



Resource Production and Consumption System: Focus on Wetland biodiversity of Uttar Pradesh

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Introduction

The text presented here is a review article based on some of the works of first author on aquatic systems of Uttar Pradesh (UP) and relevant literature accessible to the authors. This produces a brief account of wetlands in UP and some important biodiversity found in and around the protected wetlands under management of the Forest Department. The biodiversity is grouped into resource producer and resource consumer components. They are further presented in specific categories depending on their closeness. This presentation in its completeness lacks many links due to paucity of knowledge, however, gives overall biodiversity scene in interdependence concept of the components in an aquatic ecosystem in the form of ecological profile and food web, avian, reptilian and piscine fauna and hydrophytic flora of freshwater marshes commonly found in UP. The pictorial presentations of the ecological concepts have been produced by the second author.

Long regarded as wastelands, wetlands are today recognized as important features in the landscape that provide numerous beneficial services. Some of these services, or functions, include protecting and improving water quality, providing fish and wildlife habitats, storing floodwaters, and maintaining surface water flow during dry periods. These

beneficial services, considered valuable to societies worldwide, are the result of the inherent and unique natural characteristics of wetlands. Uttar Pradesh (UP) is endowed with such natural resource in plenty. Latest report of RSAC (2009) records that UP has 1145178 ha area (4.8% of its geographical area) as wetlands. This excludes smaller wetlands (<2.25 ha), actually the tanks, numbering 97,352. The major wetlands are categorized into lakes/ponds (1,22,531 ha), oxbow lakes/cutoff meanders (51,371 ha), riverine wetlands (61,100 ha), waterlogged (1,63,957 ha), river stream (6,07,315 ha), reservoirs/barrages (1,05,641 ha) and tanks/ponds (33,263 ha).

Frequently encountered definition of wetland is a land where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Wetlands are the transitional zones that occupy intermediate position between land and open water. They are one of the most productive ecosystems and rank with the tropical rain forests (Cross and Vohs 1998). Their productivity lies in the nature of biodiversity they harbor and the frequency of transfer of energy from one to another organism. However, the productivity, rather existence of wetlands is under threat due to several anthropogenic activities like, excess withdrawal of water resources for irrigation, non-judicial use of fertilizer, insecticides and pesticides, drainage



Fig.1 : Map of Uttar Pradesh showing different protected wetlands in four different ecozones, namely Tarai plain (Green), Gangetic Plain (Yellow), Semi Arid Plain (Pink) and Vindhyan Bundelkhand region (Brown).

of polluting agents, conversion of the site for various other land uses, etc (Rahmani *et al.* 2011).

Some of the wetlands of UP, very important from ecological point of view, have legal protection under Wildlife (Protection) Act, 1972. Present review is based primarily on the works in such wetlands (details given in Figure 1 and Table 1) scattered in different ecological zones of the state and relevant literature on the subject.

Components of wetland based biodiversity

The wetlands are characterized by lush growth of hydrophytes with plenty of vertebrates and invertebrates, maintaining the producers and consumers relationship. However, direct con-

sumption of wetland plants is relatively low. Selectively seeds, soft stem or leaf tissue and tubers or roots of selected plants are eaten by the invertebrates, fish and avian flora, therefore, major part of the vegetation becomes detritus. This forms one of the several important substrates and energy sources for wetland invertebrates that in turn provide forage for vertebrates such as fishes, waterfowl, shorebirds and wading birds (Cross and Vohs 1998). These elements form the resource producing and resource consuming components of the wetlands. Schematic representation of the producers and consumers is given in Fig. 2.

