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Diversity and distribution of birds in Jamnagar, Gujarat, India

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Abstract

The current research focused on the study of birds checklist, systematic updates, diversity, distribution, abundance and present status at Jamnagar, Gujarat, India. A total of 04 urban and 13 rural sites of the study area surveyed throughout the 18 months from July 2015 to December 2016. Data collection with a visual encounter survey method at random 01 to 08 days every month by three man-hours. A total of 103 species of birds were recorded belonging to 42 families, 81 genera and 19 orders during the study period. Family Scolopacidae represents the significant number of species (13) and family Laridae represents the significant number of individuals (5535) during the survey. From local status 69 rare, 19 Occasional, 13 frequent, 01 common and 01 abundant species reported; As per International Union for Conservation of Nature status, total 90 Least Concern, 12 Nearly Threatened and 01 Vulnerable species were recorded; from migratory status, a higher number of species were recorded from Common resident (43) category. Urban site Lakhota Lake represents a significant number of individuals (12158) and species (45) during the survey. During October 2015 a significant number of individuals (22.4%) were recorded. *Himantopus himantopus* species was the highest occurrences in site wise (11) and month wise (14) distribution during the study period. Site wise and month wise ecological indices were calculated. This study is a first attempt of exploring a bird diversity and distribution in urban and rural areas of the Jamnagar.

Keywords: Birds, Jamnagar, urban-rural sites, diversity, distribution, status

Introduction

Birds are a very important component in any ecosystem such as prey, predators, pollinators, scavengers, seed dispersals and ecosystem engineers. Decreasing numbers of birds are the sign of threatening the environment and bird population states that we are disturbing the ecosystem or not. So the conservation of the avian community is a too important aspect for maintaining the balance of the ecosystem.

The eBird/Clements checklist of birds of the world listed a total of 10721 species globally [1]. Checklist of the birds of South Asia region [2] stands a total of 1412 species, a checklist of the birds of the Indian subcontinent [3] stands a total of 1392 species and a checklist of the birds of India [4] stands a total of 1318 bird species were reported.

In Gujarat, a total of 526 species and 76 families were listed from the state [5]. From the various localities of the Gujarat state listed 574 species of birds [6]. Some of the studies (Jain *et al.*, 2005 [7]; Pandya and Vachhrajani, 2010 [8]; Dhandhukia *et al.*, 2011 [9]; Samsoor Ali *et al.*, 2012 [10]; Radadia, 2013 [11]; Rathod *et al.*, 2015a [12]; Rathod *et al.*, 2015b [13]; Rathod *et al.*, 2017 [14]; Dal and Vaghela, 2015 [15]; Rathod and Padate, 2008 [16]; Rathod and Padate, 2017 [17]; Suthar *et al.*, 2017 [18]; Patel *et al.*, 2017 [19]; Vala and Trivedi, 2018 [20]; Vargiya and Chakraborty, 2019 [21]; Patel and Raval, 2019 [22]; Parihar *et al.*, 2020a [23]; Parihar *et al.*, 2020b [24]) have been carried out in different places of Gujarat state and compiled the studies of avifauna in cities, villages, reservoirs, lakes, rivers, agriculture farms, wind farms, coastal areas, wetlands, ponds, gardens/parks and others different habitats.

A total of 400 species of birds reported from the Jamnagar district [25]. A total of 206 bird species were listed from the checklist of the Jamnagar [26]. Most of the studies were done in the Marine National Park, Khijadiya Bird Sanctuary and coastal area. Data are scarce on birds of urban and rural areas. Therefore the present study was carried out and this work aims to study the updates systematics, local conservation and migratory status, site-wise and month-wise diversity and distribution of avifauna from the Jamnagar city and some rural sites.

2. Materials and Methods

2.1. Study area

Jamnagar is a district of India located at the coast of the Gulf of Kutch in the state of Gujarat at the Northern Kathiawar Peninsula from Western India and an elevation of approximately 20 m above mean sea level (Fig. 1). There are three defined seasons: Winter – November to February, Summer- March to May and Monsoon – June to October. Jamnagar has a hot semi-arid climate. It is one of the extreme kind with hot summers and cold winters except in the coastal region, where it is generally pleasant throughout the year. The air is humid due to the coastal location. For the study of avifauna, urban (04 sites) and rural (13 sites) areas were selected of Jamnagar tehsil. For the urban areas (sites) Jamnagar city boundary and the rural areas (sites) outside the city boundary were considered.

