Response of Avian Community to Vegetation Pattern and Hydrological Variability in Hokersar Wetland, a Kashmir Himalayan Ramsar Site

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Abstract: The Kashmir Himalayan wetland ecosystems harbours a rich diversity of resident and migratory birds, yet have not received adequate attention by the researchers. In view of the pivotal role of bird communities in wetland ecology, we studied the correlative patterns of spatio-temporal structure of the avifaunal and macrophytic communities in Hokersar wetland in relation to habitat complexity and varied water depths, during the breeding season of 2017 and 2018. Greater abundance and diversity of birds was found in emergent vegetation zone where purple moorhens, Indian moorhens, warblers and bitterns predominated and in the willows where mallards, wagtails, starlings and pied cuckoos were dominant. Most of the nests were observed at the water depth ranging between 20-58 cm. The Purple Moorhen and Indian Moorhen were the most abundant birds, whereas, Typha, Phragmites, Trapa, Ceratophyllum and Nymphoides were the most abundant macrophytes in the wetland. Total bird species diversity was highest in the emergent macrophytic vegetation zone, willow (Salix) grooves and the macrophytic species richness was highest in the marshes. Nesting behaviour of birds reflected not only species specific vegetation preferences, but often the negative influence of boat traffic and predator birds nesting in the woody edges of the wetland. While more rigorous studies are suggested , we conclude that holistic knowledge of links between various life forms inhabiting the wetland is pivotal for evolving appropriate conservation strategies for relatively rarer elements of wetland biodiversity and ecosystem functioning.

Keywords: Macrophytic assemblages, Habitat complexity, nesting behaviour, Water-level changes, Hokersar wetland, Kashmir Himalaya.

INTRODUCTION

Wetlands, deltas and alpine lakes are reckoned as diversity hotspots sand altitude being an important factor in regulating species distribution and abundance (Chappius et al 2011). Although wetlands are one of the most productive areas but severely affected habitats next to tropical forests, they are being neglected in densely populated countries like India too. In the last century, over 50% of wetlands in the world have been lost and the remaining wetlands have been degraded to different degrees, because of the adverse influences of human activities (Fraser and Keddy 2005).In Asia, freshwater wetlands are being reclaimed and drained for agriculture and are being cut off from rivers (Berezowski et al 2018). Most aquatic ecosystems are under immense pressure from human activities so freshwater biodiversity is highly threatened (Oertli 2018).

Of all the ecosystems, freshwaters harbour the most vital and concerted biodiversity on the planet (Rolls et al 2018). Special focus has been given to the ecological value of wetlands for water birds (Wetlands international 2010, Gray et al 2013). At least 20% of the threatened bird species inhabit wetlands in the Asiatic region which is far more than the 10% of the globally threatened birds (Kumar et al 2005). Water birds are not only the most prominent groups which attract people to wetlands, but also are good bio indicators and useful models for studying a variety of environmental problems (Urfi et al 2005). Birds are considered to be the forerunners of the aquatic ecosystems and also good indicators of wetland health (Amat and Green 2010).The wetlands of South Asia are facing tremendous anthropogenic pressure, which can greatly influence the structure of the bird community.

The earth is in an era of Anthropocene, that is the phase that started since industrial revolution in which human activities have created the environmental change (Berezowski et al 2018). The loss of water birds through direct and indirect human interferences has led to a decline in several water bird populations. Variability in plant distribution and water depths influences the spatio-temporal distribution of these birds. Different habitats, soil types, and inundation levels are responsible for the great variety of vegetation, producing a mosaic landscape (Zeilhofer & Schessi, 1999). Manipulated water level changes had an effect on abundance of benthic animals, which helped in improving habitat for feeding birds (Lindegarth and Chapman 2001). Water level fluctuations affect lake shore vegetation in flood plain lakes of the Yangtse river, China (Zhang et al 2015) and waterfowl density has a significant positive linear relationship with reduction in plant standing crop (Wood et al, 2012). The availability of food affects the reproductive success of bird populations,that implies, prey abundance and its accessibility are regulated by different environmental conditions (Chastant and Gawlik 2018).

