Functional Plant Science and Biotechnology ©2009 Global Science Books

Overview of Some Wetlands in the Lakkavali Range of Bhadra Wildlife Sanctuary, Mid Western Ghat Region Karnataka: Threats, Management and Conservation Issues

H. T. Raghavendra Gowda • Vijaya Kumara*

Department of Wildlife and Management, Bioscience Complex, Kuvempu University, Jnana Sahyadri, Shankaraghatta – 577 451, Karnataka, India

Corresponding author: * vijayakumarawlm@rediffmail.com

ABSTRACT

The Lakkavalli range comprises an endangered habitat with several endemic species that can be found in many countries, mainly in the Lakkavalli range of the Bhadra Wildlife Sanctuary, but that are rapidly disappearing. For designing optimal conservation and management strategies for this ecosystem, appropriate characterization and classification of these wetlands is necessary based on the different types of habitats and their varying environmental conditions. This paper presents the current ecological status and threat to Lakkavalli range wetlands of Bhadra Wildlife Sanctuary and summarizes some management and conservation issues based on the existing experience on a regional level. The study reveals that most of the water and Soil quality parameters are in the normal range.

Keywords: diversity, ecology, flora, plankton, soil, typology

INTRODUCTION

Biodiversity is now attracting many ecologists to work and understand the variety in organisms residing on this planet. The most common definition of biodiversity is that provided by the International Union for Conservation of Nature and Natural Resources (IUCN 1992): "Biodiversity means totality of genes, species and ecosystem in a region". Recently, Gaston and Spicer (2004) defined biodiversity as the sum total of species richness i.e., the number of species of plants, animals and microorganisms in a given habitat. Water is the universal solvent, is the component of a biosphere, and is needed for the existence of living organisms. India is rich in fresh water resources, which have great economic, scientific and aesthetic importance. Wetlands provide a multitude of services, including water purification and regulation of flows, fisheries, habitats for plants, animals and microorganisms, opportunities for recreation and tourism (Wetlands International 2002). BirdLife International (2002) indicates that wetland should be selected for their "International significance in terms of ecology, botany, zoology, limnology or hydrology." The criteria have been modified many times having been approved at conferences by several parties. Valuable wetland habitats are being lost and degraded at an alarming rate; more than 200,000 ha of wetlands are lost per year (Payne 1992). The loss of wetlands worldwide in 1956 was estimated at 50% of those that existed since 1900 (reviewed at a global scale by Spiers 1998/99). Ironically there have been modest annual gains in the acreage of wetlands in the USA over the past 12 years (Copeland and Zinn 2008).

Wetlands of the Lakkavalli range, Bhadra Wildlife Sanctuary are shallow water bodies that remain flooded for a sufficiently long period of time during winter and spring. In the Lakkavalli range there are two types of wetlands (natural and man-made). They vary from small copular waterholes hollowed out in rocks to almost permanent wetlands. They are usually inundated for at least a few months every year. Some wetlands may hold water throughout the year, whereas others may remain dry for more than one season, depending on the amount of rainfall. Thus, they present a significant variability in size, shape, depth, and diversity among flora and fauna.

The physico-chemical characteristics of water play a significant role in determining abundance and periodicity of plankton. Environmental factors such as temperature, pH and proper supply of oxygen, CO_2 and essential elements like nitrate, phosphate and chloride influence plankton diversity and density (Ahmed and Singh 1993; Suresh Kumar 2002).

Soil

Since the beginnings of scientific study of wetlands, soils have been recognized as an important feature of wetlands. Plant ecologists and geologists alike found that the nature of the soils had a profound effect on plant growth and the formation of the peat deposits (a mineral resource of considerable economic value). Soil is a complex physico-biological system providing water, mineral salts nutrients dissolved oxygen and anchorage to plants (Sharma and Kaur 1994). Land or soils not only provide a solid susbtrata for us to live on, but it also feeds us (Asthana and Meera Asthana 2003). Healthy soils give us cleaner air and water, forest product range land, diverse wildlife and beautiful landscapes (Herrick 2000).

