

# Aquatic Food Plants and their Consumer Birds at Sandi Bird Sanctuary, Hardoi, Northern India

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## ABSTRACT

One of the Bird Sanctuaries of Uttar Pradesh, Sandi, was selected for studying some ecological aspects like, aquatic food plants, their food calendar and dependent birds of migratory as well as resident origin. The study site is considered as an ideal wetland. This is located at 27°15' N and 79°55' E. Thirty four food plant species were identified to be eaten by 16 birds. These plants were the species of *Alloteropsis*, *Arundo*, *Azolla*, *Ceratophyllum*, *Chloris*, *Commelina*, *Cyperus*, *Echinochloa*, *Eichhornia*, *Eleocharis*, *Hydrilla*, *Ipomoea*, *Jussiaea*, *Lemna*, *Najas*, *Nelumbo*, *Nymphaea*, *Nymphoides*, *Oryza*, *Pistia*, *Polygonum*, *Potamogeton*, *Scirpus*, *Spirodela*, *Trapa*, *Typha*, *Vallisneria*, and *Wolffia*. Common consumer birds eating plant parts were Coot, Pochards, Teal, Wigeon, Gadwall, Gargany, Goose, Whistling-duck, Mallard, Pintail, Shoveler, and Swampen. These are primarily the migratory birds except Coot, Whistling-duck and Swampen. Spot-billed Duck, and Indian Moorhen were occasionally seen eating submerged hydrophytes and filamentous slimy green algae. On the basis of multi-strata growth of plants in the Sanctuary a wetland profile was prepared. Food calendar i.e., availability of palatable parts of plants during different months was recorded. Information collected in the study could be used for habitat management, especially the weed removal and ensuring food sustainability for the vegetarian birds.

**Key words:** wetland, profile, vegetation, food calendar, birds, richness, abundance

## INTRODUCTION

Uttar Pradesh (UP), one of the north Indian states, comes under the Central Asian flyway completely and under the East Africa West Asia flyway partly (Flyway map reproduced by Rahmani and Islam, 2008). Thousands of birds coming from northern and north western higher latitudes alight in the wetlands in the state. The migratory birds along with the resident birds spend their winter and survive on the food resources available therein (Rahmani *et al.*, 2010; UP Forest Department file record). This state has more than twenty three thousand wetlands larger than 2.25ha (GOI, 2011) which includes more than eighteen hundred larger (>56 ha) wetlands (SACON, 2004). Some of these are potential Ramsar sites and Important Bird Areas (Islam and Rahmani, 2004; 2008). Twelve wetlands of ecological importance are managed as the Bird (Wildlife) Sanctuaries in the State.

UP wetlands are rich in aquatic flora of floating, submerged and emergent types (Agnihotri *et al.*, 2008; Mishra and Narain, 2010). Several ducks, geese and swans and some resident aquatic birds consume vegetative materials like root, shoot, foliage, fruits and seeds produced by the emergent, submerged and floating plants in the wetlands (Ali and Ripley, 1987; Rahmani and Islam, 2008; Jha, 2010). Some of the ducks also use agriculture field in the neighboring area as foraging ground (Mukherji *et al.*, 2002). In view of the availability of generalized information about food plants and their consumers it was attempted to identify the plant with the consumer bird at species level in

Sandi Bird Sanctuary of UP which qualifies for potential Ramsar site and Important Bird Area also (Islam and Rahmani, 2004; 2008).

## MATERIALS AND METHODS

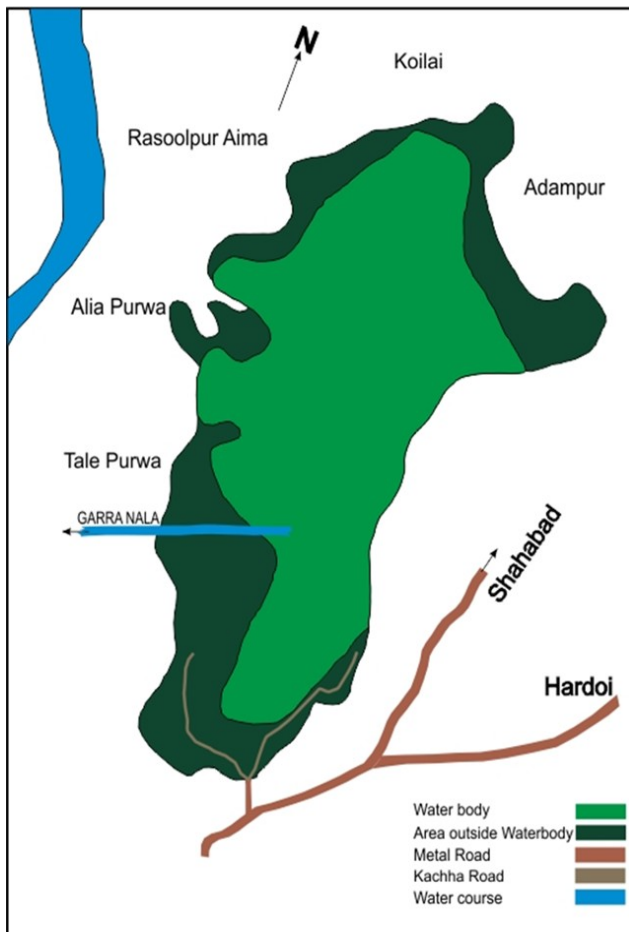
With the help of binoculars and sometimes with naked eyes the birds were observed eating upon the plants with focus on the plant parts (roots, stem, leaves, flowers, fruits and seeds) being eaten during day time. Guide book of Grimmett and Inskip (2010) and Saini *et al.* (2010) were used for identification of birds and plants, respectively. Observation was made during migration and wintering period (October to March) of 2009-10, 2010-11 and 2011-12.