Therefore, it is vital to understand the underlying causes for the decline in populations and to control these trends in order to prevent the loss of key components of the biodiversity of wetland habitats. It has been seen that small wetlands are important for biodiversity maintenance, ecosystem functioning and conservation (Blackwell and pilgrim 2011). In recent decades, many man-made wetlands of different types have been created throughout the Meta piedmont region of Columbia, while human pressures on natural wetlands have grown significantly (Pandit, 1999 ; Pandit 2008). In this scenario man-made wetlands have become alternative habitats for birds, but it is known that these wetlands cannot be compared or be a substitute for natural wetlands (Sebastian Gonzalez and Green 2016).

River Jhelum in Kashmir Valley and its associated lakes and wetlands spread along its flood basin is a tiny part of the world freshwater scenario. Kashmir is home to a large number of lakes and wetlands. These aquatic systems are replenished by a continuous supply of water by perennial glaciers, streams, high altitude lakes and numerous springs. It has been seen that more than 6% of the land area in Kashmir valley is occupied by various types of aquatic ecosystems. (Zutshi and Gopal 1990).

The fundamental objective of this study was to assess whether macrophytic community architecture influence the avifaunal community dynamics. For this purpose, we evaluated the diversity, richness and spatial distribution of aquatic and semi-aquatic birds in the Hokersar wetland, an important Ramsar site and to identify the consequences of varied water depths, macrophyte assemblages and human interferences on the bird groups.

MATERIAS &METHODS

STUDY AREA

Hokersar wetland with snow draped Pir Panchal Mountains looming in the backdrop lies within geographical coordinates 34◦ 05’N to 34◦06’N latitude and 74◦40’ to 74◦45’ longitude towards north west of capital city of Kashmir. It lies at an altitude of 1584 metres above mean sea level. For the present study 5 sites were selected mainly on the basis of dominant vegetation. The sites selected were: Marshes, Reeds zone, surface floating vegetation zone, submerged vegetation zone and willow grooves. The wetland encompassed an area of 19.50 sq km in the year 1962, but today only 14.34 sq km falls in the territorial jurisdiction of the state wildlife protection department. Most of the area has been lost to siltation and land use change. The change analysis reveals that out of 19.50 sq km about 13.68 sq km has changed to different land use categories, while only 5.82 sq km has remained unchanged during this period. Open water area has decreased from 1.90 sq km to 0.94 sq km and marshy area has decreased from 15.99 sq km to 10.10 sq km. Now since several years bird shooting has been banned in the wetland. (Fig 1)

