

1. INTRODUCTION

1.1 Migration

Migration has been defined as the periodic swing of animal population or a part of population from a breeding and nesting quarter to a feeding and resting quarter. It is a regular movement either annual or seasonal of at least a part of the population from its breeding place to unbreeding place either for obtained food and shelter or to pass the unfavorable climate and again its return to the same breeding ground for breeding and resting. Majorities of the birds have the habit of moving from one region to another during the change of seasons. These birds are known as migratory birds. The remaining birds, which do not migrate are known as resident birds.

In most cases, migration of population may occur for food, shelter and reproduction. The greatest advantage derived from the migrating movements are the better utilization of untouched new habitats and their resources. According to Nilolskym, migration is an adaptation towards abundance. The nesting grounds alone do not have sufficient food to maintain both mature and immature members of a large population. Hence, it would be advantageous to have separate feeding and resting, and breeding and nesting habitat (Gundevia and Singh 2003).

Several bird species visit Nepal, seasonally coming from different parts like India, Arab, Tibet, China, Russia and Northern Himalayas to escape from scorching heat and chilling cold. These birds again return to their home land when the climate is favourable. These migratory birds are mainly found to be the water birds. About 150 species migrate to Nepal from the northern side in summer (Giri 1999). About 148 species visit Nepal in winter. These include ducks (*Anas species*), terns (*Sterna species*), wagtail (*Motacilla species*), thrushes (*Garrulax species*) and pipits (*Anthus species*) (Inskipp and Inskipp 1991). Birds follow certain migratory routes usually following a river system Koshi in the East, Bagmati and Narayani in the central and Karnali in the western part of Nepal (Nepali 1980).

1.2 Diversity of Birds in Nepal

There are about 9,600 species of birds in the world. About 1300 species of birds representing 90 families live and breed in Indian sub-continent. In Nepal 879 species

have been recorded. The number of breeding birds (permanent, residents and migrants) falls about 640 species (Shrestha 2001).

The avian distribution in Nepal is unique and interesting. Nepal occupies parts of two of the world's eight biogeographical realms. These are Palearctic towards the north and Oriental towards the south. The birds of the Himalayan Zone are related to that of Europe and North Asia and those of Oriental are related to those of southern Nepal. On the basis of avian fauna, (Fleming 1971) has divided the country into four zones. a) Lowland zone b) Midland zone c) Himalayan zone and d) Trans-Himalayan zone.

Wetlands are among the most productive ecosystem in the world. Wetland being an important natural base of the economic development of the country, it plays a pivotal role for subsistence population. The wetlands of Nepal are well-known for unusually rich biodiversity. They occupy approximately five percent of the total area of Nepal in the form of rivers, stream, lakes, reservoirs, village ponds, paddy fields, marsh and swamp land. It has been estimated that there are over 405 wetland areas in Nepal from the Tarai to the Himalayas. Of these, the Koshi Tappu is the most outstanding wetland designated internationally in 1987 as the first Ramsar site in Nepal. Other Ramsar sites include Bishazari Tal, Ghodaghodi Tal and Jagadishpur reservoir in Nepal. In Nepal more than 230 bird species are known to depend on wetlands (Shrestha 2000).

They support many resident and migratory species of water fowls. The Wild ducks, geese and swans are tangible resources in Nepal. They are an essential component of our ecosystem, source of beauty and valuable genetic resource useful for duck breeding. The loss of diversity of the water birds reduces the natural resource base of the country. Wetlands are one of the most threatened habitats because of their vulnerability and attractiveness for development (Hollis et al. 1988).

The wetlands of Nepal also have faced serious environmental problems: loss of species (birds and animals which are endemic to the region), soil erosion, deforestation, draining etc (Shrestha 2000). Consequently, the wildfowl population of Nepal is everywhere in a declining state. Therefore, conservation and management of both wetlands and waterfowl in Nepal is vital.

The main objective of my study was to investigate the diversity of migratory birds at Taudaha lake. Specific objectives were to;

1.3 Objectives

- a) access the diversity of migratory birds and seasonal change
- b) examine the arrival and departure of the migratory birds and
- c) explore the reason of decline of migratory birds and its consequences

1.4 Justification

For a long time Taudaha Lake has been an enriched habitat for the migratory birds. (Shah 2000) has recorded thirty three species of migratory birds at Taudaha. Out of these species, seventeen species have been already declined (Annex iv). Researchers have studied on several aspects in this lake. But so far the study of the specific objectives mentioned above are concerned, least study has been done. No study has been done in some of these objectives like exploring the cues according to which birds migrate a long distance, their timing of arrival and departure, their origin and distribution and role of birds in the ecological balance of lake ecosystem. (Riessen 2007) reported vulnerable species like Baikal teal (*Anas formosa*) and threatened species like Ferruginous pochard (*Aythya nyroca*) at Taudaha lake. Thus, this lake could be one of the important wetland in Nepal.

