5.1 Aquatic Avifaunal Diversity:

During the course of present investigation, 63 species of wetland birds belonging to 20 families and 10 orders were recorded from Jammu region of J&K state. Of the 63 species, 53 were waterbirds and 10 were wetland dependent birds. Kumar et al. (2005) reported 310 species of wetland birds from India, which included 243 waterbirds and 67 wetland dependent and associated birds. The aquatic avifauna reported from the study area represent 20.32% of the total wetland bird species recorded from India and thus show a fair contribution to the aquatic avifauna of the country.

The study revealed that the order Charadriiformes represented by 18 species dominated the wetland bird community of the study area. It accounted for 28.57% of the total identified wetland bird species followed by order Anseriformes with 23.81% of species (15 species), order Pelecaniformes had 17.46% (11 species), Passeriformes 9.52% (6 species), Gruiformes 6.35% (4 species), Coraciformes 4.76% (3 species), orders Suliformes and Ciconiiformes were represented by 3.17% of species each (2
species each) while the orders Podicipediformes and Accipitriformes were least represented with 1.59% of species each (1 species each). Of the 20 families of wetland birds recorded from the study area, 7 families (35%) belonged to order Charadriiformes, 3 families (15%) belonged to order Coraciformes, 2 families belonged to order Passeriformes and Pelecaniformes each (10% each) while orders Anseriformes, Gruiformes, Suliformes, Ciconiiformes, Accipitriformes and Podicipediformes were represented by 1 family each (5% each).

Two species of wetland birds namely Chestnut Bittern (*Ixobrychus cinnamomeus*) and Glossy Ibis (*Plegadis falcinellus*) were new records for Jammu region. Both the species were recorded at Gharana Wetland Reserve. They are new records to Jammu region as they have not been recorded by earlier workers like Alfred *et al.* (2001), Grewal *et al.* (2002), Sharma (2003), Kumar and Sahi (2006), Wani *et al.* (2009), Choudhary (2010), Aggarwal (2011), Kait (2011), Kotwal (2012), Motup (2013), Singh (2015) and Pandotra (2015) from their studies.

Among the 63 recorded species, 14 (22.22%) were resident (Rst), 34 (53.97%) were winter migrant (WM), 02 (3.17%) were summer migrant (SM) and 13 (20.63%) were passage migrant (PM). Thus, the maximum proportion of wetland birds recorded in the study area was constituted by the winter migrants. Out of 310 Indian wetland birds, 107 species are winter migrants (Kumar *et al.*, 2005) and visit India from their breeding grounds in China, Russia, Central Asia, Tibet and from the entire range of the Himalayas (Kumar and Gupta, 2013). Migration is one of the most fascinating phenomena of the nature by which it becomes possible for birds to avail habitats in two different geographical areas (Grewal, 2000). The migratory wetland bird species displayed a definite pattern for arrival and departure from the study area. The winter migrants were recorded to arrive from September onwards and stayed up to March-April. The summer migrants were spotted from April to July while the passage migrants were recorded only for a short duration in the study area.

The studies on local abundance status revealed that the aquatic avifauna of the study area can be placed into four abundance categories i.e. Common, Frequent, Occasional and Rare. Of the 65 species and subspecies of wetland birds recorded during present study, 29 (44.62%) were Common (C), 14 (21.54%) were Frequent
(F), 17 (26.15%) were Occasional (O) and 05 (7.69%) were Rare (R). The occasional and rare wetland birds collectively accounts for 33.84% of the reported species and subspecies in the study area, which accentuate the need to conserve them, otherwise their abundance status could degrade further.

The conservation status of the wetland bird species reported during present study was assessed as per IUCN (International Union for Conservation of Nature and Natural Resources), CITES (Convention on International Trade in Endangered species of Wild Flora and fauna), CMS (Convention on the Conservation of Migratory Species of Wild Animals) and Wildlife (Protection) Act, 1972 amended upto 2006. According to IUCN red list (2016), amongst 63 recorded species, 2 species i.e. White-necked Stork (recorded from Gharana wetland) and Common Pochard (recorded from Gharana wetland, Lake Mansar and Surinsar) were reported to be Vulnerable (Vu) while Ferruginous Pochard (recorded from Gharana wetland and Ditch Rakh) and River tern (recorded from Gharana wetland, Pargwal wetland, River Basantar and Gho-Manhasan stream) belonged to ‘Near Threatened’ category (NT). The remaining 59 species reported during present study belonged to least concern (LC) category of IUCN. Moreover, 2 species i.e. Eurasian Spoonbill (belonging to Schedule I of Wildlife (Protection) Act, 1972) and Black Stork recorded from Gharana wetland were reported to be listed under Appendix II of CITES. In addition to this, Ferruginous Pochard was also listed in Appendix I of CMS while 27 of the reported species were listed in Appendix II of CMS. The Western Marsh Harrier recorded from Gharana wetland was reported to fall under Schedule I of Wildlife (Protection) Act, 1972. The spotting of the aforementioned threatened migratory wetland bird species from various study sites highlights the significance of these water bodies in the study area as important wintering and staging ground for these migratory wetland birds.

During present work, the distribution of aquatic bird species was determined in different wetland habitats in the study area. Both natural as well as artificial wetland habitats viz. lakes, marshes, rivers, streams, ponds, ditches and irrigated/flooded agricultural fields were recorded to be utilized by the aquatic birds as feeding, roosting and breeding sites. Basavarajappa (2006) put forth that the artificial wetland habitats by supporting different food sources like fish, crustaceans, invertebrates, water plants and planktons further add to the diversity of wetland birds.
Moreover, the importance of habitat heterogeneity in wetland bird species richness and abundance has been demonstrated in many studies (Edward and Otis, 1999; Fairbairn and Dinsmore, 2001; Riffel et al., 2001; Zarate-Ovando et al., 2008 and Datta, 2011). Among the various wetland habitats in the study area, marshes were recorded to harbour the maximum number of species (61) followed by streams (30), lakes (25), ditch (19), rivers (18) and ponds (15) while the least number (12) was recorded in irrigated/flooded agricultural fields. The reason for maximum species number in marshes particularly Gharana wetland was its shallow water depth making food easily accessible for diverse group of wetland birds like waders, dabblers and plovers. Moreover, the vast stretch of agricultural fields around the wetland also served as a secondary foraging and roosting ground for these birds. Thus, the results of the study indicated that marshes were highly attractive for different wetland bird species as compared to other habitats. These observations are in agreement with Macdonald (1977) who also reported that marshes provide heterogeneous habitats that attract high diversity of birds through offering shelter, abundant food, suitable nesting and safe roosting sites for different group of birds. Moreover, Arya et al. (2014) put forth that shallow open water and marshy areas support a variety of aquatic and semi aquatic vegetation that provides an adequate food spectrum and good habitation for living of wetland birds. Out of 65 wetland bird species and subspecies recorded, there were 19 (29.23%) that were found restricted to just one type of wetland habitat while there were 3 (4.62%) that were found in all seven wetland types, 6 (9.23%) utilized 6 wetland types, 2 (3.08%) inhabited 5 wetland types, 6 (9.23%) were found in 4 wetland types, 12 (18.46%) were distributed in 3 wetland types and 17 (26.15%) inhabited 2 wetland types. From these findings it can be concluded that the distribution of bird species in an area depend upon the nature of the habitat as different species prefer different habitat types. The main reason for difference in habitat preference by bird species could be due to different vegetation types (Weller, 1978) and abundant food resources (Puttick, 1984). Furthermore, the value of Sorensen’s Quotient of Similarity was recorded to be highest between ponds and irrigated/flooded agricultural fields (74.07%) and lowest between rivers and ditches (21.62%).
The distribution and seasonal population dynamics of wetland birds was recorded in four selected study stations. 61 species of wetland birds including 52 waterbirds and 9 wetland dependent birds belonging to 19 families and 10 orders were recorded from Gharana Wetland Reserve (GWR) during two years of study period. Out of 61 species, 14 were resident and 47 were migrant. Family Anatidae was found to be the most dominant one with 15 species. Rana (1988) reported 14 species of waterfowl from Gharana Wetland Reserve. Sharma (2002) recorded 24 species of aquatic birds migrating in Gharana wetland. Singh (2004) recorded 43 species of water birds from Gharana wetland. Saini (2009) reported 21 species of aquatic birds from Gharana wetland with highest number of species belonging to family Ardeidae.

From Lake Mansar, 24 species of wetland birds including 17 waterbirds and 7 wetland dependent birds belonging to 10 families and 8 orders were recorded. Out of 24 species, 12 were resident and 12 were migrant. Maximum number of wetland bird species was noted to belong to family Anatidae (05) and Ardeidae (05). Thus, a total of 5 species of waterfowl were reported from this lake during the study period. However, Namgyal (1990) and Malhotra et al. (1996) reported 15 species of waterfowl from Lake Mansar. Singh (2004) recorded 34 species of water birds from the lake. Moreover, Kotwal et al. (2009a) reported 21 species of wintering birds from Lake Mansar, of which 8 species were of migratory waterfowls. These results indicate that a decline in number of migratory aquatic birds that were visiting Lake Mansar has occurred over the years. This observation is in accordance with Kotwal et al. (2009b) who also observed a sudden decline in diversity as well as population of migratory avifauna in Lake Mansar. From Lake Surinsar, 22 species of wetland birds including 15 waterbirds and 7 wetland dependent birds belonging to 10 families and 8 orders were recorded. Out of 22 species, 12 were resident and 10 were migrant. Maximum number of wetland bird species was recorded to belong to family Ardeidae (06). Singh (2004) reported 38 species of water birds from Lake Surinsar. Thus, a similar trend of decline in diversity of aquatic birds as observed in Lake Mansar was also recorded in Lake Surinsar. Furthermore, 28 species of wetland birds were recorded from Gho-Manhasan Stream which included 22 waterbirds and 6 wetland dependent birds belonging to 12 families and 7 orders. Out of 28 species, 10 were resident and
18 were migrant. Maximum number of wetland bird species was recorded to belong to family Scolopacidae (07).

A well marked seasonal variation was recorded in the population of wetland birds in the four selected study stations. In Gharana wetland, the species number during first year of study (July, 2012 – June, 2013) was recorded to be highest in February (44) and lowest in July (08) whereas during following year (July, 2013 – June, 2014), it was highest in November (44) and lowest in June and August (10). The monthly species abundance varied from a minimum of 35 in July to a maximum of 4048 in February during first year and from a minimum of 37 in August to a maximum of 3346 in December during consecutive year. In Lake Mansar, the species number was recorded to be highest in March (19) and lowest in July (7) during first year whereas during following year, it was again recorded to be highest in March (17) while lowest in June, July and August (8). The monthly abundance was observed to vary from a minimum of 21 in September to a maximum of 240 in March during first year and from a minimum of 29 in September to a maximum of 165 in March during successive year.

In Lake Surinsar, species number was recorded to be highest in February (18) and lowest in July (04) during first year while highest in October with 16 species and lowest in July with 4 species during following year. The monthly abundance varied from a minimum of 16 in September to a maximum of 139 in February during first year and from a minimum of 16 in August to a maximum of 118 in December during second year. In Gho-Manhasan Stream, species number was recorded to be highest in the months of February-March (22) during both years of investigation while lowest was recorded in July (8) during first year and in July-August (8) during following year. The monthly abundance varied from a minimum of 38 in September to a maximum of 91 in March during first year and from a minimum of 32 in August to a maximum of 84 in February during consecutive year.

Thus, the number as well as abundance of wetland bird species was found to be higher in winters and low during summers in all four stations. Similar kind of varying aquatic bird population trend in relation to season has been reported by Ysebaert (2000), Maheswaran and Rahmani (2001), Basavarajappa and Kanamadi
(2002), Singh (2004), Giri and Chalise (2008), Saini (2009) and Rajashekara and Venkatesha (2011). The reason for higher species number and abundance in winter months was the influx of migratory birds. The maximum number and abundance of wetland birds was recorded during their journey period i.e. in October-November (Palaearctic to Oriental) and February-March (Oriental to Palaearctic). Similar observations were made by Untoo (1989), Rana (1988), Namgyal (1990), Malhotra et al. (1996), Sharma et al. (1999) and Singh (2004). Moreover, seasonal fluctuations in population of aquatic birds due to migratory influx of waterfowl particularly from Palaearctic region have also been well documented by Ali (1996). However, the species number and abundance was found to decrease from May to September when the winter migratory birds were absent from the study sites and the resident species were also engaged in breeding activities. This observation is in line with Sharma (2002), Singh (2004) and Saini (2009). Norris and Marra (2007) advocated that seasonal fluctuations of birds occur due to change in weather conditions or fluctuation in food productivity and habitat.