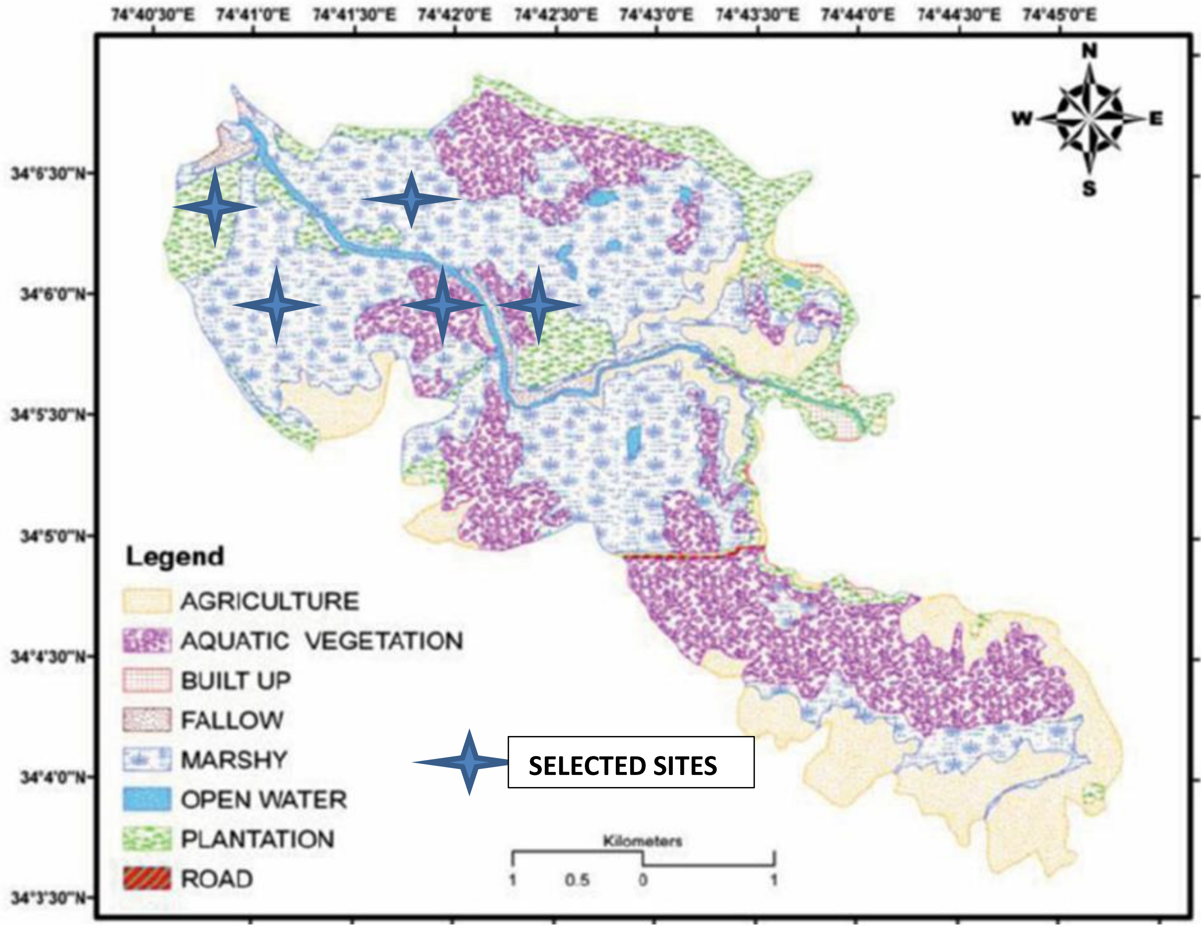

Figure 1: Outline map of study area and location of 5 targetsites in Hokersar wetland, Kashmir Himalaya

Vegetation analysis

From the wetland, 75 quadrants of $1m^2$ area with 15 quadrants in each of the five selected habitats were sampled at random on monthly basis for macrophytic studies. The vegetation survey was carried out in the wetlands. Macrophytes were collected and identified as per guidelines of Tomovic et al, (2001). The water body was divided into subunits and population of birds was estimated once every two weeks by visual census and transect method (Gaston 1975, Gaston and Ardle 1994).

Bird Studies

Bird surveys were conducted during the breeding season. Bi-monthly boat visits were made to all the recognised habitat types to study materials used for building nests. Habitat use was evaluated by investigating each habitat and species occurring in it, noting maximum occurrence of each species in each habitat. Water depth of the wetland at different sites was obtained by using a graduated nylon rope, attached to a lead weight. Statistical analysis was done by STAT PAST programme

RESULTS

The study provides insights into the macrophytic and avifaunal assemblages of this protected wetland. A striking zonation could be seen in Hokersar wetland, a marked difference in the distribution of macrophytes in the waterbody was observed. Emergent plants like *Sparganium erectum, Phragmite*s *australis, Butomus umbellatus* and *Typha angustata* were found along the shoreline and in patches throughout the wetland. A belt of plants with floating leaves composed of *Nympheae mexicana, Nymphoides peltata* and *Trapa natans* were observed in the open water area, submerged plants like *Ceratophyllum demersum, Myriophyllum spicatum,* species of *Potamogeton* and *Utricularia flexuosa* were also recorded in this zone. Marshes were found scattered in patches all over the surface, characterised by emergent vegetation like *Menyanthes trifoliate,Ranunculus lingua, Carex sp, Scirpus lacustris, Juncus articulates, Cyprus rotundus, Berula erecta, Myriophyllum verticillatum, Hydrocharis dubia*. Willow grooves (*Salix alba*) grew all along the banks , incoming and outgoing channels of the wetland. The number of species of macrophytes were recorded so far from all the habitat zones was 57.