2.2. Data collection and identification

The study was conducted from the year July 2015 to December 2016. The study sites have visited an average of 01 to 08 days in a month by three man-hours. Samplings were randomly done by a visual encounter survey method in all the sites. For the data collection and field survey, a pair of binocular (Celestron Up-close 12x50 and Celestron Up-close G2 10x25), Digital Single-Lens Reflex (700D, 1100D and Nikon D5800) cameras were used for photography and observed the birds accurately. Identification of birds species by using books [27, 28, 29] and online versions of the birds database Birdlife International [30], Birds of Gujarat [31]. Systematic were followed as per HBW and BirdLife International [32] and Xeno-canto database [33] used for some bird call identification.

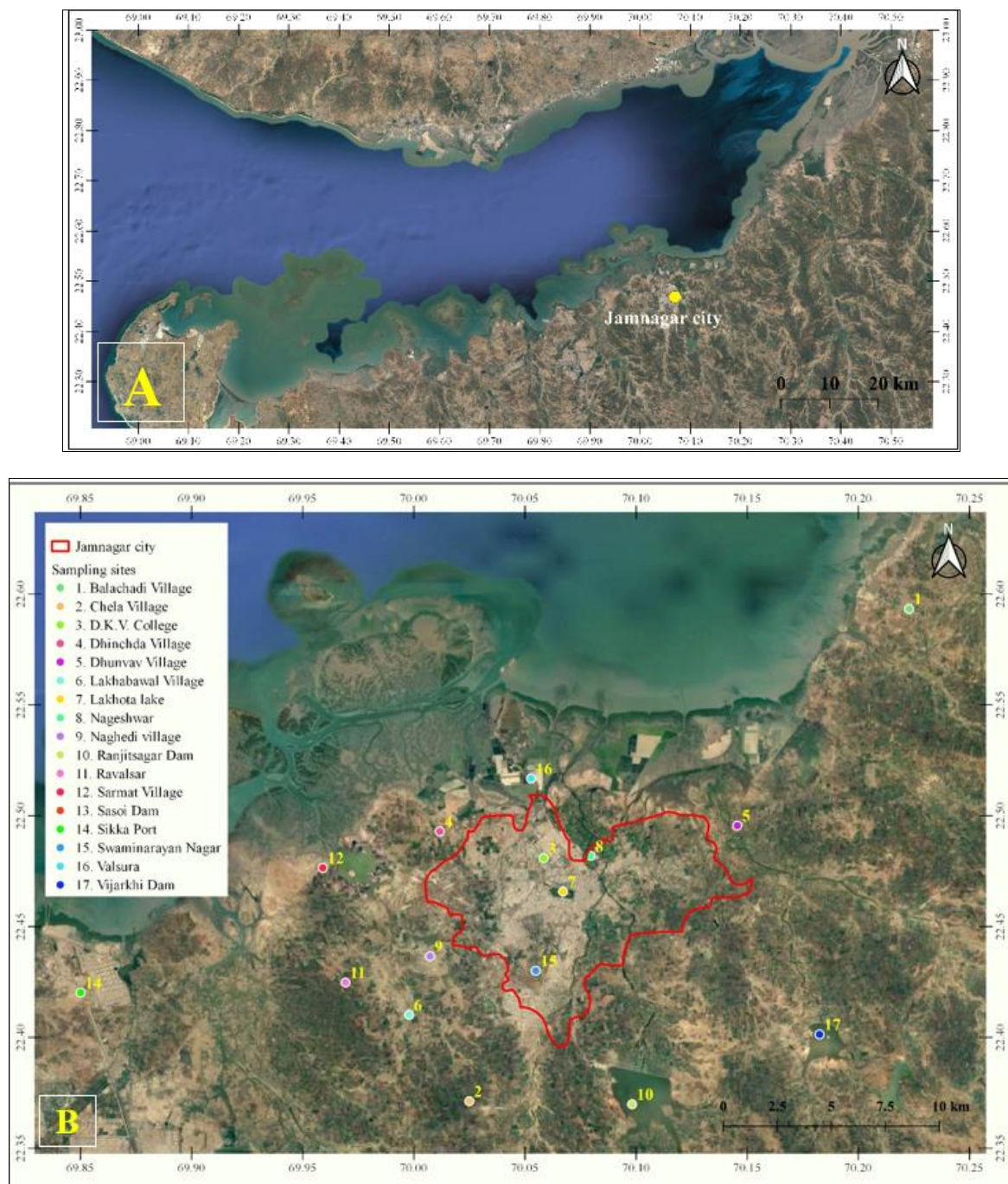


Fig 1: Map of the selected study area and sampling sites. A. Location of Jamnagar city in Gujarat state. B. Location of sites in urban and rural areas. “Red” line or boundary denotes urban (city) areas and outside of the urban considered as a rural area.

2.3. Data analysis

Checklist with systematics updates, local status, International Union for Conservation of Nature (IUCN) status [34] and migratory status [6] of the recorded birds from the study area in Table 1.