Furthermore, on the basis of relative abundance (%), the five most abundant wetland bird species in Gharana wetland were recorded to be Bar-headed Goose (*Anser indicus*), Common Teal (*Anas crecca*), Common Coot (*Fulica atra atra*), Little Cormorant (*Phalacrocorax niger*) and Grey-headed Swamphen (*Porphyrio poliocephalus*); in Lake Mansar were Great Cormorant (*Phalacrocorax carbo*), Common Moorhen (*Gallinula chloropus indica*), White-breasted Waterhen (*Amaurornis phoenicurus phoenicurus*), Little Egret (*Egretta garzetta garzetta*) and Northern Pintail (*Anas acuta*); in Lake Surinsar were Great Cormorant (*Phalacrocorax carbo*), White-breasted Waterhen (*Amaurornis phoenicurus phoenicurus*), Common Moorhen (*Gallinula chloropus indica*), Northern Pintail (*Anas acuta*) and Little Egret (*Egretta garzetta garzetta*) and in Gho-Manhasan Stream were Little Cormorant (*Phalacrocorax niger*), Red-wattled Lapwing (*Vanellus indicus indicus*), White-breasted Waterhen (*Amaurornis phoenicurus phoenicurus*), Cattle Egret (*Bubulcus ibis coromandus*) and Common Moorhen (*Gallinula chloropus indica*).

The statistical analysis of the data obtained from four study stations was also attempted and diversity indices were computed using PAST software. Species
diversity was determined by applying Shannon index, Species evenness was calculated by using the Pielou’s index, Species richness was determined by applying Margalef’s index and Species dominance by Berger-Parker index.

The species diversity, richness, evenness and dominance was found to fluctuate from month to month in all four stations. In Gharana Wetland Reserve (GWR), during first year of investigation, the maximum species diversity was noted in the month of April (2.902) and minimum in March (0.708). Species richness was maximum in January (5.642) and minimum in the month of July (1.969). Species evenness was recorded to be maximum in August (0.804) and minimum in February (0.051). Species dominance was maximum in the month of March (0.882) and minimum in October (0.160). During following year, species diversity was recorded to be maximum in the month of November (3.002) and minimum was 0.800 in the month of December. Species richness was maximum in the month of November (6.825) and minimum in June (2.301). Species evenness was maximum in March (0.779) and minimum in December (0.060). Species dominance was recorded to be maximum in the month of December (0.847) and minimum in March (0.146).

In Lake Mansar (LM), during first year, species diversity was recorded to be maximum in the month of October (2.677) and minimum in August (1.625). Species richness was maximum in the month of October (4.262) and minimum in July (1.747). Species evenness was maximum in July (0.845) and minimum in January (0.494). Species dominance was maximum in the month of August (0.500) and minimum in October (0.148). However, during consecutive year, maximum species diversity was noted in the month of September (2.285) and minimum in June (1.624). Species richness was maximum in the month of September (3.564) and minimum in June (1.911). Species evenness was maximum in May (0.762) and minimum in February (0.450). Species dominance was maximum in the month of June (0.435) and minimum in October (0.193).

In Lake Surinsar (LS), during first year, species diversity was recorded to be maximum in the month of March (2.029) and minimum in August (0.978). Species richness was maximum in the month of February (3.445) and minimum in July (1.038). Species evenness was maximum in April (0.755) and minimum in December
Species dominance was maximum in the month of December (0.731) and minimum in April (0.296). During second year, maximum species diversity was noted in the month of October (2.433) and minimum in July (1.094). Species richness was maximum in the month of October (4.066) and minimum in July (1.335). Species evenness was maximum in April (0.768) and minimum in November (0.362). Species dominance was maximum in the month of July (0.650) and minimum in October (0.175).

In Gho-Manhasan Stream (GMS), during first year, the maximum species diversity was noted in the month of February (2.802) and minimum in July (1.877). Species richness was maximum in February (5.088) and minimum in July (1.898). Species evenness was maximum in October (0.878) and minimum in November (0.679). Species dominance was maximum in the month of August (0.311) and minimum in October (0.137). During following year, species diversity was maximum in the month of March (2.871) and minimum in August (1.734). Species richness was maximum in the month of March (4.977) and minimum in July (1.939). Species evenness was maximum in September (0.922) and minimum in October (0.660). Species dominance was recorded to be maximum in the month of August (0.343) and minimum in November (0.096).

The comparative analysis of the four stations revealed that during both years of study (July, 2012 - June, 2014), the species diversity was highest in Gho-Manhasan Stream and lowest in Lake Surinsar. On the other hand, the species dominance value was noted to be highest in Lake Surinsar and lowest in Gho-Manhasan Stream. Species evenness was highest in Gho-Manhasan Stream and lowest in Gharana wetland whereas the species richness was highest in Gharana wetland and lowest in Lake Surinsar. The high species evenness recorded in Gho-Manhasan Stream, shows that there was less amount of variance in the population size of different wetland bird species. Species diversity considers both species richness and evenness. It increases as the number of individuals in the total population is more equitably distributed among the species. Bock et al. (2007) also reported that species diversity is more positively correlated with evenness. This explains the reason for high species diversity noted in Gho-Manhasan Stream. However, the main reason behind low species diversity in
Lake Surinsar was the increased anthropogenic activities resulting in occurrence of fewer species and dominance of more specialized ones.

Moreover, the similarity between aquatic bird community structures of four stations was compared by calculating Sorenson’s index (Q/S). Comparison between Gharana Wetland Reserve and Lake Mansar showed that 23 species were common to both the stations, 21 species were found to be common between Gharana Wetland Reserve and Lake Surinsar, 27 species were common between Gharana Wetland Reserve and Gho-Manhasan Stream, 21 species between Lake Mansar and Surinsar, 12 species were observed to be common at Lake Mansar and Gho-Manhasan Stream and 13 species between Lake Surinsar and Gho-Manhasan Stream. The highest value of Sorenson’s Quotient of Similarity was recorded between Lake Mansar and Surinsar (91.3%) whereas lowest similarity was found between Lake Mansar and Gho-Manhasan Stream (46.15%). The high similarity recorded between aquatic bird community structures of Lake Mansar and Surinsar was due to the reason that the two lakes were closely situated and were similar in habitat whereas the least similarity recorded between Lake Mansar and Gho-Manhasan Stream was mainly attributed to the difference in the habitat of the two stations as the former was a lentic and deep water body while the latter was a lotic and shallow water body.

Guild structure can be defined as the patterns of resource use among co-occurring species, with emphasis on the similarities and differences in how those species exploit resources (Holmes and Recher, 1986). Guilds have been viewed as natural ecological units which are recurrent in different communities and are in a sense, the building blocks of ecological communities (Hawkins & Mahon, 1989). The guild concept is useful because comparisons of the functional organizations between the communities can be investigated even when no common species are shared (Terborgh and Robinson, 1986). For birds, food is usually considered to be the most important resource and the feeding guilds have been used most extensively by ornithologists in interpreting the assemblages of species (Pandotra and Sahi, 2014).

The wetland birds reported during present work were classified into four major feeding guilds i.e. carnivorous, insectivorous, herbivorous and omnivorous depending upon the various ecological similarities among them like feeding location,
Discussion

Foraging method and type of food taken. Foraging habitat use and feeding methods are important factors involved in resource partitioning (Wiens, 1989 and Weller, 1999) and can be used to assign foraging guilds to birds (Gatto et al., 2008 and Lopez de Casenave et al., 2008). Of the total 63 species reported, the feeding guilds of 61 were ascertained while that of 2 species could not be determined as they were sighted rarely and were observed resting during field surveys. Out of 61 species, 31 (50.82%) were carnivorous, 8 species (13.11%) were insectivorous, 9 species (14.75%) were herbivorous, 11 species (18.03%) were omnivorous and 2 species (3.28%) utilized more than one feeding guild. Thus, overall the highest proportion was of carnivorous birds followed by omnivorous. The domination of the aquatic bird communities by carnivores has also been reported in other studies (Sharma, 2001; Kotwal, 2012 and Mistry and Mukherjee, 2015). Karr et al. (1990) emphasized the presence of food resources available to and exploited by the birds in defining the trophic structure of the community.

The carnivorous feeding guild was further categorised into 5 sub guilds i.e. Surface Diving Carnivore (SDC), Wading Carnivore (WC), Aerial Diving Carnivore (ADC), Arboreal Aquatic Carnivore (AAqC) and Arboreal Terrestrial Carnivore (ATC). Out of 31 carnivorous species, 3 were SDC, 23 were WC, 1 was ADC, 1 was AAqC, 1 was ADC/AAqC and 2 species were ATC/AAqC. The wading birds were highest in number and were observed to forage mainly in shallow water. This may be due to fact that edges might have high level of prey availability and is easy to catch due to shallow water depth as reported by Ntiamoabaidu et al. (1998) and Moreno et al. (2005). These birds were recorded to employ a wide range of foraging tactics to feed on diverse food items such as fishes, amphibians and invertebrates. The larger wading birds like Grey Heron, Purple Heron, Large Egret, Median Egret, Little Egret, Indian Pond Heron and Storks hunted by employing stand and wait strategy and captured the prey with their long, sharp bills. The egrets were also seen stirring water by feet to expose the prey and sometimes running with exposed wings to chase prey in shallow water. Similar observations were made by Zakaria et al. (2009). Small to medium sized waders like Black Winged Stilt, Sandpipers, Redshanks and Ruff used tactile hunting, visual feeding, probing and pecking methods to capture invertebrates.
The insectivorous category was further divided into Wading Insectivore (WI), Shore Insect Plover (SIP), Aerial Insectivore (AI) and Terrestrial Insectivore (TI). Of the 8 insectivorous species, 6 were SIP/TI, 1 species was WI/TI and 1 species was AI/TI. The herbivores were further categorized into Aquatic Surface-Diving Herbivore (AqSDH), Dabbling Herbivore (DbH) and Terrestrial Herbivore (TH) and of the 9 species, 1 was AqSDH, 2 were TH and 6 were DbH. The dabbling ducks viz. Mallard, Common Teal, Eurasian Wigeon, Gadwall, Northern Pintail and Spot-billed Duck were observed to forage in shallow water primarily along the surface by pecking, sieving or head and neck dipping. Some of them also upended to feed on the aquatic plants while some grazed on the shores. The omnivores were further categorized into Wading Omnivore (WO), Dabbling Omnivore (DbO), Diving Omnivore (DvO) and Aquatic-Terrestrial Omnivore (AqTO) and of the 11 species, 1 was WO, 3 were DbO, 3 were DvO and 4 species belonged to AqTO category. Ali and Ripley (1987) reported that the wetland birds are in general heterogeneous in their feeding habits. Furthermore, the 2 species i.e. Cattle Egret and Red-wattled Lapwing recorded to utilize more than one feeding guild were found to shift between terrestrial and aquatic habitats. Such shifts between habitats are correlated with relative availability of prey and the ability of birds to use it (Valentine, 1958). These species were found to be more common and abundant in the study area.

Furthermore, in all four study stations, the carnivorous feeding guild was dominant and was represented by 51.72%, 37.5%, 45.45% and 59.26% in Gharana Wetland Reserve, Lake Mansar, Lake Surinsar and Gho-Manhasan Stream respectively. The percentage of insectivores was 10.34%, 20.83%, 22.73% and 18.52% in Gharana Wetland Reserve, Lake Mansar, Lake Surinsar and Gho-Manhasan Stream respectively. The contribution of herbivores was 15.52%, 16.67%, 9.09% and 3.71% while that of omnivores was 18.97%, 16.67%, 13.64% and 11.11% in Gharana Wetland Reserve, Lake Mansar, Lake Surinsar and Gho-Manhasan Stream respectively. The multiple guild constituted 3.45%, 8.33%, 9.09% and 7.4% in Gharana Wetland Reserve, Lake Mansar, Lake Surinsar and Gho-Manhasan Stream respectively.