Overall 18 bird species, including both resident and non-resident, were recorded from the wetland. 12 bird species observed breeding in the wetland were found in or around the wetland and exploited it for various purposes. On the basis of the nesting behaviour the birds could be grouped as nesting in emergent vegetation were Indian Moorhen (*Gallinula chloropus),* Purple Moorhen (*Porphyrio porphyrio),* Reed Wrabler (*Acrocephalus stentorious brunnescene)* and Bittern(*Ixobrychus minutus)*.Birds nesting in marshes were Little grebe (*Podiceps rufficolus)* and Mallard (*Anas platyrhynchos*). In open water area, Whiskered Tern (*Chlidonias hybrida*) and Pheasent Tailed Jacana *(Hydrophasianus chirurgus*) nests were observed and birds nesting in willows were Starling (*Sturnus vulgaris*), Cuckoo (*Cuculus canorus*), Little Egret (*Egretta garzetta*), Wagtails (*Motacilla* spp*)* and Mallards (*Anas platyrhynchos*) (Table1, Fig2).

During the course of study, water level of the wetland varied between 10 and 200cm with maximum values registered in April and minimum in December. On seasonal basis, water level was generally higher in spring in comparison to other seasons. In winter, some parts of the wetlands were exposed due to the very low water level creating moist banks. Most of the birds were found nesting in the water depth ranging between 20cm and 58cm (Figs 3 and 4). A positive correlation although not strong (Pearson's correlation=0.174), was found between the water depth and number of active nests recorded of various bird species breeding in the wetland. The avifaunal density was found to be positively correlated with macrophytic density (Pearson's Correlation = 0.340). The height of vegetation cover over the nests was found to project a positive correlation (Pearson's correlation = 0.135) with the number of active nests of different bird species.

Considering the breeding behaviour and distance of nesting areas from the boat traffic, Purple Moorhen is found to be the most sensitive and Reed Warbler the least responsive nesting bird in the wetland. The sensitivity pattern of these birds in the marshes, emergent vegetation zone and floating vegetation areas is Reed Warbler>Bittern>Pheasant Tail Jacana> Indian Moorhen>Mallard>Little Grebe>Purple Moorhen. Distance from boat traffic was found to have a positive influence on the nesting behaviour of these birds species (Pearson's correlation = 0.488). A regression value of 0.38 ($p<0.05$) between number of active of avifauna and height of vegetation cover over the nests was recorded and the regression value for number of active nests vs water depth at nesting sites was found to be 0.56 ($p<0.05$) (Figs 5 and 6).

Table 1: Description of studied habitat variables

Bird species	Water depth at nesting site(cm)	Height of nest above	Vegetation cover over	Distance from the	Number of active nests recorded±SD

	Range Mean	**water level (cm) Range Mean**	**the nests(cm) Range Mean**	**boat traffic (m) Range Mean**	
1.Indian Moorhen	25-58 41.5	8-15 12.0	58-60 59.0	2-19 8.0	64 ±4
2.Purple Moorhen	23-28 25.5	12-18 15.5	56-61 58.0	5-26 17.5	26 ±3.5
3.Reed Warbler	23-27 25.0	20-28 25.5	41-48 45.0	2-4 3.0	40 ±2.5
4. Bittern	24-26 25.0	4 – 6 5.0	55- 57 56.0	4.5-5.5 5.0	6 ±1.5
5.Little Grebe	25-30 27.5	2-3 2.5	26-28 26.5	8-20 13.0	14 ± 2
6.Mallard	20-26 23.0	2-11 6.5	72-85 80.5	8-18 12.5	53 ±5
7.Whiskered Tern	59.0	2.0	Not covered	15.0	4 ± 1
8.Pheasant Tailed Jacana	65.0	2.0	Not covered	6.0	3 ±1.5
9.Starling	3-5 4.5	90-115 98.0	,,	0.5-2 1.25	9 ± 2
10.Wagtail	3.0	110	,,	2.0	4 ±1
11.Cuckoo	4.0	110	,,	2.0	2 ± 1
12.Little Egret	7.5-8 7.7	121.0	,,	1.0	11 ± 2