Resource production components

In simple scientific terms, the resource



Table 1. Protected Wetlands (Study sites) of Uttar Pradesh

Wetlands/ Sanctuary	Coordinates (00° 00' 00")	Ecozone	Rainfall (mm) and temperature (°C)	Threats and conservation issues
Bakhira	26 34 60 N 83 00 00 E	Tarai plain	800-1000 4-48	Drainage, Grazing, Poaching, Illegal fishing, Pesticide inflow, Private holdings
Lakh Bahosi	27 30 00 N 79 30 00 E	Gangetic (central) plain	ca 900 4-40	Grazing, Fisheries, Grass collection
Nawabganj	26 34 60 N 80 40 00 E	Gangetic (central) plain	<1000 01-48	Unwanted trees and weeds, Siltation, Pesticide inflow, Disturbance to birds
Okhla	28 33 00 N 77 17 60 E	Semi-arid plain	660-670 4-46	Disturbance to birds, Poaching, Water pollution, Encroachment, Cultivation, Fishing
Parvati Arga	27 25 00 N 82 19 00 E	Tarai plain	827 4-48	Fishing, Drainage, Pesticide inflow
Patna	27 34 60 N 78 45 00 E	Gangetic (western) plain	800-1000 4-48	Plantation, Tourists and boating, Invasive species, Trapa cultivation
Saman	27 04 60 N 79 00 00 E	Gangetic (western) plain	880 01-48	Invasive species. Illegal bird trapping, Agriculture and pesticide, Private holding
Samaspur	26 00 00 N 81 25 00 E	Gangetic (central) plain	850 4-48	Fishing, Drainage, Livestock grazing, Siltation, Pesticide inflow
Sandi	27 15 00 N 79 55 00 E	Gangetic (central) plain	830 4-40	Poaching, Grazing, Fishing, Encroachment
Sur Sarovar	27 00 00 N 77 45 00 E	Semi-arid plain	>600 2-48	Drainage, Grazing, firewood collection, Siltation, Eutrophication
Surha Taal	25 45 00 N 84 19 60 E	Gangetic (eastern) plain	>1000 4-40	Uncontrolled fishing, Drainage for irrigation, weed infestation, excessive exploitation
Vijai Sagar	25 15 78 N 79 68 20 E	Bundelkhand plain	<1000 5-47	Poaching, Fishing and Weed infestation

production components of the biodiversity are the primary producers, which can be defined as the living organisms involved in generating the resources which are consumed, fully or partially, by the other organisms dependent on them. e.g, plants of different types that manufacture carbohydrates from carbon and water as a result of physiological process. In aquatic systems, phytoplanktons also produce the food resource. Different categories of resource

producers of a wetland for this text with suitable examples are narrated in following subheads:

Phytoplanktons

They are the wandering or drifting plants visible only by aided eye, except for discolouration of water when present in large enough numbers. Like other plants they also contain chlorophyll and convert

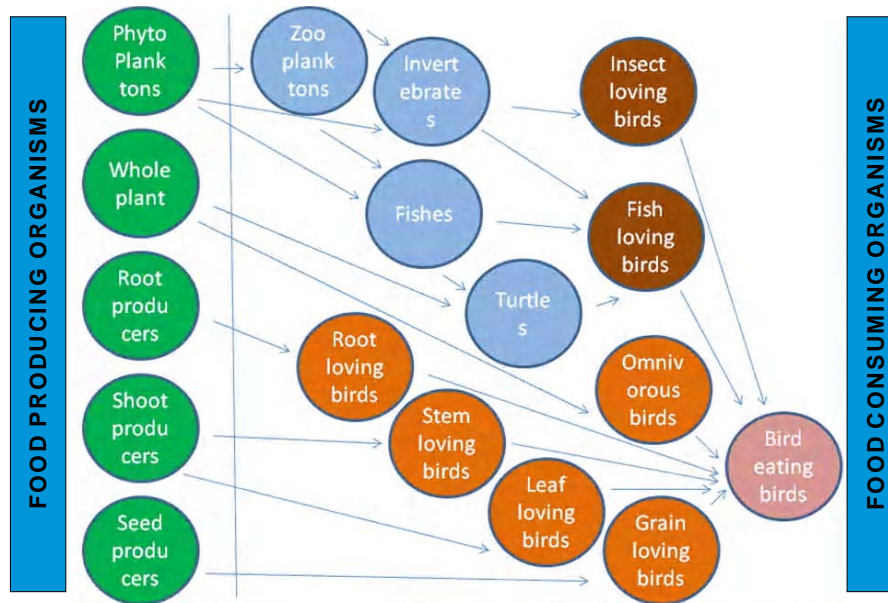


Fig. 2 : Resource linked compartments in a wetland. A circle represents specific group of diversity and the arrow its dependence on the others in a producer and consumer system.

carbon dioxide and water to carbohydrates or chemical energy. Some phytoplanktons are bacteria, some are protists, and most are single celled plants. Among the common kinds are cyanobacteria, silica encased diatoms, dinoflagellates, green algae, and chalk coated coccolithophores. Phytoplanktons are present in both fresh water and sea water. Phytoplanktons need to have access to sunlight to photosynthesize, hence are found near the surface of water. They are consumed generally by zooplanktons.