Phytoplankton

Planktonic studies are very useful tools for the assessment of water quality in any type of water-body and also contribute to an understanding of the basic nature and general economy of the wetland. Phytoplanktons are ecologically significant as they form the basic link in the food chain of all aquatic animals (Mishra *et al.* 2001). The number and species of phytoplankton serves to determine the quality of a water body. The structure of aquatic communities is important in monitoring the water quality. Plankton is strongly influenced by certain non-biological aspects of water quality such as pH, colour, taste and odour (Nagarathna and

Received: 15 February, 2009. Accepted: 22 September, 2009.

Original Research Paper

Hosmani 2002). Phytoplankton, which includes green algae, blue-green algae, diatoms, desmids, euglenoids, etc., are important among the aquatic flora. They are of greater importance as they form the basic link in the food chain of all aquatic animals, these organisms along with other aquatic and terrestrial plants make up biodiversity and also sustain life by providing food, shelter, oxygen and play a fundamental role in regulating global climate (Dwivedi *et al.* 2002). They have revealed tremendous scope for environmental management as soil conditioner, biofertilziers, bioindicators, biomonitors ameliorators, feed for animals, protein supplement and rehabilitation of degraded ecosystem through bioabsorption of pollutants (Whitton and Potts 2000).

Zooplankton

Zooplanktonic components of any aquatic ecosystem symbolizes the balance between growth and reproduction in the relation to food availability and utilization zooplankton play a key role in transferring energy from one trophic to another and thus are of foecal significance in maintaining equilibrium in a particular aquatic medium. Besides, they are also used as biological indicators of determining the physical and chemical nature of fresh water ecosystem. Various ecological aspects of zooplankton have been extensively studied in India (Das *et al.* 2002; Narayan *et al.* 2003; Banakar *et al.* 2005; Khapekar and Nandkar 2007). Zooplankton occupy a central position between the autotrophs and other heterotrophs and or an important link in food web of a freshwater ecosystem. The occurrence and abundance of zooplankton depends on its productivity which in turn, is influenced by physico-chemical parameters and the level of nutrients in the water. Zooplankton, in general, belong to four main taxonomic groups – Rotifera, Cladocera, protozoans and Copepoda.

The most striking feature of the earth is the existence of life and the most striking feature of life is its diversity, topography, soil, climate and geographical location of a region influence the vegetation diversity of forest ecosystem. Flora lying at the base of the food chain drive the energy flow in an aquatic system Their composition in the community has an enormous implication on local biodiversity. They strongly influence the water chemistry acting as both nutritional sinks through uptake and as nutrient pumps. They also have the property to improve the water quality by capturing heavy metals and ions.

During the last four decades there have been a large number of publications within the context of ecosystem functions, services and structures, but a respective systematic typology for most habitat types is missing (Groot *et al.* 2002). National parks and wildlife sanctuaries have been studied for their ecological significance and to implement measures to conserve endemic and endangered species of flora and fauna. The habitat preferences of larger carnivores and their relationship with the prey species (herbivores) in Bandipur (Johnsingh 1983) and Nagarahole, National Park (Karanth 2002) have been reported. Studies on ecological status in Sharavathi Valley Wildlife Sanctuary (Ali *et al.* 2007), apart from case-specific behavioural studies in a few pockets of the Sharavathi Valley Wildlife Sanctuary were reported. However, an ecobiological study of wetlands of wildlife sanctuaries is lacking; particularly Bhadra wildlife sanctuary wetlands have been neglected and there is no study pertaining to their diversity and ecology. The limnological study is scanty and available in the form of only some reservoirs like Hemavathi reservoir (Manjappa 1999) and Bhadra reservoir (Venkateshwarlu *et al.* 2002, 2005), Harangi, Kabini, Vani Vilas Sagar, Ghataprabha, Malaprabha (Ramakrishnaiah *et al.* 2000) and Markonhalli reservoir (Sukumaran and Das 2005). Lakkavalli range wetlands of Bhadra Wildlife Sanctuary are of major conservation importance regardless of their relatively small size, and they often shelter many rare and endangered species. Therefore, in the background of the above literature it is worthy to study the present characteristics, threats and current ecological status of the Lakkavalli wetland habitats to illustrate some necessary conservation and management activities for their long-term preservation, as well as to introduce a simple typology system based on morphological and water quality criteria.