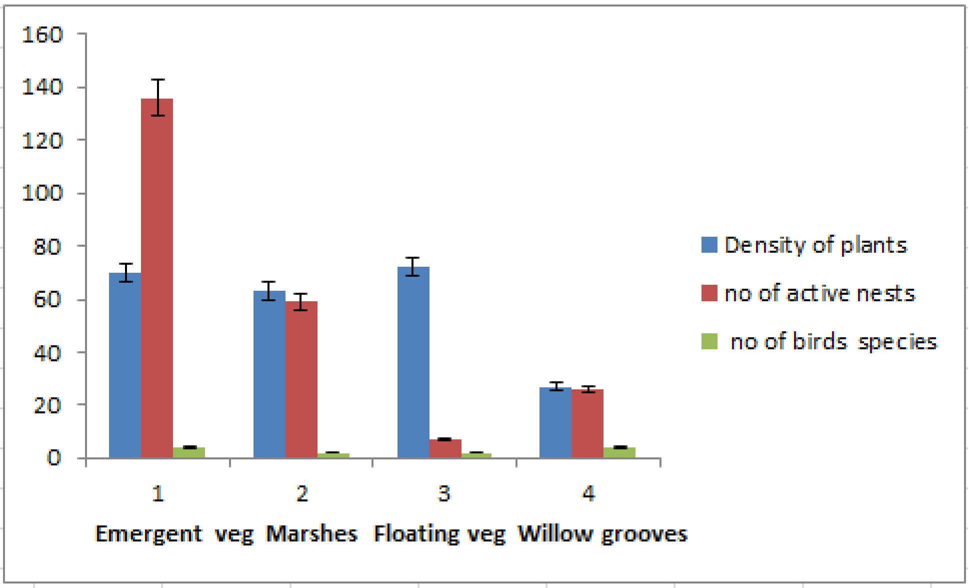

Fig 2. Number of bird species and their active nests recorded in different macrophytic zones.

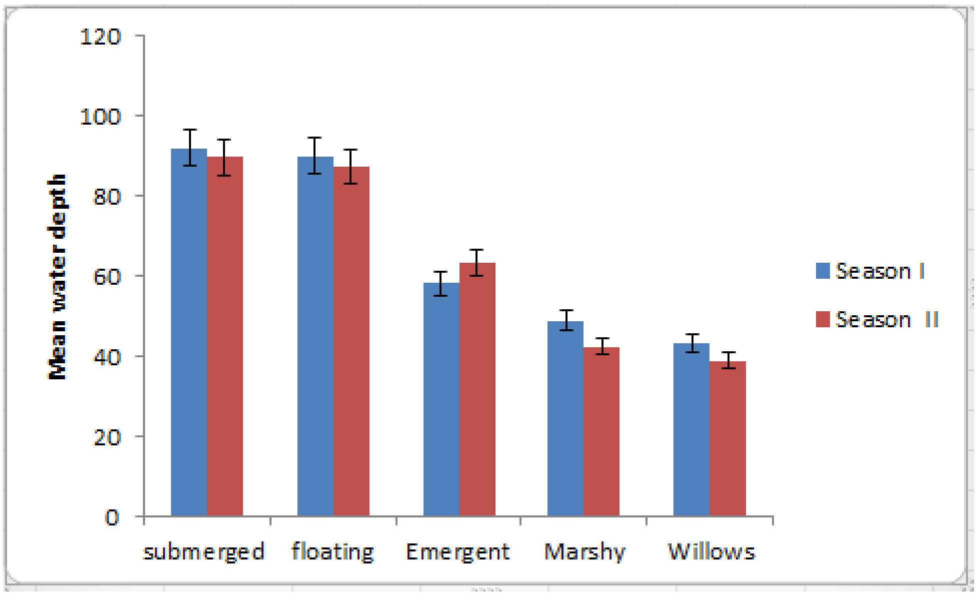

Fig 3.Mean water depth observed at 5 different macrophytic assemblage zones during two seasons of the study period