Order Podicipediformes was represented by a single species namely Little Grebe or Dabchick belonging to family Podicipedidae. It was recorded to be resident...
in the study area and was reported from six stations viz. Gharana wetland, Hamirpur marsh, Lake Mansar, Lake Surinsar, Ditch Rakh and Sainik Colony pond. Rana (1988) and Singh (2004) also assigned it the status of resident bird. The present study revealed that it is a surface diving carnivore. Sharma (2003), Kumar (2006), Aggarwal (2011), Kotwal (2012) and Pandotra (2015) also reported it as diving carnivore. Order Suliformes was represented by two species belonging to family Phalacrocoracidae namely Little Cormorant and Great Cormorant. The Little Cormorant was recorded to be resident in the study area but it showed an increase in number during winters particularly at Gharana Wetland Reserve. The increase in number was due to winter influx. Saini (2009) reported it to be a winter migrant and first to enter the Gharana wetland in the month of August. The Great Cormorant was reported to be a winter migrant in the study area. It was found in large flocks in Lake Mansar and Surinsar while in small numbers in Gharana wetland, Pargwal wetland and River Tawi. Both the species of cormorants were recorded to be surface diving carnivore. On contrary, Kotwal (2012) and Pandotra (2015) recorded the two species of cormorants as wading carnivore.

Order Pelecaniformes was represented by 11 species belonging to two families namely Ardeidae and Threskiornithidae. Family Ardeidae was represented by 9 species viz. Indian Pond Heron, Black-crowned Night Heron, Grey Heron, Purple Heron, Little Egret, Cattle Egret, Median Egret, Large Egret and Chestnut Bittern. Among theses, the Indian Pond Heron was a resident species and was also recorded to breed in the study area. It was mostly observed foraging solitarily along the water edges by standing still and waiting patiently for the prey to come within its range. This observation is in consonance with Andrews and Mathew (1997), Kumar (2006) and Kotwal (2012) who reported Indian Pond Heron to use stand and wait method for capturing food. It was recorded to feed mainly on fishes and sometimes on frogs, tadpoles, earthworms, snails and leeches. It was not observed to exhibit any type of flocking as also reported by Andrews and Mathew (1997) and Sharma (2003).

Black-crowned Night Heron was reported from Gharana wetland, Lake Mansar and Lake Surinsar. It was recorded to be resident in the study area. This observation is in accordance with Kumar (2006), Aggarwal (2011) and Pandotra (2015) while in contradiction with Kotwal (2012) who reported it as winter migrant. It
was recorded to be a wading carnivore. Sharma (2001) also assigned it the status of wading carnivore. Grey Heron and Purple Heron were recorded to be winter migrants. Similar observations were made by Saini (2009). The Grey Heron was reported from Gharana wetland, Hamirpur marsh, Lake Mansar, Lake Surinsar and Ditch Rakh while Purple Heron was reported from Gharana wetland and Ditch Rakh only. Both the species were observed to feed solitarily like other herons by standing still and waiting patiently for the prey along the edges and were also recorded wading in shallow water. Both were noted to feed mainly on fishes and frogs. Ali and Ripley (1983) also reported Grey Heron to feed on fishes and frogs. Snow et al. (1998) mentioned the food of Grey Heron as chiefly fish, amphibians, small mammals, insects, reptiles and occasionally crustaceans, molluscs, worms and plant material. Little Egret was found either singly or in small flocks along streams, rivers, ponds, marshes, ditch, lakes and paddy fields in the study area. It was categorized as wading carnivore. Jose and Zacharias (2003) recorded it as insectivore and piscivore. It was noted to forage in company of Cattle Egrets, Indian Pond Herons and Red-wattled Lapwings as also reported by Pandotra (2015). It was recorded to utilize a small raised island covered with Ipomoea vegetation in Lake Mansar as its breeding and roosting site. Similar observations were made by Kotwal (2007) and Kaur (2012). Moreover, it was also recorded nesting on trees in R. S. Pura area during present work.

The Cattle Egret was also recorded to be a breeding resident waterbird species in the study area. It was found to nest on Acacia nilotica and Mangifera indica trees in the form of monospecific colonies. Similar findings were made by Kour (2009). It was observed to exploit drier habitat more than other heron species and was seen foraging in close association with cattle. These findings concur with that of Ali (1941), Kumar (2006), Kour (2009), Kotwal (2012) and Pandotra (2015). It was recorded to feed mainly on insects and occasionally on fishes, frogs, tadpoles and earthworms. Similar observations regarding its dietary items were made by Whistler (1928), Ali and Ripley (1983), Sharma (2003), Aggarwal (2011), Kotwal (2012) and Pandotra (2015). During present study, it was seen foraging in large flocks in irrigated agricultural fields in association with Indian Pond Herons, Red-wattled Lapwings and Little Egrets. Andrews and Mathew (1997) reported that Cattle Egret tried to attack
Pond Heron and other egret species, when they were sharing same patch of field. No such observations were made during present study. Median and Large Egret were reported as winter migrants. These observations are in consonance with Saini (2009). Median Egret was observed either solitarily or in small parties while Large Egret was always sighted singly. Both were categorized as wading carnivore. Pandotra (2015) and Kotwal (2012) also made similar observations in case of Median Egret and Large Egret respectively. Chestnut/Cinnamon Bittern was reported as a rare passage migrant and was recorded only once from Gharana Wetland Reserve. The family Threskiornithidae was represented by two species i.e. Glossy Ibis and Eurasian Spoonbill, both of which were reported from Gharana Wetland Reserve and assigned the status of rare passage migrants. Glossy Ibis were recorded in a small flock while Eurasian Spoonbill was observed singly. Both were recorded as wading carnivores. The two species i.e. Cinnamon Bittern and Glossy Ibis are new records from Jammu region.

Order Charadriiformes was represented by 18 species belonging to seven families viz. Recurvirostridae, Charadriidae, Scolopacidae, Jacanidae, Glareolidae, Rostratulidae and Laridae. Family Recurvirostridae included only one species i.e. Black Winged Stilt belonging to subfamily Recurvirostrini. It was recorded from 7 stations of the study area and was reported to be a winter migrant. Similar observation was made by Kotwal (2012). On contrary, Kumar (2006) reported it as resident in district Kathua. Family Charadriidae was represented by three species belonging to subfamily Charadiinae i.e. Little Ringed Plover, Red-wattled Lapwing and White-tailed Lapwing.

Little Ringed Plover was recorded to be an occasional passage migrant and was observed singly along sandy and muddy margins of rivers and streams. It was reported from only 2 stations i.e. River Basantar and Gho-Manhasan stream. It was recorded to be insectivorous in feeding habits. The Red-wattled Lapwing was resident in the study area and was found singly, in pairs as well as in flocks along the shores of freshwater lakes, marshes, rivers, streams, ponds, canals and also in agricultural fields. Kumar (2006) also reported loose congregations of 10-15 birds along the edges of lake or feeding in the open fields. It was recorded to exploit both terrestrial and aquatic habitats for foraging and was reported as wading carnivore/terrestrial
insectivore. On contrary, Sharma (2001) reported it as grassland insectivore. During the course of study, it was also found to forage at garbage dumping sites, thus showing a changing trend in its feeding habit. It was found to nest on ground along shores of Mansar Lake and in agricultural fields during the months of May-June. The nest was a simple depression in ground lined with debris and some dry grass. Similar observations were made by Singh (2004) and Koul (2015). The increased anthropogenic activities along the lake shores and multiple cropping patterns in agricultural areas were found to have an adverse impact on its breeding activities. White-tailed Lapwing was reported to be a winter migrant and was recorded from Gharana wetland and Gho-Manhasan stream.

Family Scolopacidae was represented by 10 species belonging to subfamily Scolopacinae. Of the 10 species, 9 species i.e. Common Snipe, Common Redshank, Common Greenshank, Green Sandpiper, Common Sandpiper, Wood Sandpiper, Marsh Sandpiper, Temminck’s stint and Ruff were reported to be winter migrants while one species i.e. Spotted Redshank was recorded to be an occasional passage migrant. Similar observations were made by Sharma (2003), Kumar (2006) and Aggarwal (2011) in case of Common Greenshank and Common Sandpiper. 9 species were categorised as wading carnivore while 1 species i.e. Wood Sandpiper was recorded as wading omnivore. Common Snipe was reported from Gharana wetland and was observed solitarily or in small parties. Motup (2013) recorded it singly and reported it to be a rare passage migrant in Ladakh region (J&K). Common Redshank was observed singly or in small groups and was reported from Gharana wetland, Gho-Manhasan stream and River Tawi. It was observed to feed often in company of other waders. Spotted Redshank was reported from Gharana wetland only. It was observed in small flock, wading actively in shallow to fairly deep water. Alfred et al. (2001) reported it to be a winter migrant in much of India including Kashmir. Common Greenshank was recorded singly or in small parties and was reported from Gharana wetland, Pargwal wetland, Gho-Manhasan stream, River Tawi, River Basantar, Kheri stream, Salehar stream, Ratnuchak stream and Sehe stream. Green Sandpiper was reported from Gharana wetland, Gho-Manhasan stream, Salehar stream, Kheri stream and Sehe stream. It was observed to feed solitarily at the edges or in shallow water.
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Common Sandpiper was mostly recorded solitarily and sometimes in small scattered parties along streams, rivers, marshes, ponds and puddles. Similar observations were made by Kumar (2006). Wood Sandpiper was observed singly or in small parties and was reported from Gharana wetland, Gho-Manhasan stream and Kheri stream. However, Motup (2013) recorded it singly near rivers, ponds and lakes in Ladakh region (J&K). Marsh Sandpiper was observed to arrive by August in the study area. It was recorded solitarily and was reported from Gharana wetland, Salehar stream and Gho-Manhasan stream. Temminck’s stint was found solitarily and was reported from 8 stations of the study area. Ruff was recorded in small flocks and reported from Gharana wetland and River Tawi. The river was recorded to be used mainly as a stop-over site while the marsh was preferred for wintering.

Family Jacanidae was represented by a lone species i.e. Pheasant-tailed Jacana which was recorded to be a summer migrant. It was reported from Gharana wetland only. It was recorded in small groups of 3-7 individuals feeding along the shores of the wetland and also in open water. Similar observations were made by Motup (2013) who reported it to be a rare passage migrant in district Kargil of Ladakh region (J&K) and observed it feeding in the marshes, stagnant pools and flooded fields. Family Glareolidae included one species, Collared Pratincole. It was observed singly inhabiting dry bare ground or ploughed fields near Gharana wetland. This observation is in consonance with Pandotra (2015). Family Rostratulidae included one species viz. Greater Painted-Snipe which was reported to be an occasional passage migrant. It was reported from Gharana wetland and Gho-Manhasan stream. Family Laridae was represented by one species, River tern which was recorded to be a winter migrant. On contrary, Saini (2009) reported it as occasional visitor. It was reported from Gharana wetland, Pargwal wetland, River Basantar and Gho-Manhasan stream. It was categorized as aerial diving carnivore. This observation goes well with Motup (2013).

Order Gruiformes included 4 species belonging to a single family, Rallidae i.e. Common Moorhen, Grey-headed Swamphen, Common Coot and Indian White-breasted Waterhen. Local abundance status depicted that all four species were common. Common Moorhen was resident in the study area and was reported from 6 stations viz. Gharana wetland, Lake Mansar, Lake Surinsar, Gho-Manhasan stream, Ditch Rakh and Hamirpur marsh. Kotwal (2012) and Pandotra (2015) also reported it
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to be resident in their respective study areas. On contrary, Namgyal (1990) reported it to be a migrant species. It was observed singly, in pairs or in small parties. However, increase in number was recorded during winter months due to local migration. Rana (1988) and Kotwal (2012) also made similar observations. It was recorded to be omnivorous and was seen feeding in both aquatic and terrestrial habitats. On contrary, Kumar (2006) and Ahmed (2009) recorded it as wading carnivore or shore insect plover in its feeding habits. Sharma (2001) reported it as terrestrial omnivore. During the study period, little downy chicks were seen along with parents in Gho-Manhasan stream and Gharana wetland during the months of May-June. Juveniles were also recorded at some stations of the study area. Grimmett et al. (1998) reported this bird to breed up to 2400m in Kashmir. Motup (2013) also found a number of pairs raising their little downy chicks in Ladakh region.

