PODOCES
2014
Vol. 9, No. 2
Journal homepage: www.wesca.net

Species Diversity and Density of Some Common Birds in Relation to Human Disturbance along the Bank of Dal Lake, Srinagar, Jammu and Kashmir, Northwestern India

Athar Noor[1], Zaffar Rais Mir[1], Mohd. Amir Khan[2], Amjad Kamal[2], Mujahid Ahamad[2], Bilal Habib[1] & Junid N. Shah[3*]

1) Wildlife Institute of India, P.O. Box 18, Dehradun, India
2) Department of Wildlife Sciences, Aligarh Muslim University, Aligarh, India
3) Environment Agency – Abu Dhabi, P.O. Box 45553, Abu Dhabi, United Arab Emirates

Article Info
Original Research

Received 12 August 2014
Accepted 10 September 2015

Keywords
Birds
Common birds
Dal Lake
Density
Diversity
Human disturbance

Abstract
This study was conducted to estimate species density and diversity of some common resident bird species in relation to increasing human disturbance along the bank of Dal Lake during summer 2013. Data were collected by direct counts made on three fixed width transects (1 km long and 0.1 km wide) which were marked on the road running along the bank of the lake. These three transects represent a gradient of disturbance due to human habitation whereby the first and farthest transect involved low degree and the third transect involved a high level of disturbance. In total, 1,161 birds belonging to 20 species were recorded. Mean bird density differed significantly between transects (ANOVA; $F = 3.494$, $P = 0.037$) with the highest being 67.7±26.80 birds/km^2 on the first transect and the least density on the third transect (4.5±1.77 birds/km^2). The maximum number of bird species (19) was recorded in the low level disturbance transect followed by the medium level of disturbance transect (15) and least in the high level disturbance transect (5). The species studied showed their wariness by avoiding unwanted human social interactions when it lives very near human habitations despite being residents. The low density and low diversity of these birds in the high human disturbance transect point to an almost unbearable tolerance of these species to humans which might ultimately force them to avoid human habitations leading to a more impoverished environment.

1. Introduction

The state of Jammu and Kashmir is in the Western Himalaya and Trans-Himalayan bio-geographical region of India and lies between the temperate Palaearctic and tropical Oriental biogeographic regions of the world (Rahmani *et al*. 2012). Because of its picturesque location together with good climatic conditions, this state is one of the most popular tourist destinations in India. The Kashmir region in particular attracts many domestic as well as international tourists during the summer season.

Dal Lake is very popular with tourists because of its scenic beauty but this lake also serves as a stopover for thousands of migratory and wintering birds especially during winter from late October to late February. Despite the aesthetic, economic and ecological values of this lake, it faces severe threats from eutrophication, siltation, encroachment, pollution, etc. It was therefore felt important to

