Variations In Abundance And Diversity Of Waterbirds Along Spatiotemporal Gradient In Shallabugh Wetland, Jammu And Kashmir, India

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Abstract: Present study was conducted to determine the spatio-temporal variations in the diversity and abundance of waterbirds in Shallabugh wetland, from March 2017 to February 2019. A total of 19 waterbird species were recorded. Highest population of 227016 individuals was observed during mid-winter. 63.15 % of the species (n= 12) were migratory in nature. Of the seven habitats identified, habitat with open water had maximum diversity and abundance of birds. Anatidae was the most dominant family in terms of abundance. Highest density of 768.11 individuals per hectare was recorded in open water and lowest density of 1.1 individuals per hectare in paddy fields. Open water habitat was found with highest bird diversity (H=2.2) while as paddy fields were with lowest bird diversity (H=0.63).

Index Terms: Abundance, Density, Diversity, Habitat, Spatio-temporal, Shallabugh, Waterbirds, Wetland

1. INTRODUCTION

Wetlands, the imperative ecosystems have been categorized as important bird areas for providing abundant habitats for avian populations round the year [1]. Nevertheless, they are the most threatened habitats due to anthropogenic instabilities like encroachment, intensive agricultural practices and livestock grazing [2] which adversely affects the abundance, diversity and community composition of bird species [3]. Waterbirds, the most important tenants of the ecosystem are the indicators of wetland health and function; establish the terminal links in many food chains, reflecting changes that originate in several different components of ecosystem [4], [5], [6]. The waterbird populations are migratory with entire or a significant proportion of population crossing the international borders either cyclically or predictably. Since the populations of species vary in time and space their spatial turnover and tenacity of individuals over time should be taken into consideration for their protection as well as their habitats. Bird population parameters such as richness, relative density and diversity provide information on quality of habitats and any change in their habitat can cause alteration in distribution of individuals and population [7], [8], [9], [10], [11], [12]. Population trends of waterbirds are linked to the health and sustainable use of a wetland ecosystem [13] and many globally threatened avian species depend on them [14]. So, understanding spatial and temporal patterns of bird species distribution is a pre-requisite for understanding population dynamics, success of species and habitat conservation. However, loss of natural wetlands in recent decade due to intensification of human activities and environmental changes has been a serious threat to waterbird populations [15], [16], [17]. Thus, present study was undertaken to evaluate distribution, density and abundance of waterbirds along spatio-temporal gradient of Shallabugh wetland for their management and conservation.

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2 MATERIAL AND METHODS

2.1. Study Area

Present study was carried out in Shallabugh wetland (34° 10' N, 74° 42' E) Kashmir (Fig. 1). It is a shallow fresh water body with an area of 7 km2 and depth of 0.3 to 2.2 m, situated at a distance of 18 km from Srinagar city at an altitude of 1580m above sea level with mean temperature of 28° C [18], [19]. Wetland surrounded by willow and poplar plantation is fed by Anchar Lake and various tributaries of Jhelum and Sindh [20], [21]. It is a large bird reserve that serves as an important wintering and feeding ground for majority of birds migrating from central Asia and Siberia [22]. Most of the wetland is marshy but several compartments have been made that retain considerable amount of water for migratory waterfowl. The marshy area along with shallow open water also contained a variety of free floating and submerged vegetation that provided ample food for waterfowl. The important food species were Potamogeton spp., Myriophyllum verticillatum, and Nymphaea spp. In addition, the wetland had dominant vegetation comprising of Phragmites australis, Trapa natans, Nelumbo nucifera and Typha spp. which support a rich population of insects, molluscs, and zooplanktons supplementing the food chain [18].