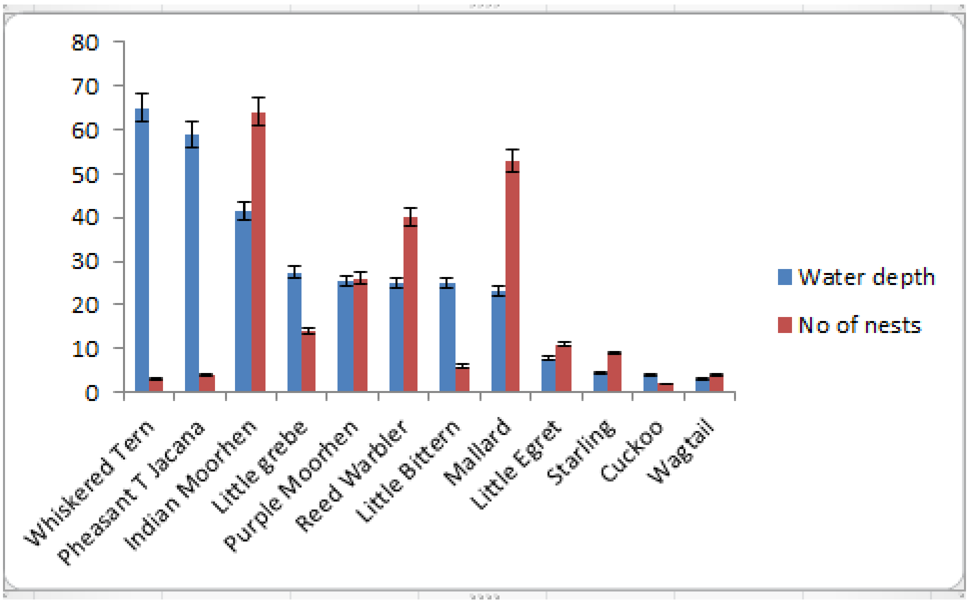

Fig 4. Number of active nests and the mean water depth as recorded for various avifaunal species in Hokersar wetland.

