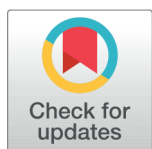


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Waterbird Density and Habitat Utilisation Pattern in Wular Lake, Kashmir, India

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Abstract

Background: Understanding abundance, diversity and density of waterbird species along with detailed description of habitat utilization pattern is significant to understand species ecology and consequently for management and conservation. Waterbird density and their utilisation pattern of different habitats in Wular lake was investigated during study period from 2017-2019.

Methods: Population estimation of waterbirds was carried out by point count and line transect method. Length of the transect varied from 50-100 meters. Waterbird density was estimated using Reynolds formula in a circular plot. Radius of circle varied from 45- 50 meters. Pattern of habitat utilisation was calculated by Ivlev's index. **Findings:** Twenty-five (25) species of waterbirds belonging to eighteen (18) genera, seven families (7) and six orders (6) were recorded. Mean population of 62819 ± 3874.20 during mid-winter and 420.58 ± 142.10 individuals during post winter was observed. Mean density of 810.81 ± 387.3 birds ha^{-1} during mid-winter and 71.29 ± 1.33 birds ha^{-1} during post winter was recorded. Of all the habitats, open water had highest waterbird density (630.32 ± 58.32 birds ha^{-1}) while as paddy fields had lowest waterbird density (0.44 ± 0.08 birds ha^{-1}) during mid-winter. During post winter also open water habitat was the most densely populated habitat (30.2 ± 4.85 birds ha^{-1}) but marshes were least densely populated habitat (0.41 ± 0.05 birds ha^{-1}) during this season. Open water habitat was most preferred habitat and peatlands the most avoided one. Variation in densities among different habitats was statistically significant ($p < 0.05$). **Novelty:** Anthropogenic threats like agricultural conversion, habitat degradation and pollution greatly affect the utilisation of different habitats by waterbirds. Knowledge indicating the density and diversity of waterbirds along with their preference and avoidance towards different habitats will help in managing those habitats as well as framing conservation policies for survival of waterbirds inhabiting them.

Keywords: Habitat utilisation; Density; Population; Ramsar; Waterbirds; Wetlands; Wular

1 Introduction

Wetlands harbouring diverse biological communities with extensive ecosystem services such as water purification, flood abatement and climate regulation provide habitat for a diversity of animals especially waterbirds^{(1), (2)}. However, rapid urbanization and development has deteriorated wetland conditions and about 50 % of them have been lost during last century⁽³⁾. Jammu and Kashmir harbours diversified number of wetlands, of which four wetlands have been designated as Ramsar sites and Wular is one among them. These wetlands act as transitional camps and provide wintering grounds to waterbirds particularly waterfowl that migrate during winter from Palearctic regions⁽⁴⁾. Waterbirds are usually considered sensitive indicators of wetland health and biodiversity^(5–9) and their abundance and diversity are often used as criteria to identify and qualify wetlands of international importance and to designate them as protected areas^(10–12). Their population trend, diet and habitat utilisation pattern can be used for monitoring changes in wetland ecosystems^{(13), (14)}.

Habitat utilisation is a critical facet in the management of wildlife populations and gives an idea about how organisms use habitat and the reasons for preferring those specific habitats⁽¹⁵⁾. Habitat is the address of an organism but specifically, it refers to physical and biological environment in which a species is usually found^{(16), (17)}. The necessity of determining preference or avoidance of a given habitat by an organism in terms of its availability has long been recognized^{(18), (19)} but interpreting species preferences to certain habitat features from a human perspective is often ambiguous and scale dependent⁽²⁰⁾. True habitat preference and avoidance occurs when individuals exercise a choice among available habitats, instead of differentially occupying them as a consequence of extrinsic factors like predation and competition^{(21), (22)}. Therefore, knowledge about waterbird densities and patterns of their habitat preference and avoidance is fundamental for developing effective guidelines for management and conservation of waterbirds as well as their habitats⁽²⁾ and present study is a step towards that.