MATERIALS AND METHODS

Study area

The study was carried out in Lakkavalli range of Bhadra Wildlife Sanctuary, consisting an area of 223.17 km^2 (13° 34' to 13° 46' N and 75° 29' to 75° 45' E) in the Karnataka state of Southern India. The altitude varies from 650 to 1875 m above sea level (masl) with a general elevation of 1200-1500 m. The sanctuary is located in the Malnad region of Karnataka about 50 km to the east of Western Ghats. The temperature in the valley ranges from 9-35°C. The region receives an annual rainfall of 1600 to 2000 mm during the southwest monsoon between June and September (Sathisha 2007). A distinct rainfall gradient results in a variation in vegetation types from semi-evergreen forest and moist deciduous forest through dry deciduous forest shoals and grassland type forest. It supports more than 19 waterholes that support a diversity of species including plants, animals, phytoplankton, many microorganisms and macro invertebrates and vertebrates which are endemic. In view of this we have selected and designated five wetlands in the Lakkavalli range of Bhadra Wildlife Sanctuary: Anegundi (13° 35' 506" N, 75° 38' 620" E); Ramannanakere (13° 36' 562" N, 75° 37' 943" E); Koramaguddadakere (13° 37' 173" N, 75° 39' 095" E); Pickupkere (13° 36' 957" N, 75° 39' 307" E); Mavinahalla-(backwater) (13° 38' 518" N, 75° 39' 271" E) and as a result can cope in a great variety of environmental changes and protect these wetlands at alarming rate of loss and degradation (**Fig. 1**).

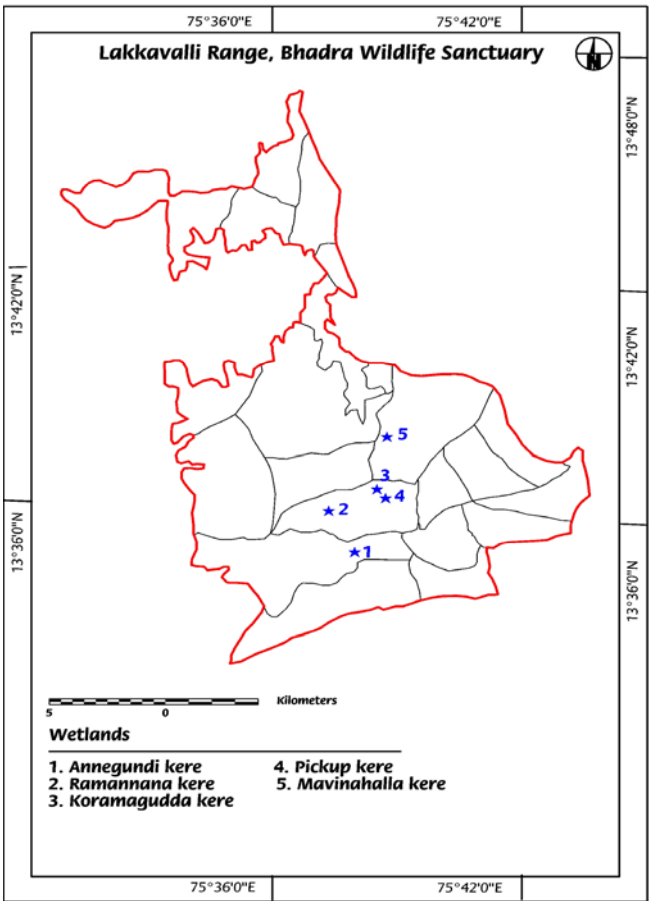

Fig. 1 Diagrammatic representation of wetlands in Lakkavali range of Bhadra Wildlife Sanctuary.

Table 1 Average data of physico-chemical parameters of selected wetlandsin Lakkavalli range of Bhadra Wildlife Sanctuary from April 2007-March 2008.

