

Floral-faunal mutualism and its role in sustenance of the Upper Ganga Ramsar Site in Uttar Pradesh, India

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ABSTRACT

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Mutual interaction between the floral and faunal components of the Upper Ganga Ramsar Site in Uttar Pradesh, the only riverine Ramsar site in India, is studied in terms of the aquatic food chain involving aquatic flora and fauna and their impact on birds. Ample availability of food resources is key to the success of birds' migration into wetlands. Abundance of food resource plants in the form of 29 plant species under 20 families in this Ramsar site was pivotal in establishing co-existence between floral and faunal components and served as the driving force for birds' ingress and sustenance of the Ramsar site on the whole.

Key-words: Birds, mutualism, wetland, Upper Ganga Ramsar Site, Uttar Pradesh, India.

INTRODUCTION

Wetlands, including rivers, lakes, ponds and other water reservoirs either natural or artificial, occupy about 4% of the earth's ice-free land surface and play an important role in maintaining the hydrological cycle (Prigent et al. 2001). Wetlands are the most productive ecosystems of the world and are potential sources of carbon sequestration. They also provide the most precious life-sustaining water resources. In spite of their multifarious ecological benefits, the wetlands are becoming inadvertent victims of modernization, developmental activities and population pressure. In this view, a concerted effort is focused recently all over the world to conserve and preserve these natural resources in order to avert the unremitting losses through water depletion. The Ramsar Convention for conservation and

prudent use of all wetlands for achieving sustainable development was therefore developed in 1971 at Ramsar, Iran and India became a contracting party of this on 1st Feb, 1982 with six wetlands covering 1,92,973 ha area as internationally important (Sarkar 2011). The Upper Ganga Ramsar Site in Uttar Pradesh, India was included in this on 8th November 2005 as the only riverine Ramsar site of India (Murthy et al. 2013).

The Upper Ganga Ramsar Site is 85 km long stretch of the holy river Ganga, extending from Brijghat in Ghaziabad district to Narora in Bulandshahar district. This was declared as Ramsar site owing to its compliance of criteria 2 and 5 of the Ramsar Convention under which it supports threatened ecological communities such as the endangered river dolphins

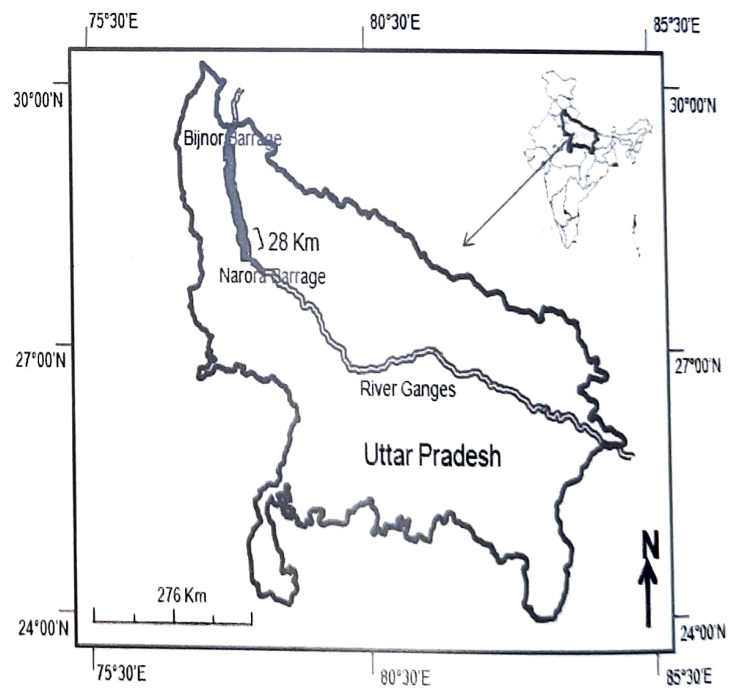
(*Platanista gangetica* subsp. *gangetica*), common otters (*Lutra lutra*), crocodiles (*Gavialis gangeticus* and *Crocodylus palustris*) and six species of endangered turtles including the Indian soft-shell turtle (*Aspideretes gangeticus*) and its avifauna includes more than 100 species of birds (Murthy et al. 2013). Fish fauna of this Ramsar site forms the largest group of living natural resources with fishes like *Wallago attu*, *Chela laubuca*, *Colisa fasciatus*, *Chandra ranga*, *Glossogobius giuris*, *Nangra punctata*, *Puntius sophore*, etc. Sustenance of the Ramsar site therefore, has direct bearing with conservation and perpetuation of its endangered fauna along with its avifauna, which in turn, depends on availability of nutritional resources in the form of aquatic herbs, fishes, frogs, snails, arthropods and other faunal forms (Jha 2013). These life forms therefore, constitute integral components of the wetland ecosystem, having key role in maintaining the wetland equilibrium. Any threat to their existence is likely to result in imbalance of the food chain, detrimental to the operational mutualism between the wetland floral and faunal components and eventually, to the very sustenance of the Ramsar site (Chinnadurai et al. 2006, Panigrahi et al. 2012). Habitat shrinkage resulting from climatic perturbations or anthropogenic interferences is most detrimental for rare and endangered species and may even event in their extinction. Diminished food resource availability, either floral or faunal, is deleterious for stability of the food chain which depends on mutualism between floral and faunal elements.