2.2. Methods

Population estimation of waterbirds was achieved by following point count, block count and line transect methods [23],[24],[25], [26], [27], [28], [29]. Waterbird species data was gathered in different seasons during 2017-2019 (March-August Post winter and September- February Mid-winter) with extensive collection during mid-winter seasons. Wetland was divided into seven habitat types depending upon the vegetation type and water depth. Each habitat type represented a sampling site. All the identified habitats

were surveyed and scanned for waterbird population from vantage points using field binoculars (10x40X). Species were identified using field guides [30] and data was collected species wise. Survey was abandoned on days with rain snow and wind [31]. Observations were made 2 times a week at each site in the morning and evening sessions. Data collected was analyzed separately for assessing the relative abundance on the basis of sighting. Estimation of abundance of birds was done by following standard methods [32], [33], [34]; Very abundant (VA): over 1000 individuals seen per day; Abundant (A) 201-1000 individuals seen per day; Very common (VC) 51-200 individuals seen per day; common (C) 21-50 individuals seen per day; Fairly common (FC) 7-20 individuals seen per day; uncommon (UC) 1-6 individuals seen per day; Rare (Re) 1-6 individuals seen per season; Very rare (VR) infrequent occurrence. Checklist of species was also prepared. The data collected was compiled in Microsoft excel. One-way ANOVA was used to compare densities. Data analysis was performed using Minitab v19.00 [35]. For estimating diversity and abundance Shannon-Weiner (H) and Pielou's evenness (J) indices were used. After counting waterbirds in circular plots their density was calculated by using Reynold's formula D=n x1000/π r2 [36]

where
n = number of individuals
π = 3.1415
r= radius of the area under observation

Fig 1. *Map of Shallabugh wetland*

RESULTS

Nineteen (19) species of waterbirds belonging to seven families viz; Anatidae, Ardeidae, Rallidae, Scolopacidae, Podicepididae, Halcyonidae were recorded in Shallabugh wetland during winter (Table 1). Majority of the species (52.6%) belonged to family Anatidae with an abundance of 61% in mid-winter however, in post winter most of the population was dominated by Ardeidae (43.11 %) (Table 2). Of the 19 species 63.15% (n=12) were winter migratory and contributed maximum to the bird composition while 26.32% and 10.53% were resident and partially migrant respectively. A total 2,27,016 birds were recorded during both the seasons among all the identified habitats with a mean of 24850 ± 3119.2 individuals during mid-winter and 102.69 ± 21.96 individuals in post winter season. There was a great variation in the distribution and density of waterbirds among different habitats. Open water had maximum number of individuals (n=187,011) with highest density of 768.11±87.11 individuals ha-1 and paddy fields had the minimum number of individuals (n=42) and lowest density of 1.1 individuals ha-1 (Table 3). The Variation in densities and number of waterbirds among different habitats was statistically significant P <0.05. (One-way ANOVA F 7, 89 = 5.325, p = 0.001, n =65). A gradient was also observed in species richness and abundance in different habitat types in post winter season. In post winter season mean density of waterbirds was 111.25±98.40 individuals ha-1. During this season floating vegetation was most densely populated (495.6 individuals) and tall emergents least populated (3.76 individuals) (Table 4). Mean density of ardeid members was 3.41 individuals ha-1 (Pond herons) and 2.50 individuals ha-1(Night herons). Among anatids, mallard had the density of 154.35±23.02 individuals ha-1followed by common teal with density of 98±12.78 individuals ha-1. Similarly, in rallids the moorhen and common coot had density of 78.11±14.36 and 97.47±18.00 individuals ha-1 respectively. In podicipedidae the only species little grebe recorded had mean density of 25.87±14.88 individuals ha-1. Diversity of waterbirds varied among different habitats. Open water had highest bird diversity (H= 2.28) in mid-winter season while as paddy fields had lowest diversity (H=0.63). (Table 5). During post winter tall emergent habitat had maximum diversity (H=1.25) and plantation habitat least diverse (H=0.21). Species were evenly distributed in open water habitat (J=0.77) and tall emergent vegetation (J=0.56) during mid-winter and post winter season respectively (Table 6).

