marina* 2. *Arthrocnemum macrostachyum* 3. *Suaeda fruticosa* 4. *Cistanche tubulosa* 5. *Aeluropus lagopoides*	c) Species on higher, dry rocky, or sandy land: 1 *Aerva javanica* *2 Calotropis procera* 3 *Heliotropium ophioglossum* 4 *Heliotropium strigosum* 5 *Senna holosericea* 6 *Senna italica* 7 *Capparis cartilaginea* 8 *Cleome brachycarpa* 9 *Cleome viscosa* 10 *Convolvulus glomeratus* 11 *Euphorbia caducifolia* 12 *Abutilon fruticosum* 13 *Abutilon indicum* 14 *Sida ovata* 15 *Tephrosia uniflora* 16 *Tribulus terrestris* 17 *Dactyloctenium aristatum* 18 *Leptothrium senegalense* 19 *Sporobolus arabicus* 20 *Fagonia indica*
b) Species on moist saline soil, somewhat away from mangroves: 1. *Aizoon canariense* 2. *Launaea resedifolia* 3. *Heliotropium crispum* 4. *Polycarpaea spicata* 5. *Atriplex stocksii* 6. *Salsola imbricata* 7. *Cressa cretica* 8. *Ipomoea pes-caprae* 9. *Astragalus fatmensis* 10. *Indigofera argentea* 11. *Indigofera oblongifolia* 12. *Lotus garcinii* 13. *Limonium stocksii* 14. *Tamarix alii* 15. *Zygophyllum simplex* 16. *Cyperus longus* 17. *Cyperus rotundus* 18. *Halopyrum mucronatum* 19. *Urochondra setulosa*	d) <u>Species in proximity of cultivated places</u>: 1 *Alternanthera sessilis* 2 *Amaranthus graecizans* 3 *Amaranthus viridis* 4 *Digera muricata* 5 *Launaea procumbens* 6 *Chenopodium murale* 7 *Euphorbia clarkeana* 8 *Euphorbia hirta* 9 *Euphorbia serpens* 10 *Glinus lotoides* 11 *Cynodon dactylon* 12 *Dactyloctenium aegyptium* 13 *Setaria verticillata*

DISCUSSION

The mangrove ecosystem involves a complex network of species interacting with each other and with the abiotic parts of the ecosystem (McFarlane, 2001). Effective management and conservation require basic information including species composition and physicochemical and biological indicators of ecosystem health (Holguin *et al*. 2006).

The Karachi Backwaters mangroves are unique in not only being the arid climate mangroves, but also by the fact that they do not lie in a deltaic plain, and the microclimate and physiognomic difference is quite sharp in the surrounding areas.

The entire Backwaters area of Karachi is under the control of the Karachi Port Trust (KPT). According to KPT, the total Western Backwaters area is approximately 2590 hectares (http://kpt.gov.pk/pages/Default.aspx?id=144 4/19/2014). According to Ahmed (2006), the area contains 400 hectares of mangrove swamps. Anonymous (2005) gave Karachi harbor mangrove forest area as 985.50 hectares on the basis of SPOTXS 2003 data, but in the same report mentioned the mangroves area under the KPT control as 500 hectares. Therefore the exact extent of the Karachi Western Backwaters mangrove forest is not accurately known.

The Karachi Western Backwaters mangrove forest consists of the trees of a single mangrove species, i.e. *Avicennia marina*, unlike the Indus delta mangrove forests which are historically reported to have had eight mangrove species (Blatter *et al.*, 1929), now they have 4 (Imran 2013).

Karachi is surrounded by low calcareous hills which are the continuation of the Kirthar foothills. In this way, the City of Karachi lies at the meeting point of the deltaic plain of Indus River and the rugged hilly terrain of Balochistan. Likewise the mangrove ecosystem of the western backwaters is also fringed by comparatively high and rocky ground with small hillocks along its main-landwards margins. This dry-land supports a flora totally different from the flora of the mangrove ecosystem and its close vicinity. This characteristic also differentiates this mangrove ecosystem from that of the Indus delta, where such an abrupt edaphic and physiognomic difference is not present in the adjoining areas.

In the present study, birds were particularly observed in detail as they are the most prominent faunal component in the mangrove ecosystems. The present study is the first of its kind anywhere along Pakistan's coast in which monthly monitoring of the populations of bird species has been done and trends of population dynamics have been recognized. It is interesting that the number of species (96 species) found in the present study, although being lower than that previously reported (114 species by Durranee *et al*. 2008), was still fairly high considering the small size of the study area, and in comparison to certain other studies. Holguin *et al*. (2006) report 38 bird species from undamaged mangroves at the southern end of the Bahia de La Paz in Mexico. Mohd-Azlan *et al*. (2012) found 70 species of birds in the northern Australian mangroves. Mestre *et al*. (2007) reported 81 species from Paranaguá bay, Brazil. Pawar (2011) reported 56 species from the mangroves of Uran (Maharashtra, India). From the mangrove areas of Sindh, Hasan (1994) reported 62 species; and Ward (1999) found 26 species in the Gharo creek mangroves of the Indus delta. A possible reason for this comparatively high number of bird species in the Backwaters could be the unique location of this mangrove ecosystem amid the dry rocky and sandy territory where the surrounding area flora abruptly changes. Over quite a large area, these mangroves are the only dense forest available. Therefore a fairly large number of terrestrial resident birds are also present here (in addition to aquatic and migratory birds) as they find this place quite suitable for shelter and breeding. In case of Indus delta on the other hand, there are vast irrigated croplands with dense thickets of *Acacia nilotica* and certain other trees, shrubs, and fairly rich herbaceous cover. Therefore the terrestrial resident birds may not be interested in mangroves as they find better living and feeding places inland. The mangrove forests of Indus delta are inhabited mostly by aquatic birds.

It is notable that both the number of bird species and individuals continued to decrease over the study years; and 14 species totally disappeared by the end of the study. All these 14 species were migratory species; and in comparison to the work of Durranee *et al.* (2008), another 25 of the migratory species listed by them were not found in the present study. It is therefore obvious that the conditions for the migratory species are fast becoming unfavourable in the study area. The obvious reasons for this trend appear to be a high degree of pollution through Lyari River which drains both domestic and industrial effluents (from the SITE area) into the Western Backwaters, as well as continually increasing anthropogenic activities like construction of large warehouses, shops, and residential areas in the close vicinity of mangroves or even by encroaching upon them; and thus the increasing human presence in the area. All these factors are disrupting the natural ecosystem, which is in a dire need of protection as this lush green forest provides the much needed oxygen to the polluted atmosphere of Karachi.

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