Grey-headed Swamphen was reported from Gharana Wetland Reserve and Ditch Rakh. It was also recorded to be a resident species and was observed throughout the year. However, increase in number was recorded during winter months. Similar observations were made by Menon (2008) and Pandotra (2015) in their respective study areas. Moreover, Singh (2015) also reported it to be a resident species while studying the avian diversity of district Udhampur (J&K). It was observed to be omnivorous in its feeding habits. White-breasted Waterhen was observed to be resident and was found to inhabit areas around marshes, lakes, streams, ponds, irrigated agricultural fields, canals to ditches and was recorded from 7 stations in the study area. Similar type of habitat was reported by Kumar (2006) and Singh (2015). It was recorded as aquatic-terrestrial omnivore. However, Bhatt and Sharma (2000) reported it as wading carnivore while Jose and Zacharias (2003) recorded it as insectivore and grainivore. Common Coot was recorded to be a winter visitor to the study area and was reported from Gharana wetland, Ditch Rakh, Lake Mansar and Surinsar. It was observed in small to large flocks swimming and feeding in open water on aquatic vegetation. Similar observations were made by Kotwal (2012) and Pandotra (2015).

Order Anseriformes included a single family Anatidae comprising of 15 species. Motup (2013) reported 14 species of order Anseriformes from Ladakh region (J&K). Pandotra (2015) reported 7 species of order Anseriformes from Gharana
Wetland Reserve. Subfamily Anatinae was represented by 8 species, out of which 7 species were winter migrant and 1 species i.e. Spot-billed Duck was reported to be a summer migrant to the study area.

During present study, Mallard, Northern Shoveler, Gadwall and Garganey were reported from Gharana Wetland Reserve only. However, Kotwal (2012) reported Mallard, Northern Shoveler and Gadwall from Lake Mansar and Surinsar. The reason that these migratory birds did not prefer the twin lakes anymore for wintering was the increased anthropogenic pressure. Jorde (1981) found that human creation and alteration of water bodies and plant communities have changed the migration and wintering patterns of Mallards. Moreover, in Gharana wetland also, Mallard was observed in small numbers only. It was recorded to be herbivore. This observation goes well with Kotwal (2012). In contrast, Motup (2013) reported it to be omnivorous in feeding habits. Northern Shoveler was observed to arrive in the month of October in small numbers which increased progressively. It was reported to be an omnivore. Gadwall was recorded in small to large flocks and was reported as herbivore. Similar observation was made by Pandotra and Sahi (2014). Garganey was observed in pairs or small flocks and was recorded to be omnivorous in feeding habits. Northern Pintail was gregarious in habit and was reported from Gharana Wetland Reserve, Lake Mansar and Surinsar. On contrary, Pandotra (2015) observed it singly or in pairs.

Common Teal was reported from Gharana wetland and Lake Mansar. In Gharana wetland, it was observed in large flocks however, only one or two individuals were recorded at Lake Mansar. It was reported as herbivore. This observation is in accordance with Pandotra and Sahi (2014). Eurasian Wigeon was recorded in small flocks at Gharana wetland and Lake Mansar. Spot-billed Duck was reported from Gharana wetland, Gho-Manhasan stream and Ditch Rakh and recorded singly or in small family parties. Adult with chicks were seen in the month of May during both years of study. It was categorised as herbivorous in feeding habits. Kumar and Gupta (2013) recorded it to be a winter migrant in Chhilchhila Wildlife Sanctuary, Haryana.

Subfamily Aythyinae included 3 species i.e. Common Pochard, Tufted Duck and Ferruginous Pochard, all of which were recorded to be occasional passage
migrants and visited the study area during autumn and spring migration. Similar observations were made by Motup (2013) while studying the avian diversity of Trans-Himalayan region of Ladakh. Common Pochard was recorded in small flocks from Gharana wetland, Lake Mansar and Surinsar. Tufted Duck was observed in pairs or in mixed flock with Common Pochard in Gharana wetland and Lake Mansar. Singh (1992) also recorded Common Pochard, Red-crested Pochard and Tufted Pochard in mixed flocks at Harike wetland in Punjab. Ferruginous Pochard was observed singly or in small groups in Gharana wetland and Ditch Rakh. All three species were reported to be diving omnivore.

Subfamily Anserinae was represented by 2 species of large waterfowls i.e. Bar-headed Goose and Greylag Goose. Both the species were reported from Gharana wetland only. Bar-headed Goose was reported to be a winter migrant and was recorded to arrive in large numbers in the month of December. The agricultural fields near Gharana wetland provided a suitable shelter and foraging ground to these birds. It was reported to be a terrestrial herbivore and was recorded to feed in large flocks on the tender shoots of wheat and grasses. The Greylag Goose was a passage migrant and was recorded in small numbers along with flock of Bar-headed Goose. It was also reported as terrestrial herbivore. Hupp et al. (2008) reported that goose being herbivorous prefers regions of agricultural habitat in winters. Ruddy Shelduck was recorded from Gharana and Pargwal wetlands during winter months. Grimmett et al. (1998) reported that it is a widespread winter visitor to the Indian subcontinent and breeds in Ladakh, Sikkim and Nepal. It was reported to be omnivorous. This observation goes well with Motup (2013).

Order Ciconiiformes was represented by two species viz. Black Stork and White-necked Stork belonging to a single family Ciconiidae. Black Stork was reported to be a rare passage migrant and was recorded from Gharana wetland. Motup (2013) also reported it to be a rare passage migrant in Ladakh. White-necked Stork was a winter migrant and it was also recorded from Gharana wetland.

Order Coraciformes included 3 species belonging to 3 families i.e. White-breasted Kingfisher belonging to family Halcyonidae, Lesser Pied Kingfisher belonging to family Cerylidae and Common Kingfisher belonging to family
Alcedinidae. All three species were recorded to be resident. Local abundance status showed that 2 species were common while 1 species was frequent. White-breasted Kingfisher was the most common of all kingfishers found in the study area and was observed to exploit a wide variety of habitats. On many occasions, it was also found well away from water. It was observed to forage solitarily and exploited both terrestrial and aquatic habitats. Lesser Pied Kingfisher was recorded from 6 stations viz. Gharana wetland, Pargwal wetland, Gho-Manhasan stream, Kheri stream, Sehe stream and Rakh ditch and was always sighted near water as also reported by Ali (1941) and Oommen and Andrews (1996). It was found singly, in pairs or small family parties. Its hunting manoeuvre was distinctive and was observed to forage by hovering over water surface or by scanning the prey from a perch. Similar observations were made by Kait (2011). Common Kingfisher was the smallest of all kingfishers found in the study area. It was observed singly and sometimes in pairs along shores of lakes, marsh and ditch. However, Kumar (2006) recorded it to inhabit streams, lakes, canals, ponds, ditches etc. It was recorded to hunt from a perch such as an overhanging branch, post, wire or reeds about 2-3m above water. It was reported as arboreal aquatic carnivore. This observation is in conformity with Kotwal (2012) and Pandotra (2015).

Order Passeriformes included two families comprising of 6 species. Family Motacillidae included 5 species of wagtails viz. Large Pied Wagtail, Grey Wagtail, Citrine Wagtail, White Wagtail and Yellow Wagtail. All five species were categorized as shore insect plover and terrestrial insectivore. Large Pied Wagtail was recorded to be resident in the study area and was reported from 13 stations. It was found singly or in pairs along lake shores, river banks, streams, puddles, ponds, canals, marshes and agricultural fields. Similar observations regarding its residential status were made by Kotwal and Sahi (2007) while studying the avifauna of Lake Mansar. On contrary, Ahmed (2009) and Singh (2015) reported it as summer migrant while Kumar (2006) and Kait (2011) as winter migrant in their respective study areas.

Grey Wagtail was reported to be a winter migrant to the study area and was observed singly along lake shores, streams, marshes, ponds, canals and near fields. Kumar (2006), Kotwal and Sahi (2007), Kait (2011) and Pandotra (2015) also reported it as winter migrant. However, Noori (2014) reported it to be resident in
district Poonch (J&K) and observed it singly or in pairs during breeding season. Citrine Wagtail was also reported to be a winter migrant and was recorded to stay in the study area till the month of March-April. It was recorded singly and sometimes in mixed flocks with other wagtails along river banks, lakes, marshes, streams, ponds, small puddles and irrigated agricultural fields. Motup (2013) reported it to be a common summer visitor in Ladakh region and also recorded it breeding along the banks of a marshy lake.

During the course of present investigation, three subspecies of White Wagtail were reported from the study area namely *Motacilla alba personata*, *Motacilla alba alboides* and *Motacilla alba dukhunensis*. They were reported as winter migrant to the study area. Motup (2013) also recorded similar subspecies of White Wagtail while studying the avian diversity of Ladakh region and reported them to be summer visitors. Of the three subspecies, *Motacilla alba personata* was common, *Motacilla alba dukhunensis* was frequent while *Motacilla alba alboides* was observed as an occasional bird in the study area. They were reported as shore insect plover and terrestrial insectivore. Similar observations were made by Aggarwal (2011) for *M. a. dukhunensis*. However, Sharma (2001) reported it as terrestrial insectivore only. Kumar (2006) and Kait (2011) reported *M. a. dukhunensis* to be a winter migrant in their respective study areas. However, Singh (2015) reported this subspecies of White Wagtail as summer visitor in district Udhampur and found it to inhabit open country around rivers, streams, crop fields and paddy fields. Noori (2014) also reported it as summer migrant in district Poonch (J&K). Yellow Wagtail was reported to be a passage migrant and was recorded from Gharana wetland only. It was recorded to be similar to other wagtails in habits but was not as common as other species. Singh (2015) reported it to be a summer visitor in district Udhampur. It was observed solitarily or in loose mixed flocks with other wagtails foraging in flooded agricultural fields and was also found perched on telegraph wires. Kumar (2006) recorded it in pastures and moist grassy grounds along the water bodies in district Kathua.

Family Muscicapidae was represented by a single species, the White-capped Water Redstart. It was reported from Lake Mansar and Surinsar during winter months. Aggarwal (2011) also reported it to be a winter migrant while studying the bird communities of Ramnagar and Nandini Wildlife Sanctuaries in Jammu. Kumar (2006)
found it to be a bird of higher altitude during summers and descending down to lower altitudes in winters affecting rocky and stony edges of running streams, also forested areas and open country near water. Whistler (1928), Ali and Ripley (1983), Grimmett et al. (1998) and Alfred et al. (2001) also reported it to migrate to lower altitude in winters. However, Noori (2014) reported it to be a resident bird in district Poonch of J&K. Order Accipitriformes was represented by a single species, Western Marsh Harrier belonging to family Accipitridae. It was recorded to be a winter migrant and was found at Gharana wetland only. It was categorized as carnivore and observed to exploit both aquatic and terrestrial habitats. It was recorded gliding low over water surface and also over the neighbouring fields in search of prey. These observations are in concordance with Pandotra (2015).

5.2 Eco-biology of White-breasted Waterhen (*Amaurornis phoenicurus phoenicurus*):

The White-breasted Waterhen was found to be a common resident waterbird in the study area. It was discerned to be a medium-sized bird with a slender body and a short tail. The upperparts were dark slaty grey with an olive tinge while the rump and upper tail coverts were grey-brown. The wings had a narrow white line along the edges. The forehead, face, chin, foreneck, breast and belly were white. The vent and the undertail coverts were rufous chestnut. The long legs and toes were yellow in colour. Iris was red in colour. The bill was green with a red swollen knob on upper mandible and some yellow on lower mandible. The sexes were identical and no peculiar variation was detected in the plumage of the breeding pair during the breeding season. Grimmett et al. (1998), Chaudhari (2002), Kumar (2006), Aggarwal (2011), Kotwal (2012), Singh (2015) and Pandotra (2015) recorded the same field characters for this species. Robson (2007) reported that females are generally smaller than the males. In the present study, no such size variations were recorded. However, the juvenile was observed to be a duller version of the adult with olive-brown colouration.