While assessing the floral constituents of the Upper Ganga Ramsar Site, it was felt necessary to establish the interdependence of the floral components with the faunal, as their coexistence reflected a definite path of energy flow which maintains equilibrium within all living beings coexisting within the precincts of this Ramsar site. Present studies were therefore made to portray

floral-faunal mutualism and its implications in sustenance of the Ramsar site.

MATERIAL AND METHODS

The river stretch of 85 km, from Brijghat in Ghaziabad district to Narora in Bulandshahar district (Text-figure 1), covers 26,590 ha area along its banks and is the only riverine Ramsar site in India. These plains lie between latitudes 28°10'26"N and 28°47'18"N and between longitudes 77°07'04"E and 78°25'57"E and have a perimeter of 167 km. The entire region is infiltrated with diverse life forms, both floral and faunal. Due to the presence of riverine islands, the open-water spread is about 50% of the wetland with an observed reduction from 5584 ha in post-monsoon to 5373 ha in the pre-monsoon with rich wetland vegetation. The entire expanse covers four districts, viz. Ghaziabad, Bulandshahar, Badaun and Moradabad. It was pronounced as Ramsar site in 2005 due to its bird



Text-figure 1. Map showing Upper Ganga Ramsar Site in Uttar Pradesh, India with 28 km dolphin sanctuary near Narora.

Plate 1

General view and various birds in the Upper Ganga Ramsar Site in Uttar Pradesh, India. A-B. Islands in winter and summer seasons. C. White throated kingfisher (*Halcyon smyrnensis*). D. Ruddy shelducks (*Tadorna ferruginea*). E. Pair of Sarus crane. F. Little cormorants (*Phalacrocorax sulcirostris*). G-H. Asian openbill stork (*Anastomus oscitans*) and little and large intermediate egrets. I-J. Purple moorhens (*Porphyrio porphyrio*).