* Corresponding: *junaidnazir.shah@gmail.com*

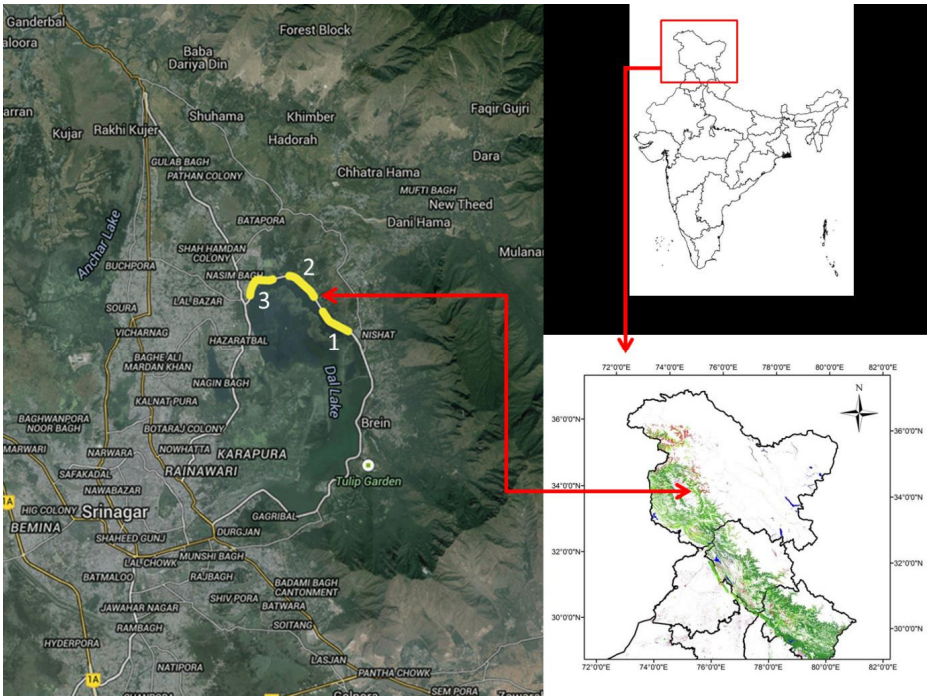

Fig. 1. Study area depicting the three transects which represent three disturbance gradients (1=Low; 2=Medium; 3=High) along the northern bank of the Dal Lake, Srinagar, Jammu and Kashmir, India.

study and monitor the avifauna of this lake in order to try and determine the factors which might be affecting the bird species present in one or more ways.

Several studies have been conducted on the avian species of different wetlands of the valley (Qadri 1980; Shah & Qadri 1988, Holmes & Parr 1989; Shah *et al*. 2000; Fazili 2002; Khan *et al*. 2004; Foziah 2009; Hussain *et al*. 2012) and on the resident avifaunal diversity of this lake (Nisar 2012; Kait *et al*. 2014). But none of them have given a thought to try and analyse the disturbance that might be very important in shaping and regulating the social and ecological behaviour of various species. According to Burger & Gochfeld (1991), birds have to be continuously vigilant in order to avoid unwanted human social interactions, approaching potential predators, search for food, monitoring conspecific members for mates, or, alternatively potential competitors.

In India, Burger & Gochfeld (1991) have estimated flushing distances of some migrant and resident birds in the presence of humans, extrapolating tolerance and response distances. While, generally the effects of human disturbance on birds are studied either in breeding colonies (Kury & Gochfeld, 1975; Robert & Ralph 1975; Ellison & Cleary 1978; Burger 1981; Safina & Burger 1983) or for solitary-nesters (Knight & Fitzner 1985), we studied bird species diversity and density of some of the common birds in the northern most stretch of Dal Lake during the summer season when almost no winter migratory bird is found. We expected that most of the birds and species would be found away from the disturbed human habitation areas. We assumed traffic plying on the road would have a uniform effect across the three transects since moving traffic was continuous.

2. Study Area and Methods

2.1. Study area

Dal Lake is a large shallow urban, hyper eutrophic lake (34° 05' - 34° 09' N, 74° 50' - 74° 53' E, 1583 m a.s.l.), situated to the north-east of Srinagar city in the Kashmir valley (Fig. 1). The lake is known as a tourist attraction providing recreational opportunities for tourists and local people. Large areas of this lake are covered by floating gardens, which are land masses used for vegetable cultivation. This lake has an approximate area of 25 km^2 comprised of open water area, floating gardens, built-up land masses with human settlements and houseboats (which are large traditional wooden boats by providing temporary accommodation for tourists). Only about 15.4 km^2 consists of open water with a maximum depth of 6 m. The lake has also been observed to freeze over

during extreme winters (~ –11 °C). Early spring and summer are the wet periods when maximum rainfall occurs - the average annual rainfall recorded is 655 mm. It is in this season that the snow thaws at higher altitudes and results in maximum discharge in Dachigam and Dara Nallah which flow into the lake.

2.2. Materials and Methods

2.2.1. Population estimation

The line transect method described by Gaston (1975) was followed to study the population density of birds from 28 June to 12 July 2013, along a 4.5 km stretch (called Foreshore road). Though many methods of avian population enumeration are available, the line transect method is preferred because of the nature of the study area which is predominantly open with sparse distribution of trees and vegetation along the northern bank of Dal Lake. We divided this road stretch into three 1 km long transects and for each transect birds were counted in a 50 m strip on both sides. The three transects represent an increasing gradient of human disturbance (e.g. vehicular traffic and human habitation) from the first through to the third transect. Counts were made early in the morning from 06:00h to 09:00h whereby each observation recorded comprised species and the total number of individuals involved. The transect lines were separated from each other by a distance of 500 m to account for independence of observations and each was repeated five times during the study period. A total of 15 km of effort was attempted in transects by walking. The data obtained were extrapolated to estimate the bird densities per square km using the following formula:

D= Number of birds /2 x L x W where, L= Length of transect and W= half-width of transect (i.e. 50 m). Double counting was avoided by noting the direction of movements of the birds while counting.