Table 1.Birds identified in Shallabugh wetland and their status

Order	Family	Common name (Scientific name)	Status
Charadriiformes	Scolopacidae	Pin-tailed snipe (*Gallinago stenura*)	LC(WM)*
Anseriformes	Anatidae	Northern Pintail (*Anas acuta*)	LC (WM)*
		Northern Shoveler (*Anas clypeata*)	LC (WM)*
		Common Teal (*Anas crecca*)	LC (WM)*
		Common Mallard (*Anas platyrhynchos*)	LC (WM)*
		Gadwall (*Anas strepera*)	LC (WM)*
		Red-crested Pochard (*Netta rufina*)	LC (WM)*
		Ruddy Shelduck (*Tadorna ferruginea*)	LC (WM)*
		Common Pochard (*Aythya rufina*)	LC (WM)*
		Tufted Duck (*Aythya fuligula*)	LC (WM)*
Coraciiformes	Halcyonidae	White-throated Kingfisher (*Halcyon smyrnensis*)	LC (R)*
Ciconiiformes	Ardeidae	Gray Heron (*Ardea cinerea*)	LC (WM)*
		Indian Pond-Heron (*Ardeola grayii*)	LC (R)*
		Little Egret (*Egretta garzetta*)	LC (R)*
		Night Heron (*Nycticorax nycticorax*)	LC(R)*
		Cattle Egret (*Bubulcus ibis*)	LC (R)*
Podicipediformes	Podicipedidae	Little Grebe (*Tachybaptus ruficollis*)	LC (PM)*
Gruiformes	Rallidae	Common coot (*Fulica atra*)	LC (WM)*
		Indian moorhen (*Gallinula chloropus*)	LC (PM)*

Table 2: *Relative abundance of Waterbird families from Shallabugh wetland*

Mid-Winter		Post-Winter	
Family	Abundance (%)	Family	Abundance (%)
Anatidae	61.00	Anatidae	13.88
Ardeidae	14.30	Ardeidae	43.11
Podicipedidae	7.90	Podicipedidae	10.21
Rallidae	15.80	Rallidae	29.79
Scolopacidae	0.00	Scolopacidae	2.01
Halcyonidae	1.00	Halcyonidae	2.00

Table 3: *Bird density and number among habitats in Shallabugh (Mid-winter)*

Habitat type	Area (ha)	Birds/ha	Number of birds (Mean±SD)
Open water	230.49	768.2	177062.41 ±471.53
Floating vegetation	24.78	1.2	29.73±31
Plantation	72.12	4.21	303.62±11.28
Paddy fields	38.98	1.1	42.87±9.3
Tall emergent	47.12	1.22	57.48±4.28
Marshes	125.21	8.4	1051.74 ±214.35
Submerged vegetation	114	1.2	136.8± 123.58

Table 4: *Bird density and number among habitats in Shallabugh (post winter)*

Habitat type	Area (ha)	Birds/ha	Number of birds (Mean±SD)
Paddy fields	38.98	0.33	12.86±70.26
Floating vegetation	24.78	20.11	495.6±325.43
Tall emergent	47.12	0.08	3.76±0.72
Open water	230.49	0.203	46.69±3.8
Submerged vegetation	114.35	2.01	229.7±0.006
Plantation	72.12	2.01	144.96±0.18
Marshes	125.21	0.37	46.32±2.39

Table 5: *Diversity indices and richness among different habitats in Shallabugh (Mid-Winter)*

Habitat type	Shannon index (H)	Pielou's index (J)	No. of species observed
Floating vegetation	1.32	0.44	12
Marshes	1.3	0.44	4
Paddy fields	0.63	0.21	2
Open water	2.28	0.77	19
Plantation	1.73	0.58	12
Tall emergent	1.27	0.43	14
Submerged vegetation	1.08	0.36	8

Table 6: *Diversity indices and richness among different habitats in Shallabugh (Post-Winter)*

Habitat type	Shannon index (H)	Pielou's index (J)	Species observed
Submerged vegetation	0.88	0.40	4
Submerged paddy fields	0.50	0.22	2
Tall emergent	1.25	0.56	9
Marshes	0.62	0.28	2
Floating vegetation	0.70	0.31	4
Open water	0.77	0.35	3
Plantation	0.21	0.09	3

DISCUSSION

Essential component of wetland landscapes, the waterbirds because of their congregational habit and excellent wetland health indicators have made them research and monitoring targets [37]. They form important links in the food webs and nutrient cycles, of most wetland ecosystems and have social, cultural and food resource significance in the lives of humans [38]. Wetlands sustain diverse waterbird communities with great inter specific variation by providing functional habitats for a variety of their seasonal needs [39]. Shallabugh wetland one of the biggest game reserves of the valley and home to thousands of waterbirds especially migratory waterfowl [16], [22] was found to harbour a total of 19 waterbird species in midwinter and minimum of 8 species in post winter season. Earlier,32 species of waterbirds were reported from this wetland of Kashmir [16]. The recent decline in the number of species could be attributed to low water level that prevailed in the wetland.