2 Material and Method

2.1 Study area

Present study was carried out in world famous Ramsar site, the Wular Lake from 2017-2019. Wular Lake (Figure 1) being the largest freshwater lake in India with an area of 13,292 hectares⁽²³⁾ is located about 34 km northwest of Srinagar at an altitude of 1580 m a.s.l. (above sea level) between 34°16' N and 74°40' E⁽²³⁾. It provides an important habitat for migratory as well as resident water birds. It has been designated as a Wetland of International Importance under Ramsar Convention in 1990 because of its biodiversity and socio-economic values. Wular Lake comprises of open water areas along with submerged and floating vegetation like *Potamogeton*, *Nymphaeodes peltatum*, *Nymphaea* spp. Shallow water supports emergent vegetation like *Phragmites communis*, *Scirpus palustris*, *Typha* spp. and *Carex* spp.⁽²⁴⁾. Study area was divided into eight habitat types depending on the vegetation characteristics viz. open water, floating vegetation, submerged vegetation, tall emergents, marshes, plantation, paddy fields and peatlands⁽¹⁵⁾. Waterbird populations, densities, habitat preferences and avoidances were estimated in these habitats and analysed.

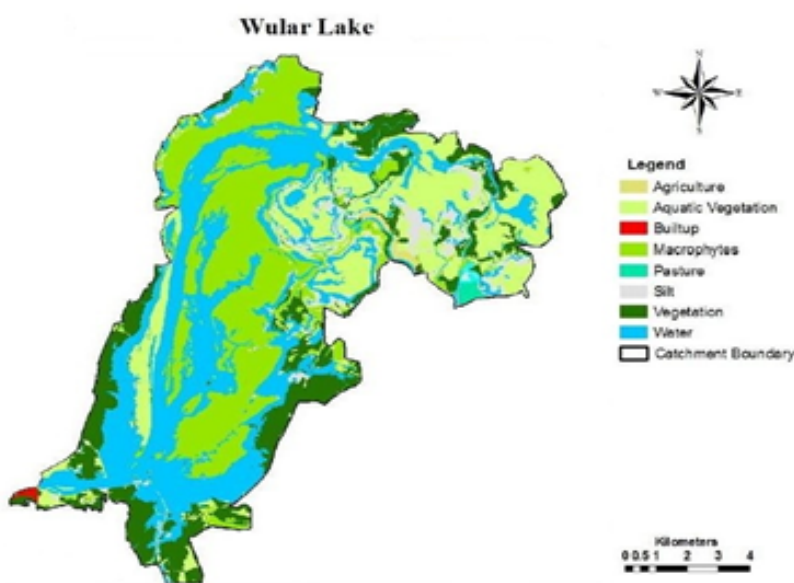


Fig 1. Map of Wular showing habitat types (DEERS)

2.2 Methods

Study period was divided into two seasons viz. mid-winter from November to March and post winter from April to October⁽¹⁵⁾. Field data for estimating population and diversity of waterbirds were collected during both seasons from March 2017 to February 2019. Transects were laid in already identified habitat types covering the whole area of the wetlands. Point count, line transect and block count method was used for estimating waterbird population^(25–31). While employing point count method different sites were selected within habitats and vantage points/hides were used for counting birds and also to avoid double counting⁽³²⁾. Large flocks were counted in tens and multiples of ten⁽¹⁵⁾. Birds were observed using Nikon field binoculars (12 x 50 X). Birds were identified using standard field identification guide⁽³³⁾ and their numbers in each habitat were recorded. Estimation of abundance of birds was calculated as; 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⁽³⁴⁾,⁽³⁵⁾. For determining the density of waterbird circular area with radius of 50-70 m was scanned within habitats and density was calculated using Reynold's formula⁽³⁶⁾:

$$D = n \times 1000 / \pi r^2$$

where

n = number of individuals

$\pi = 3.1415$

r = radius of the area under observation

A total of 38 transects (500-1000 m) were laid systematically to cover whole area of wetlands. Reconnaissance survey was done in the identified habitats along these transects⁽³⁷⁾. Habitat utilisation pattern (preferences and avoidances) was derived using Ivlev's index⁽³⁸⁾,⁽³⁹⁾ using formula:

$$E = (u_i - a_j) / (u_i + a_j)$$

Where,

u_i is proportion of observations in habitat i (habitat utilized) of that species and a_j is proportion of habitat i available. (-1 to +1 Ivlev's range: -1= Complete avoidance and +1 = complete utilisation).