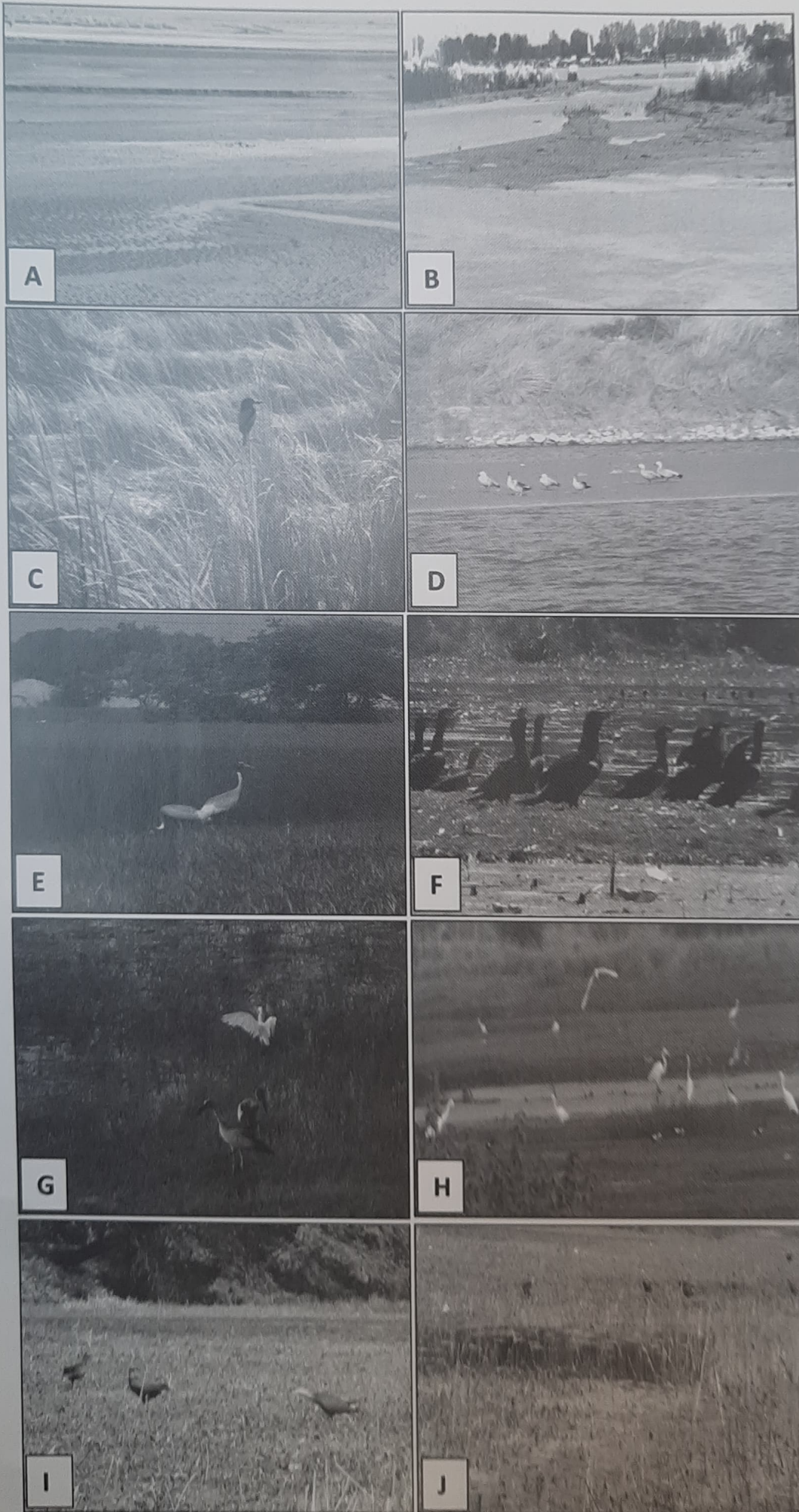


Plate 1

strength of more than 20,000 water birds, and occurrence of threatened ecological communities within its precincts.

Surveys were made to the Upper Ganga Ramsar Site regions for field studies and plant collections covering different seasons from 2012-2014. The summer, monsoon and winter seasonal variations of water influx into the rain fed wetlands were recorded. Healthy and complete plant specimens were collected, their field data were recorded and the specimens were brought to lab, dried, pressed and mounted following the standard herbarium techniques (Jain & Rao 1977) and identified with the help of relevant floras like Duthie (1903-1929), Cook (1996), Hooker (1872-1897), etc. Behavioural and sighting patterns of the gangetic river Dolphin was assessed (Garg et al. 2013) with the help of local inhabitants and personnel of World Wildlife Fund (WWF). The faunal elements and bird species within the region were also assessed and estimated with the help of forest department officials, Narora Atomic Power Station personnel and indigenous people.

OBSERVATION AND RESULTS

The direct catchments of Upper Ganga Ramsar Site including 12 km buffer area is spread over 2,54,482 ha. There are about 130 wetlands of shallow intermittent deep-water pools. Air and water temperature ranges here from 11.5–35.5°C and 15.6–30.2°C respectively. The bird influx was maximum during winter month from September to February with many different species concentrated in the region. The gangetic river Dolphins could be sighted mainly during December, while other faunal elements arthropods, snails, frogs, many insects and fishes were omnipresent throughout the year.