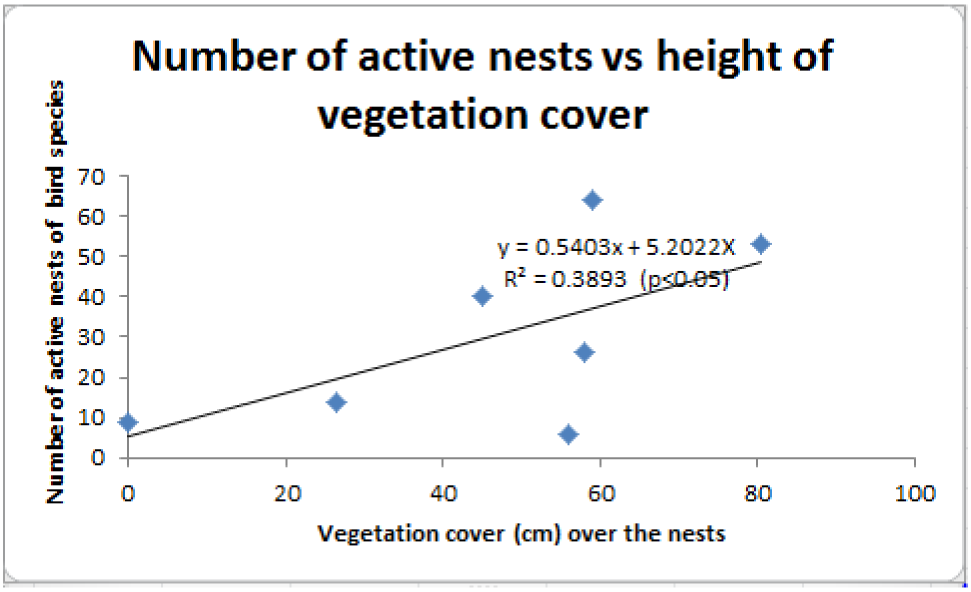

Fig 5. The regression relation between number of active nests recorded of avifauna and height of vegetation cover over the nests.

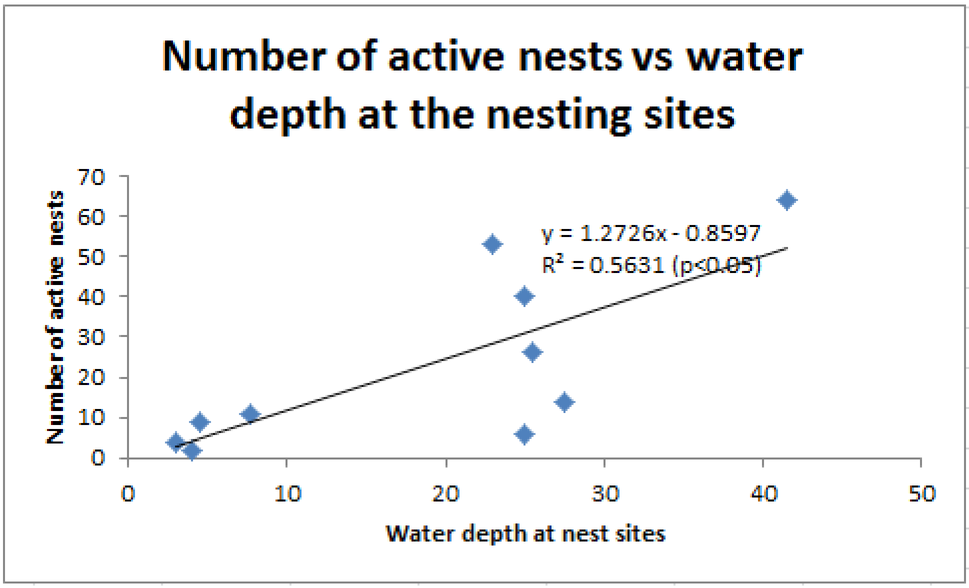

Fig 6.Regression between number of active nests of avifauna and water depth at the nesting places.

DISCUSSION

Our results, in the paradigm of classical ecological theory, support the notion that macrophyte diversity and distribution pattern in the wetlands determines its habitat complexity, which in terms influences the avifaunal diversity as well. Besides, macrophytic assemblages the habitat selection by water birds is influenced by features of surrounding landscape, water level changes, food availability. Since, habitat complexity has long been known to influence animal community structure, variation in species richness and diversity of birds between sites may suggest availability of important habitat and resources used by them in these sites. 53% of the variation in the species richness of wetland dependent birds was explained by the combination of water depth, sludge depth, human disturbance and vegetation cover; specialist birds were significantly affected by human disturbance, whereas, wetland associated birds were not much affected (Chawaka 2017).

Human activity has been found to affect many bird species like Purple Moorhen, Little Grebe, Mallard, Reed Warbler, but Indian Moorhen is relatively tolerant to human interference. Many species of water birds have secret habitats and they prefer to make nests hidden in vegetation in particular, Little Grebe, Common Moorhen, Great Bittern, Purple swamp-hen and Common Coot (Hamdi, et al 2012). However, birds nesting in willows could not be considered for the sensitivity codification as the nests were built on the top canopy branches (Little Egret and wagtails) and in the holes of the tree trunks (Starling and Cuckoo) at a distance of 3-4 metres above the water level. Whereas, Mallard nests were sighted in small willow bushes at a mean height of 6.5cm above the water level. Predator threat plays an influential role in nesting behaviour of Whiskered Tern and Pheasant tailed Jacana. Wetland size, connectivity, susceptibility to disturbance, accessibility to food within the wetland and the presence of adjacent vegetation are all known to affect wetland use by water birds (Hamdi 2012). Little and Great egrets varied their hunting behaviours according to water depth. In shallows, they used the "walking quickly" behaviour, while in deeper waters they used the "standing and wait" behaviour (Nefla and Nouira,2016). Water depth and relative fish abundance positively influenced the densities of American Bittern and Pied billed Grebe (Baschuk et al 2012). Pacific Great Blue Herons preferred building nests in close proximity to foraging sites as it is critical for their breeding success (Knight et al , 2016).