During the course of study, the White-breasted Waterhen was found to be well adapted to different types of wetland habitats which ranged from marshes, streams, lakes, ponds, canals, ditches to irrigated agricultural fields. It was recorded to mainly
prefer those sites which provided sufficient cover for concealment as it was very sensitive even to slight disturbances and was observed to immediately seek cover. In agricultural areas, they were recorded to make extensive use of irrigation canals, small marshy areas as well as streams as the trees near these sites provided a suitable nesting site to these birds while the water bodies served as a rearing ground for raising chicks. Moreover, in lakes, they were found to inhabit the thick vegetation cover present along the shores and were also seen venturing in the adjoining fields. In addition to these habitats, they were also recorded to make use of nullahs during present study.

With regard to population count, it was recorded that all stations experienced an increase in number of individuals from March to September which was mainly due to the addition of young birds during this period. Furthermore, among all the stations scrutinized for recording the monthly count, R. S. Pura area was found to have the highest monthly count of individuals whereas the lowest monthly count was recorded in University campus. The high count recorded in R. S. Pura area was due to more availability of preferred feeding and breeding sites in this station whereas in University campus, the increased disturbances and less availability of suitable feeding and breeding sites resulted in low count of individuals. Newton (1995) has put forth that the population size of birds are affected by food resources, availability of nesting sites, weather, predation, diseases and disturbances.

A comprehensive account pertaining to the food and feeding ecology of White-breasted Waterhen was made during the study period. During the course of work, it was found to forage singly during the non breeding season and in pairs or small family parties during the breeding season. It was observed to be an opportunistic feeder and was recorded to make use of both terrestrial and aquatic habitats for foraging. It was mostly observed foraging along the exposed muddy margins of the water bodies, in the adjoining terrestrial areas and was also sometimes seen exploring the garbage and cow dung heaps.

It was mostly observed to forage by walking slowly and simultaneously searching for food. Akhtar et al. (2013) also reported it to employ mainly this method for foraging. While walking, it was recorded to constantly flick its short tail, exposing
the chestnut undertail coverts. Ryan et al. (1996) reported that tail twitching in Dusky Moorhen (Gallinula tenebrosa) represents both an interspecific signal of alertness and intraspecific signal of social status. In shallow water, it walked with high steps and pecked at the water surface or probed into the mud for finding food. Moreover, it was also observed exploring the leaf litter on ground by using its bill so as to locate insects and worms residing beneath them. Furthermore, for feeding on grass seeds, it was noted to use its long toes to bend the grass and was then seen pulling the seeds with its bill. In addition to it, while searching for food in the aquatic habitats, it was occasionally seen to dip its head completely into water to pull out the shoots or tubers of the aquatic plants. Similar type of foraging technique has been reported to be used by Yellow Rails (Coturnicops noveboracensis) by Savaloja (1981).

During the study, seasonal as well as diurnal variations were recorded in the feeding pattern of White-breasted Waterhen. During summers, the Waterhens started feeding in early hours reaching a peak around 0700-0800 hours while during winters due to low morning temperature, feeding was found to begin late and reached a peak around 0900-1000 hours. Moreover, during summer months, feeding was found to be almost negligible during mid-day due to soaring temperature and the Waterhens were observed to rest in shade of trees, vegetation or under the small bridges during this period. Feeding was recorded to be resumed after 1530-1600 hours in summers and 1400-1430 hours in winters reaching a peak in evening before roosting.

On the basis of study of its food and feeding habits, it was categorized as omnivore as it was seen feeding on both plant and animal matter. This observation is in consonance with that of Whistler (1963), Ali and Ripley (1969) and Grewal et al. (2002) while in contradiction with Kumar (2006) who reported it as carnivore. The animal matter was recorded to constitute the major portion of its diet (60.96%). Among animal matter, it was noted to feed mainly on insects belonging to order Orthoptera (Grasshoppers and crickets), Coleoptera (Beetles), Lepidoptera (larvae), Hymenoptera (large ants), Diptera (Flies), Hemiptera (Bugs) and Blattodea (Cockroaches). Akhtar et al. (2013) also reported it to be chiefly insectivore. Besides this, it was also recorded to take spiders, earthworms, other worms, leeches, snails and occasionally small fishes. In addition, among plant matter which constituted about 39.04% of its diet, grains of rice, maize and wheat, seeds of grasses, shoots of young
rice, grasses and aquatic plants as well as tubers of aquatic plants were recorded to be consumed. Wang (2004) also reported White-breasted Waterhen to feed on young shoots of paddy, marsh plants and on small fishes. Moreover, Zakaria et al. (2009) reported it to feed on worms, insects, seeds and vegetable matter. Furthermore, it was also observed to supplement its diet with some kitchen scrap like cooked rice and other left over. Namgyal (1990) and Kotwal (2007) also reported it to feed on human refuse. The consumption of animal matter was recorded to be more during the breeding season due to abundance of insect food during this period which constituted the major portion of the diet of both adults and young birds.

The feeding rate of White-breasted Waterhen was recorded during breeding and non breeding season by noting the average number of pecks made per minute in different foraging substrates. The observations were taken during morning and evening bouts when they were observed to forage more actively. The overall feeding rate was found to be higher during breeding season (21.87 ± 4.47) than non breeding season (18.58 ± 3.59) as during breeding season they also had to feed their chicks. Furthermore, among various substrates i.e. grass/vegetation, shallow water, dry/moist mud utilized by White-breasted Waterhen for foraging, the average number of pecks made per minute were recorded to be highest in grass/vegetation and lowest in shallow water during both the seasons as they are mainly insectivore and occasionally feed on small fishes and snails. Rajpar et al. (2010) also recorded Waterhen to prefer adjacent terrestrial areas covered with grasses to forage on seeds, vegetable matter and invertebrates such as worms and insects.

During the course of study, the White-breasted Waterhen was recorded to share its feeding sites with 22 aquatic and 5 terrestrial bird species. These feeding associations were more frequent during the non breeding season than breeding season as the White-breasted Waterhen was highly territorial during the latter season. The observations are in accordance with Akhtar et al. (2013). Moreover, in aquatic habitats, interspecific aggressions were also sometimes recorded between White-breasted Waterhen and other waterbird species like Little Egret and Indian Pond Heron. Among birds belonging to diverse orders that were found to share feeding sites with White-breasted Waterhen, the maximum proportion was constituted by that of order Passeriformes (33.33%). Koul (2015) also reported House Crow, Red-vented
Bulbul and Red-wattled Lapwing to show feeding association with White-breasted Waterhen

Time budget data are useful in studying the life history and ecological adaptations of birds (Evers, 1994; Hamilton et al., 2002 and Jonsson and Afton, 2006) as the time and amount of energy the bird devotes to different activities must inevitably influence its survival (Orians, 1961). Moreover, each species has its own optimum time budget that is adapted to local environmental conditions (Verner, 1965). During the course of study, the diurnal time activity budget of White-breasted Waterhen was recorded during breeding and non breeding season in different time blocks of the day in order to elucidate seasonal as well as diurnal variations in its activity pattern. The various daily activities viz. feeding, locomotion, resting, hiding, maintenance behaviour and breeding activities were taken into consideration. The proportion of time spent in each of these activities was ascertained during different time blocks of the day i.e. Early morning (0600-0900 hours), Late morning (0900-1200 hours), Mid day (1200-1500 hours) and Early evening (1500-1800 hours).

Feeding was recorded to be the most prominent activity during non breeding season whereas during breeding season, the major portion of the day was noted to be spent in various breeding activities followed by feeding. Martinez (2000) advocated that although energetic requirements are the key factor in the time allocated to feeding, other factors could change the time budget, especially breeding activity. Diurnal variations were recorded in the feeding activity and it was observed to be higher during early morning and evening hours during both breeding and non breeding season. The diurnal peak observed in foraging must be for meeting the energetic constraints of long night as also observed by Akhtar et al. (2013) who reported higher feeding rate in evening hours. With regard to locomotion activity which included the time spent in walking, running, swimming and flying, more time was recorded to be spent during non breeding season than breeding season. Locomotion was noted to be higher in late morning hours during both the seasons. Similar observations were made by Akhtar et al. (2013). However, resting activity was found to be higher during mid day in both the seasons. An increase in resting in mid day as a mechanism to minimize the heat load on a bird at high environmental temperatures has been suggested by Tamisier (1976). As regards hiding activity, it
was higher in non breeding season than breeding season and was noted to be more pronounced during late morning hours in non breeding season while during mid day in breeding season. These observations are in accordance with Akhtar et al. (2013). The decrease in hiding activity during breeding season is attributed to the various breeding activities like nest site selection, nest construction, nest guarding and feeding the young ones. Furthermore, more time was noted to be allocated to various maintenance activities during non breeding season than breeding season and it was recorded to be higher during mid day in both the seasons. The maintenance activity particularly preening was related to resting but it was also recorded to be carried out along with other activities. Moreover, the time apportioned to various breeding activities was found to be higher during late morning hours and lower during mid day.

Information on the biology of a species with the selection of a particular habitat and other requirements for a successful breeding is essential for its management and conservation (Vijayan, 2006). During the present work, a detailed study on the breeding biology of White-breasted Waterhen was carried out from January, 2013 to December, 2015. A total of 78 nests were found during the study, of which 67 were studied thoroughly for recording the various breeding parameters.

In the area under investigation, the breeding season of White-breasted Waterhen was found to extend from March to September and it was recorded to raise upto two broods in a season. The observations are similar to Sharma and Singh (2013) who reported its breeding season to extend from April to September. Gopakumar and Kaimal (2008) noted its breeding season to start in April and extend upto October. However, Ali (1996) reported its breeding season to extent from June to October. Pair formation was observed to occur from mid to late March. After pairing, the breeding partners were observed to stay together during most part of the day and looked for a suitable nesting site. They were found to be highly vocal and territorial during the breeding season. Territorial behaviour in case of rails has also been reported by other workers (Meanley, 1963; Siegfried and Frost, 1975; Rabe, 2001). Moreover, Akhtar et al. (2013) also reported an increase in the calling activity of this bird during the breeding season. A small breeding territory was occupied by each pair and defended against members of same species by giving loud territorial calls which included harsh, croaking Kurwak-Kurwak and Kwak-Kwak-Kwak calls. Ali (1996) put forth that these
 calls begins with loud hoarse grunts, croaks and chuckles and settles down to metallic monotonous notes. The calls were noted to be given throughout day and even during night but with higher intensity during morning and evening hours. Similar observations were made by Smythies (1968). The calls initiated by one pair were observed to be responded by other pairs present in the adjacent areas with same or higher intensity and aggressive chases were also sometime recorded between them but no direct fights or combats were recorded during the present study.

The courtship displays in case of White-breasted Waterhen were recorded to be simple and included bowing, pecking and standing on the back. However, Gopakumar and Kaimal (2008) recorded the prominent courtship activities to be bowing, billing and nibbling. Courtship feeding was also noted in one instance. Mating was recorded during nest building and even after completion of the nests. The calls were also found to be a part of pre-copulatory behaviour and the breeding partners were observed to approach each other along with giving loud calls. One partner (probably female) was observed to bow in front of other (probably male) with extended neck and flattened back to show its willingness for mating which was followed by mounting behaviour and ultimately copulation was recorded.

The prime factors in selection of nesting sites by White-breasted Waterhen were ascertained to be proximity to water and concealment of nests. These observations are in accordance with Gopakumar and Kaimal (2008) who also reported that water is necessary for its breeding. However, some of the nesting plants that were found to be situated far from water during present study may be due to non availability of suitable nesting sites near water. Furthermore, most of the nests found during present study were recorded to be placed in the interior where they were well concealed and not easily visible from outside. Martin and Roper (1988) have attributed that the selection of suitable nesting sites has a direct effect on fitness through its influence on the production of young. Moreover, Buckley and Buckley (1980) have also considered the value of nesting site for the successful rearing of young which is important for the survival of individuals and the species. During the course of present study, the nests were found on ground among marshy vegetation, on shrubs as well as on small to tall trees at varying heights. However, the trees were recorded to be mainly preferred for nesting. Ali and Ripley (1969) reported that the
White-breasted Waterhen, *Amaurornis phoenicurus* constructs its nest either on ground or in the interior of a shrub or bamboo clump up to 2 to 3 metres from ground. Gopakumar and Kaimal (2008) reported nests to be located on both wild vegetation and garden trees. During the study, a total of 17 plant species were found to be utilized for nesting by the White-breasted Waterhen. The most preferred plant species among these was noted to be *Morus alba* followed by *Psidium guajava*. Furthermore, in some cases, same nesting trees were discerned to be utilized again for nest building but the use of an old nest was not recorded during the present study.