Chi square test was used to determine if there was a significant difference between the utilisation in identified habitats⁽⁴⁰⁾.

3 Results

During study, total of 25 waterbird species belonging to 18 genera, six (6) orders and seven (7) families were recorded. In mid-winter mean population of 62819 ± 3874.20 individuals and mean density of 810.81 ± 387.3 birds ha^{-1} was recorded. However, in post winter mean population of 420.58 ± 142.10 individuals and mean density of 71.29 ± 1.33 birds ha^{-1} was recorded. Identified bird species recorded during study period are listed in Table 1. The waterbirds belonged to families Anatidae, Ardeidae, Podicipedidae, Rallidae, Alcedinidae, Jacanidae and Scolopacidae. Of the observed families Anatidae was dominant in terms of number of species (47.30 %) during mid-winter while family Ardeidae was dominant (42.99 %) during post winter.

Table 1. Percentage of Waterbird families from Wular lake

Mid-Winter		Post-Winter	
Family	Abundance (%)	Family	Abundance (%)
Anatidae	47.30	Ardeidae	42.99
Ardeidae	21.89	Rallidae	23.37
Rallidae	12.41	Anatidae	10.15
Podicipedidae	8.65	Alcedinidae	8.85
Alcedinidae	5.36	Jacanidae	7.32
Scolopacidae	3.37	Scolopacidae	4.22
Jacanidae	1.02	Podicipedidae	3.10

p<0.05

3.1 Seasonal variation in waterbird density across habitats

A strong variation in waterbird abundance and density among the identified habitats in different seasons was observed. During mid-winter of all the habitats, open water had highest waterbird density (630.32 ± 58.32 birds ha^{-1}) and abundance (154113.24 ± 574.12 individuals) while as paddy fields had lowest waterbird density (0.44 ± 0.08 birds ha^{-1}) and abundance (39.76 ± 22.18 individuals) (Table 2). Variation in waterbird density between different habitats was statistically significant ($p < 0.05$). In family Anatidae mallard, gadwall and common teal

were very abundant (>1000) while as northern shoveller, common pochard and brahmini duck were common (21-50 individuals). Among anatids mallard abundance was highest in open water habitat (356.21 ± 14.88 birds ha^{-1}) followed by tall emergent vegetations with 49.26 ± 3.54 birds ha^{-1} and lowest in peatland with 0.57 ± 0.08 birds ha^{-1} . High density of ardeids was recorded in plantation zone (9.3 ± 2.54 birds ha^{-1}) and lowest density in submerged vegetation (0.12 ± 0.008 birds ha^{-1}). In plantation zone, among ardeids pond heron had highest density (7.2 ± 5.14 birds ha^{-1}) followed by cattle egret (5.5 ± 2.31 birds ha^{-1}), little egret (4.76 ± 1.11 birds ha^{-1}), night heron (2.1 ± 0.87 birds ha^{-1}) and grey heron (1.02 ± 0.09 birds ha^{-1}). Podicipedidae were represented by little grebes and abundantly found in floating vegetation. Rallid density was highest in tall emergent vegetation (18.58 ± 5.74 birds ha^{-1}) and lowest in plantation zone (0.12 ± 0.004 birds ha^{-1}). Among all waterbirds, black duck was very rare with density of 0.006 ± 0.0003 birds ha^{-1} .