1.5 Limitations of the study

As the study was carried out for a short duration of time that is from September 2007 to April 2008, it could find out the diversity of birds only for these eight months. The study included summer, winter and residential birds but the focus was migratory birds rather than other associate birds.

2. LITERATURE REVIEW

2.1 Diversity of migratory birds and seasonal change

Yu-Hong et al. (2006) studied species diversity of birds in Xingtai City and its Suburb by transect survey method from March 2003 to July 2005. Bird composition and species diversity were analysed on the basis of habitats and seasons. Bird composition seem to be highly similar among the habitat of public green land, building district and woods with a similar index of 0.60. The species of birds in water and creek was different from any other habitats. The results showed that species richness and species diversity by Shannon-Weiner Index (H^1) and Pielou Index (J) was highest in woods and least in building district.

Wu et al. (2004) recorded seventy seven native progenitive species, thirty summer migrant species, forty seven resident species and thirty three winter migrant species. Eleven traveling species, fifty eight palaeartic species, forty seven oriental species and sixteen cosmopolitan species in Laohekou airport in Hubei province, the administrant method was suggested.

Sharma (1996) has studied biodiversity of Kwar Lake, North Bihar, India. He has reported forty eight species of migratory and residential birds associated with this lake. Baral et al. (1992) cited in Taudaha Pond Restoration Project (1997), has reported one hundred and sixteen species of birds most of which were winter migrants. Thorup et al. (2006) found that winds and precipitation did not have any influence on Ospreys travel or stopover.

Koed et al. (2006) proposed that the estuarine mortality of Skjern river was mainly caused by Cormorants (*Phalacrocorax carbo*) and differed significantly between species but was high for both Atlantic Salmon (39%) and Brown Trout (12%) in both years of investigation that is the year 2000 and 2002. Thus, while planning river restoration projects caution should be used, specially where permanently flooded flood plains (lakes) develop due to subsiding soil. The migratory species such as Atlantic Salmon and Brown Trout may be severely affected due to increased exposure to predation from predatory fish and birds where river pass directly through newly developed lakes.

Schmieder et al. (2006) investigated the relationship between charophytes and herbivore water birds in the littoral zone. The water fowl extensively consumed charophyte vegetation in shallower areas at the beginning of the winter. By the end of the winter the water fowl had almost completely depleted the available charophyte biomass. Coot and Red crested pochard are the main avian chara consumers in winter. Despite their great influence on biomass in winter influence on subsequent charophyte regeneration is probably limited in lake. Singh (1992) in 'Status of Harike Wetland' has mentioned the Harike lake as the fresh water lake attracted by the largest number of water fowls which may be attributed to the abundance of food in and around the lake.

2.2 Arrival and departure of migratory birds

Jonzon et al. (2007) studied climate change and optimal arrival of migratory birds. He reported that the migration of birds initiate and breeding is earlier due to the climate change that causes increment of the food in different seasons.

2.3 Decline of migratory birds and its consequences

Exo et al. (2005) reported decrease in breeding numbers of the Eurasian Golden Plover at the Southern border of its distribution in Western Continental Europe due to extensive habitat loss. Losses took place during the incubation and in the first two weeks of brooding due to Red foxes, *Vulpes vulpes* and clutch destruction was caused by milling machines during peat excavation. The losses could be reduced by preventing the breeding areas with electric fences, protecting the nests with protection shrouds, intensive safeguarding of nests and youngs and by establishing feeding sites in the breeding areas.

Hostetler et al. (2005) studied post construction effects of an urban development on migrating, resident and wintering birds. The results suggest that remnant forest patch and adjacent marsh continued to attract migrating and resident species even after the development. The birds did not decline. It was because of the preservation of canopy and natural buffer areas in combination with existing vegetative features that resulted a minimal impact on avian richness and abundance.