Species wise counting exercise of birds was also done in above mentioned period. The “block in flock in sector” method was adopted for population estimation. Watered area of the wetland was divided into “sectors” using permanent landmark of physical features in the wetland. In these sectors, turn-wise, flock of birds was marked and the same was divided into imaginary blocks of equal size, generally 3 to 5 depending on the size of the flock. Within the block individual’s number of different bird species were identified and counted. Species individuals’ numbers were multiplied by “block” numbers to get flock numbers. Flock numbers were summed up to get “sector” numbers and “sector” numbers were added to find out wetland number.

Counting was done by a team of two members, a bird counter and a data recorder, who walked slowly along the pre-decided path, the wetland bank and or the

dykes, to cover all the “sectors” of the wetland.

Counting started at 8:30h and continued till it was finished, mostly in the forenoon. Fortnightly counting was done from October to March in Sandi Bird Sanctuary (Figure 1) by the properly trained field staff. Higher of the two numbers, mostly the second fortnight was taken as the number of individuals of the species for the month.



**Figure 1.** Sandi Bird Sanctuary during winter months. Dark green area gets flooded during monsoon. This includes some private holding also. Modified from Sharma (2011).

### Study site

Sandi Bird Sanctuary, one of the most important and protected wetlands of Uttar Pradesh was selected for the study. This is located at 27°15' N and 79°55' E. Total area of the wetland is 308.54 ha in which water spread varied from season to season, since it is a rain fed wetland. Average winter depth of the wetland is 1.5 m. Three year (2009-2011) data showed that average annual rainfall in this area was 685 mm and temperature varied from 4°C to 40°C. The sanctuary is rich in different types of vegetation. Water body is surrounded by agriculture land that provides extra foraging space and food for certain aquatic birds. There are some created islands with Acacia trees meant for resting of the birds. Trees of different species are also planted on marginal bunds being used by terrestrial birds and predators.

## OBSERVATION AND RESULTS

### Food plants' composition

Aquatic birds, mostly migratory, stayed during the winter months (November to February) in the wetland. During October and March number of birds was on lower side. These birds were seen consuming the select parts (roots, foliage, shoots, flowers, seeds and fruits) of the select plant species depending on their palatability. Such plants are grouped and described in the following paragraphs on the basis of quick identifying characters useful for the foresters or wetland managers. For detailed taxonomic description any book on Aquatic Plant Taxonomy could be consulted (for example Saini *et al.*, 2010). Plant parts eaten and their consumer birds are also mentioned along with.

### Floating hydrophytes

***Azolla pinnata* (Bhoori Kai):** Initially green but later brown leaves float on the water surface; making an appearance of brown or from distance red carpet (Figure 2) spread over the waterbody. Freely floating feathery lateral roots remain submerged in water; stem practically absent. Leaves are eaten by almost every duck (Northern Shoveler seemed to be fond of it).

***Eichhornia cracipes* (Jalkumbhi):** Floating and erect plant mostly appearing green due to dominant leaves; erect stem supports beautiful purple inflorescence; petioles are swollen spongy bladders (Figure 2). Profusely growing roots remain submerged in water. Purple Swampphen and Lesser Whistling –duck have been observed eating on the soft tissue of swollen petiole. This plant is generally considered as weed and sometimes grown as ornamental plant.

***Jussiaea repens* (Vanlong/Gahdi):** Floating plant common along the margin of aquatic body; erect stem with plenty of leaves comes of the coloured stem base creeping along the water surface; spongy white air roots grow at nodes and remain submerged in water (Figure 2). Flowers are solitary, light yellow or white. Roots and stem both are eaten by Common Coot, Common Teal, Gadwall, Eurasian Wigeon, Northern Pintail, Northern Shoveler and Purple Swampphen.

***Lemna purpusilla* (Hari kai):** Floating plant mainly with one or two to four or five small leaves and one root (Figure 3). Leaves are eaten by Northern Shoveler and Mallard.

***Pistia stratiotes* (Pistia):** Floating tufted plant composed mainly of tufted leaves and suspended roots without stem. Tuft of rippled leaves have rosette appearance (Figure 3). This plant is considered one of the most dangerous aquatic weeds but young leaves are eaten by Common Coots.



**Figure 2.** Clockwise from top left: brown red carpet and then close up view of *Azolla pinnata*, *Jussiaea repense* and *Eicchornia cracipes*.