Table 2. Bird density and number among different habitats in Wular (mid- winter)

Habitat	Area (ha)	Birds/ha	Mean no. of Birds \pm SD
Open water	244.5	630.32 ± 58.32	154113.24 ± 574.12
Floating Vegetation	296.2	205.74 ± 31.41	60928 ± 643.19
Plantation Zone	124.3	134.52 ± 21.90	16780.49 ± 80
Tall Emergents	334.9	25.9 ± 27.20	8650.13 ± 701.02
Submerged vegetation	45.7	22.3 ± 4.77	1019.15 ± 263.08
Paddy fields	90.4	0.44 ± 0.08	39.76 ± 22.18
Peatland	59.8	0.55 ± 0.02	32.31 ± 3.20
Marshes	22.8	0.65 ± 0.21	14.82 ± 4.51

$p < 0.05$

During post winter, waterbird densities among different habitats also varied and difference was statistically significant at 95% confidence levels ($p < 0.05$) (Table 3). Open water had highest mean density of 30.2 ± 4.85 birds ha^{-1} followed by floating vegetation (10.01 ± 0.21 birds ha^{-1}), plantation zone (8.20 ± 1.11 birds ha^{-1}) submerged vegetation (5.7 ± 1.2 birds ha^{-1}) and tall emergents (1.3 ± 0.58 birds ha^{-1}) and marshes had lowest waterbird density (0.41 ± 0.05 birds ha^{-1}). Of the seven families recorded, Anatidae was most abundant with mallard dominating numbers (7629 ± 541.87 individuals) and density (110.51 ± 17.21 birds ha^{-1}). Anatids like black duck, garganey and eurasian wigeon had least density with 0.0021 birds ha^{-1} , 0.0014 birds ha^{-1} and 0.024 birds ha^{-1} respectively. Among Rallidae common coot had highest density of 118.50 ± 85.20 birds ha^{-1} and abundance of 2874 ± 147.63 individuals. Alcedinids like kingfishers were fairly common while as scolopacids (common snipe) were uncommon during post winter.

Table 3. Bird density and numbers among different habitats in Wular (post winter)

Habitat type	Area (ha)	Birds/ha	Mean no. of Birds \pm SD
Open water	244.5	30.2 ± 4.85	7396.12 ± 12.1
Floating vegetation	296.2	10.01 ± 2.11	2991.62 ± 479.75
Plantation zone	124.3	8.20 ± 1.11	994.23 ± 3.81
Tall emergents	334.9	1.3 ± 0.58	435.38 ± 4.11
Submerged vegetation	45.7	5.7 ± 1.20	260.49 ± 163.8
Peatland	59.8	0.74 ± 0.08	44.25 ± 6.66
Paddy fields	90.4	0.42 ± 0.08	36.13 ± 0.33
Marshes	22.8	0.41 ± 0.05	19.34 ± 2.42

$p < 0.05$

3.2 Seasonal habitat utilization by waterbird families

Significant seasonal variations in habitat utilisation by waterbirds in different habitat types during mid-winter as well as in post winter were observed (Figure 2). During mid-winter members of family Anatidae utilised open water, floating vegetation, submerged vegetation and tall emergent habitat types but preferred open water and floating vegetation habitats. Ardeids utilised floating vegetation, marshes, open water, peatland, paddy fields and plantation habitats but preferred tall emergent and plantation habitats over other habitats. Podicipedids utilised submerged vegetation, open water and floating vegetation habitat with submerged vegetation as their preferred habitat. Rallids utilised tall emergents, open water and floating vegetation habitats but mostly preferred tall emergent habitat over other habitats. Members of family Scolopacidae showed their preference towards marshes while as individuals of family Jacanidae preferred floating vegetation. Members of family Alcedinidae utilised all the identified habitats with preference towards open water habitat. Paddy fields and peatland habitats were least utilised by waterbirds.