2.2.2. Species diversity indices

Species diversity, evenness and richness indices such as the Shannon-Weiner Index (Shannon & Weaver 1949), Simpson Index (Simpson 1949) and Margalef Index (Margalef 1958) were used to evaluate the bird species diversity.

Shannon-Weiner Index (H'): The Shannon-Weiner Index assumes that individuals are randomly sampled from an independently large population and all the species are represented in the sample. Shannon diversity is widely used index for comparing diversity between various habitats (Clarke & Warwick 2001). It was calculated in order to know the species diversity in different transects (Hutchison 1970) based on the abundance of the species by the following formula:

$H' = - \sum (p_i \times ln p_i)$ where, p_i= is the proportion of each species in the sample; $ln p_i$ = natural logarithm of this proportion. The presence of one individual of a species is not necessarily indicative of the species being present in a large number. The value of Shannon-Weiner Diversity Index usually falls between 1.5 and 3.5, only rarely it surpasses 4.5.

Simpson Index (D): This measures the probability that two individuals randomly selected from a sample will belong to the same species. Simpson gave the probability of any two individuals drawn from a noticeably large community belonging to different species. It has been measured by the given formula:

$D= 1 - \{\sum n_i \times (n_i - 1)/N \times (N - 1)\}$ where, n_i= the total number of birds of a particular species and N = the total number of birds of all species.

Margalef's Index (RI): This evaluates the species richness of a sample. We chose it for its ease of calculation and its widespread use (Magurran 2004). It is calculated by:

$RI = S - 1/ln N$ where, S= total number of bird species in a sample and N= total number of bird individuals in the sample.

3. Results

A total of 20 species of birds were counted amounting to 1,161 individuals. Among the three transects maximum number of bird individuals were recorded on the first transect (which has the lowest level of disturbance) followed by the second transect (which has a medium level of disturbance) and the least number of birds on third transect (which has the highest degree of disturbance) (Fig. 2). It was found that amongst the bird species, House Crow *Corvus splendens* has the highest density (205.3 ± 48.90 birds/km^2) followed by Common Myna *Acridotheres tristis* (124 ± 68.54 birds/km^2) whereas the Night Heron *Nycticorax nycticorax* and Large-billed Crow *Corvus macrorhynchos* are found to have the least population density (0.67 ± 0.1 birds/km^2 each) (Fig. 3). The mean density (±SE) of birds

differed significantly between transects (ANOVA; F = 3.494, P = 0.037) with the maximum mean density of 67.7 ± 26.80 birds/km^2 in the low level disturbance category and the least in the high disturbance level category (4.5 ± 1.77 birds/km^2) (Table 1). Among the recorded species 40% (8) were found in all three levels of disturbance, though their densities were lower proportionally in the highly disturbed area; 30% (6) species were observed from the least and moderately disturbed areas and absent from the highly disturbance area. Similarly, there were 20% (4) species that appear only in the low disturbance area and absent altogether from the medium to highly disturbed areas. Only one species (5%) i.e. Common Hoopoe *Upupa epops* appears in both the medium and highly disturbed areas and similarly Himalayan Bulbul *Pycnonotus leucogenys* was the only species recorded from the least as well the highly disturbed areas (Table 1).

Table 2 represents the diversity indices of the birds on transects whereby the medium level disturbance category represents the highest value of diversity Index (H') = 2.27 while the least value was in the high level human disturbance area (H' = 1.87). In terms of evenness index, the medium level represents the highest value (D = 0.87) and the least value by the low level disturbance (D = 0.80). The low level disturbance category depicts the maximum value of richness (RI = 2.76) followed by the other two levels which have almost similar richness values.

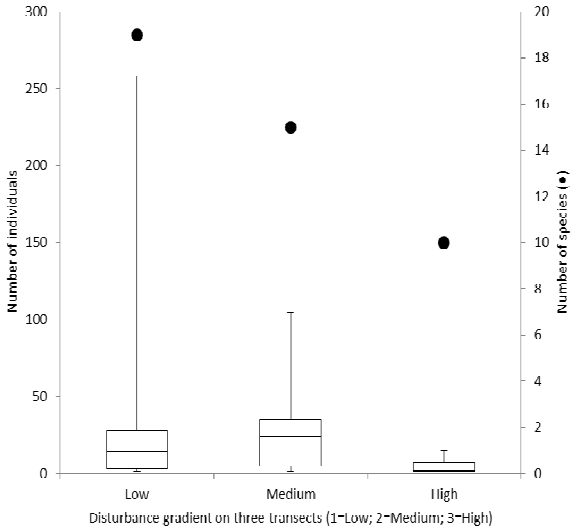

Fig. 2. Number of birds recorded on each transect of Dal Lake. Outer bars in each box indicate the 75th and 25th percentiles, the line inside each box indicates the median, and lines (error bars) represent the maxima and minima.