55% of active nests have been recorded in the emergent vegetation zone with a water depth ranging between 23cm to 58cm. 4% active nests were recorded from open water area with a water depth of 59cm to 65cm, whereas, 8% were recorded from marshes having a water depth ranging between 20cm to 30 cm. Starling, Wagtail, Cuckoo and Little Egret nests comprise 33% of the total nests recorded were found in the willow trees. Reasons for changes in nesting locations may be attributed to altering conditions in the wetland. This also suggests that the area provides suitable habitats with adequate food resources such as grains, seeds, roots, leaves, insects, in addition to nesting place and protective cover. Ecosystems that contain many different structural elements are likely to have a variety of resources and support a greater diversity of species (Bergen et al 2009). A high diversity of birds in flooded grasslands is attributed to heterogeneous vegetation structure that creates feasible conditions for nesting and foraging (Zmihorski et al., 2016). Water depth is the major factor determining distribution and abundance of birds in a wetland (Collwell 2000; Mcwethy and Austin 2009). Little and Great Egrets varied their hunting behaviours according to water depth, they used walking quickly behaviour in shallows and standing wait behaviour in deeper waters. High water levels remove distinctive microhabitats and create unfavourable conditions , high water levels are likely to reduce water bird richness and abundance (Farago and Hangya 2012). Water bird abundance and species richness were highest in the wettest year when the ponds had longer hydro periods (Sebastian et al 2014).

Plant species growing in Hokersar wetland have a strong effect on waterbird distribution, food plants like *Alisma, Trapa, Carex, Nymphoides, Scirpus* , *Sparganium*attract birds during their resting and preening sessions , while as, emergent macrophytes like *Typha, Phragmites, Butomus* , *Saccharam* are ideal for breeding purpose. High foraging habitat availability contributed to successful nesting by wading birds (Chastant 2018). There is a strong relationship between water birds and various biophysical parameters and varied habitat types benefit most species (Mcwethy and Austin 2009;Murray C.G et al 2013). Environmental variability is part of what determines which bird species will occupy and persist in a given habitat, thereby, shaping community composition and structure (Figueira et al, 2006).

High species richness and diversity of the plants observed within the study area provide an evidence for the biological richness and importance of the wet ecosystems and hence highlights the wetlands conservation significance regionally as well as internationally. The current protected status of the wet-site may not assure the long time perseverance of the species already striving for existence unless purposive attempts are taken to conserve important microhabitats of these birds. Impresarios should seek to understand these microhabitats and take lead to conserve them from disturbances or they will soon disappear.

Conclusion

We can conclude that the spatial distribution of water birds in Hokersar wetland is significantly determined by the macrophytic community architecture, though other factors such as water depth, human activities, food density and climatic disturbances also matter a great deal. Inspite of decline in wetland area due to siltation, crop cultivation, cattle grazing, the wetland still continues to be the preferred habitat for many a bird species. The diversity of habitats and of course the protection in Hokersar goes a long way to make it an ideal habitat for most of species in the system. Movement of people in the lake is restricted during winters in order not to disturb the winter migrants inhabiting it, the rules and regulations are to be followed all through the year. The summer migrants and resident birds must get the same importance as the winter migrants. Our study thus serves as a baseline for monitoring future trends of the bird communities and for evaluating conservation and management efforts over time.

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