During post winter most of the habitats were devoid of waterbirds and their preferences towards identified habitats are depicted in Figure 3. Individuals of family Anatidae although utilised open water and floating vegetation habitat, however they mostly preferred floating vegetation

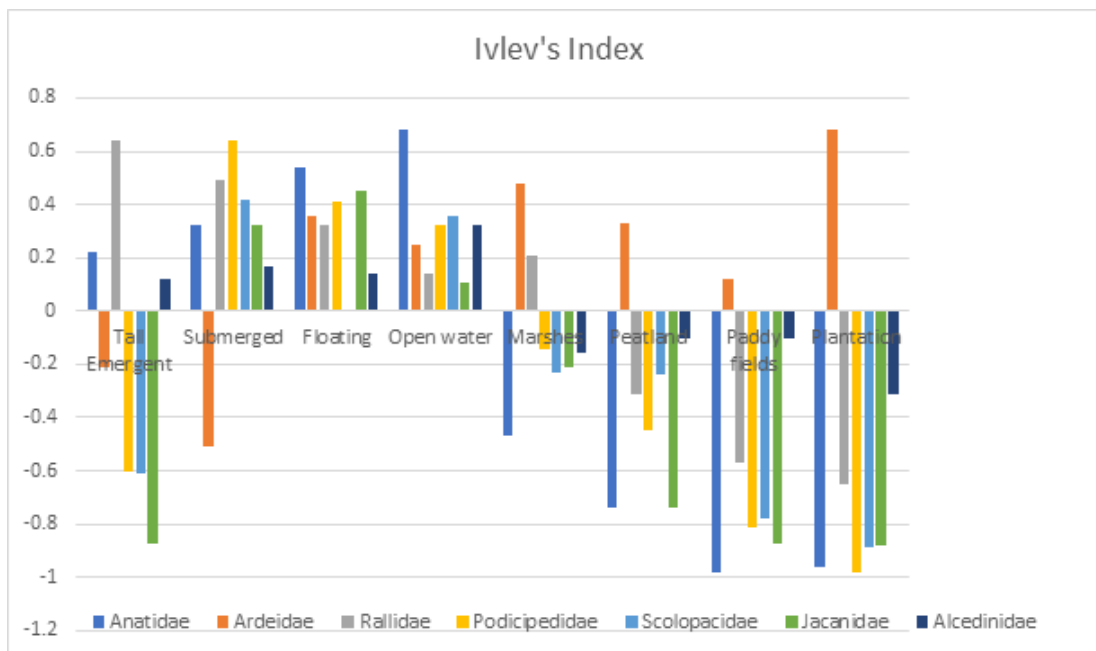


Fig 2. Habitat avoidance and utilisation by waterbird families during mid-winter

habitat. Members of family Ardeidae utilised tall emergent habitat, plantation habitat, open water and marshes but highest preference was for plantation habitat. Rallids utilised tall emergent, submerged vegetation, open water and marshy habitat but tall emergent habitat was highly preferred one. Podicipedids showed preferences for open water habitat. Alcedinids and Jacanids utilised all the habitats with slight preference towards open water and floating vegetation habitats. Marshes and peatlands were avoided by waterbirds in post winter season. Members of family Scolopacidae preferred marshes over other habitats.