There was significant intra seasonal difference in the population status and diversity of waterbirds mainly due to the contribution of migratory waterfowl which visit the wetland during winter. Waterfowl migrate from their Palearctic breeding grounds and accumulate in different wetland bodies of the valley at the arrival of winter [39]. During present study species like mallard, common teal, northern pintail, northern shoveller, gadwall, and brahmini duck were observed abundantly with rare sighting of tufted duck. Various studies have reported the presence of these species in different wetlands of the valley with the rare sighting of some [40], [41]. There was inter annual variation in waterbird population and abundance with 2,27016 individuals in 2017 and 1,27,345 in 2018. This variation may be due to different climatic conditions, varying water level and consequently variation in food availability. Spatio-temporal variation in abundance and diversity of waterbird communities in different habitats during mid-winter was significant (P value <0.05 (One-way ANOVA F 7, 89 = 5.325, p = 0.001, n =65). This variation in abundance and diversity has also been reported earlier due to a number of factors like physicochemical conditions, feeding behaviour, habitat configuration, anthropogenic pressures, varied morphological and ecological adaptations of waterbirds [42], [43], [44], [45], [46]. Seasonal populations showed great variation in number and density with an average of 24850±3119.20 and 302.69±21.69 individuals and density of 2619 ± 417.20 and 111.25 ± 98.40 individuals per hectare during mid and post winter respectively. Different studies across the world also reported high density and numbers during mid-winter season than post winter season [16], [45], [46], [47], [48]. It has been revealed that more the habitat diversity more the waterbird communities [49]. Among the categorized habitats, open water and submerged vegetation had maximum number of individuals which may be due to optimum temperature, good water level, high visibility, better food availability and less human interference. Earlier studies have also observed open water and submerged vegetation supporting higher number of individuals [16,] [50]. Among waterbirds, anatids (ducks and teal) preferred open water habitats in mid-winters that may be due to availability of food and unrestricted movement during foraging. Elafri, 2017 [50] has also attributed the preference of anatids to open water for free movement and food availability during foraging. Ardeids and shorebirds existed as dominant groups in post winter in plantation zones and paddy fields which provided them with the optimum nesting and roosting sites in post winter. Among identified habitats open water was more diverse than other habitats (H=2.28) while as paddy fields were least diverse (H=0.63). This may be because of the fact that open water provides optimum feeding and resting conditions to the waterbirds and least impact of human disturbances. [41], [42], [50]. Post winter results revealed tall emergent habitat as most diverse (H=1.25) which may be due to cover and food resources the emergent plants provided during post winter. Foziah (2009) [16] has also reported the submerged and floating vegetation as most diverse habitats during midwinter in Hokersar wetland and tall emergent habitat as diverse during post winter season attributing the variations to food resources and human disturbances [43], [51].

CONCLUSION

The attraction and response of waterbirds to water and food availability is conspicuous and reflects the status of habitat at a given time of a particular wetland. However rapidly growing human population, large-scale changes in land use- land cover and burgeoning development has caused a substantial loss of wetland resources and rapid decline of waterbird species. For effective management and conservation of wetlands and their inhabitants the waterbirds, further research on impact of anthropogenic factors limiting their population, feeding and breeding ecology is required.