**Figure 3.** Clockwise from top left: *Lemna purpusilla*, *Pistia stratiotes*, *Wolffia arrhiza* and *Trapa natans*.

***Spirodela polyrhiza* (Hari Kai):** Floating small plants with numerous roots submerged in water. Upper surface of leaf is dark green while lower surface is purplish. This plant could be distinguished with *Lemna purpusilla* in number of roots, texture and colour of leaves. Northern Shoveler, Eurasian Wigeon and Ferruginous Pochard were seen eating the leaves of this plant.

***Trapa natans* (Singhara):** Rooted floating plant with submerged as well as floating leaves which are rhomboidal, wider than length. Flowers are solitary and white (Figure 3). Two spined fleshy fruit is green or red in colour. Common Coot and Purple Swamphen were seen eating the fruits. This plant is often cultivated on private land near the wetlands for its fruit for human consumption.

***Wolffia arrhiza* (Jaljanjal):** It is a rootless and stemless minute plant, technically called thallus. When in group of millions they appear like greenish carpet spread on the water (Figure 3). When seen closely the carpet gets distinguished into grains adhered to each other in one plane on water surface. Whole plant is eaten by Common Pochard, Northern Shoveler, Mallard and Red-crested Pochard.

***Nelumbo nucifera* (Kamal):** It is a floating anchored plant with large and ribbed leaves. Flowers are pinkish red, generally erect high above water with imposing appearance, large fruits locally known as kamalgatta is also used by the villagers (Figure 4). The seeds were eaten by Common Coot and Ferruginous Pochard. This plant is not common in this Sanctuary. Only few plants were seen in 2009 and 2010. It was suspected that some people extracted it for local use.

***Nymphaea nouchali* (Kamalini):** Floating leaf rooted at the base, sub-sagittate leaves appear toothed when old, lower surface is hairy. Flower colour white or pinkish red. *N. stellata* differs in leaf characteristic, elliptic or circular leaf with entire margin in this case, and petals are comparatively less wide and more of longer appearance; flower colour purplish or white (Figure 4). Fruits and seeds are eaten by Northern Pintail, Northern Shoveler, Common Teal, Gadwall, Red-crested Pochard, Common Pochard, Eurasian Wigeon, Ferruginous Pochard, Mallard, and Common Coot. Spot-billed Duck was seen eating seeds occasionally.

***Nymphoides cristatum* (Jalrani):** Looks like mini water lily on account of smaller chordate leaves, and smaller flower size and colour, and free floating habit, but a remarkable difference is reduced number of petals, only five in this case (Figure 5). *N. indicum* has unmistakable copiously hairy flower petals. Flowers and seeds, sometimes leaves, are eaten by Common Teal, Gadwall, Northern Pintail and Northern Shoveler.

***Ipomoea aquatica* (Nari/Kamali Sag):** A floating anchored hydrophyte, may grow in muddy soil at the margins of wetland also. Stem hollow and rooted at nodes. Leaves are oblong, sagittate at the base. Purple white

flower, very similar to *Ipomoea carnea* (Besharam/Behaya) except in size, is solitary or sometimes in groups (Figure 5). Stem leaves and flowers are eaten by Common Coot, Eurasian Wigeon, Ferruginous Pochard and Northern Shoveler. Green leaf of this plant is edible to human being also.

### Submerged hydrophytes

***Ceratophyllum demersum* (Khaja chhoti):** This plant is submerged but suspended in water. There are no roots but the plant is highly branched. Leaves are filiform and appear to originate in whorls at regular distance on green stem with reddish tinge when young (Figure 6). Flowers and seeds are eaten by Common Coot, Common Teal, Gadwall and Northern Shoveler.

***Hydrilla verticillata* (Sewar/Khaja motipatti):** Copiously leaved submerged green plants. Leaves are opposite or verticillate, linear or linear-oblong and entire. In comparison to *Ceratophyllum* and *Najas* leaves are flat, much wider and dense. Almost sessile flowers are minute and white (Figure 6). Shoot, leaves and flower are eaten by Common Coot, Common Teal, Gadwall, Northern Pintail and Northern Shoveler.

***Najas graminea* (Katia):** Grassy submerged herb rooting at the basal node, falsely whorled leaves are lanceolate, narrowly triangular and toothed. Flowers are green and minute. Very small fruits and seeds are produced (Figure 6). Leaves of *N. minor* are not toothed. Leaves and seeds are eaten by Common Coot, Common Teal, and Northern Pintail.

***Potamogeton nodosus* (Potamogeton):** This is an anchored plant with large submerged leaves, sometimes seen very close to water surface. Leaves are alternately arranged on stem. They are petiolate, oblong or elliptic with entire margin. *P. pectinatus* could be distinguished from *P. nodosus* in leaf characteristics. Unmistakable inflorescence is vertically erect generally above water appearing brownish. Flowers are white or pink and very small in size (Figure 5). Former has sessile and filiform leaves. Common Coot, Northern Shoveler and Purple Swamphen have been seen eating the seeds of this plant.