Seasonal variations in avifauna: During winter and summer, when water level in the river is low (Plate 1, figures A-B), a large number of islands appear all along the course of the river Ganga. These small

temporary islands and sand bars formed due to decreased water level, provide ideal habitats for summer breeding species such as the Indian Skimmer, River Tern (*Sterna aurantia*), Black-bellied Tern (*S. acuticauda*), Spur-winged Plover or River Lapwing (*Vanellus duvaucelii* and *Pratincoles glareola*). As many as 120 species of birds have been identified in and around the Narora reservoir during summers and in winters (Rahmani 1981). Thousands of waterfowls especially the diving ducks are seen in the main reservoir along with flocks of several thousand Common Pochards (*Aythya farina*), Red-crested Pochard (*Rhodonessa rufina*), Tufted Pochard (*Aythya fuligula*) and White-eyed Pochard or Ferruginous Duck (*Aythya nyroca*), Little and Large intermediate egrets, Little cormorants (*Phalacrocorax sulcirostris*), Purple moorhens (*Porphyrio porphyrio*) and sometimes white throated kingfisher (*Halcyon smyrnensis*), pure flocks of Red-crested Pochards and Ruddy shelducks (*Tadorna ferruginea*) and rarely one or two pairs of Sarus cranes, few Asian openbill storks (*Anastomus oscitans*) are found which portrays a rare site of such bird congregation in India (Plate 1).

Floristic elements: The Upper Ganga Ramsar Site was endowed with a rich floristic constitution of about 450 plant species including the aquatic, terrestrial and wetland plants (Plate 2). All these contributed in constructing a rich biodiversity zone of the Ramsar site impregnated with two sacred groves (Garg & Singh 2013a, b) and a sacred site in forest pockets along the banks of the holy river. Among these, a total number of 29 hydrophytic plant species of all forms, viz. the submerged, anchored, floating, etc. under 20 families (Text-figures 2, 3) were recorded as food resource plants for birds. These plants were useful due to their differential maturation time of flowering, fruiting and seed production, which was an important aspect in maintenance of continuous supply of nutritional resources to the faunal components round the year.

Plate 2

Floristic constituents of the Upper Ganga Ramsar Site in Uttar Pradesh, India. A. *Pistia stratiotes* L. B. *Ipomoea carnea* Jacq. C. *Eichhornia crassipes* (Mart.) Solms. D. *Trapa natans* L. E. *Ceratophyllum demersum* L. F. *Neptunia oleracea* Lour. G. *Ludwigia adscendens* (L.) Hara. H. *Nymphaea nouchali* Burm. f. I. *Nelumbo nucifera* Gaertn.