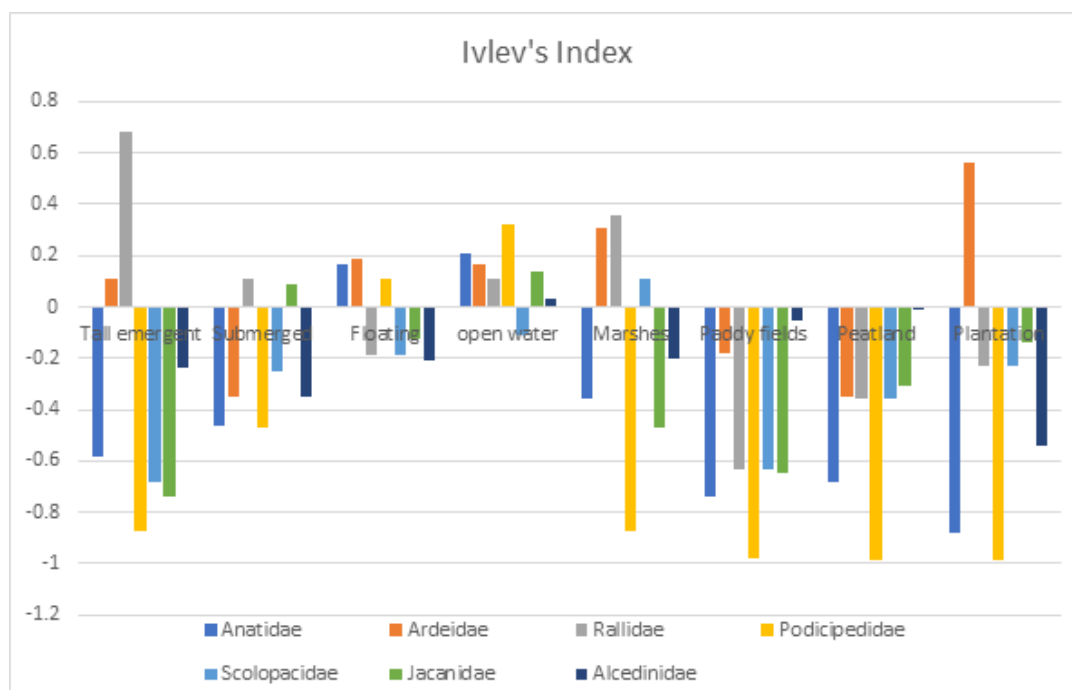


Fig 3. Habitat avoidance and utilisation by waterbird families during post winter

4 Discussion

Wetlands of Kashmir valley provide wintering resort to millions of migratory birds particularly waterfowl and conducive breeding ground to a segment of resident and non-resident summer migrants⁽¹⁵⁾. These water bodies often regarded as stop over sites help migratory birds in replenishing energy during their long migratory routes⁽⁴¹⁾. 25 waterbird species belonging to 18 genera, seven families and six orders comprising a total of 2,75,658 individuals were recorded during our study. Earlier 24 waterbird species with 6748 individuals have been reported in Wular⁽²⁴⁾. This variation in population size and number of waterbird families could be attributed to difference in feeding resources, water levels, encroachment level and human disturbances during the study periods. Mean population of 62819 ± 3874.20 individuals during mid-winter and 420.58 ± 142.10 individuals during post winter were recorded. The great variation in population between two seasons is attributed to the migratory nature of waterbirds particularly waterfowl. Wintering waterbirds migrate to the wetlands of valley from their Palearctic breeding grounds and depart back on the arrival of spring season^{(4), (15), (42)}.

Number of habitats were identified in wetland depending on the vegetation types. Presence of various habitat types in wetlands leads to an increased number of waterbird species^(43–45). Of the eight habitats, open water and floating vegetation showed highest density of waterbirds and paddy fields had lowest density and number during mid-winter. This variation in density may be due to optimal availability of food items in open water and floating vegetation habitats as diversity and distribution of small and large waterbirds in wetlands is related to presence and availability of food items in the habitats^(46–48). On the arrival of spring, a gradual decline in the population size was observed due to departure of waterfowl to their Palearctic breeding grounds. But in post winter, plantation zone and tall emergent habitats had good population of waterbirds as these habitats provided cover, nesting sites and feeding resources during this season. Further growth of new macrophytic vegetation, rhizome, seeds, leaves and invertebrates may also attract waterbirds to these habitats as it has been reported that waterbird abundance is related to the growth of submerged macrophytic vegetation⁽⁴⁹⁾ and water area is an important driver of waterbird abundance and diversity^(50–52).

Dominance of anatids was indicated by their numbers in different habitats and mostly open water. Open water provided them with opportunity for diving and dabbling for food procurement. Anatids have been reported to prefer open water and floating vegetation habitats for dabbling and food resources these habitats provide them⁽²⁾. Elafri et al., (2017)⁽⁵³⁾ has also suggested that open water is a shallow habitat and provides organic matter to dabbling and diving ducks, coots and grebes. Anatids showed low presence in tall emergents during mid-winter, because dense vegetative cover restricts their movement and foraging efficiency^{(53), (54–56)}. In post winter anatids were abundant in floating vegetation due to the growth of new macrophytes which provided food. During mid-winter, rallids were abundant in open water and tall emergent habitats while as in post winter season they were found in tall emergent habitats only. This distribution pattern can be attributed to the difference in water level between seasons and abundance of food in the habitats. A similar kind of pattern of waterbird distribution has been observed in earlier studies^(57–60). Ardeids were observed in tall emergent habitat in mid-winter while as in post winter they were mostly observed in plantation zone which provided them with nesting, breeding and foraging sites as has also been reported by Rajpar & Zakaria (2011)⁽⁶¹⁾. Podicipedids were found abundantly in open water and floating vegetation habitats during mid-winter but only in submerged vegetation during post winter. Other waterbird families like alcedinids, jacanids and scolopacids were found more or less scattered among all habitats. Food and disturbances have been reported as main factors for fluctuating waterbird populations in different habitats^{(2), (24), (62)}.