During the investigation, both the partners were recorded to take equal part in nest building activities. Similar observations were made by Gopakumar and Kaimal (2008). Once the nest construction was initiated, the pairs were recorded to remain in the near-by area only. The intensity of nest building process was recorded to be high during morning and late afternoon hours but low to almost negligible during mid-day. The nests were found to be constructed mainly by using plant material either of the host plant or other materials that were readily available in the vicinity of nesting sites. The use of animal or synthetic matter for nest construction was not recorded during present study. On contrary, Dhindsa *et al.* (1983) recorded the nest to be constructed of dry twigs, feathers, grass, dry leaves, pieces of polythene, some thin iron rods and also reported the use of two thicker spokes of cycle wheel to strengthen it. No such observations were made during present study.

The main body structure of the nest was built by using paddy straw, grass blades, stems, roots and twigs that were loosely inter-woven to form a shallow flat cup shaped structure that was usually rough in appearance. Similar type of nests has been reported in other rail species as well (Terrill, 1943 and Fredrickson, 1971). The blades and roots of grasses such as *Cyperus rotundus*, *Cynodon dactylon*, *Digitaria ciliaris* and *Imperata cylindrica* were recorded to be utilized in different nests. The inner cavity of the nest was observed to be primarily lined with fresh and dead leaves. Similar observations were made by Gopakumar and Kaimal (2008). The fresh leaves of host plant were found to be used and the birds were recorded to add them during egg laying and incubation period also. Moreover, the dry leaves of other plant species like *Eucalyptus globulus*, *Melia azaderach* and others that were present in the surrounding area were also noted to be utilized. In addition, the nests found on ground
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were observed to be placed over the interlaced roots and stems of surrounding macrophytic vegetation and were topped with a lining of straw, stems and leaves. Similar type of nest has been reported in case of Yuma clapper rails by Bennett and Ohmart (1978). The nests were completed in about 6-11 days. However, Gopakumar and Kaimal (2008) reported that 8 to 10 days were taken to complete the nests.

The mean diameter of 45 nests was recorded to be $21.4 \pm 2.48$ cm, mean inner nest depth was $6.25 \pm 0.88$ cm and mean outer nest height was $9.66 \pm 1.87$ cm. Gopakumar and Kaimal (2008) reported mean nest diameter to be $22$ cm, height to be $15.2$ cm and nest thickness to be $4.8$ cm. Furthermore, the average height of nest from ground was recorded to be $220.2 \pm 94.67$ cm while the average height of plant species was $342.6 \pm 97.2$ cm. The mean distance of nests to nearest water source was noted to be $229.4 \pm 186.1$ cm and to the nearest agricultural area was $247.6 \pm 125.1$ cm. However, Gopakumar and Kaimal (2008) recorded the egg nests to be situated $4$ to $5$ m above ground and $0$ to $1.5$ m away from water bodies.

The nests were found to be built on ground up to the height of $450$ cm. The height of the nest from ground had a significant effect on the nesting success. The nesting success rate was recorded to be highest in the height range of $161$-240 cm which was also found to be the most favoured height range for building nest. The reason for selecting this height range was related to protection from predators as well as less chick mortality due to falling on the ground. Chick mortality due to falling of ground as a result of selection of wrong nesting site was also reported by Dhindsa et al. (1983) who recorded the nest at a height of $3.73$ m from ground. The most unsuccessful nests were recorded at the height range of $81$-160 cm as they were more vulnerable to both disturbances as well as predation.

Egg laying was recorded from mid April till late August. Daily observations regarding egg-laying pattern revealed that the White-breasted Waterhen laid an egg each day at a time interval of nearly $24$ hrs until the clutch was completed. Similar observations regarding egg laying pattern were made by Kumar (2006) and Gopakumar and Kaimal (2008). Dhindsa et al. (1983) also observed similar pattern in case of last two eggs of the clutch, although the laying pattern of first four eggs was not recorded by them. The eggs were oval in shape and cream in colour. The eggs
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were marked with light and dark brown as well as purple blotches and spots that were scattered over the entire surface but the broader end was observed to be more profusely spotted and appeared darker. The texture of the egg shell was smooth and slightly glossy. Similar observations were made by Dhindsa et al. (1983), Kumar (2006), Gopakumar and Kaimal (2008) and Samsoor Ali et al. (2011).

The mean length of 110 eggs was noted to be 4.06 ± 0.19 cm (3.7 - 4.6 cm), mean breadth was 3.09 ± 0.09 cm (2.8 – 3.4 cm) and mean egg weight was 18.86 ± 0.63 gm (17.5 – 20.5 gm). Baker (1929) reported the average egg size for 100 eggs to be 40.5 × 29.7 mm. Gopakumar and Kaimal (2008) recorded mean egg length, breadth and weight to range from 43.2 – 45.3 mm, 29.8 - 31.8 mm and 18.3 – 19.5 gm respectively. Further, the mean egg volume was recorded to be 19.95 ± 1.94 cm$^3$ (15.86 - 25.35 cm$^3$) while egg shape index was 76.22 ± 3.05 (66.66 - 82.05).

A statistically significant and strong positive correlation was recorded between egg length and egg volume ($r = 0.840$) as well as between egg breadth and egg volume ($r = 0.903$). The egg weight also had a strong positive correlation with egg length ($r = 0.355$), egg breadth ($r = 0.463$) and egg volume ($r = 0.474$) while a low negative insignificant correlation with shape index ($r = -0.058$). Abanikannda et al. (2007) put forth that relationship between egg breadth and egg weight is stronger than association between egg length and egg weight. Besides, a strong negative correlation was registered between egg length and egg shape index ($r = -0.762$) and between egg volume and egg shape index ($r = -0.292$). According to Panda (1996), the reason for negative relationship between egg length and shape index is that the egg length is the denominating factor in estimating shape index. However, an insignificant low but positive correlation found between egg breadth and egg shape index ($r = 0.144$) may is due to the fact that shape index is directly related to egg breadth. The correlations between egg length and egg breadth ($r =0.529$) were also statistically significant.

The clutch size during present study was observed to vary from 3 to 8 eggs with mean clutch size of 5.97 ± 1.35. Among 67 nests, there were 3 nests (4.48%) with clutch size 3, 6 (8.96%) with clutch size 4, 15 (22.39%) with clutch size 5, 20 (29.85%) with clutch size 6, 12 (17.91%) with clutch size 7 and 11 (16.41%) with clutch size 8. Thus, nests with clutch of 6 eggs were significantly more common.
Earlier workers, Baker (1929), Whistler (1949) and Ali and Ripley (1969) have reported clutch size to be 4 to 8. Gopakumar and Kaimal (2008) recorded the clutch size to vary from 3 to 7 with mean clutch size of 5.3. The mean clutch size was recorded to vary during three breeding years. It was 5.84 ± 1.3 in 2013, 6.36 ± 1.32 in 2014 and 5.73 ± 1.4 in 2015. Klomp (1970) stated that the mean clutch size can vary with food supply, habitat, population density, age of the breeding adults, latitude, longitude, altitude and other factors. However, Lack (1947) suggested that the characteristic clutch size of each species should correspond to the number of young that parents can nourish adequately. Furthermore, the overall mean nesting, hatching and breeding success was recorded to be 76.12%, 63.21% and 45.51% respectively. Gopakumar and Kaimal (2008) reported hatching success to decline from 78.1% to 68-69% and breeding success to decline from 39% to 33% during their study.

Incubation was recorded to be carried out by both the partners and started before clutch completion with laying of third or second last egg of the clutch. However, Gopakumar and Kaimal (2008) reported incubation to start after clutch completion. The average length of incubation period was noted to be 20.5 days ranging from 19-22 days. Gopakumar and Kaimal (2008) reported incubation period to range from 19 to 21 days while Dhindsa et al. (1983) recorded incubation period as 19 days. During incubation period, the breeding birds became very silent and were observed to emit alarm calls only when an intruder or predator approached very close to the nesting plant. They were observed to approach the nest cautiously and climbed up on a bush, tree or any other vegetation available near the nesting plant and then directly flew to it after checking the surroundings. The predatory birds such as House Crows were usually not tolerated near the nest and were recorded to be chased away. Similar observations were made by Gopakumar and Kaimal (2008). The change-over between partners were recorded at intervals and the nests were also left unattended for short periods. At evening, one bird remained in the nest while the other was found to roost on a nearby tree.

Hatching pattern was noted to be more or less synchronous with most eggs hatching on the same day at different hours of the day while other on next day. On contrary, Gopakumar and Kaimal (2008) recorded all eggs to hatch on same day. However, as per reporting of Dhindsa et al. (1983), three eggs hatched on the same
day followed by two together after an interval of 24 hours and the last egg of the clutch hatched 24 hours thereafter. Synchronous hatching of eggs is usually considered to be favourable (Lack, 1954), partly because a brood of nestlings that are of similar age may be more easily cared for once they have left the nest (Lack, 1968). After hatching, the egg shells were recorded to be removed from the nest and were dropped away from it. The newly hatched chicks were observed to be nidifugous and precocial. They were covered with a black downy plumage. Eyes were open and beak was black with a white tip and conspicuous white egg tooth on tip of upper mandible. The legs and toes were also black in colour and slender. The iris was noted to be grey in colour. Similar observations were made by Dhindsa et al. (1983) and Gopakumar and Kaimal (2008).

During the study period, various morphometric measurements of the newly hatched chicks were recorded (n = 42). The mean bill length was recorded to be 1.32 ± 0.09 cm while mean bill width was 0.5 ± 0.06 cm. The mean head length and width were 2.23 ± 0.16 and 1.58 ± 0.11 cm respectively while the mean body length and breadth were 7.04 ± 0.29 and 2.49 ± 0.26 cm respectively. The mean tarsal length was found to be 2.1 ± 0.14 cm. The mean wing length was 2.69 ± 0.17 cm. The mean body weight was recorded to be 12.93 ± 0.38 gm.

The newly hatched chicks were observed to be constantly brooded by one of the parents. The plumage of chicks which was wet at the time of hatching was observed to dry after 2-3 hours of brooding, after which they looked fluffy and were very active. The chicks were observed to stay in the nest till all or most of the eggs were hatched. However, the time period for which the chicks stayed in the nest was also sometimes affected by the prevailing weather conditions and in few instances their stay was extended due to adverse weather conditions. The unhatched eggs were found to be left in the nest only. After leaving nest, the chicks were reared by both the parents. The chicks were capable of walking and swimming and were guided by the parents to the nearest vegetation cover present along a water body. Gopakumar and Kaimal (2008) reported that a brood nest was constructed by the White-breasted Waterhen after hatching of the eggs in which the chicks roosted with one of the parents. However, no such observations were made during the present study.
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The parents were found to be very vigilant and were observed to protect the chicks from all dangers by emitting loud aggressive calls and exhibiting wing spread display. On appearance of any predator, they were noted to acquire an intimidating posture by spreading their wings and the chicks in response were recorded to move hurriedly into water or hide themselves in the vegetation. Ali and Ripley (1980) reported that the chicks often dive underwater to escape predation. However, no such observation was made during present study. During initial days, the chicks were found to be completely dependent on parents for food. However, after few days, they were also seen to make some attempt to locate food themselves. The chicks were found to be accompanied by the parents for atleast two to three weeks after which they were self dependent.

The change in plumage of chicks was also noted during the present study. The black downy chicks were first observed to develop a white patch near ear coverts. The white patches were then noted to spread on the underside within next few weeks and the undertail coverts were also turned dull rufous. The white was then noted to spread on the face although tinged with grey while the upperparts turned olive-grey. The juvenile plumage was recorded to be attained in about 2 months.