Parameters	Annegundi Kere	Ramannana Kere	Koramaguddada Kere	Pickup Kere	Mavina Halla
Atmospheric temperature	24.50	24.67	26.08	25.42	27.41
Water temperature	22.67	23.17	23.50	23.67	25.79
pH	7.44	7.69	7.24	7.62	7.23
Electrical conductivity	60.08	107.67	61.17	119.64	50.17
Total dissolved solids	33.10	62.18	36.01	120.17	30.27
Turbidity	10.58	7.72	6.25	9.86	9.28
Dissolved oxygen	6.14	6.91	6.99	4.18	7.43
Biological oxygen demand	1.02	1.88	0.90	4.40	0.70
Chemical oxygen demand	0.83	8.84	1.00	15.94	0.97
Free carbon dioxide	3.92	3.00	2.59	6.78	5.75
Chloride	8.16	15.02	13.17	27.23	13.5
Total hardness	11.67	84.83	64.25	69.25	19.58
Calcium	3.55	10.76	13.98	15.32	5.43
Magnesium	1.95	17.55	12.21	13.13	3.41
Total alkalinity	33.67	34.66	36.75	64.25	57.08
Total acidity	3.02	5.11	6.59	15.46	9.92
Phosphate	0.02	0.18	0.18	0.06	0.00
Nitrate	0.05	0.21	0.21	0.22	0.02
Nitrite	0.02	0.001	0.00	0.00	0.00
Sulphate	8.89	9.75	3.84	10.18	10.47
Sodium	0.25	2.85	3.28	12.14	13.78
Potassium	0.03	0.83	2.08	7.38	9.12
Organic matter	2.05	2.96	2.23	4.76	1.10
Iron	0.21	0.24	0.17	0.50	0.48
Silica	0.29	0.36	0.46	1.54	0.61

All the parameters are in mg/L except air and water temperature (°C), pH, Electrical conductivity (µmhos/cm) and turbidity (NTU)

Water quality

Surface water samples were collected at an interval of 30 days from April 2007 to March 2008 from all the five sampling stations for physico-chemical analysis. Water samples were collected in 2-L black coloured carboys from three permanent spots for each location. Parameter such as water temperature, pH and dissolved oxygen were analyzed in the spot. The samples were estimated in the lab for other physico-chemical parameters using the standard method (APHA 1998).

Soil analysis

Soil samples from wetland was collected and were air dried in the laboratory and then analzed for pH, EC, organic carbon, Available N, P_2O_5, exchangeable Ca, Mg, micronutrients, Fe, Zn, Co, Mn by standard methods (Brey and Kurtz 1945; Walkley and Black 1934; APHA 2000).

Estimation of plankton

The water samples for phytoplankton analysis were collected from the selected wetlands. The sample was collected from the plankton net. The sample was taken in 500 ml of bottles and preserved in 4% formalin. The samples were collected monthly in the morning between 7.00 am to 9.00 am. The quantitative and qualitative analysis was carried out by taking 20ml of concentrate obtained by siphoning supernatant liquid. Identification of phytoplankton in different class of different genera was carried out under research microscope. Phytoplanktons were counted by drop count method and the results were converted to organisms per ml of water. The identification was done up to generic level as described by Smith (1950), Patrick and Reimer (1966, 1975), Prescot (1962), Hegde and Bharathi (1985), Edmondson (1995) and APHA (2000). Zooplankton were calculated by Lackey's drop count method identification of zooplankton were carried out by using (Tonapy 1980; APHA 2000).

Floral diversity

Belt transects were used to estimate plant diversity in this type of habitat. Transects 1000 m × 5 m in size were laid in the adjacent forest cover of each wetland. All plant species including trees, herbs and climbers present in the transects were identified to the species level and their number was counted and systematic enumeration was made with the available monographs relevant literatures and taxonomic revisions (Mathew 1983; Gentry 1988; Rath 1999).

Species similarity among the wetlands was computed using Sorenson's index (Wilson *et al*. 1984).

$I = 2J/A+B$.

where I = similarity, J = Common species of both the series a and b. A = Total number of species in series a and B = Total number of species in series b.

RESULTS AND DISCUSSION

Water quality

Physical and chemical characteristics often fluctuates considerably and many temporarily approach or exceeds the biological limits that organisms can endure (Angelibert *et al*. 2004; Eitam *et al*. 2004). Quality of an aquatic ecosystem is dependent on the physico-chemical qualities of water as also on the biological diversity of the system (Ghavzan *et al*. 2006; Tiwari and Chauhan 2006; Tas and Gonulol 2007). The current study based on physico-chemical factors thus concludes that these parameters are well within the limits of BIS and hence water is potable and the results are given in **Table 1**.