***Vallisneria spiralis* (Feeta ghas):** Submerged and tufted plants, long, lanceolate leaves originate at the base, the plant gives appearance of green spiraled ribbon. Minute white flowers float on water surface but remain attached to the plant by green spiral thread like structure. Leaves and seeds are eaten by Common Coot, Common Teal, Gadwall, Lesser Whistling-duck, Northern Shoveler, Northern Pintail and Red-crested Pochard.

### Emergent hydrophytes

***Alloteropsis cimicina* (Alloteropsis):** An erect, slender, hairy annual herb of 40-60 cm height; Leaves ovate lanceolate with hairy margin; Spiciform inflorescence. Flowers and seeds are eaten by Northern Pintail,



**Figure 4.** Clockwise from top left: *Nelumbo nucifera* and close up of the fruit, *Nymphaea stellata* and *N. nauchali*.



**Figure 5.** Clockwise from top left: *Nymphoides cristatum*, *Ipomoea aquatica* and *Potamogeton pectinatus*.

Common Teal, Gadwall and Eurasian Wigeon.

***Arundo donax* (Balehra):** It is a tall perennial grass; leaves are ensiform and hairy up to 60 cm long; inflorescence also up to 60 cm long (Figure 7). Seeds are eaten by Common Teal, Gargany and Purple Swamphen.

***Chloris barbata* (Chloris):** An erect, tufted annual grass up to 1 m height; leaves are narrowly linear up to 45 cm; inflorescence is terminal bunches of spikes. Seeds are eaten by Common Teal, Northern Pintail, Gadwall and Eurasian Wigeon.

***Commelina harsskarlii* (Oona):** It is an annual erect herb with purple flowers; leaves are hairy and lanceolate. Roots and fruits are eaten by Eurasian Wigeon, Common Coot, Greylag Goose and Purple Swamphen.

***Cyperus alopecuroides* (Motha):** Large tufted perennial herb; stem stout and trigonous; leaves are linear; inflorescence in terminal stout bunches. New leaves and fruits are eaten by Common Coot, Greylag Goose, Northern Pintail and Gadwall.

***Echinochloa stagnina* (Shama):** Annual grass grows up to waist height, leaves linear and more than 10 cm long. Spike / inflorescence erect spikelet in several rows. Seeds are eaten by Common Teal.

***Eleocharis dulcis* (Pola/Poli/Narai):** The sedge grows in dense tuft, dark green cylindrical stem partly submerged, hollow stem has septa giving the appearance of nodes if observed minutely or the stem pressed between two fingers and run through. It was not seen growing above waist height (Figure 7). *E. palustris* is similar in appearance, lacks the septa and shorter in height to *E. dulcis*. Roots and soft shoots are eaten by Greylag Goose and Eurasian Wigeon.

***Oryza rufipogon* (Tinna/Janglidhan/Fasai ghas):** Tall annual grass giving the look of wild paddy (Photo-plate 6). Food grains are eaten by Common Teal and Purple Swamphen.

***Polygonum barbatum* (Anjuar/Kolonchh):** An erect annual herb, leaves lanceolate or linear-lanceolate with tapering base, dense but loose inflorescence of white flowers. *P. glabrum* has longer and erect leaves at the top, pink flowers form dense and stout inflorescence. New shoots and leaves are eaten by Purple Swamphen and Common Teal.

***Scirpus articulatus* (Chichora):** Annual erect sedge, stem hollow, inflorescence closer to base. Seeds are eaten by Purple Swamphen.

***Typha angustifolia* (Patera):** Perennial tall grass, leaves longer than a meter, spongy. Initially green but later brown coloured cylindrical structure is seen very often (Figure 8). New soft shoot is eaten by Purple Swamphen.

Above described food plants were growing in the wetland in different strata with successive depth gradient. A vegetation profile was drawn and depicted in Figure 9.

### Food resource availability

Different hydrophytic plants recorded as food for avian flora produced flower, fruits and seeds at different time, therefore, availability of food also varied. Food production time was divided into initial, peak and late residency period. Several plants (21 species) produced food during initial residency period (October-November). Certain species (nine) ceased food production but some new species (eight) also started producing food materials during the peak residency period (December-January). Most of the species' food production period was over by the end of peak period. However, 11 species continued producing food before the end of late residency period (February-March). Species detail with food availability period or food calendar is presented in Figure 10. Number of days represent the month of October (0-30), November (31-60) and so on up to March (150-180) on x axis in this figure.