Local status (LS) calculated by using the formula,

$$LS = \frac{A + B + C + D}{4} \times 100$$

Where A is Sampling-wise distribution of individual, B is the Month-wise distribution of individual, C is Site-wise distribution of individuals and D is Population status.

Sampling-wise distribution of individual was calculated by using the formula,

$$A = \frac{\text{Occurrences of individuals in sampling units}}{\text{Total numbers of sampling units}} \times 100$$

Month-wise distribution of individuals was calculated by using the formula,

$$B = \frac{\text{Occurrences of individuals in months}}{\text{Total numbers of months}} \times 100$$

Site-wise distribution of individuals was calculated as,

$$C = \frac{\text{Occurrences of individuals in sites}}{\text{Total numbers of sites}} \times 100$$

Population status is given by the average of the individual in a community,

$$D = \frac{\text{Total individual of species}}{\text{Total individual of community}} \times 100$$

As per ACFOR classification used for measuring the abundance of species [35]. We classified avifaunal species into a total of five categories based on the frequency (%) of avian species. The value in between 45 to 55 assigned as abundant species (A), 34 to 44 is common species (C), 23 to 33 is frequent species (F), 12 to 22 is occasional species (O) and 1 to 11 is rare (R) species for the study area.

3.2 Statistical analysis

Diversity indices like Simpson's index of diversity and Simpson's reciprocal index (1-D and 1/D); Shannon – Wiener diversity-H', Pielou's evenness - e^H/S and Margalef's species richness (d) were computed by using software PAST (Paleontological Statistics software) [36] and interpretation as per Magurran (2013) [37].

4. Results and Discussion

A total of 13968 individuals, 103 species of birds belong to 81 genera, 42 families and 19 orders were recorded from July 2015 to December 2016 from the 17 study sites (Table 1). Family Scolopacidae represents the higher number of species (13) followed by Ardeidae (08) and Anatidae (07). Family Laridae had the highest individuals (5535) recorded in the study area during the study period.

As per local status, 69 Rare, 19 Occasional, 13 Frequent, 01 Common species - Red-wattled Lapwing *Vanellus indicus*) and 01 Abundant species - Black-winged Stilt *Himantopus himantopus*) were recorded (Table 1).

As per the IUCN Red List of Threatened Species only one Vulnerable species Common Pochard (*Aythya farina*), 12 Near Threatened and 90 Least Concern species were recorded from the study area (Table 1).

As per the migratory status, a maximum number of species were recorded from common resident (43) category followed by common winter visitor (28 species), very common resident (09 species), 03 species (Common to uncommon resident and Very common winter visitor), 02 species (Common to uncommon winter visitor and Fairly common resident) and remaining were one species record in the study area (Table 1).

Table 1: Checklist of recorded birds species in the study area.

Common Name	Scientific Name	STATUS		
		LOCAL	IUCN	MS
Order: Galliformes				
Family: Phasianidae (Pheasants, Partridges, Turkeys, Grouse)				
1. Indian Peafowl	<i>Pavo cristatus</i>	R	LC	a
Order: Anseriformes				
Family: Anatidae (Ducks, Geese, Swans)				
2. Common Teal	<i>Anas crecca</i>	O	LC	j
3. Mallard	<i>Anas platyrhynchos</i>	R	LC	q
4. Indian Spot-billed Duck	<i>Anas poecilorhyncha</i>	F	LC	a
5. Common Pochard	<i>Aythya ferina</i>	O	VU	a
6. Tufted Duck	<i>Aythya fuligula</i>	R	LC	j
7. African Comb Duck	<i>Sarkidiornis melanotos</i>	O	LC	a
8. Northern Shoveler	<i>Spatula clypeata</i>	F	LC	t
Order: Podicipediformes				
Family: Podicipedidae (Grebes)				
9. Great Crested Grebe	<i>Podiceps cristatus</i>	R	LC	n
10. Little Grebe	<i>Tachybaptus ruficollis</i>	R	LC	a
Order: Phoenicopteriformes				
Family: Phoenicopteridae (Flamingos)				
11. Lesser Flamingo	<i>Phoeniconaias minor</i>	R	NT	a
12. Greater Flamingo	<i>Phoenicopterus roseus</i>	R	LC	a
Order: Columbiformes				
Family: Columbidae (Pigeons, Doves)				