3. MATERIALS AND METHODS

3.1 STUDY AREA

(a) Taudaha Lake

It is supposed to be one of the fascinating site and historically famous lake of the Kathmandu valley. It is also an ecologically rich habitat for the birds, fishes and other aquatic fauna. It is situated in the Southern corner of the Kathmandu valley midway to Dakshinakali. The lake is situated about 12 Km away from the centre of the Kathmandu. It occupies an area of eighty Ropanis and fourteen anas. It is about 6.8 m in depth. The lake is partly surrounded by rice terraces with its characteristic zigzag shape. It is also said to be one of the religious place. Thus, people celebrate Nagpanchami in the name of Karkat Nag Raja and Nag Rani, once a year.

(b) Study Area and climate

The lake is situated at 27° 38'N latitude and 85° 17' E longitudes. It is about 1400m above the sea level and is situated on the southern edge of the Kathmandu Valley (Shah 2000).

The climatic condition of Taudaha lake resemble with the Kathmandu city. The average annual temperature varies from 10°C to 26°C. The lake shows subtropical climate with three distinct seasons as summer, rainy and winter.



Figure 1. A gateway to Taudaha lake

Winter commences from September and lasts till the end of February. December and January are the coldest months. During this season, a huge population of winter



Figure 2. Map showing Taudaha Lake (Courtesy: Department of Topography, Government of Nepal)

migratory birds can be seen in this site. Summer begins from mid of March and lasts till the early June. The maximum temperature reaches to 36° with the beginning of this season, all the winter migratory birds return to their breeding home while the summer migratory birds start to visit this lake. Monsoon properly begins by the second week of June and lasts till late September.