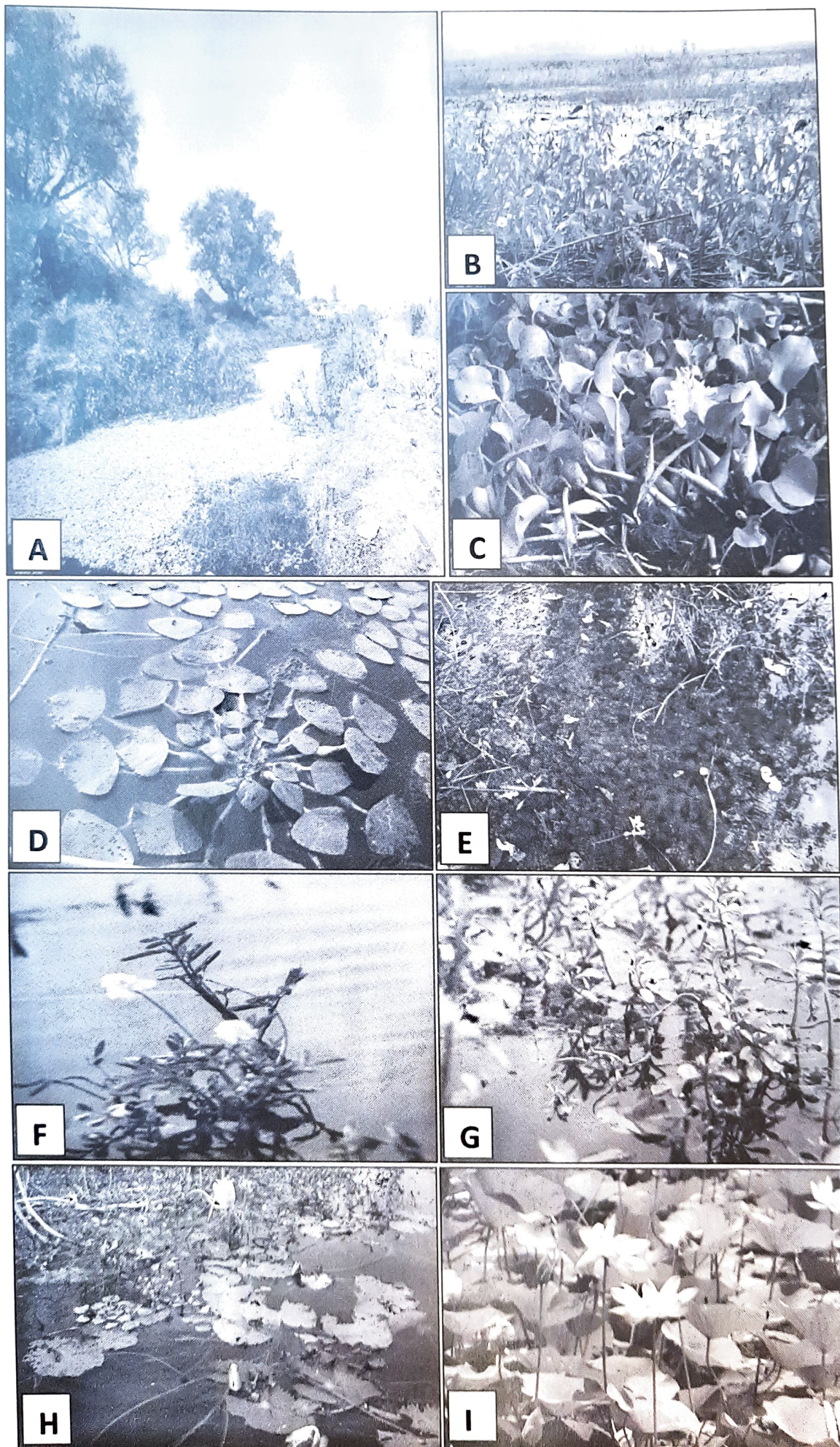
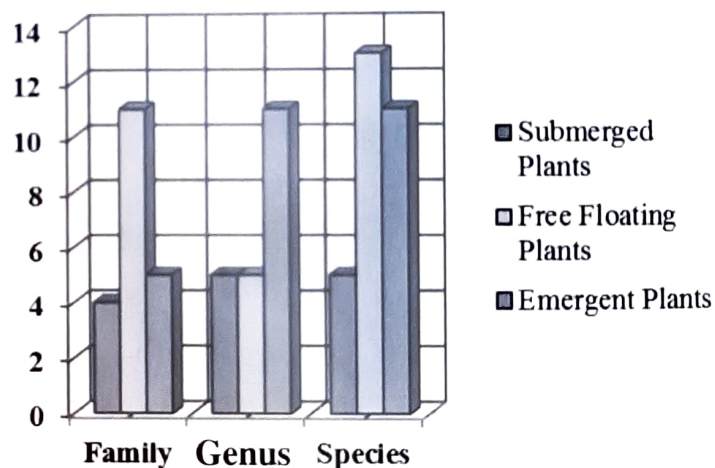