13.	Rock Dove	<i>Columba livia</i>	O	LC	s
14.	Laughing Dove	<i>Spilopelia senegalensis</i>	R	LC	a
Order: Cuculiformes					
Family: Cuculidae (Cuckoos)					
15.	Western Koel	<i>Eudynamis scolopaceus</i>	R	LC	a
Order: Gruiformes					
Family: Rallidae (Rails, Gallinules, Coots)					
16.	Common Coot	<i>Fulica atra</i>	F	LC	a
17.	Common Moorhen	<i>Gallinula chloropus</i>	R	LC	a
18.	Purple Swamphen	<i>Porphyrio</i>	R	LC	a
Family: Gruidae (Cranes)					
19.	Demoiselle Crane	<i>Anthropoides virgo</i>	R	LC	j
20.	Common Crane	<i>Grus</i>	R	LC	j
Order: Ciconiiformes					
Family: Ciconidae (Storks)					
21.	Black-necked Stork	<i>Ephippiorhynchus asiaticus</i>	R	NT	p
22.	Painted Stork	<i>Mycteria leucocephala</i>	O	NT	o
Order: Pelicaniformes					
Family: Ardeidae (Herons)					
23.	Great White Egret	<i>Ardea alba</i>	F	LC	a
24.	Grey Heron	<i>Ardea cinerea</i>	F	LC	e
25.	Intermediate Egret	<i>Ardea intermedia</i>	R	LC	a
26.	Indian Pond-heron	<i>Ardeola grayii</i>	R	LC	a
27.	Cattle Egret	<i>Bubulcus ibis</i>	R	LC	a
28.	Little Egret	<i>Egretta garzetta</i>	F	LC	a
29.	Western Reef-egret	<i>Egretta gularis</i>	R	LC	d
30.	Yellow Bittern	<i>Ixobrychus sinensis</i>	R	LC	l
Family: Pelecanidae (Pelicans)					
31.	Dalmatian Pelican	<i>Pelecanus crispus</i>	O	NT	h
32.	Great White Pelican	<i>Pelecanus onocrotalus</i>	R	LC	j
Family: Threskiornithidae (Ibises, Spoonbills)					
33.	Eurasian Spoonbill	<i>Platalea leucorodia</i>	O	LC	b
34.	Glossy Ibis	<i>Plegadis falcinellus</i>	R	LC	g
35.	Red-naped Ibis	<i>Pseudibis papillosa</i>	F	LC	a
36.	Black-headed Ibis	<i>Threskiornis melanocephalus</i>	O	NT	a
Order: Suliformes					
Family: Anhingidae (Darters)					
37.	Oriental Darter	<i>Anhinga melanogaster</i>	F	NT	m
Family: Phalacrocoracidae (Cormorants)					
38.	Little Cormorant	<i>Microcarbo niger</i>	F	LC	k
39.	Great Cormorant	<i>Phalacrocorax carbo</i>	O	LC	k
40.	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>	F	LC	a
Order: Charadriiformes					
Family: Burhinidae (Thick-knees)					
41.	Indian Thick-knee	<i>Burhinus indicus</i>	R	LC	a
42.	Great Thick-knee	<i>Esacus recurvirostris</i>	R	NT	f
Family: Charadriidae (Plovers)					
43.	Kentish Plover	<i>Charadrius alexandrinus</i>	R	LC	c
44.	Little Ringed Plover	<i>Charadrius dubius</i>	O	LC	a
45.	Red-wattled Lapwing	<i>Vanellus indicus</i>	C	LC	s
46.	Yellow-wattled Lapwing	<i>Vanellus malabaricus</i>	R	LC	a
Family: Jacanidae (Jacanas)					
47.	Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>	R	LC	a
Family: Laridae (Gulls, Terns, Skimmers)					
48.	Whiskered Tern	<i>Chlidonias hybrida</i>	O	LC	j
49.	Brown-headed Gull	<i>Larus brunnicephalus</i>	F	LC	j
50.	Pallas's Gull	<i>Larus ichthyaetus</i>	R	LC	j
51.	Black-headed Gull	<i>Larus ridibundus</i>	F	LC	j
52.	River Tern	<i>Sterna aurantia</i>	F	NT	a
Family: Recurvirostridae (Avocets, Stilts)					
53.	Black-winged Stilt	<i>Himantopus</i>	A	LC	a
54.	Pied Avocet	<i>Recurvirostra avosetta</i>	R	LC	j
Family: Scolopacidae (Sandpipers, Snipes, Phalaropes)					
55.	Common Sandpiper	<i>Actitis hypoleucos</i>	R	LC	j
56.	Sanderling	<i>Calidris alba</i>	R	LC	j
57.	Curlew Sandpiper	<i>Calidris ferruginea</i>	R	NT	j
58.	Little Stint	<i>Calidris minuta</i>	R	LC	j