6 REFERENCES

1. Bird Life International. Threatened birds of the world. Lynx Edicions, Barcelona, Spain and Bird Life International, Cambridge, U.K. 2007.
2. J. B. Zedler, S. Kercher. Wetland resources: status, trends, ecosystem services and restorability. *Annual Review of Environment and Resources*. 30(1), 39-74, 2005.
3. M. I. Evans. Important bird areas in the Middle East. Vol 2. Cambridge, UK, Birdlife International. 1994.
4. T. W. Custer, R. G. Osborne. Wading birds as biological indicators: 1975 Colony survey. U.S. Fish and Wildlife service, Washington, D.C. 1977.
5. M. G. Bellio, R. T. Kingsford. Alteration of wetland hydrology in coastal lagoons: implications for shorebird conservation and wetland restoration at a Ramsar site in Sri Lanka. *Biological Conservation.* 167:57– 68, 2013.
6. R. Grimmett, C. Inskipp, T. Inskipp. Birds of India. Princeton University Press, New Jersey. 1999.
7. A. J. Gaston. A national park for Kistwar. *Hornbill*. (1982); (4), 10-14, 1982.
8. A. R. Hardy, P. I. Stanley and S. P. W. Greeing. Birds as indicator of the intensity of use of agricultural pesticide in U.K. In. The value of Birds. Diamond A.W. and F.N. Falion (eds). Tech. Pub. 6, 119 – 121, 1987.
9. J. A. Wiens. The ecology of bird communities, Vol. I. Cambridge University Press, Cambridge, U.K. 1989.
10. R. Virkkala. Bird communities. In: Nierenberg, W.A (Eds).Encyclopedia of Environmental Biology. Academic Press, San Diego, CA, USA. 335- 344, 1995.
11. S. Roos and T. Part. Nest predators affect spatial dynamics of breeding Red-backed Shrikes (Lanius collurio). *Journal of Animal Ecology*. 73: 117-127, 2004.
12. Birdlife International. Important Bird Areas and potential Ramsar sites in Asia. Cambridge, Birdlife International, UK, 2005.
13. M. Owen and J. M. Black. Waterfowl Ecology. Blackie and Son Ltd; Glasgow, London. 1990
14. C. M. Finlayson, G. E. Hollis, T. J. Davis. Managing Mediterranean Wetlands and their Birds. IWRB Special Publication 20. IWRB, Slimbridge. 1992.
15. J. B. Zedler and S. Kercher. Wetland resources: status, trends, ecosystem services, and restorability. *Annual Review of Environment and Resources.* 30, 39–74, 2005
16. H. Foziah. Study on waterfowl population and human use of Hokersar and Hygam wetlands of Kashmir valley