Zooplanktons

Zooplanktons are of animal origin. They mainly comprise of protozoa, rotifers, and two subclasses of crustacean the cladocerans, copepods and their larval forms. Protozoans generally feed on bacteria- sized particles and detritus. They play their role in the aquatic foodweb as a resource for consumers on higher trophic levels. For zooplankton to have access to their food source, they need to be located near the

phytoplankton (mostly surface of water). They are usually suspended in water with limited powers of locomotion. They are denser than water and sink by gravity to lower depths.

Vegetation

Vegetation is important to water birds for producing seeds, tubers and browse; providing nest sites; and serving as substrates for animal food. Both the types of plants, lower and higher, are recorded in wetlands of Uttar Pradesh. Some of the notable contributions are from Jha (2010), Mishra and Narain (2010), Saini *et al* (2010), Agnihotri *et al* (2008) etc. The aquatic plants have varied features (of floating, suspended, submerged, anchored, emergent, and otherwise nature) and therefore classified differently from ecological point of view. As suggested by Mishra and Narain (2010) plants of the wetlands can be grouped ecologically as below:

- I. Free floating hydrophytes: *Azolla pinnata*, *Lemna*



Fig. 3 Left to right : (top) *Ipomea aquatica*, *Cyperus sp* *Nelumbo nucifera*. (Centre) *Ceratophyllum demersum*, *Najas graminea*, *Eleocharis dulcis* (bottom) *Trapa natans*, *Bymphoides sp.* water meal

- minor*, *Spirodella polyrhiza*, *Wolfia globosa*, *Trapa natans*, etc.
- II. Suspended hydrophytes: *Ceratophyllum demersum*, etc.
- III. Submerged anchored hydrophytes: *Hydrilla verticillata*, *Najas graminea*, *Najas minor*, *Potamogeton crispus*, *Potamogeton pectinatus*, *Potamogeton nodosus*, *Vallisneria spiralis*, etc.
- IV. Floating leaved anchored hydrophytes: *Nymphaea nouchali*, *Nymphaea pubescence*, *Nelumbo nucifera*, *Nymphoides hydrophylla*, *Nymphoides indica*, etc.
- V. Floating shoots anchored hydrophytes: *Ipomea*

aquatica, *Jussiaea repens*, *Neptunia oleracia*, etc.

- VI. Emergent amphibious hydrophytes: *Sagittaria cuneata*, *Sagittaria latifolia*, *Sagittaria graminea*, etc.
- VII. Wetland hydrophytes: *Oryza rufipogon*, *Eleocharis acutangula*, *Eleocharis dulcis*, *Cyperus alopecuroides*, *Polygonum barbatum*, *Polygonum limbatum*, *Polygonum glabrum*, *Scirpus*, *Typha angustifolia*, etc.

The producers in the aquatic ecosystem are useful from the viewpoint of the consumers' feed. Some of them provide support to the inhabitants in different ways and many are not useful or of unknown use generally known as weeds. The food producing plants are either consumed as whole plant or some



part of it like, roots, tubers, shoots, nodes, leaves, seeds or fruits. Some very common and useful plants are shown in Figure 3.

Edible whole plant: Generally the free floating small sized lower plants like, *Azolla pinnata*, *Lemna minor*, *Spirodella polyrhiza*, *Wolffia globosa* etc. are consumed as entire plant by the migratory birds for example, shoveller, pintail, mallard etc.

Edible root producing plants: *Cyperus alopecuroides*, *Ipomea aquatica*, *Jussiaea repense*, *Neptunia oleracea*, *Nymphaea nouchali*, *Potamogeton* spp., *Scirpus articulatus*, *Typha angustifolia*, *Vallisneria spiralis*, etc. are the edible root producing plants. The birds like, bar headed goose, whistling duck, shoveler, gadwall etc. are seen to be eating on them.