59.	Ruff	<i>Calidris pugnax</i>	O	LC	T
60.	Common Snipe	<i>Gallinago</i>	R	LC	j
61.	Bar-tailed Godwit	<i>Limosa lapponica</i>	R	NT	h
62.	Black-tailed Godwit	<i>Limosa</i>	O	NT	j
63.	Eurasian Curlew	<i>Numenius arquata</i>	R	NT	j
64.	Wood Sandpiper	<i>Tringa glareola</i>	O	LC	j
65.	Common Greenshank	<i>Tringa nebularia</i>	R	LC	j
66.	Green Sandpiper	<i>Tringa ochropus</i>	O	LC	j
67.	Common Redshank	<i>Tringa totanus</i>	R	LC	j
Order: Strigiformes					
Family: Strigidae (Typical Owls)					
68.	Spotted Owlet	<i>Athene brama</i>	R	LC	a
Order: Accipitriformes					
Family: Accipitridae (Hawks, Eagles)					
69.	Black-winged Kite	<i>Elanus caeruleus</i>	R	LC	a
70.	Black Kite	<i>Milvus migrans</i>	R	LC	a
Family: Pandionidae (Osprey)					
71.	Osprey	<i>Pandion haliaetus</i>	R	LC	j
Order: Bucerotiformes					
Family: Upupidae (Hoopoes)					
72.	Common Hoopoe	<i>Upupa epops</i>	R	LC	j
Order: Coraciiformes					
Family: Alcedinidae (Kingfishers)					
73.	Pied Kingfisher	<i>Ceryle rudis</i>	R	LC	a
74.	White-breasted Kingfisher	<i>Halcyon smyrnensis</i>	F	LC	s
Family: Coraciidae (Rollers)					
75.	Indian Roller	<i>Coracias benghalensis</i>	R	LC	a
Family: Meropidae (Bee-eaters)					
76.	Asian Green Bee-eater	<i>Merops orientalis</i>	R	LC	a
Order: Piciformes					
Family: Megalaimidae (Asian Barbets)					
77.	Coppersmith Barbet	<i>Psilopogon haemacephalus</i>	R	LC	a
Order: Falconiformes					
Family: Falconidae (Falcons, Caracaras)					
78.	Common Kestrel	<i>Falco tinnunculus</i>	R	LC	j
Order: Psittaciformes					
Family: Psittacidae (Parrots)					
79.	Rose-ringed Parakeet	<i>Psittacula krameri</i>	R	LC	s
Order: Passeriformes					
Family: Alaudidae (Larks)					
80.	Oriental Skylark	<i>Alauda gulgula</i>	R	LC	f
81.	Greater Short-toed Lark	<i>Calandrella brachydactyla</i>	R	LC	j
82.	Ashy-crowned Sparrow-lark	<i>Eremopterix griseus</i>	R	LC	s
83.	Crested Lark	<i>Galerida cristata</i>	R	LC	a
84.	Indian Bushlark	<i>Mirafra erythroptera</i>	R	LC	a
Family: Cisticolidae (Cisticolas and allies)					
85.	Plain Prinia	<i>Prinia inornata</i>	R	LC	a
Family: Dicruridae (Drongos)					
86.	Black Drongo	<i>Dicrurus macrocercus</i>	R	LC	s
Family: Emberizidae (Buntings, American sparrows and allies)					
87.	Rock Bunting	<i>Emberiza cia</i>	R	LC	r
Family: Hirundinidae (Swallows and martins)					
88.	Barn Swallow	<i>Hirundo rustica</i>	O	LC	i
89.	Wire-tailed Swallow	<i>Hirundo smithii</i>	R	LC	a
Family: Leiotrichidae (Laughingthrushes and allies)					
90.	Jungle Babbler	<i>Turdoides striata</i>	R	LC	a
Family: Motacillidae (Wagtails and pipits)					
91.	Paddyfield Pipit	<i>Anthus rufulus</i>	R	LC	a
92.	Western Yellow Wagtail	<i>Motacilla flava</i>	R	LC	j
Family: Muscipidae (Chats and Old World flycatchers)					
93.	Oriental Magpie-robin	<i>Copsychus saularis</i>	R	LC	a
94.	Desert Wheatear	<i>Oenanthe deserti</i>	R	LC	j
95.	Common Stonechat	<i>Saxicola torquatus</i>	R	LC	j
96.	Indian Robin	<i>Saxicoloides fulicatus</i>	R	LC	a
Family: Nectariniidae (Sunbirds)					
97.	Purple Sunbird	<i>Cinnyris asiaticus</i>	R	LC	a
Family: Passeridae (Sparrows, snowfinches and allies)					