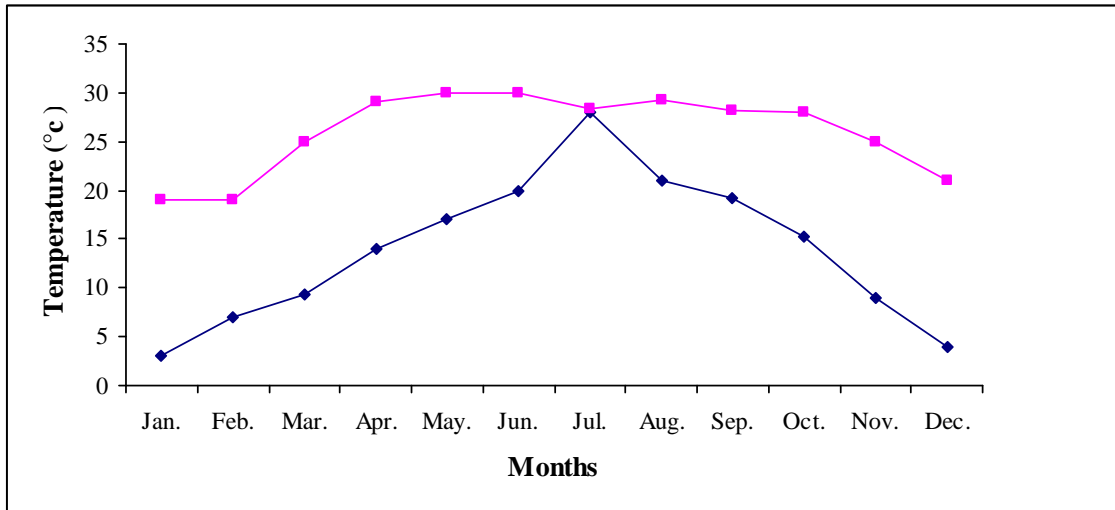


Figure 3 . Temperature in Kathmandu from January 2007 to December 2007

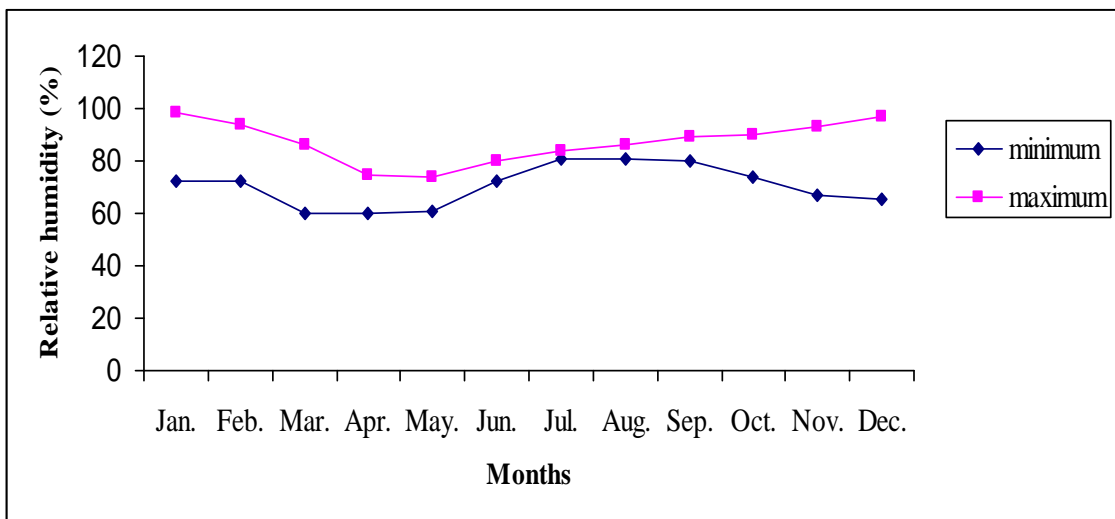


Figure 4 . Relative Humidity in Kathmandu from Jan 2007 to Dec 2007

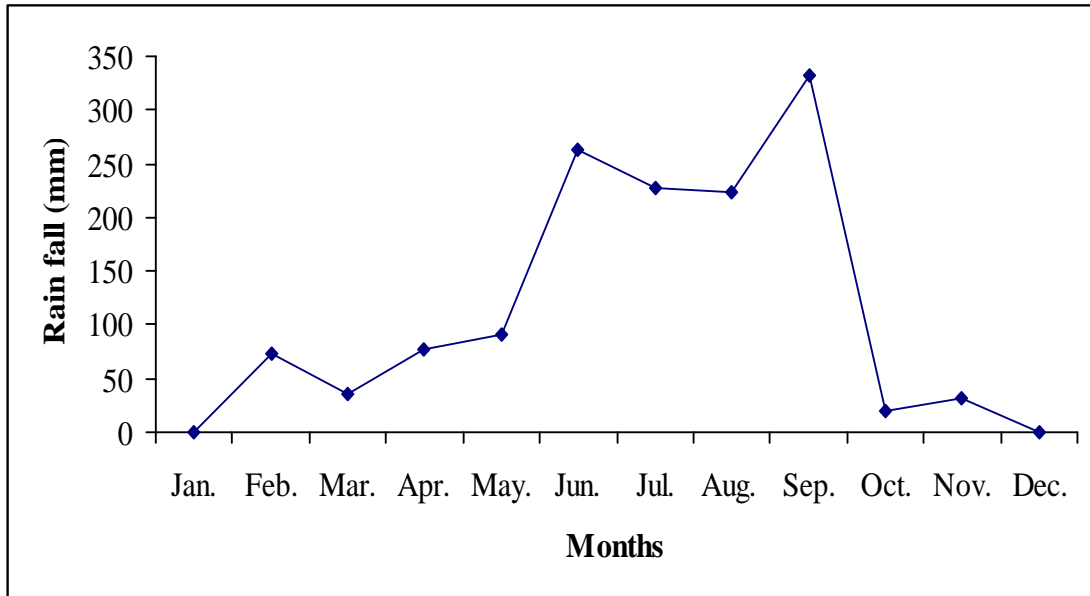


Figure 5 . Rainfall in Kathmandu from January 2007 to December 2007

(c) Flora and fauna of Taudaha lake

(Yadav et al. 1983) has recorded total of 39 taxa of macrovegetation and 36 taxa of macroinvertebrates. (RajKarnikar 1977) has recorded six species of fishes in Taudaha. (Shah 2000) has recorded 55 species of birds in Taudaha.

3.2 Direct Observation

The field study was carried out for eight months from September 2007 to April 2008. During this period, the study site was visited once a week that is every Saturday. Direct observations were made for three hours that is from 8 am to 11 am, mostly focussing upon the migratory birds. The birds were observed and identified with the help of Olympus Binocular (10×25 RC II R, weather proof field 5°). The field guide book of (Grimmet et al. 2003) and (Inskipp and Inskipp 1985) were referred for the identification of birds. Birds were censused by applying direct count method. Such a method has widely been used for enumerating aquatic birds especially ducks (Roux 1973). Counts were performed in the same time 8 am to 11am through out the study period. Three permanent vantage points were taken around the lake and repeated one after another per week. In each month, four data sets were filled up from which the maximum numbers of birds were taken as the real or total population.

The photos of the birds, which were distinct were taken by the help of two digital camera of (300 mm Nikon D 40x) and (4.5 mega pixel) respectively.