Soil analysis

The analysis of soil for available, exchangeable and water soluble nutrients provide information on nutrients available to plant in soil and helps in build up or depletion of nutrients on soils (Jeevan Rao and Shantharam 1995). Soil quality is largely a function of chemical proportions such as calcium, magnesium, pH, potassium, phosphorus, nitrate, organic carbon. Assessment of these parameters is essential in determining the effect on soil quality. The study reveals that all parameters are within permissible limits. The soil analysis data are depicted in **Tables 2-5**.

Estimation of plankton

The diversity of biota such as phytoplankton and zooplankton of Lakkavalli range wetlands of Bhadra wildlife sanctuary are as follows.

Table 2 pH, EC and organic carbon of selected wetlands in Lakkavalli range of Bhadra Wildlife Sanctuary

Soil sample	pH	EC (dsm^{-1})	Organic carbon (%)
Anegundi	6.39	0.102	0.49
Ramannanakere	5.58	0.056	0.63
Koramaguddakere	6.90	0.060	0.53
Pickupkere	6.14	0.065	0.39
Mavinahalla (backwater)	5.57	0.022	0.51

Table 3 Estimation of primary macronutrients of soil samples from selected wetlands in Lakkavalli range of Bhadra Wildlife Sanctuary.

Soil Sample	Available N ($kg\ ha^{-1}$)	Available P_2O_5 ($kg\ ha^{-1}$)	Available K_2O ($kg\ ha^{-1}$)
Anegundi	272.83	45.53	481.15
Ramannanakere	319.87	52.00	325.25
Koramaguddakere	275.97	32.51	357.50
Pickupkere	222.66	42.26	341.38
Mavinahalla (backwater)	269.70	53.31	255.36

Table 4 Estimation of Secondary macronutrients of soil samples from selected wetlands in Lakkavalli range of Bhadra Wildlife Sanctuary.

Soil sample	Exchangeable Ca ($c.mol(P^{+})kg^{-1}$	Exchangeable Mg ($c.mol(P^{+})kg^{-1}$
Anegundi	4.2	2.3
Ramannanakere	3.8	2.2
Koramaguddakere	4.0	1.8
Pickupkere	3.9	1.7
Mavinahalla (backwater)	3.2	2.1

Table 5 Estimation of micronutrients of soil samples from selected wetlands in Lakkavalli range of Bhadra Wildlife Sanctuary.

Soil sample	Fe ($mg\ kg^{-1}$)	Zn ($mg\ kg^{-1}$)	Cu ($mg\ kg^{-1}$)	Mn ($mg\ kg^{-1}$)
Anegundi	58.82	1.424	8.594	33.10
Ramannanakere	62.84	0.790	4.138	41.00
Koramaguddakere	71.40	1.124	4.802	20.88
Pickupkere	62.72	1.482	7.702	17.30
Mavinahalla (backwater)	76.00	3.204	6.674	30.76

Phytoplankton

The collected phytoplankton samples from wetland have been identified upto generic as well as species level. Further distribution and pattern of the recorded phytoplankton forms belonging to four classes of algae i.e., Chlorophyceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae and are listed in **Table 6**. Chlorophyceae dominated over other group of planktons reaching up to 26 species, Bacillariophyceae represents 17 species while Cyanophyceae and Euglenophyceae represent 11 and 4 species, respectively. The phytoplanktonic population was found in the order of Chlorophyceae > Bacillariophyceae > Cyanophyceae > Euglenophyceae.

Zooplankon

Identification of various zooplankton were made up to genus level and some of them were tried to identify up to species. Although there were fourteen species of zooplankton were identified during the study period which includes Rotifera (4), Copepoda (4), Cladocera (3) and Protozoa (3) whereas rotifera formed the dominant group of zooplankton population in all four water bodies (**Table 7**).

Floral diversity

A total of 133 species belonging to 56 families were identified during the study. Among the five study areas Anegundikere wetland was more speciose (N = 54) followed by Mavinahallakere and Ramananakere. Koramaguddakere and Pickupkere were less species compared to Anegundikere. However, number of individuals is in case of Mavinahallakere (Back water) followed by Anegundikere and Ramannanakere (**Table 8, Fig. 2**). Among the pooled data a weed, *Chrmolina oderata*, was the most dominant followed by *Tectona grandis*, *Anogessus latifolia*, etc. (**Table 9**).