Edible shoot/node producing plants: *Cyperus alopecuroides*, *Eleocharis dulcis*, *Ipomea aquatica*, *Limnophyton obtusifolium*, *Najas major*, *Nelumbo nucifera*, *Neptunia oleracea*, *Nymphaea nouchali*, *Potamogeton natans*, *Potamogeton amplifolius*, *Typha angustifolia* etc. provide edible shoot fragments or the nodal portion for many birds including pochard, goose, moorhen, wigeon, etc.

Edible fruit/seed producing plants: Seeds and fruits of several aquatic plants like, *Hydrilla verticillata*, *Jussiaea repens*, *Najas graminea*, *Najas minor*, *Nelumbo nucifera*, *Neptunia oleracea*, *Nymphaeoides chordatum*, *Potamogeton natans*, *Trapa natans*, etc. are eaten by migratory and some local birds like, whistling duck, common coot, shoveler, gadwall etc.

Resource consumption components

Invertebrates

Aquatic invertebrates play an important role in the ducks especially the females during breeding season. Most waterfowl hens shift from winter diet of seeds and plant material to a spring diet of mainly invertebrates. The calcareous material of the shells contributes to the calcium need of female fowls (Cross and Vohs 1988). Some of the important invertebrates consumed by the northern pintail, northern shoveler, gadwall, and mallard are the

aquatic earthworms, leeches, fairy shrimp, clam shrimp, water fleas, copepods, seed shrimp, scuds, fresh water shrimp, mayflies, dragonflies, damselflies, true bugs, caddis flies, beetles, flies and midges, and snails.

Fishes

They are a group of consumers of different trophic levels. They eat others (plant and animal both), they eat themselves (big ones eat smaller ones) and they are eaten by others (bigger animals), therefore, they are in trophic levels one and two, both. Around 45 species of freshwater fish are recorded in UP wetlands. Some commonly found fishes of protected wetlands (Figure 4) are cyprinid (*Labeo bata*, *Labeo rohita* etc.), perciformes (*Anabas testudineus*, *Channa marulius* etc.), and siluroid (*Wallago attu*, *Mystus cavacius* etc.). Some socio-commercially important fish of wetlands have following dietary composition:

- i. *Anabas testudineus*– algae and insects.
- ii. *Clarias batrachus*– insects and small fish.
- iii. *Channa marulius*– small fish, frog and detritus.
- iv. *Chitala chitala*– planktons, insects, flies, shrimp, mollusks and small fish.
- v. *Cirrhinus mrigala*– aquatic animals, algae, and aquatic plants.

There are many plant species that play specific role in the life of fish flora as food, shelter and oxygenation of water (Fassett, 2000). Some important examples are as below:

- i. *Ceratophyllum demersum*: good shelter for young fish; which is the prey for big fish, supports insects valuable as fish food
- ii. *Lemna* sp.: poor quality food
- iii. *Wolffia* sp.: good food and cover
- iv. *Najas* sp.: good food producer and shelter



Fig. 4 Fresh water fishes (clockwise from top to left) : *Cirrhinus mrigala*, *Wallago attu*, *Channa punctatus*, *Channa marulius*, not identified, *Anabas testudeni*

- v. *Nymphoides* sp.: excellent shelter and fair food producer
- vi. *Polygonum* sp.: good food and cover
- vii. *Potamogeton* sp.: food and shelter
- viii. *Trapa natans*: poor food producer and shelter

Turtles

They are the consumers of varied orders like first generation consumers, which eat vegetation or

aquatic plants only, one and a half generation consumers that feed on aquatic plants as well as animals, and second-generation consumers which survive on first generation consumers only. As many as fourteen species of fresh water turtles have been found in wetlands of UP (Singh *et al* 2009). They are reported to feed on vegetation, fish etc. They are briefly discussed as below and some of them are shown in Figure 5:

First generation consumers: *Batagur dhongoka*,



Fig. 5 Fresh water turtles (Clockwise from topleft) : *Herdella thurjii*, *Lissemys* sp., *Mornia petresi*, *Geoclemys*, *Lissemys punctata*, *Pangshura tecta*. Photo courtesy : KS Bhadauria and Shailendra Singh. Turtle Survival Alliance

Melanochelys tricarinata, *Pangshura tecta*, and *Hardella thurjii* fall in this category. They eat aquatic or marsh plants, fruits and grasses (Ahmed *et al.* 2009).