Plate 2

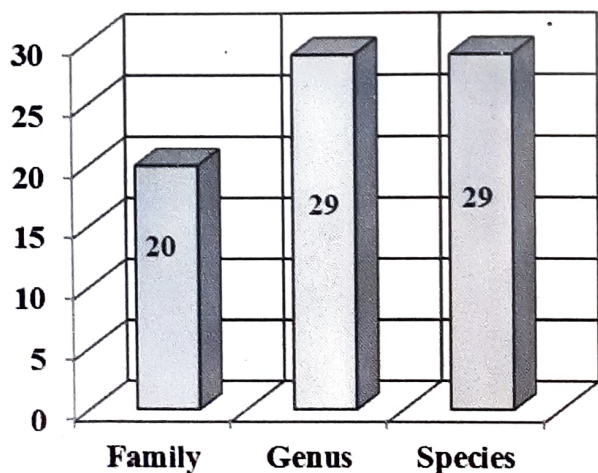
Food chain: The food chain in riverine wetland regions originates from aquatic plants as primary producers and is maintained at all trophic levels. The soft vegetative tissues of aquatic plants provide sufficient dietary supplements to primary consumers while their leaves, flowers, fruits and seeds are recurrent food resources of birds in different seasons (Tucker & Sellers 1986). The secondary consumers, mainly birds, small insects and herbivores, regularly feed on plants while the tertiary consumers, mainly carnivores and omnivores, feed on herbivores, insects as well as some birds. Herbaceous plants therefore, served as most useful components in maintaining the energy pathway in this ecosystem as they trap solar energy and convert into chemical, at the base of the food chain (Text-figure 4). The plants and plant parts of each resource species, preferred as food by the faunal community, mainly birds, are shown in (Table 1). It was also evidenced that the site of occurrence of these food resources coincided with the congregation of birds in the same area of the wetland, within the precincts of the Ramsar expanse. These species included, the 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*) (Islam & Rahmani

2008). Majority of these birds were observed pecking on small insects and other invertebrates, both in core wetland zones as well as in adjacent agricultural field, however, some were found confined around aquatic plant species, few others ventured to feed in agriculture fields growing in vicinity.

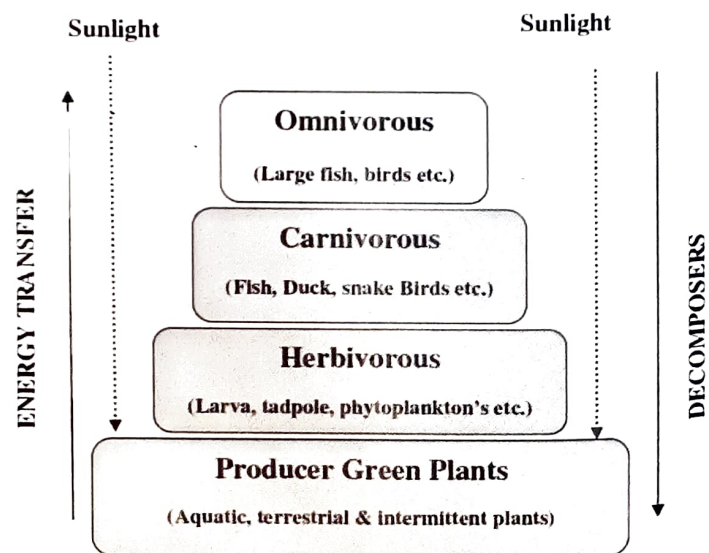
Uninterrupted food resource availability acts as key to successful operation of the wetland food chain and energy flow from producers to consumers. A number of similar food chains operate simultaneously in an integrated way and event in construction of food web, with aquatic plants and phytoplanktons at the base. With a definite role of each plant, animal and bird, a dynamic equilibrium is sustained in the entire wetland ecosystem through this biological cycle which becomes a repository



Text-figure 3. Aquatic food resource plants of birds in the Nawabgunj bird sanctuary



Text-figure 2. Number of taxa of birds' food resource plants



Text-figure 4. Floral-faunal mutualism depicted through natural food chain in the Upper Ganga Ramsar Site

Table 1. Aquatic plants and their respective parts consumed by birds as food resources.