98.	House Sparrow	<i>Passer domesticus</i>	R	LC	a
Family: Pycnonotidae (Bulbuls)					
99.	Red-vented Bulbul	<i>Pycnonotus cafer</i>	O	LC	s
100.	White-eared Bulbul	<i>Pycnonotus leucotis</i>	R	LC	f
Family: Sturnidae (Starlings)					
101.	Common Myna	<i>Acridotheres tristis</i>	R	LC	s
102.	Rosy Starling	<i>Pastor roseus</i>	O	LC	t
103.	Brahminy Starling	<i>Sturnia pagodarum</i>	R	LC	s

Abbreviation: Local status ^[35]: abundant (A), common species (C), frequent (F), occasional (O) and rare (R). (IUCN, 2020) ^[34]: LC-Least concern, VU-Venerable, NT-Nearly Threatened. Migratory status ^[6]: a - Common resident, b - Common resident and local migrant, c - Common resident and local winter migrant, d - Common resident and winter migrant, e - Common resident and winter visitor, f - Common to uncommon resident, g - Common to uncommon resident and migrant, h - Common to uncommon winter visitor, i - Common winter migrant, j - Common winter visitor, k - Fairly common resident, l - Uncommon monsoon /breeding migrant, m - Uncommon resident, n - Uncommon to common resident and local migrant, o - Uncommon to locally common resident, p - Uncommon to rare resident, q - Uncommon winter visitor, r - Vagrant, s - Very common resident, t - Very common winter visitor.

4.1 Site-wise distribution

A total of 12215 individuals (87%) recorded from the 04 urban sites and 1753 individuals (13%) recorded from the 13 rural sites during the study period. The supreme number of individuals (12158) and species (45) were recorded from the urban site - Lakhota Lake. Maximum individuals (2664) of Brown-headed Gull *Larus brunnicephalus* species were also recorded from the Lakhota Lake. Fewer individuals (03) recorded from the Nageshwar site whereas fewer species recorded from the Swaminarayannagar which are located in the urban area. (Fig. 2 & 3).

4.2 Month-wise distribution

The maximum distribution of birds was recorded in October 2015 during the monsoon season (22.4% individuals) followed by the winter season in December (19.3% individuals) and the summer season in March (6.1% individuals) (Fig. 4 & 5).

Major individuals of Brown-headed Gull *Larus brunnicephalus* species were recorded during the winter (1460) followed by monsoon (819) and summer (385) season. Black-winged Stilt *Himantopus himantopus* species was the higher occurrences in site wise (11) and monthwise (14) distribution during the study period.

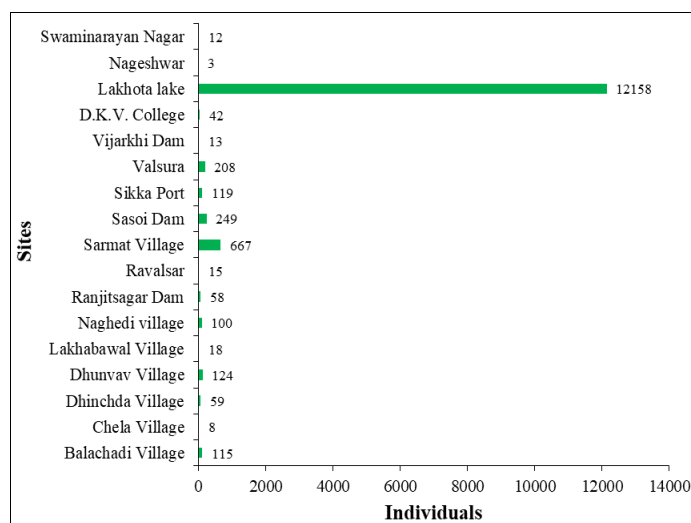


Fig 2: Site-wise distribution of avifaunal individuals in the study area.

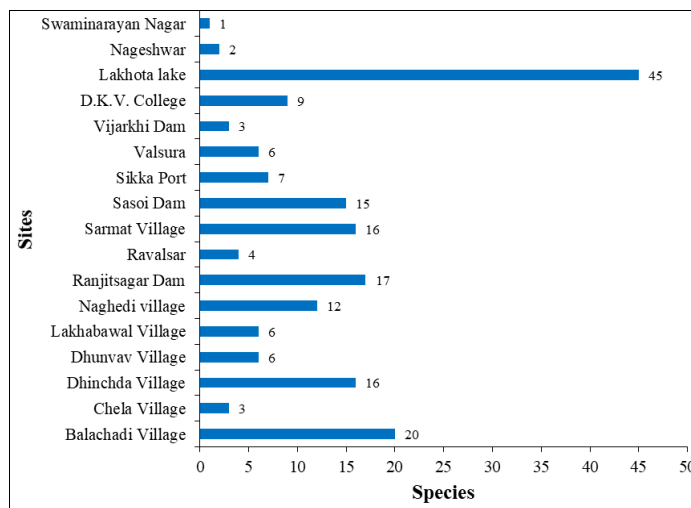


Fig 3: Site-wise distribution of avifaunal species in the study area.