One and a half generation consumers: *Lissemys punctata*, *Melanochelys trijuga*, *Pangshura tentoria*, *Pangshura smithii*, *Geoclemys hamiltonii*, *Nilssonina gangeticus*, and *Morenia petresi* belong to this category. These turtles

eat variety of organisms like, tadpoles, fishes, mollusks, aquatic plants, grasses, fruits, birds, insects, and carrions or dead animals (Ahmed *et al.* 2009).

Second generation consumers: *Chitra indica*, and *Nilssonina hurum* can be classified in this group since they consume fishes and mollusks (Ahmed *et al.* 2009).



Birds

Birds are one of the largest consumers in aquatic ecosystems since they are larger in numbers, especially in winter when migratory birds add to the population of local birds. Since the protected wetlands in Uttar Pradesh have tree surroundings, either natural or planted, the variety of birds found near wetland complex are water residing, partly water dependent and tree inhabiting (Rahmani *et al* 2010). These birds consume anything available in or around water body for example, roots, shoots, seeds, of aquatic plants, even whole plant growing in the water body. The birds forage on neighbouring agriculture field also on crops as well as insects. Within the water body different animals like worms, insects, crustaceans, mollusks, small fish etc. are also the major or supplementary food for some of the water dependent birds. Predominantly they are either vegetation dependent or animal feeders or both. However, as a thumb rule, food rich wetland complex could have 41% herbivorous, 37% omnivorous, 15% insectivorous and 7% carnivorous birds in its food pyramid (Ali 2005). Avian floras recorded during winter 2010 in different protected wetlands are categorized for the purpose of this text into wetland inhabiting birds, nonresident wetland birds and wetland independent birds. They are further grouped into different families as per Ali (1964) and Grimmett and Inskipp (2003). A small section on prey birds, raptors, is also included as they were also seen in the wetland vicinity. Predominantly herbivorous and carnivorous birds encountered frequently on UP wetlands are shown in Figure 6 and 7. For detailed information on feeding habit of birds Rahmani and Islam (2008), Fassett (2000) and Islam *et al.* (1999) could be consulted.

Wetland inhabiting birds

- i. **Dendrocygnidae and Anatidae:** They are aquatic and highly gregarious, typically migrating and are represented by *Dendrocygna javanica*; *Sarkidiornis melanotos*, *Anser anser*; *Anser indicus*; *Tadorna ferruginea*; *Tadorna tadorna*, *Anas strepera*; *Anas penelope*; *Anas platyrhynchos*; *Anas poecilorhyncha*, *Nettapus coromandelianus*; *Anas crecca*; *Anas querquedula*; *Anas acuta*; *Anas clypeata*, and *Rhodonessa rufina*; *Aythya nyroca*; *Aythya fuligala*; *Aythya marila*. These ducks are chiefly vegetarian and feed on seeds and vegetative parts of grasses, sedges, and aquatic vegetation. Occasionally food is supplemented by water insects and their larvae, worms and molluscs like water snails etc.
- ii. **Gruidae:** Only one crane, *Grus antigone* was seen around the protected wetland. Being opportunistic feeder or omnivorous bird it can eat both plants and animals of lower order.
- iii. **Rallidae:** This family was represented by *Amaurornis phoenicurus*, *Porphyrio porphyrio*, *Gallinula chloropus* and *Fulica atra*. They eat insects, crustaceans, amphibians, fish and vegetable matter.
- iv. **Scolopacidae:** This family was represented by snipes, sandpipers and godwits. They are represented further by *Gallinago gallinago*; *Gallinago stenura*; *Rostratula benghalensis*; *Lymnocyrtes minimus*, *Tringa ochropus*; *Tringa stagnatilis* and *Limosa limosa*, respectively. They feed mainly by probing in soft ground and also by picking from the surface. Their main diet consists mostly of small aquatic invertebrates.
- v. **Jacanidae:** Jacana family was represented by *Metopidius indicus* and *Hydrophasianus chirurgus*. They were seen feeding on grounds of marshy area.
- vi. **Charadriidae:** This family was represented by some of the waders like, *Vanellus divaucelli*, *Vanellus gregarius*, *Vanellus indicus*, *Vanellus malabaricus*, *Recurvirostra avocetta*. They feed on aquatic invertebrates.
- vii. **Laridae:** Gulls, and terns like *Larus ichthyæetus*, and *Sterna hirundo* and *Sterna aurantia* represented this family. They are the opportunistic feeders and generally pick their prey from water surface.