In addition to this, egg and chick mortality rate in case of White-breasted Waterhen was also recorded during three consecutive breeding years (2013-2015). Among various factors resulting in egg mortality, hatching failure was observed to be the major cause followed by predation. The potential predators in the study area were House Crow, cats, Monitor Lizard and Crow Pheasant. Gopakumar and Kaimal (2008) also propounded that desertion, predation and hatching failure may be the major causes affecting hatching success in White-Breasted Waterhen. However, the major cause for chick mortality was due to falling on the ground while leaving nest.

5.3 Eco-biology of White-breasted Kingfisher (*Halcyon smyrnensis smyrnensis*):

The White-breasted Kingfisher was a common resident wetland dependent bird in the study area. It was observed to have a stocky body, a long, heavy pointed red bill and a long tail. The upperparts including back, rump and tail were bright turquoise-blue in colour while the head, neck, shoulders, flanks and lower belly were chocolate-brown. The throat and central breast region was white. The wings were blue.
black with prominent white patches on primaries on both upper and lower wing that were visible only during flight. The legs were short and red in colour. The toes were also red with black claws. Iris was dark brown in colour. The sexes were identical and no peculiar variation was detected in the plumage of the breeding pair during the breeding season. Similar physical descriptions were put forth by Grimmett et al. (1998), Chaudhari (2002), Kumar (2006), Ahmed (2009), Kait (2011), Aggarwal (2011), Kotwal (2012), Singh (2015) and Pandotra (2015). The juveniles were similar to adults but had a duller plumage with more greenish tinge on the upper parts and slightly shorter and duskier bill. The white on throat was also patchy.

During the course of study, the White-breasted Kingfisher was recorded solitarily during the non breeding season and in pairs during the breeding season. In comparison to other two species i.e. Lesser Pied Kingfisher and Common Kingfisher found in the study area, it was less dependent on water. Similar observations were made by Ali (1941), Oommen and Andrews (1996), Kait (2011) and Singh (2015). It was observed to inhabit a wide range of habitats that varied from streams, marshes, lakes, ponds, ditches, canals, gardens to open agricultural fields. Similar type of habitat was reported by Ali and Ripley (1983), Aggarwal (2011) and Noori (2014). In agricultural areas, it was frequently observed feeding in the fields, along irrigation canals, marshes and streams while in urban and semi-urban areas, it was seen feeding in the gardens, parks, ponds and puddles. Furthermore, at some stations, it was recorded to share its habitat with the other two species of kingfishers. The three species were able to coexist due to differences in their ecological requirements and niches. Moreover, they were also found to differ in their foraging methods. The studies done by Mac Arthur (1958), Cody (1968) and Terborgh (1971) on ecological isolation also support this view.

With regard to population count, an increase in number of individuals was recorded from June to August in all stations which was mainly owing to the addition of young birds during this period. The observations are in accordance with Ali et al. (2010b). Besides, among all stations scrutinized for recording the monthly count, R. S. Pura area was found to have the highest while Lake Surinsar the lowest monthly count of individuals. The high count recorded in R. S. Pura area was due to more availability of preferred feeding and breeding sites in this station whereas in Lake
Surinsar, the increased anthropogenic activities and less availability of suitable breeding sites accounted for low count of individuals.

Due to wide variations in the habitat of the White-breasted Kingfisher, it was recorded to have a versatile diet which included both terrestrial and aquatic organisms. It was observed to be carnivorous in feeding habits and was recorded to hunt solitarily during both breeding and non breeding season. The observations are in accordance with Naher and Sarker (2014). Its food was recorded to include mainly insects belonging to 8 orders which constituted about 61.85% of its diet. Among insects, order Orthoptera was most preferred followed by Hymenoptera, Odonata, Coleoptera, Mantodea, Lepidoptera, Blattodea whereas order Hemiptera was least preferred. Besides this, it was also noted to feed on spiders, earthworms, fishes, frogs, tadpoles, lizards, snakes and mice during the study. The present observations are in accordance with earlier studies by Ali and Ripley (1983), Mukherjee (1975), Yahya & Yasmin (1991), Tehsin (1995) and Soud et al. (2010). Asokan et al. (2009) reported that arthropods constitute their main diet (83.4%) while fishes, amphibians, reptiles and crabs comprise about 16.6% of the diet. Furthermore, Naher and Sarker (2014) recorded a total of 16 species of food items to be taken by the bird, of which, fishes were the most preferred.

Its diet was found to vary seasonally depending upon the availability of the prey. The insects and frogs were taken throughout year but their consumption was more during summer and rainy season so as to meet their own requirements as well as to feed their nestlings and fledglings. The consumption of earthworms was also mainly recorded during rainy season due to their abundance. Moreover, the fishes were also recorded to be consumed mainly during breeding season but in very less quantities as compared to other food items. The lizards, snakes and mice were observed to be taken occasionally throughout the year. Similar observations were made by Muhkerjee (1976) who also reported its diet to vary seasonally and recorded that it takes aquatic organisms mainly during the wet season (monsoon) but terrestrial ones during the dry season.

Seasonal as well as diurnal variations were recorded in its feeding pattern. The feeding intensity was recorded to be high during morning and evening hours and low
during midday. During summers, they started feeding in early hours (0530-0600 hrs) and were observed to rest in shade of trees during mid day. The feeding was resumed after 1500 hrs and reached its peak in the evening. However, during winters feeding was observed to begin late in between 0700 hrs to 0730 hrs and a considerable amount of time was recorded to be spent in scanning for prey.

It was recorded to employ mainly sit and wait strategy for foraging. Similar observations were made by Naher and Sarker (2014). The prey was scanned from a suitable and exposed post for long durations of time and was then seized from ground, water or vegetation after which it was brought back to the perch. The time spent in scanning was recorded to range from 5 to 70 minutes with an average of 34.52 minutes (n=21). The smaller food items like beetles, spiders, ants were found to be engulfed quickly after perching or handling in the bill for few seconds whereas the larger preys like earthworms, frogs, lizards, mice and snakes were beaten to death before swallowing. These observations are in agreement with Naher and Sarker (2014). The prey was knocked against the surface of perch several times until it was dead and was then finally flipped and swallowed entirely from the side of head. Similar type of foraging behaviour has been reported in other species of kingfishers (Skutch, 1957; Greig-Smith, 1978a and Passmore and Thompson, 1981). The time taken to handle and engulf different prey items after catching ranged from 5 to 960 seconds. Out of the various attempts made by White-breasted Kingfisher for foraging on different substrates, 76.54% were recorded to be successful. Naher and Sarker (2014) recorded 70% of the attempts to be successful. Moreover, the foraging attempts made on ground were recorded to be most successful (81.39%) while the most unsuccessful attempts were recorded in water (31.57%).

During the course of investigation, different perching sites were recorded to be utilized by the White-breasted Kingfisher for foraging. These included overhead telegraph wires, tree branches, shrubs, walls, fences, iron rods and occasionally ground. Islam and Kamruzzaman (2008) recorded them to use fence-posts, cables and branches for scanning the prey. The relative use of different perching sites was recorded during breeding and non breeding season and among them telegraph/electric wires were observed to be used most frequently in both the seasons. Furthermore, the perching height used by White-breasted Kingfisher during foraging was recorded to
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range from 0 to 8 m from ground and they were noted to prefer mostly a height range of 4–6 m for foraging. Naher and Sarker (2014) reported them to use 0.3 to 2.25 m height for foraging and recorded highest preference at 0.9 m.

In addition, the White-breasted Kingfisher was recorded to share its feeding and perching sites with a number of other terrestrial and aquatic bird species. The feeding sites were reported to be shared with a total of 17 bird species while the perching sites with 20 bird species. Koul (2015) reported House Crow, Red-vented bulbul, Rose-ringed Parakeet and European Hoopoe to share perching sites while Red-wattled Lapwing and Green Bee-eater to share feeding sites with White-breasted Kingfisher. The highest proportion of birds sharing feeding and perching sites with White-breasted Kingfisher was recorded to belong to order Passeriformes. No intra or interspecific aggressions or fights over food were recorded during present study.

The diurnal time activity budget of White-breasted Kingfisher was recorded during breeding and non breeding season in different time blocks of the day. The various daily activities viz. scanning, feeding, resting, flying, maintenance behaviour and breeding activities were taken into consideration. The proportion of time spent in each of these activities was ascertained during different time blocks of the day i.e. Early morning (0600-0900 hours), Late morning (0900-1200 hours), Mid day (1200-1500 hours) and Early evening (1500-1800 hours).

Being a sit and wait predator, it was recorded to spend a considerable time in scanning for prey. Many workers have reported scanning to be the major activity among predatory birds (Mahabal, 1991; Sivakumaran and Thiagesan, 2003 and Martinez, 2000). It was recorded to be the most prominent activity during non breeding season due to less availability of food during this period due to which the birds had to spend more time in searching for prey. These observations are in accordance with Ali et al. (2010b). Moreover, the amount of time spent in scanning was noted to vary among different time blocks of the day. It was reported to be higher during mid day and lower during early morning during non breeding season whereas higher during early morning and lower during mid day during breeding season. The soaring temperature during breeding season especially during mid day resulted in less scanning activity during this period while during non breeding season, less
temperature as well as availability of food resulted in more scanning activity during mid day. Feeding activity was also noted to vary among different time blocks and followed the same trend during both breeding and non-breeding seasons. Two feeding peaks were observed, one during early morning and other during early evening with higher feeding rate during latter. The bimodal pattern of feeding has been reported in other bird species also (Evers, 1994; Asokan, 1995; Ramachandran, 1998; Sivakumaran and Thiyagesan, 2003). Higher feeding rate recorded during evening hours is to obtain energy to tide over the requirements of long night as also put forth by Asokan and Ali (2010).

With regard to resting activity, it was higher in non-breeding season than breeding season and was noted to be more pronounced during mid day in both the seasons. Similar observations were made by Ali et al. (2010b). Flying was also recorded to be higher in non-breeding season than breeding season and was more pronounced during late morning hours in both the seasons. Moreover, more time was noted to be allocated to various maintenance activities during non-breeding season than breeding season and it was recorded to be higher during evening hours in non-breeding season and in late morning hours in breeding season. Furthermore, the various breeding activities were noted to constitute the major portion of the day during breeding season with higher time spend during late morning hours and lower during mid day.

During the course of work, a detailed study on the breeding biology of White-breasted Kingfisher was carried out from January, 2013 to December, 2015. A total of 41 nests were found during the study of which, 34 were studied thoroughly for recording the various breeding parameters.

In the area under investigation, the breeding season of White-breasted Kingfisher was found to extend from March to July with peak in May-June. These observations are in consonance with Ali and Ripley (2001). The reason for a peak period of breeding just prior to the monsoon season is related to abundance of food during this period. Therefore, raising chicks prior to this season ensures their survival. Many workers have reported that the availability of ample food for nestlings control the timing of breeding in several bird species (Thomson, 1950; Lack, 1954; Perrins,
1970 and Kushlan, 1978). It was recorded to raise one brood in a season. However, if
the initial nesting attempt was failed, the birds were noted to re-nest. Hamas (1994)
made similar observations in case of Belted Kingfisher (*Ceryle alcyon*).

Pair formation was recorded from mid March to early April. They were very
vocal during the initial part of breeding season and loud calls were recorded to be
given by one partner during morning hours from tree tops, towers, wires or buildings.
Similar observations were made by Ali and Ripley (2001). Moreover, Oommen and
Andrews (1996) also recorded higher vocal activity in the breeding season while
studying their awakening, roosting and vocalization behaviour. These calls were given
to attract potential mates for pairing. As there was no sexual dimorphism and the birds
were also not ringed during the study, so it could not be determined whether these
calls were given by males or females.

During courtship period, the breeding partners were recorded to perform a
conspicuous wing display. They were seen to extend their wings laterally for few
seconds and displayed to each other in sync. One partner was also observed to raise its
bill upward and displayed the white throat. The wing display was usually
accompanied by calls given by both the partners and they were also seen bobbing
their heads in between. The partners were also recorded to chase each other while
flying over the canopy. They were noted to perch on lofty trees or wires and when one
partner extended its wings, the other one was recorded to reciprocate and greet it by
doing the same. Ali and Ripley (1983) and Rassmussen and Anderton (2005) reported
that the female White-breasted Kingfisher during breeding months, employ her wings
for signalling to the male that she is receptive. Mating was also preceded by these
courtship displays after which the male was observed to leave and perch on some
other site.