Both primary and secondary data and questionnaire were used but the main parts of the study depend on primary data. The primary data were collected by direct observation. While secondary data were collected by reviewing literatures such as journals, articles, proceedings and books.

3.3 Shanon Wiener Species Diversity

Species diversity of birds was calculated by using Shanon Wiener function (Shanon-Wiener 1963, cited in Krebs 1988 and Yadav et al. 1987)

$$H = \frac{\sum_{i=1}^n -f_i \log f_i}{n}$$

Where,

H= index of species diversity

n = total individuals

f_i = number of individual species.

To calculate Jakob's coefficient,

$$J = \frac{H}{H_{\max}}$$
$$= \frac{H}{\log K}$$

Where,

J = relative diversity

H = observed diversity

H max = proportion of maximum possible diversity, H max = Log K

K= number of species present



a



b



c

Plate 1. a) Researcher conducting questionnaire survey in Tauaha b) Researcher in discussion with Maheshor Karki, a committee member of Taudaha and c) Researcher observing birds through binoculars

4. RESULTS

4.1 Diversity of Migratory Birds and seasonal change

From the present study, about forty, species of birds belonging to eleven families were recorded. These included twenty one species of winter migrants, two species of summer migrants and seventeen species of resident birds (Annex VI).

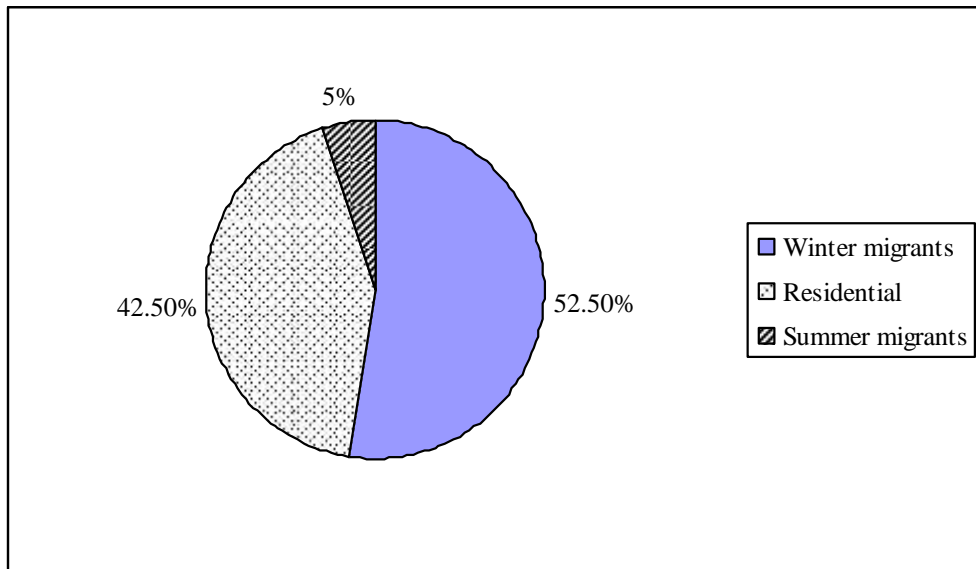


Figure 6. Pie chart showing the percentage of Winter and Summer migrants and residential birds