Table 1. Density (km^{-2}) of bird species recorded on each transect in varying disturbance levels.

Species		**Low**	**Medium**	**High**
Little Grebe	*Tachybaptus ruficollis*	24	2	-
Night Heron	*Nycticorax nycticorax*	2	-	-
Indian Pond Heron	*Ardeola grayii*	108	84	8
Cattle Egret	*Bubulcus ibis*	4	-	-
Little Egret	*Egretta garzetta*	150	104	2
Black Kite	*Milvus migrans*	36	12	-
Common Moorhen	*Gallinula chloropus*	8	4	-
Whiskered Tern	*Chlidonias hybrida*	6	-	-
Rock Pigeon	*Columba livia*	36	34	-
Eurasian Collared Dove	*Streptopelia decaocta*	18	2	4
White-throated Kingfisher	*Halcyon smyrnensis*	36	38	2
Common Kingfisher	*Alcedo atthis*	48	48	4
Pied Kingfisher	*Ceryle rudis*	80	64	-
Common Hoopoe	*Upupa epops*	-	8	4
House Crow	*Corvus splendens*	516	82	**18**
Large-billed Crow	*Corvus macrorhynchos*	2	-	-
Himalayan Bulbul	*Pycnonotus leucogenys*	20	-	2
Barn Swallow	*Hirundo rustica*	32	66	-
Common Myna	*Acridotheres tristis*	222	120	**30**
House Sparrow	*Passer domesticus*	6	210	**16**
Mean Density (±SE)		**67.7±26.80**	**43.9±12.37**	**4.5±1.77**

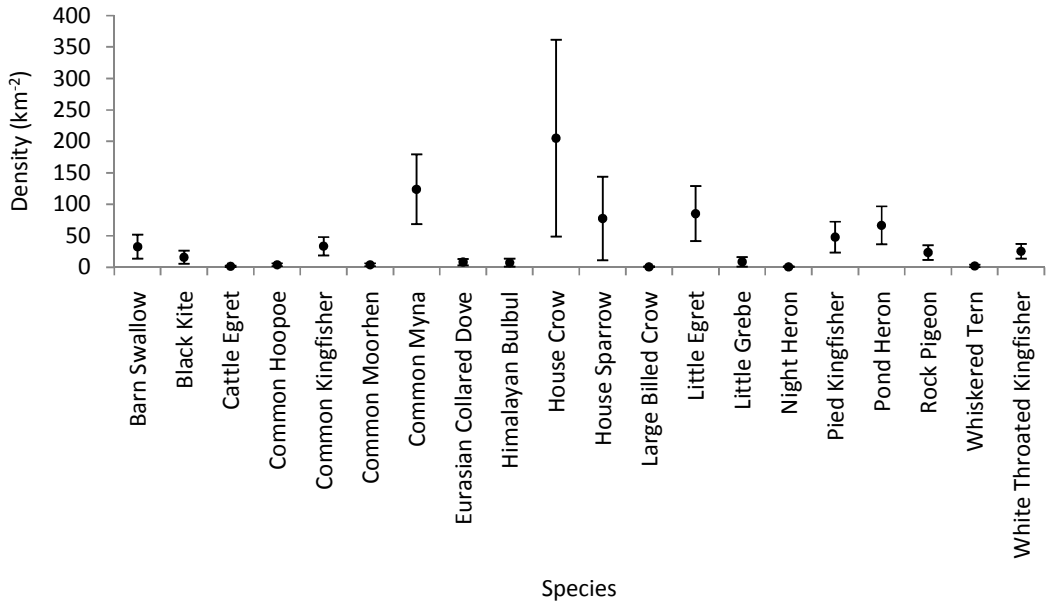

Fig. 3. Overall density of each bird species (km^{-2}) recorded in the study transects. Error bars represent standard error (±SE).

Table 2. Diversity of bird species recorded on each transect in the study area.