### Avian composition

All together 54 aquatic birds (*Amaurornis phoenicurus*, *Anas acuta*, *Anas clypeata*, *Anas crecca*, *Anas penelope*, *Anas platyrhynchos*, *Anas poecilorhyncha*, *Anas strepera*, *Anas querquedula*, *Anastomus oscitans*, *Anhinga melanogaster*, *Anser anser*, *Anser indicus*, *Ardea cinerea*, *Ardea purpurea*, *Ardeola grayii*, *Aythya ferina*, *Aythya fuligula*, *Aythya nyroca*, *Casmerodius albus*, *Dendrocygna javanica*, *Egretta garzetta*, *Ephippiorhynchus asiaticus*, *Fulica atra*, *Gallicrex cinerea*, *Gallinago gallinago*, *Gallinago stenura*, *Gallinula chloropus*, *Himantopus himantopus*, *Hydrophasianus chirurgus*, *Ixobrychus sinensis*, *Limosa limosa*, *Mesophoyx intermedia*, *Metopidius indicus*, *Motacilla citreola*, *Mycteria leucocephala*, *Nettapus coromandelianus*, *Nycticorax nycticorax*, *Phalacrocorax carbo*, *Phalacrocorax fuscicollis*, *Phalacrocorax niger*, *Platelea leucorodia*, *Plegadis falcinellus*, *Podiceps cristatus*, *Porphyrio porphyrio*, *Rhodonessa rufina*, *Rynchops albigollis*, *Sarkidiornis melanotos*, *Sterna aurantia*, *Tachybaptus ruficollis*, *Tadorna ferruginea*, *Threskiornis melanocephalus* and *Tringa stagnatilis*) were recorded inhabiting the wetland during the study period of three years. Majority of these birds were seen pecking on lower animals or different invertebrate species in the wetland or agriculture field, few were restricted to aquatic plants of the wetland and few consumed agriculture crops also.



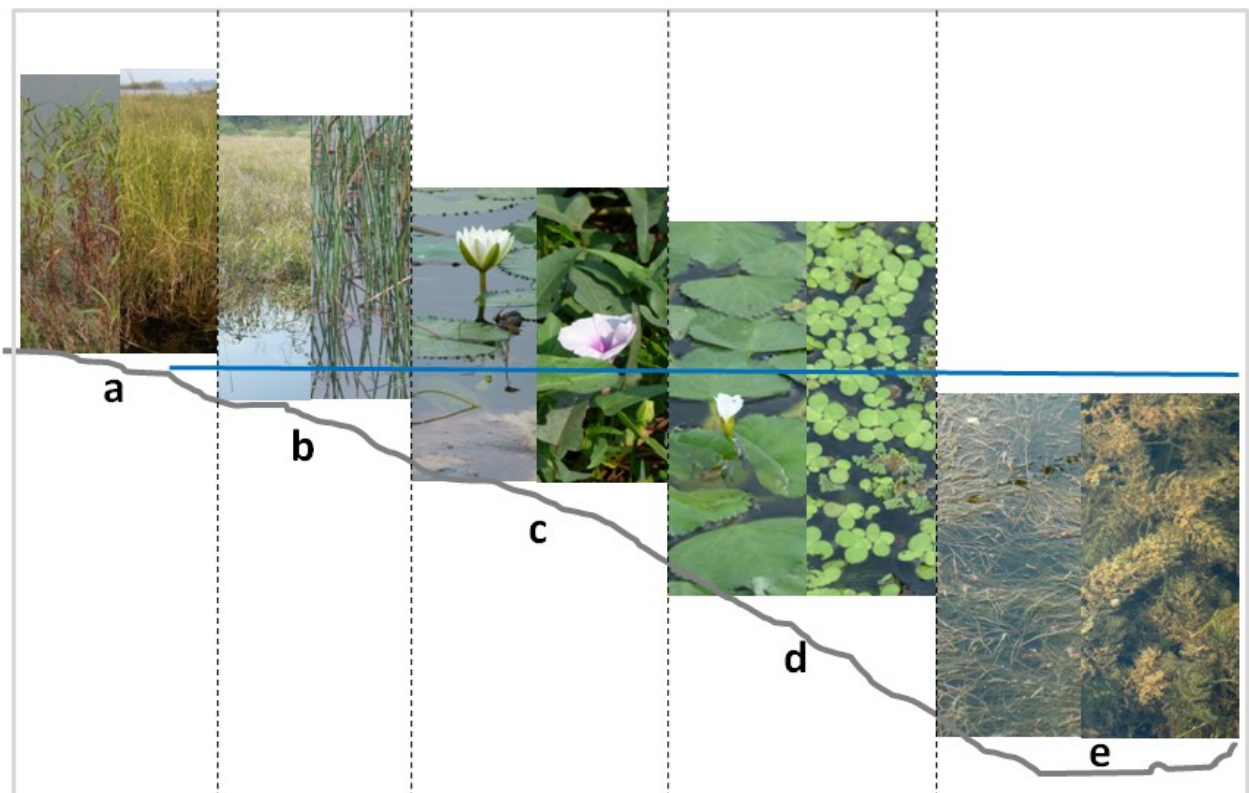
**Figure 6.** Clockwise from top left: *Ceratophyllum demersum*, *Najas graminea* and *Hydrilla verticillata*. All specimens are photographed outside water, not in natural growing condition.