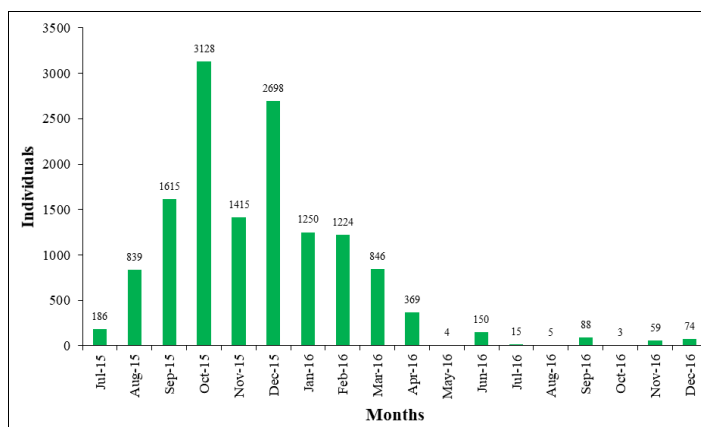


Fig 4: Month-wise distribution of birds individuals during the study period.

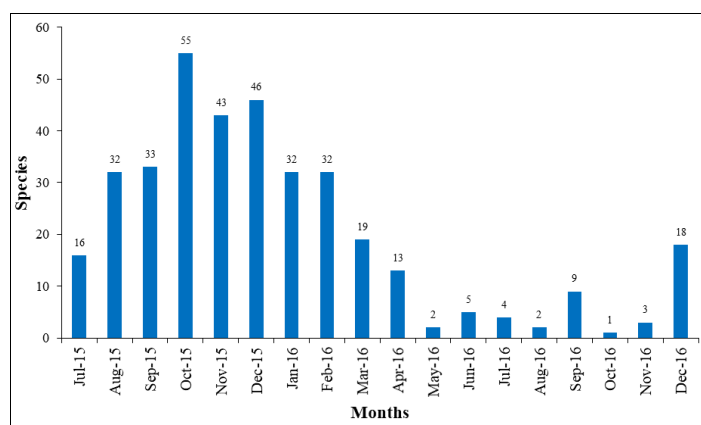


Fig 5: Month-wise distribution of bird species during the study period

4.3 Site-wise diversity indices

Dominance (D): 0.1 and Simpson (1-D) was significant in rural sites (i.e. Balachadi Village, Dhinchda Village, Ranjitsagar Dam, and Sarmat Village) as well as only one urban site i.e. Lakhota lake. Swaminarayan Nagar site has insignificant diversity (D = 1.0, 1-D = 0) among all the urban sites. Shannon (H') and Margalef (d) was significant in the Lakhota lake site (H' = 2.7, d = 4.7) and insignificant in the urban site - Swaminarayan Nagar site (H' = 0, d = 0). Chela Village, Ravalsar and Swaminarayan Nagar sites were more evenly distributed as compared to other sites. (Table 2). The result indicates that diversity indices significant in the rural site as compare to the urban site. It revealed that most of

the bird's species preferred rural areas except the Lakhota Lake site which is located in the center of the city and it has daily many visitors for food offering to birds. These birds are known as opportunistic species.

4.4 Month-wise diversity indices

Dominance (D): 0.1, Simpson diversity (1-D): 0.9, Margalef species richness (d) : >4 and Shannon Weiner Index (H'): 3.0 were significant from August 2015 to February 2016 (Table 3). It concludes that August to October period is a standing interval for the arrival of migratory birds and November to February period is the peak point of residing for migratory birds in the study area.

Table 2: Site wise diversity indices of avian fauna of Jamnagar.

Sites	Indices					
	D	1/D	1-D	H'	e	d
Balachadi Village	0.12	8.33	0.88	2.57	0.65	4.00
Chela Village	0.34	2.91	0.66	1.08	0.98	0.96
Dhinchda Village	0.13	7.45	0.87	2.35	0.66	3.68
Dhunvav Village	0.74	1.36	0.26	0.64	0.32	1.04
Lakhabawal Village	0.35	2.84	0.65	1.38	0.66	1.73
Naghedi village	0.21	4.84	0.79	1.96	0.59	2.39
Ranjitsagar Dam	0.09	11.07	0.91	2.60	0.79	3.94
Ravalsar	0.26	3.81	0.74	1.36	0.98	1.11
Sarmat Village	0.13	7.56	0.87	2.26	0.60	2.31
Sasoi Dam	0.67	1.50	0.33	0.93	0.17	2.54
Sikka Port	0.19	5.36	0.81	1.78	0.84	1.26
Valsura	0.43	2.30	0.57	1.06	0.48	0.94
Vijarkhi Dam	0.62	1.61	0.38	0.69	0.66	0.78
D.K.V. College	0.15	6.58	0.85	1.99	0.81	2.14
Lakhota lake	0.11	8.98	0.89	2.68	0.32	4.68
Nageshwar	0.56	1.80	0.44	0.64	0.94	0.91
Swaminarayan Nagar	1.00	1.00	0.00	0.00	1.00	0.00