Diversity Index	Low	Medium	High
Shannon-Wiener Diversity Index (H')	2.0789	2.2727	1.8792
Simpson's Evenness Index (1-D)	0.8022	0.8765	0.8202
Margalef's Richness Index (RI)	2.7617	2.3009	2.3643

4. Discussion

4.1. Species diversity and density

In this short study we present abundance estimates of some of the common species found along the northern bank of the Dal Lake during summer 2013. We recorded 20 species during the study of which five were summer migrants. Nisar (2012) recorded a total of 76 species of birds belonging to 34 families in and around Dal Lake. These comprised 26 species of summer visitors, 20 species of winter visitors, 21 species of residents and 9 species of local altitudinal migrants. Kait *et al*. (2014) reported a total of 54 species of which 25 were resident, 17 summer visitors and 12 winter migrants. The population densities varied across the varying degrees of disturbance (Fig. 2) with the maximum number of recordings being on the transect which had relatively low disturbance from surrounding human settlements. This clearly becomes more significant when we move towards the third transect which almost ended up in human habitation. Therefore, as the human disturbance gradient increases from low to high levels the number of sightings decreases. This results in low records of even those species which are more tolerant to humans such as Common Myna, House Sparrow and House Crow (Burger & Gochfeld 1991) (Table 1). The high density of House Crow in the least disturbed area can be attributed to a small *willow* sp. plantation nearby which they use as their roosting or nesting sites (as the study period falls within their breeding season). Similarly, House Sparrow density was high in the medium disturbance transect which, in our opinion, was due to presence of agricultural fields a little far away which might have acted as food resource for the sparrows. Species which are totally intolerant and wary of human disturbance have not been recorded in the transect with high level of disturbance. The common species, found in all three transects, which are generally considered to be resilient to disturbance decline in numbers as we move further towards the increased disturbance and this is visible with both terrestrial (e.g. Common Myna) and waterbirds (e.g. Indian Pond Heron *Ardeola grayii* and Kingfishers) alike (Table 1). Burger & Gochfeld (1991) have estimated the flushing distances of most of the species covered in this

study and have documented their tolerance and responses.

It has been observed that the allocation and abundance of numerous bird species are determined by the composition of the vegetation that forms a major element of their habitats. As vegetation changes along complex biological and environmental gradients, a particular bird species can appear, increase or decrease in number and vanish as the habitat changes (Lee & Rotenberry 2005). Although the first transect is richer in terms of avifaunal species, more bird diversity was found in the medium disturbance category. This could be attributed to the uneven distribution of the number of individuals in the species and thus an artefact of the number of individuals in each species of a sample. Nisar (2012) reported the Shannon-Wiener diversity values in the range 1.78 to 3.48 at four sites in nearby locations of our study location and the diversity values in our study fall well under this range.

4.2. Conservation

This study shows the abundance of some common species of birds which are often not studied and ignored because of their low conservation status in India. Although these species are of Least Concern on the Red List of the International Union for Conservation of Nature (IUCN) but many of them are shown to have decreasing population trends (IUCN 2014). The foremost species which has garnered much attention in the recent past is the House Sparrow which has been in decline in India (Singh *et al*. 2013) and elsewhere (Robinson *et al*. 2005). This is a matter of concern since if this trend continues, many common species will soon be uncommon to find. Some of these species are more tolerant to human presence but in the face of ever increasing human pressure on their habitats they may soon lose their ecological elasticity. Meanwhile, other species which would also be affected are their natural predator birds, thus affecting the whole ecological balance.

Acknowledgements

We thank M. Sc. students (Aliya Khan, Farha Ansaari, Maryam J. Khan, Shanila Ansari, Shariq Ansari and Umar Saeed) who took part and helped us in various ways to get this study done. We thank Younus Khatana who assisted in the field during data collection. We thank Abolghasem Khaleghizadeh and Muhammad Sajid Nadeem for their valuable comments in improving the manuscript. We also thank the Wildlife Environment Conservation Society (WECS) which provided resources and logistics.

References

Burger J. (1981). The effect of human activity on birds at a coastal bay. *Biol. Conserv.,* 21, 231–241.

Burger J. & Gochfeld M. (1991). Human Distance and Birds: Tolerance and Response Distances of Resident and Migrant Species in India. *Environmental Conservation,* 18(2), 158–165.

Clarke K.R. & Warwick R.M. (2001). Changes in marine communities: an approach to statistical analysis and interpretation. 2nd edition, *PRIMERE: Plymouth*. 172 pp.