**Figure 7.** Clockwise from top left: *Arundo donax*, *Cyperus* sp., *Oryza rufipagon* and *Eleocharis dulcis*.

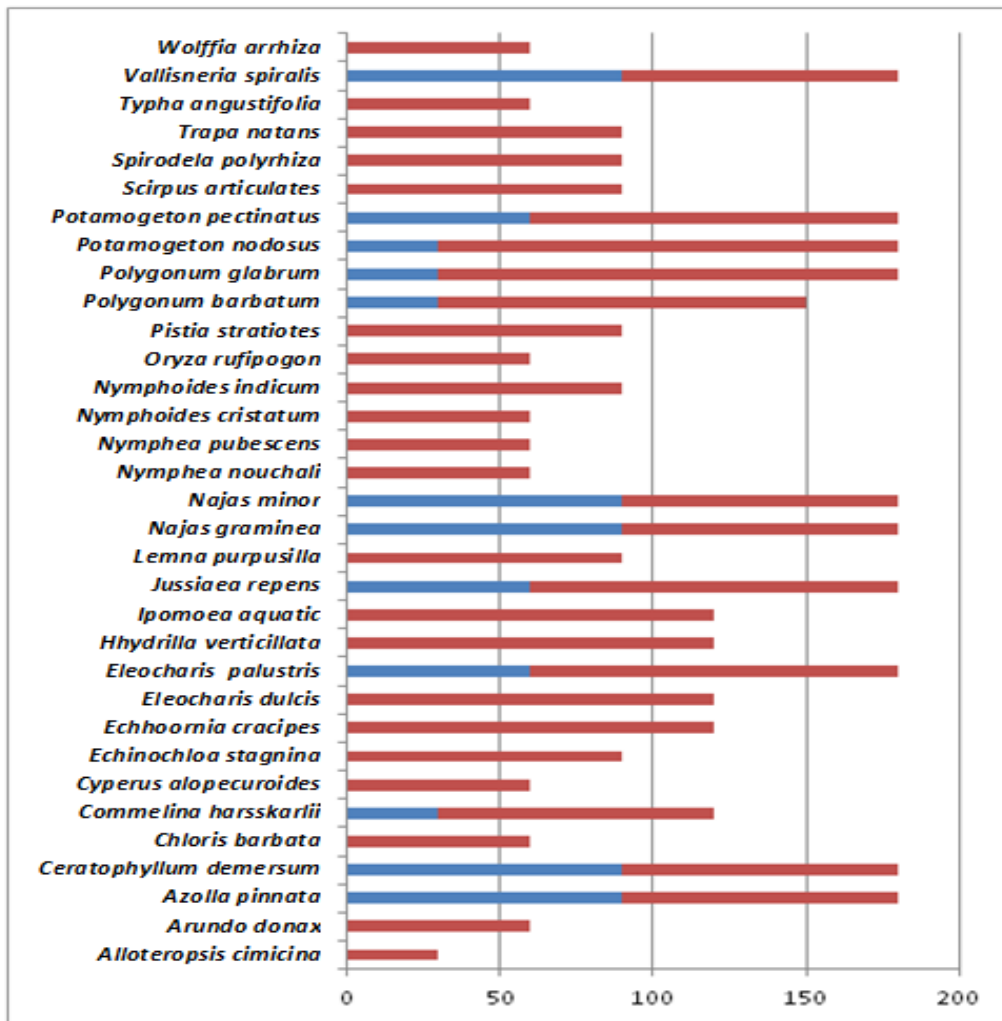


**Figure 8.** Clockwise from top left: *Polygonum* sp., *Typha angustifolia* and *Cyperus* sp.



**Figure 9.** Schematic depiction of Sandi Bird Sanctuary profile with selected examples of food plants in different stratum of wetland. a: shore or marshy plant, *Polygonum* and *Arundo*; b: swampy or emergent plant, *Oryza* and *Eleocharis*; c: floating anchored, *Nymphaea* and *Ipomoea*; d: free floating, *Trapa* and *Lemna*; e: submerged, *Najas* and *Ceratophyllum*.





**Figure 10.** Availability of plant food of different species in days starting from October. Blue bar indicates non-availability period.



**Figure 11.** Clockwise from top left: Common Teal, Greylag Goose, Northern Shoveler and Gargany.



**Figure 12.** Clockwise from top left: Red-crested Pochard, Northern Pintail, common duck (Gadwall) and Ferruginous Pochard.



**Figure 13.** Clockwise from top left: Common coots wading in deep water, eating on *Jussiaea repens* and *Pisteia stratiotes*.



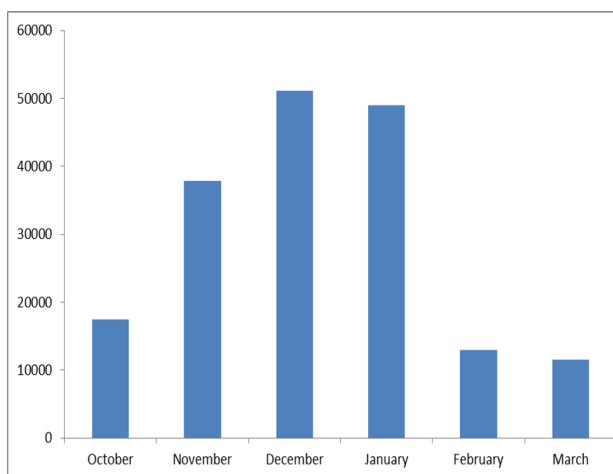
**Figure 14.** Clockwise from top: Lesser Whistling-duck and Spot-billed Duck and Common Moorhen.