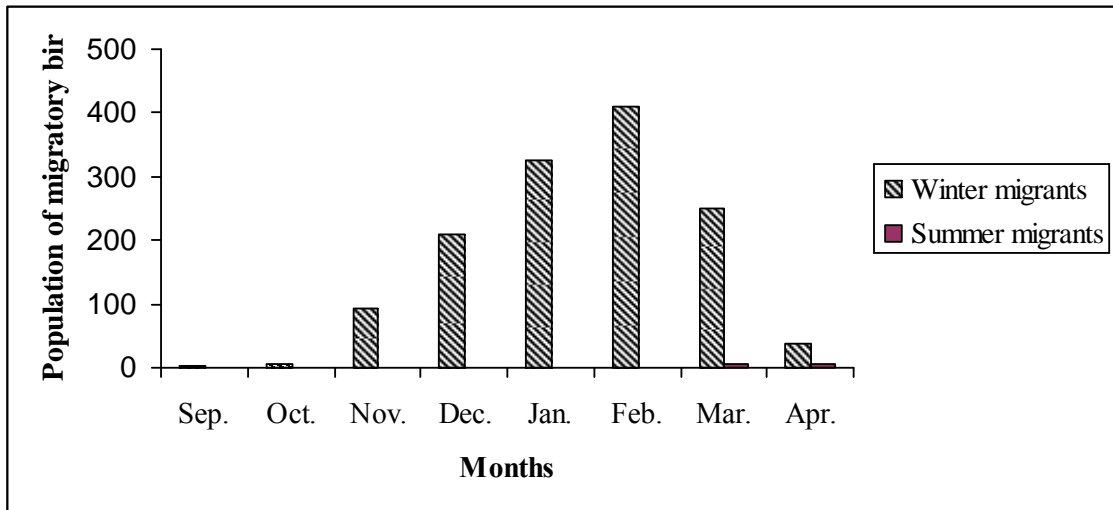


Figure 7. Multiple bar diagram showing distribution of migratory birds from September 2007 to April 2008



a



b

Plate 2. a) Coots *Fulica atra* and b) Breeding and non-breeding Great cormorants *Phalacrocorax carbo*



a



b

Plate 3. a) Northern shoveler *Anas clypeata* and b) Mallards *Anas platyrhynchos*



a



b

Plate 4. a) Ruddy shelduck *Tadorna ferruginea* and b) Bar headed goose

Anser indicus



a



b

Plate 5. a) Northern pintail *Anas acuta* and b) Coots *Fulica atra* feeding

The observed diversity of birds in winter season and summer season were 0.753 (Annex VII) and 0.178 (Annex VIII) respectively which showed that the species diversity of birds in winter season were more than in summer season. Jakob's Coefficient also showed the same type of result that is relative diversity of birds in winter was 0.57 and in summer was 0.059. Thus, the diversity of birds in winter season was more than in comparison to summer season. Species Diversity and Jackobs Coefficient were calculated by using the tables 1, 2, 3 and 4.

Table 1. Number of winter migratory birds in each month

S. N.	Common Name	Scientific name	Se p.	Oc t.	No v.	Dec.	Jan.	Feb.	Mar .	Ap r.
1.	Mallard	<i>Anas platyrhynchos</i>	-	-	8	51	75	80	35	-
2.	Ferruginous pochard	<i>Aythya nyroca</i>	-	-	-	3	3	3	2	-
3.	Little grebe	<i>Tachybaptus ruficollis</i>	-	-	-	-	-	2	-	-
4.	Common coot	<i>Fulica atra</i>	2	2	10	20	32	25	20	1
5.	Gadwall	<i>Anas strepera</i>	-	-	64	99	91	90	45	21
6.	Great cormorant	<i>Phalacrocorax carbo</i>	-	-	-	10	6	24	20	-
7.	Eurasian wigeon	<i>Anas penelope</i>	-	-	-	1	4	3	5	1
8.	Ruddy shelduck	<i>Tadorna ferruginea</i>	-	-	2	5	8	8	6	4
9.	Northern shoveler	<i>Anas clypeata</i>	-	-	-	-	-	3	3	1
10.	Bar headed goose	<i>Anser indicus</i>	-	-	-	-	-	1	-	-
11.	Red crested pochard	<i>Rhodonessa rufina</i>	-	-	-	-	-	3	3	1
12.	Northern pintail	<i>Anas acuta</i>	-	-	-	-	-	-	2	-
13.	Spot billed duck	<i>Anas poecilorhyncha</i>	-	-	-	1	-	-	-	-
14.	Common teal	<i>Anas crecca</i>	-	-	2	13	101	165	101	10
15.	Common pochard	<i>Aythya ferina</i>	-	-	-	1	1	1	1	-
16.	Pied wagtail	<i>Motacilla alba</i>	-	-	-	-	-	-	1	-
17.	Stone chat	<i>Saxicola torquata</i>	-	-	1	1	1	1	1	-
18.	Olive backed pipit	<i>Anthus hodgsoni</i>	-	-	2	3	3	-	2	-
19.	Tufted duck	<i>Aythya fuligula</i>	-	-	-	-	-	-	2	-
20.	Grey heron	<i>Ardea cinerea</i>	-	1	-	-	-	-	-	-
21.	Black crowned night heron	<i>Nycticorax nycticorax</i>	-	4	3	1	-	-	-	-
	Total		2	7	92	209	325	409	249	39