Fig. 6. Left to right (top) ruddy shelduck, bronze winged jacana, (Centre) purple moorhen, stilt, garganey, (bottom) coot, cotton teal, shoveler.

viii. **Podicipedidae:** The members of this family are aquatic birds adapted for diving from the surface and swimming under water to catch fish and aquatic invertebrates. *Podiceps cristatus* and *Tachybaptus ruficollis* are the grebes that represented this family.

ix. **Anhingidae:** *Anhinga melanogaster* (darter) representing this family is a large aquatic bird adapted for hunting fish underwater.

x. **Phalacrocoracidae:** The cormorants, *Phalacrocorax*

carbo; *Phalacrocorax fuscicollis*; and *Phalacrocorax niger*, belonging to this family are also adapted to eat fish caught by underwater pursuit.

xi. **Ardeidae:** The family of herons and bitterns was represented by *Ardea cinerea*, *Ardea purpurea*, *Ardeola grayii*, *Butorides striatus*, *Nycticorax nycticorax* (herons) and *Botaurus stellaris*, *Dupetor flavicollis*, *Ixobrychus cinnamomeus* *Ixobrychus sinensis* (bitterns). They feed on wide variety of aquatic prey.



- xii. **Phoenicopteridae:** The flamingo family was represented by only one species (*Phoenicopterus ruber*) and showed their presence like a vagrant.
- xiii. **Threskiornithidae:** The family of ibises and spoonbills were represented by *Pseudibis papillosa*, *Threskiornis melanocephalus*, *Plegadis falcinellus* and *Platelea leuceroia*, respectively. They forage by probing in shallow water, mud and grass.
- xiv. **Ciconiidae:** The family of storks was represented by *Ephippiorhynchus asiaticus*, *Mycteria leucocephala*, *Ciconia episcopus* and *Anastomus oscitans*. They capture fish, frog, snakes, lizards, large insects, crustaceans and mollusks while walking slowly in marshes.

Nonresident wetland birds

- i. **Alcedinidae, Halcyonidae and Cerylidae:** These are the kingfisher families represented by *Alcedo atthis*, *Halcyon smyrnensis* and *Ceryle rudis* respectively. They are seen perching on trees or higher objects close to water body in search of small fish, tadpoles and small frogs, lizards, crabs etc.
- ii. **Glareolidae:** This family was represented by one courser species known as *Cursorius coromandelicus*. This species feed mostly on the invertebrates and on the ground.

Wetland independent birds

- i. **Phasianidae:** They are the terrestrial birds feeding and nesting on the ground, some perching on



Fig. 7. Left to right (top) black necked stork, purple heron, intermediate egret, painted stork, (Centre) cattle egret, darter, common kingfisher, (bottom) large cormorant, serpent eagle, fish eagle, asian openbill.