S. No	Species (Family) – Common name	Habit, Habitat	Flowering-Fruiting	Plant part/s eaten by birds and other aquatic animals
Floating hydrophytes				
1.	<i>Azolla pinnata</i> R.Br. (Azollaceae) - Bhoori kai	Free floating herb; in rice fields, canals and ponds.	-	Whole plant eaten by Gadwall, Shoveller, Pintail and Mallard birds.
2.	<i>Eichornia crassipes</i> (Mart.) Solms (Pontederiaceae) - Jalkumbhi	Free floating stoloniferous herb; in rivers, lakes and ponds	May-Oct.	Soft tissue of swollen petiole consumed by Purple swamphen and Lesser whistling-duck.
3.	<i>Ludwigia adscendens</i> (L.) Hara (Onagraceae) - Gahdi	Floating herb with gas filled spongy spindle shaped pneumatophores; in wet swampy places.	Sept.-Jan.	Roots and stem eaten by Common coot, Common teal, Gadwall, Eurasian wigeon, Northern pintail, Northern shoveler and Purple swamphen.
4.	<i>Lemna perpusilla</i> Torr. (Lemnaceae) - Hari Kai	Fronds floating flattened herb; near rice fields in sluggish canals and ditches.	Oct.-Dec.	Leaves eaten by Northern shoveler and Mallard.
5.	<i>Pistia stratiotes</i> L. (Araceae) - Pistia	Free floating rosette herbs with emergent leaves; near lagoons, tank and rice fields.	July-Nov.	Young leaves eaten by Common coots.
6.	<i>Spirodela polyrhiza</i> (L.) Schleid. (Lemnaceae) - Hari kai	Fronde floating gibbous herbs; on water surface of lakes and large tanks.	Sept.-Dec.	Entire plant eaten by water birds.
7.	<i>Trapa natans</i> L. (Trapaceae) - Singhara	Floating herb with submerged roots; in slow flowing water.	Sept.-Dec.	Fruit pulp eaten by Common coot and Purple swamphen.
8.	<i>Wolffia globosa</i> (Roxb.) Hartog and Plas (Lemnaceae) - Jaljanjal	Fronde floating at or just below the surface of water; in pond and lakes.	Oct.-Feb.	Whole plant eaten by Shoveller.
9.	<i>Nelumbo nucifera</i> Gaertn. (Nelumbonaceae) - Kamalgatta	Anchored herb with floating or emergent leaves; in lakes and water reservoirs.	June - Oct.	Fruits and seeds eaten by birds. Seeds mostly eaten by Common coot and Ferruginous Pochard.
10.	<i>Neptunia oleracea</i> Lour. (Mimosaceae) - Lajalu	Free floating herb; in Shallow or moderately deep water level with spongy white tissue developed from nodes.	July -Nov.	Fruits, nodes and roots eaten by Whistling teal, Coot, Pintail and Gadwal
11.	<i>Nymphaea pubescens</i> Willd. (Nymphaeaceae) - Koka	Leaf blades mostly floating with submerged rhizome; in shallow and permanent water.	Oct.-Dec.	Tuber, anther and seeds eaten by majority of water birds.
12.	<i>Nymphoides indicum</i> (L.) Kuntze (Gentianaceae) - Barachuli.	Floating leaves with rhizome bearing scars and scaly leaves; in fresh and brackish water.	April- Dec.	Flowers and fruits favoured food of migratory birds.
13.	<i>Ipomoea aquatica</i> Forssk. (Convolvulaceae) – Nari.	Stem floating and swollen. Common; in floating and stagnant water of canals, ditches.	July-Nov.	Root bud and seeds consumed by water birds.
Submerged hydrophytes				
14.	<i>Ceratophyllum demersum</i> L. (Ceratophyllaceae) - Khaja chhoti	Submerged, free swimming and rootless; in eutrophic water.	March- June.	Seed and leaves favoured by migratory birds (Gadwall mallard), moles and other small wild animals.
15.	<i>Hydrilla verticillata</i> (L.f.) Royle (Hydrocharitaceae) - Sewar	Submerged with unbranched root and elongated stem; common in still or slowly flowing water.	July-Dec.	Flowers and seeds eaten by ducks.
16.	<i>Najas graminea</i> Delile (Najadaceae) - Katia	Submerged herb look like feather due to closely packed leaves; abundant in standing fresh or brackish water.	Sept.- Dec.	Stem, leaves, fruits and seeds eaten by all water ducks.
17.	<i>Potamogeton nodosus</i> Poir. (Potamogetonaceae)	Submerged, leaves with rhizome and terete stem having swollen nodes; in flowing water.	Nov.-March	Root, stem, fruits and seeds eaten by water birds and turtles.
18.	<i>Vallisneria spiralis</i> L. (Hydrocharitaceae) - Feeta ghas	Submerged, leaves with unbranched root and contracted or elongated stem; common in ditches and channels.	Jan.-April	Leaves and seeds eaten by Common coot, Common teal, Gadwall, Lesser whistling-duck, Northern shoveler, Northern pintail and Red-crested Pochard.
Emergent hydrophytes				
19.	<i>Alloteropsis cimicina</i> (L.) Stapf. (Poaceae) - Alloteropsis	Erect culms having hairy nodes; common in paddy fields.	July-Oct.	Flowers and seeds eaten by Northern pintail,
20.	<i>Arundo donax</i> L. (Poaceae) - Balehra	Erect culms with knotty, creeping rhizome; in standing water along ditches and canals.	Sept.- Nov.	Seeds eaten by Common teal, Gargany and Purple swamphen.
21.	<i>Chloris barbata</i> Sw. (Poaceae) - Chloris	Ascending or erect culms with narrowly acuminate leaves; in marshy places.	July- Nov.	Seeds eaten by Common teal, Northern pintail, Gadwall and Eurasian wigeon.
22.	<i>Commelina harsskarlii</i> C.B. Clarke (Commelinaceae) - Oona	Erect slender herbs, rooting from nodes; common in moist places, semi dried drains and along river banks.	Nov.-Jan.	Roots and fruits eaten by Eurasian wigeon, Common coot, Greylag goose and Purple swamphen.
23.	<i>Cyperus alopecuroides</i> Rottb. (Cyperaceae) Motha	Culm robust and tufted, with short rhizome; common near standing waters of tanks, pools and lakes.	August-Nov.	Stem, roots and seeds eaten by marshy birds
24.	<i>Echinochloa stagnina</i> (Retz.) P. Beauv. (Poaceae) - Shama	Culm and rhizome spongy when in water; common in wet places along tanks, ditches and canals.	July-Nov.	Seeds eaten by Common teal.