Notes: " D " for Dominance, " 1/D " and " 1-D " for Simpson, " H' " for Shannon, " e " for Evenness and " d " for Margalef's richness.



Plate 1: Photographs of some bird species recorded during the study period



Plate 2: Photographs of some bird species recorded during the study period

4.5 Comparison with other studies

When the present study was compared with previous studies

done in the Gujarat state, the current bird's species were recorded more than 17.5% (Jain *et al.*, 2005) ^[7], 82.5% (Dal and Vaghela, 2015) ^[15], 50.5% (Rathod *et al.*, 2015a) ^[12], 23.3% (Rathod *et al.*, 2015b) ^[13], 59.2% (Suthar *et al.*, 2017) ^[18], 20.4% (Rathod *et al.*, 2017) ^[14], 33% (Patel *et al.*, 2017) ^[19], 50.5% (Vala and Trivedi, 2018) ^[20], 32% (Vargiya and Chakraborty, 2019) ^[21] and 6.8% (Parihar *et al.*, 2020a) ^[23] other studies.

The current study represents 1% part of the world (Clements *et al.*, 2019) ^[1], 7.3% part of the checklist of the birds of South Asia region ^[2], 7.4% part of the checklist of the birds of the Indian subcontinent ^[3], 7.8% part of the checklist of the birds of India ^[4], 17.9% part of the Gujarat state (Ganpule, 2016) ^[6], 39.5% part of the Jamnagar district ^[26]. Photographs of some bird species were showing in the Plate 1 and Plate 2.

Table 3: Month wise diversity indices of avian fauna of Jamnagar.

Months	Indices					
	D	1/D	1-D	H'	e	d
Jul-15	0.18	5.65	0.82	2.24	0.59	2.87
Aug-15	0.08	11.82	0.92	2.77	0.50	4.61
Sep-15	0.10	10.24	0.90	2.71	0.46	4.33
Oct-15	0.07	13.44	0.93	3.04	0.38	6.71
Nov-15	0.10	9.55	0.90	2.68	0.34	5.79
Dec-15	0.11	8.72	0.89	2.57	0.28	5.70
Jan-16	0.11	9.02	0.89	2.58	0.41	4.35
Feb-16	0.15	6.69	0.85	2.42	0.35	4.36
Mar-16	0.18	5.70	0.82	2.19	0.47	2.67
Apr-16	0.19	5.39	0.81	2.03	0.59	2.03
May-16	0.50	2.00	0.50	0.69	1.00	0.72
Jun-16	0.66	1.51	0.34	0.66	0.39	0.80
Jul-16	0.49	2.03	0.51	0.95	0.65	1.11
Aug-16	0.52	1.92	0.48	0.67	0.98	0.62
Sep-16	0.26	3.86	0.74	1.68	0.59	1.79
Oct-16	1.00	1.00	0.00	0.00	1.00	0.00
Nov-16	0.73	1.37	0.27	0.53	0.57	0.49
Dec-16	0.13	7.48	0.87	2.41	0.62	3.95

Notes: “D” for Dominance, “1/D” and “1-D” for Simpson, “H'” for Shannon, “e” for Evenness and “d” for Margalef’s richness.

5. Conclusion

The urban and rural areas of Jamnagar sheltered with gardens, farms, reservoirs, beaches, lakes and vegetation which sustains bird’s diversity. The result shows that significant diversity and species richness in all the urban and rural sites of Jamnagar. It may be due to habitat characteristics, water availability, food availability, shelter and climate. Among them a supreme population of birds was recorded in the urban area - Lakhota Lake as compared to the other site; so we suggest that the local government bodies, nature clubs, Gujarat government and people of Jamnagar city and villages to maintain the Lakhota Lake ecosystem, make it clean and contribute support to conserve avian community.

In conclusion bird diversity of rural and urban areas of Jamnagar maintains significant diversity and species richness; except some birds were not recorded; it may due to anthropogenic activities like vehicular traffic, the establishment of buildings, roads and other infrastructure. To understand the impact of such alterations on the diversity of birds, baseline information is critically required.

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