- the tree and represented by *Francolinus francolinus*; *Francolinus pictus*, *Coturnix coturnix*; *Perdicula asiatica*, and *Pavo cristatus*.
- ii. **Picidae:** They are chiefly arboreal and eat on termites and ants. Only one species was seen during 2010 winter: *Dinopium benghalense*.
 - iii. **Bucerotidae:** They are mainly arboreal and represented by one species *Ocyrceros birostris*. This is a frugivorous bird with heavy bill and loves figs and margosa fruits.
 - iv. **Upupidae:** This is represented by *Upupa epops*, a countryside bird which feeds insects by probing the ground.
 - v. **Coraciidae:** This family is represented by *Coracias benghalense*, another countryside bird mainly feeding on insects.
 - vi. **Cuculidae:** This is represented by *Clamator jacobinus* which is an arboreal bird.
 - vii. **Centropodidae:** This is also represented by single bird seen in the wetland. The representative, *Centropus sinensis*, is a terrestrial one and commonly seen in the thicket.
 - viii. **Psittacidae:** The parakeets belong to this family. They are the arboreal birds represented by *Psittacula cyanocephala*, *Psittacula eupatria* and *Psittacula krameri*.
 - ix. **Tytonidae and Strigidae:** Only two specimens, one each from the family, were spotted. They are *Otus bakkamoena* and *Athene brama*.
 - x. **Columbidae:** This family was represented by the pigeons - *Columba livia*, *Ducula aenea*, and doves - *Streptopelia decaocto*, *Streptopelia senegalensis*, *Streptopelia orientalis*, *Streptopelia chinensis*.
 - xi. **Corvidae:** This family was represented by jay (*Coracias benghalensis*), treepie (*Dendracitta vagabunda*) and crow (*Corvus macrorhynchus*, *Corvus splendens*).
 - xii. **Sturnidae:** The family of starlings and mynas was represented by *Acridotheres ginginianus*, *Acridotheres fuscus*, *Acridotheres tristis*, *Sturnus pagodarum* and *Sturnus contra*. They are the arboreal and gregarious birds and feed upon fruits and insects.
 - xiii. **Picnonotidae:** This was represented by only one species (*Pycnonotus jocosus*).
 - xiv. **Sylviidae:** This was also represented by only one species (*Turdoides striatus*).
 - xv. **Alaudidae:** the lark family was also represented by one species (*Galerida cristata*).
 - xvi. **Passeridae:** This family was represented by sparrow (*Passer domesticus*), wagtails (*Motacilla alba*, *Motacilla cinerea*, *Motacilla citreola*, *Motacilla flava*, *Motacilla maderaspatensis*, *Dendronanthus indicus*) and weaver birds (*Ploceus philippinus*).

Raptors

They are the group of birds known for preying on other animals including birds. Their highly specialized anatomical features make them superior hunters. They belong to Accipitridae family represented by *Pandion haliaetus* (osprey), *Ictinaetus malayensis* and *Aquila clanga* (eagles), *Circus aeruginosus* (marsh harrier), and *Accipiter badius* (shikra) in select wetlands of Uttar Pradesh. They feed on mammals, birds, amphibians, reptiles, fish, crab, mollusks and insects dead or alive. They frequent all habitat types ranging from dense forests, deserts, and mountains to fresh waters (Grimmette and Inskipp 2003). They are at the top of aquatic pyramid of trophic system.

Wetland profile and food web

Producers form the part of the habitat and their habit decides the form of the habitat. For example fresh water marsh and fresh water reservoir, two very common protected aquatic habitats in UP, have distinguished vegetation composition, at least the hydrophytes. Former have higher number of emergents while latter the submergents. Former supports higher number of plants and the



Fig. 8. Freshwater marsh profile showing flora and fauna of different order found association of each other

invertebrates, therefore, food availability varies in these two different types of wetlands. Consequently number and type of avian flora also change in these habitats. Therefore, interaction of these components gives definite ecological profile to the wetland. One such freshwater marsh profile is depicted in Figure 8 (modified from Gopal 1995). Indicator numerals and letters given to the components of the profile picture designate their specific identity, for example: (a) free floating hydrophyte, (b) suspended hydrophyte, (c) submerged anchored hydrophyte, (d) floating leaved anchored hydrophyte, (e) floating shoot anchored hydrophyte, (f) emergent amphibious hydrophyte, and (g) wetland hydrophyte; and 1. raptor (eagle), 2. carnivorous wader (heron), 3. omnivorous wader (sarus crane),

4. hovering and plunge diver (tern), 5. subsurface eater (gull), 6. surface eater (pintail), 7. diver (pochard), 8. hovering raptor (harrier), 9. vegetarian diver (coot), 10. pickers (passeriformes), 11. piscivorous diver (grebe), and 12. surface traveler (moorhen).