**Figure 15.** Clockwise from top left: Purple Swamphen using *Eleocharis dulcis*, *Jussiaea repense* and *Eichhornia cracipes*. The bird used *Echhiornia* for egg laying also.

Out of the above reported species 14 birds were observed to be eating aquatic food plants. They were Common Coot (*Fulica atra*), Common Pochard (*Aythya ferina*), Common Teal (*Anas crecca*), Eurasian Wigeon (*Anas Penelope*), Ferruginous pochard (*Aythya nyroca*), Gadwall (*Anas strepera*), Gargany (*Anas querquedula*), Greylag Goose (*Anser anser*), Lesser Whistling-duck (*Dendrocygna javanica*), Mallard (*Anas platyrhynchos*), Northern Pintail (*Anas acuta*), Northern Shoveler (*Anas clypeata*), Purple Swamphen (*Porphyrio porphyrio*), and Red-crested Pochard (*Rhodonessa rufina*). Some of these birds were photographed and presented in Figure 11 and 12. These are primarily the migratory birds except Common coot, Lesser Whistling-duck and Purple Swamphen (Figure 13 to 15). Spot-billed Duck (*Anas poecilorhyncha*), and Common Moorhen (*Gallinula chloropus*) were occasionally seen eating submerged hydrophytes and filamentous slimy green algae (Figure 14).

It was also observed that 12 aquatic birds like Bar-headed Goose (*Anser indicus*), Combduck (*Sarkidiornis melanotos*), Common Coot (*Fulica atra*), Common moorhen (*Gallinula chloropus*), Common Pochard (*Aythya ferina*), Graylag Goose (*Anser anser*), Northern Shoveler (*Anas clypeata*), Purple swamphen (*Porphyrio porphyrio*), Red-crested Pochard (*Rhodonessa rufina*), Spot-billed Duck (*Anas poecilorhyncha*), Intermediate Egret (*Mesophoyx intermedia*), and Grey Heron (*Ardea cinerea*) (Photo-plate 13) foraged in early as well as late winter agriculture crops like paddy, wheat, mustard, pigeon pea, gram, green pea, sunflower, barley, sorghum and lentil in the neighboring agriculture fields.



**Figure 16.** Incidence of Plant Eating aquatic birds in different winter months.

During the study periods of three years (2009-2012) average total number of plant eating aquatic birds in the Sanctuary increased from October to December and then kept declining until March. December population was 51,000 distributed among migratory and resident population to the tune of 70% and 30 %, respectively. However, Common Teal had the highest number (13474) and Greylag Goose the lowest (657). Monthly distribution of plant eating bird population and relative

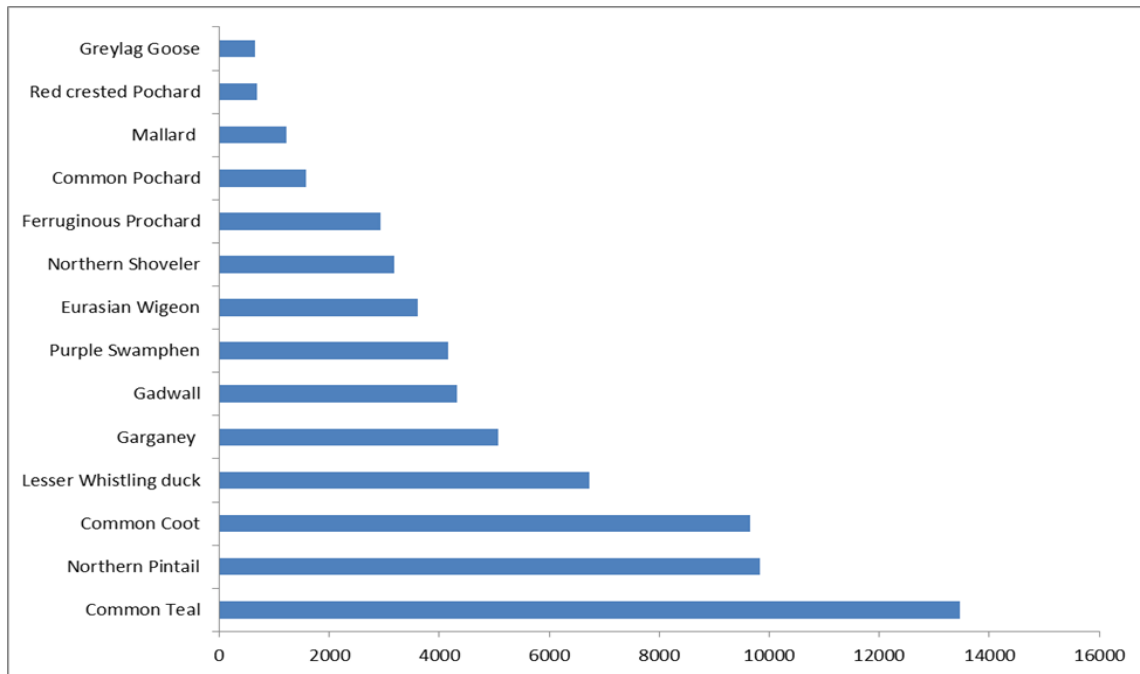
distribution of the numbers of individuals are depicted in Figure 16 and Figure 17, respectively.