Table 2. Calculation for Winter Migrants

S.N.	Common Name	Scientific name	Fi	%	fi log fi
1.	Mallard	<i>Anas platyrhynchos</i>	80	18.14	152.24
2.	Ferruginous pochard	<i>Aythya nyroca</i>	3	0.68	1.43
3.	Little grebe	<i>Tachybaptus ruficollis</i>	2	0.45	6.02
4.	Common coot	<i>Fulica atra</i>	32	7.25	48.16
5.	Gadwall	<i>Anas strepera</i>	99	22.44	197.56
6.	Great cormorant	<i>Phalacrocorax carbo</i>	24	5.44	33.12
7.	Eurasian wigeon	<i>Anas penelope</i>	5	1.1	3.49
8.	Ruddy shelduck	<i>Tadorna ferruginea</i>	8	1.81	7.22
9.	Northern shoveler	<i>Anas clypeata</i>	3	0.68	1.43
10.	Bar headed goose	<i>Anser indicus</i>	1	0.22	0
11.	Red crested pochard	<i>Rhodonessa rufina</i>	3	0.68	1.43
12.	Northern pintail	<i>Anas acuta</i>	2	0.45	6.02
13.	Spot billed duck	<i>Anas poecilorhyncha</i>	1	0.22	0
14.	Common teal	<i>Anas crecca</i>	165	37.41	365.88
15.	Common pochard	<i>Aythya ferina</i>	1	0.22	0
16.	Pied wagtail	<i>Motacilla alba</i>	1	0.22	0
17.	Stone chat	<i>Saxicola torquata</i>	1	0.22	0
18.	Olive backed pipit	<i>Anthus hodgsoni</i>	3	0.68	1.43
19.	Tufted duck	<i>Aythya fuligula</i>	2	0.45	6.02
20.	Grey heron	<i>Ardea cinerea</i>	1	0.22	0
21.	Black crowned night heron	<i>Nycticorax nycticorax</i>	4	0.90	2.40
	Total		n = 441	100	833.85