Interaction of the biotic components is linked to the energy transfer or food material intake from one another. They form the chains of different animals depending on the other. Different chains are also interlinked to one another, thus forming a web of food intake relationship among the biotic units of the ecosystem. An exhaustive but simplified food web, commonly conceivable in UP wetlands is depicted in Figure 9. Producers (phytoplankton and

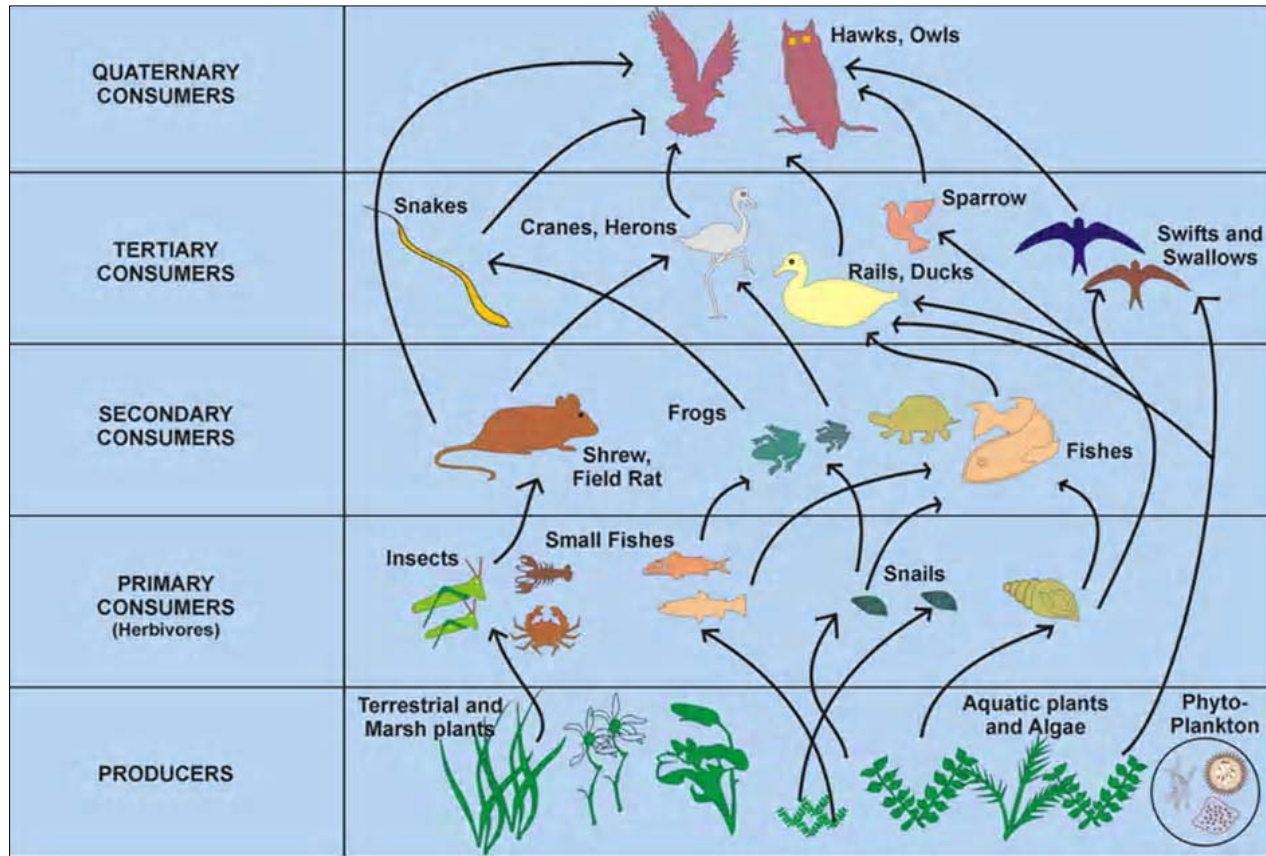


Fig. 9. Products and consumers relationship shown in aquatic food web

aquatic plants) capture natural resource (sunlight, water, carbondioxide) and produce transferable chemical energy. This energy gets transferred from lower level consumers to higher level consumers through different links of the chain and web. Major part of the energy is lost during transfer and return to the system as detritus, which is used by the plants. Thus a biotic cycle gets going in the system.

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Acknowledgement

We are thankful to the front line staffs of the Wildlife Preservation Organization, Uttar Pradesh who are constantly engaged in the protection and monitoring work at the wetlands. We also acknowledge the contribution of Sanjai Kumar, a conservationist administrator, for giving us some of his photographs to present to the readers.

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