The Shannon-Wiener diversity index did not show significant differences among different samples, while Simpson's index showed that Koramaguddakere and Pickupkere are having less plant diversity compared to other three (**Table 10**).

Sorenson's index was computed to compare the vegetation around the wetlands. It was found that Koramaguddakere and Pickupkere were significantly associated (>40%) with Ramannanakere while all other associations are less than 40% (**Table 11**). The species with family of all the wetlands are been given in **Table 12**.

Threats

There is no current research enabling the decline of forest wetlands to be measured (Grillas *et al*. 2004a). The reason for shorter hydroperiods is the invasion of woody species, which will increase the evapotranspiration rate locally. Invasion of woody species can be a natural process, but it is considerably amplified by eutrophication and other processes which favour species with greater ability to compete (Grillas *et al*. 2004a; Rhazi *et al*. 2004).

Anthropogenic disturbance is generally detrimental to overall, long term community health. Anthropogenic disturbance can be intrusive, in which people or domesticated animals enter wetland habitat and normal community processes are disrupted. Intrusive disturbance has been institutionalized at many local, state, and federal reserves with the advent of nature trails and viewing areas. Other examples of intrusive disturbance include boat and vehicle incursions, hunting, and lumbering.

The increasing number of tourists visiting the Lakkavalli range of Bhadra Wildlife Sanctuary by the tourist department (JLR) often raises the stress applied to the habitat by activities, such as 4X4 vehicles crossing, trucking during the dry season (Serrano and Serrano 1996; Grillas *et al*. 2004a). Visitor pressure in the dry season, as well as trampling by cattle, also changes the geomorphologic characteristics of the wetland bed. This can make it impossible for some plants to germinate.

Fires can cause direct damage by burning vegetation and diminishing the seedbank and animal populations. The effect of burned vegetation may sometimes be positive in the sense that the destruction of woody species and the opening-up of the habitat favors species but fire in the catchment area is also known to-have a significant impact on wetland ecosystems, causing increased erosion and adding nutrients to the wetland (Grillas *et al*. 2004a).

Finally, future climate changes could affect the existence of wetlands. If these changes result in a reduced amount of precipitation in the Lakkavalli region the hydroperiods of wetlands might become shorter, or might not even occur, because of falling groundwater levels and reduced input through rain and surface runoff water.

Conservation and management

Today, wetland classification is mainly based on the Ramsar Convention classification system, which comprises a general classification tool for facilitating communication between scientists and environmental manage.

Wetlands incorporate unique and local hydrological conditions. The main characteristics of these wetlands are the length and variation of the hydroperiod which is also closely connected to chemical conditions because when the wetland dries out, the chemical characteristics fluctuate considerably. Thus, morphological conditions such as altitude, geology settings, size and depth are considered, the above mentioned hydrologic aspects are also included, as well as water quality parameters (temperature, dissolved

Table 6 Diversity of phytoplankton in Lakkavalli range of Bhadra Wildlife Sanctuary during April 2007 to March 2008.