Table 1 (Continued).

S. No	Species (Family) – Common name	Habit, Habitat	Flowering-Fruiting	Plant part/s eaten by birds and other aquatic animals
25.	<i>Eleocharis dulcis</i> (Burm.f.) Hensch. (Cyperaceae) - Narai	Culm tufted, erect and stolons present in tuber forms; common in gregarious shallow water of ponds and along irrigation canals.	Sept.-Jan.	Tubers and nodes eaten by Purple moorhen, Wigeon and other water birds, and moles.
26.	<i>Oryza rufipogon</i> Griff. (Poaceae) - Janglidhan	Culm decumbent and floating or ascending emergent to erect, stoloniferous; common in water forming floating mat in marshy places.	July-Nov.	Seeds eaten by Red crested Pochard, Pintail shoveller and Common teal
27.	<i>Polygonum limbatum</i> Meisn. (Polygonaceae) - Nandi bhaji	Erect, stout, hairy herbs; along margins of ponds, nullahs and lakes.	Sept.- June.	Seed and buds liked by resident as well as migratory birds, also liked by moles.
28.	<i>Scirpus articulatus</i> L. (Cyperaceae) - Chichora	Erect, densely hairy herb; in paddy fields, pond and ditches.	Oct.-March	Seeds eaten by Purple swamphen.
29.	<i>Typha angustifolia</i> L. (Typhaceae) - Patera	Robust rhizome with aerial shoot having spongy arechyma; common in fresh and brackish water of marshes & pools.	Throughout the year	New soft shoot eaten by Purple swamphen

of all respective constituents interlinked and interdependent on each other. This integrated floral-faunal mutualism is key to survival of interdependent plants, insects and other invertebrates, fishes, amphibians, reptiles, birds and mammals (Mitsch & Gosselink 1986) (Plates 1, 2). In the light of these facts, any wetland management strategies adopted should essentially be oriented in such a manner so as to conserve the wetlands in terms of their floral and faunal riches without obliterating the habitat of flora and fauna mainly the nutritional plant resources of fauna (Table 1) so that their interdependence is not plugged at any trophic level and uninterrupted food chain is sustained in nature without hampering energy flow from producers to consumers.

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