## DISCUSSION

Generally the ideal wetlands have all forms of vegetation depending on the depth of the water body. It is composed of marshy, swampy, floating anchored, free floating and submerged plants as the depth progresses. The food plants in the present case also represented all these classes of vegetation which catered for different types of birds like waders, dabblers and divers indicating the suitability of the habitat for avian flora. Further, the phenology of the food plants species i.e., production of soft vegetative tissue, flowering, fruiting and seeding period matched with the rise and fall of winter. Maximum species produced food during peak winter months and this number started declining with departure of winter or rising temperature. This was very well synchronized with the arrival and departure of large number of migratory and resident birds in the wetland. High diversity and abundance of avian flora indicated intensive use of the wetland which was due to structural diversity of vegetation provided by broadleaved species and tall grasses (Mitsch and Gosselink, 1986). Rahmani *et al.*, (2010) had also observed that this Sanctuary retains all the essential characteristics of an ideal water bird habitat and attracts more than fifty thousand aquatic birds in the winter.

More than two and a half dozen of plant species were preferred by around a dozen of aquatic birds narrated in the previous section appears to be a reasonable database since intensive but not extensive survey of literature suggested that previous report on the subject is scanty. *Vallisneria* sp. and *Hydrilla verticillata* were being used by 5-7 waterfowl species (Folker, 1987 in Perry and Deller, 1996). Greylag Goose and Bar-headed Goose were reported to eat 14 and 7 species, respectively (Middleton, 1992). Some of the species common to the study site were *Ceratophyllum demersum*, *Eleocharis palustris*, *Ipomoea aquatica*, *Nymphoides cristatum*, *Oryza rufipogon* and *Spirodela polyrhiza*.

Arrival of aquatic birds, plant eating birds inclusive, in the Sanctuary in October and increase in the number of species and individuals up to December-January was consistent with earlier findings (Gadhvi, 2007; Mohan and Gaur, 2008). Further observation that migratory birds were coming in larger numbers in succession to add to the avian population was in agreement with previous records (Mukherjee *et al.*, 2002; Mohan and Gaur, 2008). All the bird species and aquatic birds exclusively, both arrived in UP wetlands in October and their number kept increasing until January end. This was consistent with earlier reporting that highest number of birds was recorded in the month of January along with highest diversity in the species (Gadhvi, 2007; Mohan and Gaur, 2008). After the peak population in the end of December it started declining through March with important observation of migratory fowls taking off in larger flocks. This was due to rise in temperature and reduction in availability of food (*Personal observation*). There are



**Figure. 17.** Relative population of vegetation eating aquatic birds at the time of high incidence

many annual aquatic avian food plants that complete their life cycle during winter (Mishra and Narain, 2010) and dry up resulting in food shortage. In the beginning of the winter season, November, when migratory waterfowl start arriving from their breeding grounds there is abundant food availability, which starts declining after January when they also start moving to other suitable wetlands (Rahmani *et al.*, 2010; Yardi *et al.*, 2007). Foraging by aquatic birds outside the wetland in agriculture area in general was reported earlier (Mukherjee *et al.*, 2002; Urfi, 2003), and soybean (Twedt *et al.*, 1998) sorghum (Rahmani and Shobrak, 1992) and rice (Lane and Fujioka, 1996) in particular. Common Coot, Northern Pintail, Eurasian Wigeon, and Common Teal were earlier reported feeding on sorghum (Rahmani and Shobrak, 1992).

### **Management Implication**

Maintaining a diverse plant community is beneficial to migrating and wintering water birds (Benedict and Hepp, 2000). Vegetation and open water ratio play an important role in marsh utilization (Duffield, 1986). Fifty percent vegetation cover and fifty percent open water is the ideal condition for supporting maximum bird richness and abundance (Smith *et al.*, 2004). However, without taking these findings in account there is a general practice of removing aquatic plants/weeds from the Bird Sanctuaries for habitat management and other wetlands for commercial or domestic use, at least in UP. This practice leads to reduction in food availability for the aquatic birds and hence possible reduction in avian diversity. It is suggested that food plants removal must be done judiciously keeping in view the bird load in particular wetland; otherwise for want of optimum carrying capacity of the wetland birds may get diverted to the neighboring agriculture field affecting the productivity of the crop adversely or they might stop landing in the wetland in future. Perry and Deller (1996)

also reviewed that decline in areal cover of submerged vegetation shifted the distribution of swan and geese from shallow water areas to upland agricultural areas.

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