Name of the organisms	Annegundi kere	Rammana kere	Koramma guddakere	Pickup Kere	Mavinahalla Kere
Chlorophyceae					
Cosmarium angulatam	+	+	+	+	+
C. regulare	-	-	+	+	+
C. obtusam	+	-	+	-	+
C. lundelli	+	-	-	+	+
C. marginatum	+	+	+	+	+
C. granatum	-	+	-	+	+
Closterium lunula	+	-	+	+	+
C. lanceolatum	+	+	+	+	+
C. acutus	+	+	+	+	+
Desmidum bengalicunm	+	+	+	-	+
Euastrum sp.	-	+	-	+	+
Euastrum insulare	-	-	+	+	+
E. serratum	-	-	-	+	+
Micrasterias inciser	+	-	+	+	+
Pediastrum simplex	-	-	+	-	+
P. duplex	-	-	+	+	+
P. obtusm	+	+	+	+	+
P. tetras	+	+	+	+	+
Spirogyra singularis	-	-	+	+	+
S. subsalsa	+	-	+	+	+
Staurastrum sebaldi	+	+	+	+	+
Staurastrum sp.	+	+	+	+	+
S. gracile	+	+	+	+	+
Ulothrix sutillissima	-	+	+	+	+
Ulothrix cylindrocium	+	-	-	+	+
Zygnema ezurda	-	+	+	+	+
Cyanophyceae					
Aphanocapsa biformis	-	+	-	+	+
Anabaena spiroides	-	-	+	+	+
A. naviculoides	+	-	+	+	+
Arthrospira nidulans	+	-	+	+	+
Chroococus turgidus	+	+	+	+	+
Gleocapsa magna	-	-	-	+	+
Microcystis aeruginosa	-	-	-	+	-
Oscillatoria subbrevis	-	-	+	+	+
O. acuta	-	-	-	-	+
Spirulina major	-	-	-	+	-
Spirulina spiroides	+	+	+	+	+
Bacillariophyceae					
Amphora cofformis	-	+	-	+	+
Amphora sp.	+	+	-	-	-
A. ovalis	+	+	+	-	+
Cymbella tumida	-	+	+	+	+
C. turgidula	-	+	-	-	+
C. lanceolata	-	+	-	+	+
Diatoma sp.	+	+	+	-	+
Fragillaria sp.	-	+	-	-	+
Gomphonema gracili	+	+	-	-	+
Gyrosigma accuminatum	-	+	-	+	+
Melosira granulata	+	+	+	+	+
Navicula radiosa	-	+	-	-	+
N. gracilis	+	+	+	+	+
N. hustedtii	+	+	+	+	+
Navicula sp.	+	+	+	-	+
Pinnularia major	-	+	-	+	+
P. viridis	-	+	-	-	+
Synedra ulna	+	+	+	+	+
Euglenophyceae					
Euglena acus	+	+	+	+	+
E. elastica	-	+	-	+	-
Phacus tortus	-	+	+	+	+
P. longicauda	+	-	-	+	-

+: present, -: absent

oxygen, pH, salinity, conductivity) and the habitat's trophic status. This classification system covers all the key characteristics of the wetlands habitat and discriminates adequately the many different types observed globally. Nevertheless, the development of a detailed and widely applicable classification system, as well as respective effort to classify the wetland water habitats, in order to clarify the genuine differences and the unique characteristics of each type, is now-a-days essential. Such an effort will contribute to designing the appropriate management activities and applying effective conservation measures on these important habitats. The simplest to counter intrusive disturbance is to prevent access to habitats. However, denying public access to natural areas is difficult to justify and even more difficult to en-

Table 7 Diversity of zooplankton in Lakkavalli range of Bhadra Wildlife Sanctuary during April 2007 to March 2008.

Name of the organisms	Annegundi kere	Rammana kere	Koramma guddakere	Pickup kere	Mavinahalla Kere
Cladocera					
Daphnia carinita	-	-	+	+	-
Diaphanosoma excisum	-	-	+	+	-
Moinacarinata	+	-	+	-	-
Copepoda					
Eucyclops agilis	+	+	-	+	+
Heliodiaptomus sp.	-	+	+	-	+
Mesocyclops hylinus	+	+	-	+	+
Nauplius larvae	+	+	+	+	+
Protozoans					
Arcella sp.	-	+	+	+	+
Euglypha sp.	-	-	-	+	-
Paramecum	+	+	-	+	-
Rotifers					
Brachionus falcatus	+	-	+	+	+
B. calyciflorus	-	+	-	+	-
Keratella tropica	+	+	+	+	+
Lecane luna	-	+	+	+	+

+: present, -: absent

Table 8 Mean species richness for all the vegetation layers in different wetlands of Lakkavalli range of Bhadra Wildlife Sanctuary during April 2007 to March 2008.