for conservation planning. Ph.D. Thesis Saurashtra University Rajkot (Gujarat). 2009.
17. X. D. Wang, F. L. Kuang, K. Tan and Z. J. Ma. Population trends, threats, and conservation recommendations for waterbirds in China. *Avian Research*. 9:14, 2018.
18. I. Dar and M. Dar. Seasonal Variations of Avifauna of Shallabug Wetland, Kashmir. *Journal of Wetlands Ecology*. 2, 20-34, 2009.
19. S. Siraj, A. R. Yousuf, F. A. Bhat, M. Parveen. The ecology of macro zoobenthos in Shallabugh wetland of Kashmir Himalaya. *India Journal of Ecology and the Natural Environment*. 2(5), 84-91, 2010.
20. A. K. Pandit and D. N. Fotedar. Restoring damaged wetlands for wildlife. Journal of Environmental. Management. 14, 359–368, 1982.
21. S. S. Qadri. Ecological factors affecting waterfowl in the wetlands of Kashmir. PhD Thesis, University of Kashmir, Srinagar. 1989.
22. Important bird areas- Jammu and Kashmir pp. 515, 2006.
23. S. A. Eltringham, Willes. Recent population changes in British ducks.12th Annual Report, The Wildfowl Trust. 40:57, 1961.
24. F. Roux. Censuses of Anatidae in the central delta of the Niger and the Senegal delta- January 1972. *Wildfowl*. 24, 63-80, 1973.
25. L. Zewarts. Density related processes in feeding dispersion and feeding activity of Teal (Anas crecca). *Ardea*. 64, 192- 209, 1976.
26. J. R. Alford and E. G. Bolen. Influence of winter temperatures on Pintail sex ratios in Texas. *Southwest Naturalist*. 21(4), 554-556, 1977.
27. J. A. Amat. Ecological segregation between Red-crested Pochard *Netta rufina* and Pochard *Aythya ferina* in a fluctuating environment. *Ardea*. 72, 229-233, 1984.
28. J. Verner. Assessment of counting techniques. In: Johnson, R. F (Eds) 1985. *Current Ornithology.* 2: 247-302, 1985.
29. M. A. Spindler, S. M. Murphy and I. B. Kessel. Ground Census of Waterbird Population in the upper Tanana Valley. In: Miller, FL; GunnA. (Eds.), Symposium On Census and inventory methods for population and habitats. Northwest section of wildlife society, Banff.Alerta. 133-148, 1981.
30. R. Grimmett, C. Inskipp and T. Inskipp. Pocket guide to Birds of Indian subcontinent. 2016.
31. C. J. Bibby, N. D. Burguess and D. A. Hill, Mustoe S. Bird census techniques. 2nd ed. New York: Academic Press; 2000.
32. Wetland International. Waterbird population estimates, Fifth Edition pp. 1-28. 2012.
33. M. F. Fazili, B. A. Bhat and F. Ahangar. Avian diversity of Anchar Lake, Kashmir, India. New York Science Journal 10(1), 2017.
34. J. Bull. Birds of New York area. Harper and Row, New York. 540pp. 1964.
35. M. J. Norussis. SPSS professional statistics Version 8.0, SPSS Inc; Chicago, Illinois. 1994.
36. R. T. Reynolds, J. M. Scott and R. A. Nussbaum. (A variable circular plot method for estimating bird numbers. *Condor*. 82: 309-313, 1980.
37. Wetlands International. Waterbird Population Estimates. Fifth Edition. pp.28. 2012.
38. A. Kumar, J. P. Sati and P. C. Tak, P.C. Checklist of Indian Waterbirds, *Buceros.* 8(1), 1-2, 2003.
39. S. Ali. The Book of Indian Birds, 11th edition, The Bombay Natural History Society, India. 1979.
40. I. A. Dar and M. A. Dar. Evaluation of bird population fluctuation inn Haigam wetland, Kashmir, India**.** *Environmental Science*. 4(5), 260-268, 2009.
41. I. Jan, G. M. Shah and U. Jan. Diversity and Abundance of Avifauna of Haigam Wetland and Its Adjoining Areas, J&K, India. *International Journal of Innovative Research in Science, Engineering and Technology***.** 5(11), 2016.
42. D. A. Cardoni, M. Favero and J. P. Isacch. Recreational activities affecting the habitat use by birds in Pampa's wetlands, Argentina: implications for waterbirds conservation. *Biologocal Conservation.* 141:797, 806, 2008.
43. B. Maciusik, M. Lenda and P. Skórka. Corridors, local food resources, and climatic conditions affect the utilization of the urban environment by the Black–headed Gull Chroicocephalus ridibundus in winter. *Ecological Research*. 25, 263–72, 2010.
44. M. A. Colwell and O. W. Taft. Waterbird communities in managed wetlands of varying water depth. *Waterbirds.* 23, 45–55, 2000.
45. M. A. Khan and S. Bashir. Habitat complexity and avifaunal diversity of Hokersar wetland in the Kashmir Himalaya. *Indian Journal of Environmental Sciences*. 7 (1), 85-88, 2003.
46. M. A. Rendón, A. J. Greena, E.Aguilera and P. Almaraz. Status, distribution and long term changes in the waterbirds community wintering in Doñana, southwest Spain. *Biological Conservation*. 141, 1371–88, 2008.
47. M. Kershaw, P. A. Cranswick. Numbers of wintering waterbirds in Great Britain. 1994/ 95- 1998/99. I. Wildfowl and selected waterbirds. *Biological Conservation*.111, 91-104, 2003.
48. S. Gillings, M. W. Andrew, J. C. Greg, A. V. Juliet and J. F. Robert. Distribution and abundance of birds and their habitats within the lowland farmland of Britain in winter, Bird Study. 55, 2008.
49. A. Hattori, S. Mae. Habitat use and diversity of waterbirds in a coastal lagoon around Lake Biwa, Japan. *Ecological Research*. 16: 543–553, 2001.
50. A. Elafri, A.M. Belhamra and M. Huhamdi Comparing habitat preferences of a set of waterbird species wintering in the coastal wetlands of North Africa: implication for management. Ekologia 36(2): 158-171, 2017.
51. Z. Ma, Y. Cai, B. Li and J. Chen. Managing wetland habitats for waterbirds: an international perspective. Wetlands 30(1):15-27, 2010.