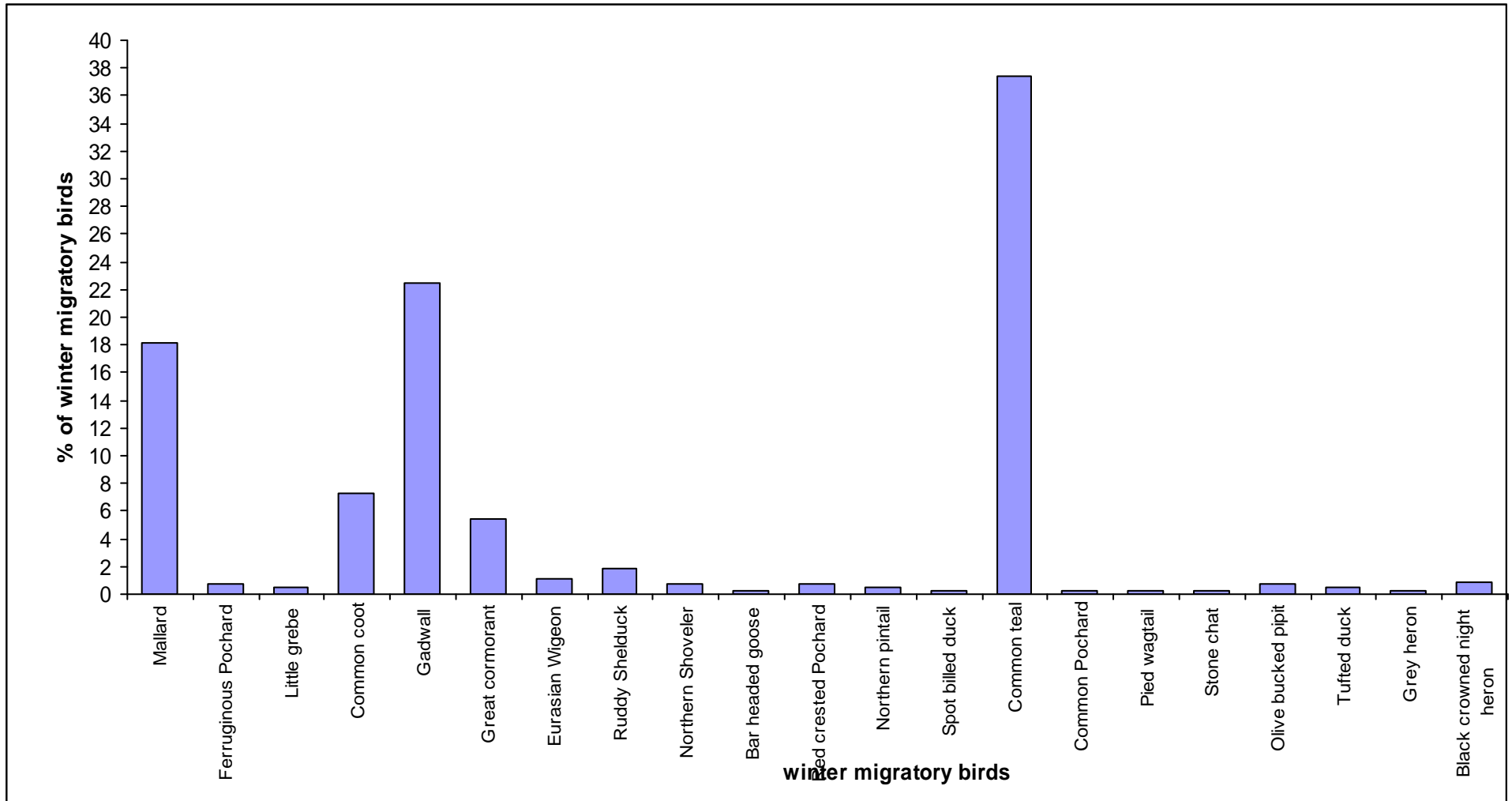


Figure 8. Relative Abundance of Migratory Birds

Table 3. Number of summer migratory birds in each month

S.N.	Common Name	Scientific name	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
1.	Bam swallow	<i>Hirundo rustica</i>	-	-	-	-	-	-	6	4
2.	Indian cuckoo	<i>Cuculus canorus</i>	-	-	-	-	-	-	-	1
	Total		0	0	0	0	0	0	6	5

Table 4. Calculation for summer migrants

S.N.	Common Name	Scientific name	fi	%	fi log fi
1.	Barn swallow	<i>Hirundo rustica</i>	6	85.71	4.66
2.	Indian cuckoo	<i>Cuculus canorus</i>	1	14.28	0
	Total		n= 7	100	fi log fi=4.66

4.2 Arrival and departure of the Migratory birds

The birds started arriving the Lake on September 22, 2007 and departed from the Lake by April 19, 2009.

Table 5. Arrival and Departure of the Migratory Birds

S.No.	Name of birds	Date of arrival	S.No.	Name of birds	Date of departure
1.	Common Coot	2007-09-22	1.	Grey heron	2007-11-03
2.	Great Cormorant, Grey Heron and Black crowned night heron	2007-10-13	2.	Spot billed duck	2007-12-15
			3.	Black Crowned night heron	2007-12-22
			4.	Bar headed goose	2008-03-01

3.	Common Pochard Mallard, Ferruginous pochard, Gadwall, Eurasian wigeon,	2007-12-01	5.	Furruginous Pochard	2008-03-08
			6.	Mallard and Little grebe	2008-03-15
			7.	Pied wagtail and Stone chat	2008-03-22
4.	Ruddy Shelduck, Spot Billed duck, Common teal, Stone chat and Olive backed pipit	2007-12-08	8.	Olive backed pipit	2008-03-29
5..	Little grebe and Northern Shoveler	2008-02-02	9.	Tufted duck, Common Coot, Common pochard, Common teal, Northern pintail, Red crested pochard, Great cormorant and Northern Shoveler	2008-04-05
6	Bar headed goose and Red crested pochard	2008-02-09			
7.	Barn Swallow	2008-03-01	10.	Gadwall and Eurasian Wigeon	2008-04-12
8.	Northern Pintail and Tufted duck	2008-03-08	11.	Ruddy Shelduck	2009-04-19
9.	Pied wagtail	2008-03-15	12.	Barn Swallow	-
10.	Indian cuckoo	2008-04-26	13.	Indian Cuckoo	-

4.3. Decline of migratory birds and its consequences

Sounds of high intensity, crowding of the people and increasing urbanization have killed the wilderness of the habitat. These have caused decline in the diversity of migratory birds at Taudaha lake . Different bird species belong to different trophic niches and are different in their food habits. Taudaha Lake inhabits a great variety of macrovegetation (Annex I) and macroinvertebrates (Annex II). It also inhabits different species of fishes (Annex III). Among all the birds observed in the study area some are omnivores, some are carnivores, some are herbivore or vegetarian and

similarly others are specified surface feeders or feeders of submerged plants (Annex IX). These birds belong to different trophic niches with different food habits. Different type of food of the lake is utilized by different species of the birds, no stress is given on any particular trophic level. After the consumption of the fauna and flora of different trophic level, the left over flora and fauna of each trophic level them get chance to repeat their life cycle and increase in number by the next arrival of the birds.