Ellison L.N. & Cleary L. (1978). Effects of human disturbance on breeding of Double-crested Cormorants. *Auk,* 95, 510–517.

Fazili M.F. (2002). Studies on Annual cycle of some birds of Wular lake, Kashmir. Ph.D. Thesis submitted to Univ. of Kashmir

Foziah A. (2009). 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), pp 245.

Gaston A.J. (1975). Estimating bird population. *Journal of the Bombay Natural History Society,* 72, 271–283.

Holmes P.R. & Parr A.J. (1989). A checklist of birds of Haigam Rakh, Kashmir (India). *J. Bomb. Nat. Hist. Soc.,* 85(3), 465–-473

Hussain A., Rao R.J. & Singh H. (2012). Diversity of Waterbird in Wular lake Jammu and Kashmir, India. *Advances in Bioresearch,* 3(3), 81-86.

Hutchison K. (1970). A test for comparing diversity based on the Shannon formula. *J. of Theoretical Biology,* 29, 151–154.

IUCN. (2014). The IUCN Red List of Threatened Species. Version 2014.1. <www.iucnredlist.org>. Downloaded on 04 July 2014.

Kait R., Manhas R., Aggarwal S. & Sahi D.N. (2014). Birds of Srinagar City, Jammu and Kashmir, India. *Int. J. Biodiver. Conserv.*, 6(3), 217–221.

Khan M.A., Shah M.A., Mir S.S. & Suzana B. (2004). The environmental status of a Kashmir Himalayan wetland game reserve: aquatic plant communities and eco-restoration measures. *Research and Management*, 125–132.

Knight R.L. & Fitzner R.E. (1985). Human disturbance and nest site placement in Black-billed Magpies. *J. Field Ornithol.,* 56, 153–157.

Kury C.R. & Gochfeld M. (1975). Human interference and gull predation in cormorant colonies. *Biol. Cons.,* 8, 23–34.

Lee P. & Rotenberry J.T. (2005). Relationships between bird species and tree species assemblages in forested habitats of eastern North America. *J. of Biogeography*, 32, 1139–1150.

Magurran A.E. (2004). Measuring biological diversity. Blackwell Science. *Oxford,* 256p.

Margalef R. (1958). Information theory in ecology. *General Systems,* 3, 36–71.

Nisar S.G. (2012). Resident and Non-Resident Birds of Dal Lake and Anthropogenic Factors affecting them. M.Phil. Thesis. University of Kashmir pp 112.

Qadri M.Y. (1980). Limnological studies on Lake Malpur Sar 1. *The Biotope Geobios,* pp. 117–119

Rahmani A.R., Islam Z., Ahmed K., Suhail I., Chandan P. & Zarri A.A. (2012). Important Bird Areas of Jammu and Kashmir. IBCN, BNHS, RSPB and BirdLife International. Oxford University Press. Pp xii+152.

Robert H.C. & Ralph C.J. (1975). Effects of human disturbance on the breeding success of gulls. *Condor,* 77, 490–495.

Robinson R.A., Siriwardena G.M. & Crick H.Q.P. (2005). Status and population trends of the House Sparrow *Passer domesticus* in Great Britain. *Ibis* 147, 552–562.

Safina C. & Burger J. (1983). Effects of human disturbance on reproductive success in the Black Skimmer. *Condor,* 85, 164–171.

Shah M.G. & Qadri M.Y. (1988). Feeding ecology of Mallard, *Anas platyrhynchos* at Hokersar wetland. Kashmir. *J. Bombay Nat. Hist. Soc.* 85(2), 325–331.

Shah M.G., Qadri M.Y. & Ulfat J. (2000). Species composition and population dynamics of birds of Hokersar wetland Kashmir. Environ, Biodiver, Conserve. M. A. Khan (ed.) 2000. A. P. H. Publ. Corp. New Delhi.

Shannon C.E. & Weaver W. (1949). The Mathematical Theory of Communication. University of Illinois, Urbana, Illinois.

Simpson E.H. (1949). Measurement of diversity. *Nature,* 163, 688.

Singh R., Kour D.N., Ahmed F. & Sahi D.N. (2013). The causes of decline of house sparrow (*Passer domesticus* Linnaeus, 1758) in urban and suburban areas of Jammu Region, J&K. *Munis Entomology & Zoology*, 8(2), 803–811.

*****