Habitat utilisation and preference occur only when a variety of habitats are available for exploitation without the impact of competition and predation^{(22), (63)}. Presence of waterbirds in a habitat was mostly dependent on food resources, water depth, disturbance and vegetation types in the habitat. Members of family Anatidae, Rallidae and Podicipedidae preferred open water during mid-winter in the Wular probably because of the openness of water, availability of food, less human disturbances and optimum water depth. Diving and dabbling ducks and grebes prefer open water because of higher foraging efficiency and unrestricted movement during foraging⁽⁵³⁾. High productivity of open water than other habitats in wetlands is the main attractiveness for waterbirds providing great organic matter and submerged plant bed⁽⁶⁴⁾. Openness of the standing water in a habitat increases the palatability of food items which affect the habitat use by waterbirds⁽⁶⁵⁾ and also decreases the risk from disturbance and predators⁽⁶⁶⁾. Waterbirds prefer habitats depending on the water depth and food availability^{(46), (67,68)}. Podicipedids and jacanids showed preference towards floating and submerged vegetation which may be because of abundance of invertebrates. Abundance of waterbirds in invertebrate rich areas has been reported in earlier studies^{(69), (70)}. Preference of rallids towards tall emergent habitat could probably be explained by the fact that tall emergents provided protection and cover from predators. Ardeids utilised plantation, floating vegetation and open water habitat depending on the availability of food resources. Scolopacids preferred floating vegetation and marshes in the wetlands. This distribution of waterbird families could be attributed to varied food availability and disturbance levels among habitats. Role of food in distribution of waterbirds in different habitats and their preferences towards them is well documented^{(69), (70), (71–79)}. Marshes, peatlands and paddy fields were mostly avoided by waterbirds during mid-winter. This can be attributed to lack of food resources, low water levels, poaching and high anthropogenic impact in peripheral habitats like paddy fields, marshes, plantation and peatlands.

Members of Ardeidae preferred plantation habitat during post winter in the wetland because of presence of nesting sites and cover for avoiding predation^{(15), (80)}. Herons select emergent vegetation because of diverse food resources and shallow water during foraging⁽⁶¹⁾. Other waterbirds like rallids, podicipedids and scolopacids utilised open water, floating vegetation and tall emergent vegetation habitat. Anatids utilised open water and floating vegetation during post winter which may be due to the growth of new food items during spring season. Waterbirds with lobate feet dive and feed on vegetation and invertebrates in floating vegetation⁽⁸¹⁾. Habitats like marshes, plantation and paddy fields which were located near human settlements showed lower presence of waterbirds. McKinney et al. (2006)⁽⁸²⁾ also reported the effect of human disturbances on habitat utilisation by waterbirds. Ecology of waterbirds is not only being related to distribution and abundance of food resources^(83–85) but is also influenced by their physiology and morphology^(86–89).

5 Conclusion

Wetlands of Kashmir provide inordinate environment to satisfy the essential requirements of both resident and over wintering waterbirds from all over globe. Present study deciphers great potential of Wular in supporting large waterbird populations. But the anthropogenic activities have altogether changed the topography and deteriorated the natural conditions of these wetlands. To maintain optimal wetland conditions and greatest utilization, their management is essential. So, conservation policies and legislative management strategies need to be framed and implemented for long term survival of wetlands as well as the waterbirds that visit them.

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