After pairing, the male and female were observed to locate a suitable site for
nesting and remained in the nearby area only. They were found perched together on
tree branches or wires and were recorded to stay together during most part of the day.
A small breeding territory was established around the nesting site and was strongly
defended against conspecifics. Territorial behaviour during breeding season has also
been recorded in other species of kingfishers (Greig-Smith, 1978b; Morgan and Glue,
1977 and Hayes, 1991). However, the pair was rarely recorded showing aggression towards other bird species foraging or nesting in the vicinity of their nesting sites.

The White-breasted Kingfisher was a primary hole-nester and was recorded to dig a long horizontal tunnel in the soil with an enlarged chamber at the end. The nest was not lined with any nesting material. Similar observations were made by Palkar et al. (2009). During the course of study, the nests were located on banks of streams, near ditch, nullahs and also on vertical sides of dug out places. Ali and Ripley (2001) also reported similar nesting sites to be used by this bird. However, it has also been recorded to make use of other locations such as well and paddy haystacks for nesting (Balasubramanian, 1992 and Hussain, 2000). Out of 41 nests, 39.02% were found on banks of streams, 26.83% near ditch, 21.95% on sides of dug out places and 12.19% near nullahs. The suitability of soil for digging, availability of a perching site close to the nest and ample food resources for the nestlings were recorded to be the main factors in selection of nesting sites. The nests were found to be excavated in both sandy and clayey soil and were usually placed towards the top of the cliff so as to protect them from predators as well as flooding. The same sites were recorded to be utilized year after year for nesting but old nests were not utilized again. These observations are in consonance with Palkar et al. (2009). During the investigation, it was recorded to share its breeding site with one bird i.e. Green Bee-eater (*Merops orientalis*) in the study area. Similar recordings were made by Koul (2015).

Both partners were observed to take part in nest construction. This observation is in agreement with Ali and Ripley (1983) and Palkar et al. (2009). Courtship feeding was observed when the nest was near completion and the food item brought by one partner was mostly accepted by the other but was sometimes also ignored. The observations are in consonance with Palkar et al. (2009).

The mean length of nest hole was recorded to be 7.98 ± 0.8 cm (6.5 – 10.1 cm), mean width of nest hole was 7.9 ± 0.71 cm (5.8 – 9.0 cm), mean length of nest tunnel was 70.98 ± 9.44 cm (51.9 – 96 cm), mean height of nest from ground was 115.37 ± 33.41 cm (43.7 – 192 cm), mean height above nest was 42.11 ± 16.14 cm (21.7 - 95.2 cm), mean distance of nests from water source was 190.82 ± 235.1 cm (0 – 610.2 cm), from nearest perching site was 234.75 ± 69.83 cm (102.4 – 482.4 cm)
and from nearest agricultural land was 461.67 ± 192.6 cm (0 - 952.2 cm). Ali and Ripley (1983) recorded the nest entrance to be 7 cm in diameter and tunnel length to range from 50 cm to more than a meter. However, Ali et al. (2010a) recorded the mean tunnel length to be 114.1 cm, mean length and circumference of nest hole to be 10.4 and 27.9 cm respectively, height of nest from ground to be 207.5 cm and height from top of bank to be 96.6 cm.

Egg laying was recorded from late April to mid June. Eggs were laid at a time interval of nearly 24 hours following completion of the nest. However, Palkar et al. (2009) recorded at least one gap of 48 hours between laying process in four nests out of five that they studied. The eggs were recorded to be round or spherical in shape, pure white in colour and spotless. The texture of eggs was smooth and glossy. These observations are in accordance with Palkar et al. (2009) and Ali et al. (2010a). The mean length of 65 eggs was recorded to be 3.07 ± 0.09 cm (2.8 – 3.3 cm), mean breadth was 2.71 ± 0.07 cm (2.5 - 2.9 cm) and mean egg weight was 9.86 ± 0.69 gm (8.5 – 11.4 gm). Ali and Ripley (2001) reported the average size of 30 eggs to be 29.4 x 26.2 mm. Ali et al. (2010a) reported the mean egg length, width and weight to be 34.8 mm, 26.6 mm and 8.9 gm respectively while Madhuramozhi (2008) recorded the mean egg length, width and weight to be 34.1 mm, 25.8 mm and 5.5 gm respectively. Furthermore, the mean egg volume was noted to be 11.58 ± 0.91 cm³ (9.56 cm³ - 14.15 cm³) and egg shape index was 88.57 ± 2.75 (83.33 - 96.55).

A statistically significant and strong positive correlation was recorded between egg length and egg volume (r = 0.780) as well as between egg breadth and egg volume (r = 0.934). The egg weight also had a significant positive correlation with egg length (r = 0.470), egg breadth (r = 0.504) and egg volume (r = 0.555). Moreover, a strong negative significant correlation was registered between egg length and egg shape index (r = - 0.580) while an insignificant one between egg volume and egg shape index (r = - 0.056) as well as between egg weight and egg shape index (r = - 0.029). The correlations between egg length and egg breadth (r =0.508) were also statistically significant.

The clutch size was recorded to vary from 3 to 5 eggs with mean clutch size of 4.5 ± 0.71. Ali et al. (2010a) also reported similar clutch size range with mean clutch
Discussion

size of 3.7. However, Ali and Ripley (1983) reported the clutch size to vary from 4 to 7. Madhuramozhi (2008) recorded all ten clutches with 4 eggs in Nagapattinam, Southern India. Clutch size variation can originate from genetic variation (Van Noordwijk et al., 1980) or phenotypic response to environmental conditions (Murphy, 1983). Among 34 nests, the clutch size of 5 was most common with 21 nests (61.76%) followed by clutch size 4 with 09 nests (26.47%) and clutch size 3 with 04 nests (11.76%). These findings are in contradiction with Ali et al. (2010a) who reported the clutch size 3 to be most common. Furthermore, the overall mean nesting, hatching and breeding success was recorded to be 70.58%, 61.57% and 51.27% respectively. Ali et al. (2010a) recorded breeding success of 75%.

Incubation was observed to begin with laying of first egg and was carried out by both the partners. These observations are in agreement with Ali et al. (2010a) while in contradiction with Palkar et al. (2009) who reported incubation to begin with laying of last egg. The incubation period ranged from 18-20 days with an average of 19 days. Oommen and Andrews (1993) recorded incubation period to range from 18-21 days. Palkar et al. (2009) noted it to be 21-22 days. Moreover, Ali et al. (2010a) reported it to be 14-17 days. During egg laying period, one partner (probably female) was recorded to spend more time in or near nest while the other partner (probably male) was found to provide it food during this period. The female was mainly recorded to be fed on insects, frogs and lizards. However, in one instance, it was recorded to be fed on a Grass snake (Amphiesma stolata) brought by its breeding partner. Hayes (1991) also made similar observations in case of New Zealand Kingfisher (Halycon sancta vagans). The nest was noted to be left unattended for very short intervals. During change over between partners, the incubating bird was observed to leave the nest on hearing the call of its mate, which then moved into the nest to carry out incubation. Similar observations were made by Palkar et al. (2009).

During the course of study, hatching pattern in White-breasted Kingfisher was recorded to be asynchronous with one chick hatching out on each successive day in order similar to laying. Thus, in same nest, chicks of different age and size were recorded. This observation is in accordance with Ali et al. (2010a). Lack (1954) has suggested that asynchronous hatching is beneficial in unpredictable environments, when food is abundant all nestlings can fledge independent of hatching order but in
case of food shortage smallest young may starve to death. However, during the present study no chick was observed to die of starvation. The hypothesis of Hahn (1981) seems more likely to be responsible for asynchronous hatching, according to which broods with established size hierarchy among nestlings results in less competition among siblings and thus energy expenditure of the nestlings are reduced which results in faster growth or better body condition.

After hatching, the egg shells were removed from the nests and disposed off at some distance. Similar observation was recorded by Palkar et al. (2009). The newly hatched chicks were naked and pinkish yellow in colour with a bulging abdomen. The eyes were closed and the eyelids appeared large and darker. The legs and feet were flesh coloured with white/cream claws that were soft. The beak was also flesh coloured with prominent white egg tooth on tip of upper and lower mandible.

During the study, the growth pattern of different body parts of nestlings of White-breasted Kingfisher was recorded from hatching to fledging stage. The increase in various body parts from hatching to fledging was as follows: bill length ranged from 0.66 ± 0.13 cm to 4.41 ± 0.25 cm, bill depth from 0.32 ± 0.08 cm to 1.13 ± 0.64 cm, body length from 4.04 ± 0.53 cm to 20.71 ± 1.53 cm, body width from 1.41 ± 0.16 cm to 4.93 ± 0.28 cm, tarsal length from 0.50 ± 0.12 cm to 3.82 ± 0.59 cm, tail length from 0.22 ± 0.08 cm to 3.91 ± 0.47 cm and wing length from 1.98 ± 0.32 cm to 14.72 ± 0.83 cm. Ali et al. (2010a) recorded the body length of nestlings to range from 3.7 to 21.9 cm, bill length from 0.6 to 4.5 cm, wing length from 1.4 to 16.4 cm, tarsal length from 0.6 to 3.5 cm and tail length from 0.2 to 4.3 cm from hatching to day 27. Furthermore, the mean weight at hatching was 3.86 ± 0.23 gm and increased to 71.02 ± 2.14 gm at day 20. However, it was observed to decrease during last few days before fledging and reached 64.31 ± 2.14 gm. Similar observations were made by Ali et al. (2010a) who proposed that the loss in body weight is due to utilization of fat deposits and skeletal muscles for the energy required to leave the nest.

After hatching, the nestlings were recorded to remain in the nests for 26-28 days. However, Palkar et al. (2009) recorded the fledging period to be 20-21 days while Ali et al. (2010a) reported a weaning period of 28-32 days. Both the parents were observed to take part in feeding the nestlings. Ali and Ripley (1983) also made
similar observations. Brooding remained high during first few days but as the chicks grew older, the parents after delivering food did not stay in the nest for long and returned quickly. The adults during nestling period were observed to approach the nest silently and were never observed to fly directly to the nest. They first moved to the nearest perching site in vicinity of nest and were then seen rearranging the prey and placing it in a position in which it could be easily received by the chicks. The time taken by parents to feed the nestlings in nest ranged from 5 to 240 seconds depending upon the prey item. Sometimes, when both parents arrived together with food, one of them moved into the nest while the other waited outside. The food delivered to nestlings consisted of various insects, arachnids, crustaceans, annelids, amphibians and reptiles. Burton (1998) reported that mostly invertebrates were fed to the young. However, Palkar et al. (2009) recorded the nestlings to be fed on garden lizards, geckos, common skinks, fishes, frogs, crabs, centipedes and cockroaches. No nest sanitation was observed to be carried out by the parents. Similar observations were made by Skutch (1957) and Palkar et al. (2009). The faecal matter, regurgitated pellets and other food remains were not removed from the nest and were observed to be covered with soil in the nest tunnel and were also found at the tunnel opening.

The highest number of average feeding visits was recorded to be 63.07 ± 37.5. The frequency of visits was observed to be high during morning and late afternoon hours and low during mid day. Moreover, the number of feeding visits made by the parents was observed to increase with age of nestlings except during last few days before fledging. The size of prey delivered to nestlings was also recorded to increase as they grew older. Since the growth in nestlings was very fast so, they needed large quantities of proteinous food. Thus, an increase in feeding visits as well as size of prey with increase in age of nestlings was recorded. The fledglings after leaving nest were observed to be fed by the parents for 2-3 weeks after which they dispersed from the breeding grounds and were observed to forage independently.

Moreover, egg and chick mortality rate was also recorded during three consecutive breeding years (2013-2015). Among various factors ensuing in egg mortality, hatching failure was the major cause. However, the major reason for chick mortality was recorded to be nest tampering. Ali et al. (2010a) also reported human
disturbances to be one of the major causes for breeding losses by the White-breasted Kingfisher.