Sample	Mean № individuals (*/**)	Variance	Standard deviation	Standard error	Total № individuals*	Total № species**
Mavinahallakere	9.09	34.749	5.895	0.498	464	51
Anegundikere	7.37	26.579	5.156	0.436	398	54
Ramannanakere	7.05	25.959	5.095	0.431	360	51
Koramaguddakere	7.25	15.147	3.892	0.329	225	31
Pickup kere	6.82	13.738	3.706	0.313	232	34

Table 9 Dominant plant species among pooled data of Lakkavalli range of Bhadra Wildlife Sanctuary during April 2007 to March 2008

Species	Variance	Mean	χ^2
Chromolina oderata	101.4667	12.3333	41.1351
Tectona grandis	97.2	14	34.7143
Anogessus latifolia	84.7	5.5	77
Randia dumentorum	78.3	6.5	60.2308
Cinnamomum malabathrum	73.5	3.5	105
Sida rhomboideae	71.2	5	71.2
Cyclea peltata	70.6667	4.3333	81.5385
Asparagus racemosus	66.1667	5.1667	64.0323
Allophyllus cobbe	64.1667	5.1667	62.0968
Dalbergia latifolia	63.6	10	31.8
Mimosa pudica	61.6	9	34.2222
Cleome viscosa	60.9667	4.8333	63.069
Lagestroemia lanceolata	57.0667	8.3333	34.24
Macaranga peltata	49.5	4.5	55
Terminalia tomentosa	49.5	9.5	26.0526
Terminalia bellarica	47.3667	5.8333	40.6
Persea macrantha	46.3	3.5	66.1429
Cryptolepis buchanani	45.7667	5.1667	44.2903
Cassia fistula	42.5667	7.1667	29.6977

Table 10 Diversity components among different wetlands in Lakkavalli range of Bhadra Wildlife Sanctuary.

Wetlands	Simpsons Diversity (1/D)	Shannon H' Natural Log
Mavinahallakere	36.388	3.669
Anegundikere	35.683	3.693
Ramannanakere	30.963	3.556
Koramaguddakere	22.48	3.177
Pickupkere	25.99	3.312

force. Moreover, denied access diminishes the educational value of natural areas. Therefore, more realistic efforts will focus on minimizing the disruptive effects of the intrusion by avoiding sensitive areas, restricting access at critical times of the year, and limiting the number of people accessing the area at any one time. Secondary efforts will include avoiding damage to vegetative and water resources by constructing low impact trails and establishing viewing areas at the periphery of the habitat (Wetlands International 2002).

Design guidelines for management

Wildlife responds to largely physical characteristics when selecting a habitat. Nevertheless, three factors, the size of the wetland, the relationship of the wetland to other wetlands and the level and type of disturbance will largely determine the effectiveness of a wetland for long-term wildlife use. Ideally, a wetland designed for wildlife, regardless of whether the design uses preservation, enhancement, restoration, or creation to achieve its objectives, should be large enough to support an estimated minimum viable population of the species of interest. In many cases, establishment of a wildlife community is the objective, and an indicator species with significant areal requirements should be identified. The wetland should be large enough to support at least 50, and ideally 500, breeding individuals, and area requirements can be estimated from knowledge about species home range sizes (Donald 2001).

Manipulation includes both drawdown and flooding. Draw downs reduce or eliminate undesirable plant species, facilitate decomposition of vegetation and the return of nutrients to the soil, allow desirable plant species to germinate or recover from flood stress, concentrate prey for wildlife, and reduce or eliminate nuisance fish and wildlife (Kadlec 1960; Weller 1987).

Manipulating water levels in wetlands can be an effective management technique for increasing wildlife productivity (Wilson 1968; Chabreck 1976; Rundle and Fredrickson 1981; Fredrickson and Taylor 1982; Knighton 1985). The degree of substrate drainage, surface relief, and substrate composition are equally important in determining vegetation interspersion (Knighton 1985). Water-level manipulation can be accomplished relatively inexpensively if a small, simple water control structure can be constructed at the downstream end of a naturally occurring basin. The water control structure should be capable of affecting a

Table 11 Sorenson's index and correlation of species between different wetlands in Lakkavalli range of Bhadra Wildlife Sanctuary.

Sorenson's index	Mavinahalla kere	Anegundi kere	Ramannana kere	Koramagudda kere	Pickup kere
Mavinahallakere	1				
Anegundikere	0.21	1			
Ramannanakere	0.22	0.36	1		
Koramaguddakere	0.27	0.31	0.44*	1	
Pickup kere	0.31	0.25	0.45*	0.37	1

* More similar populations

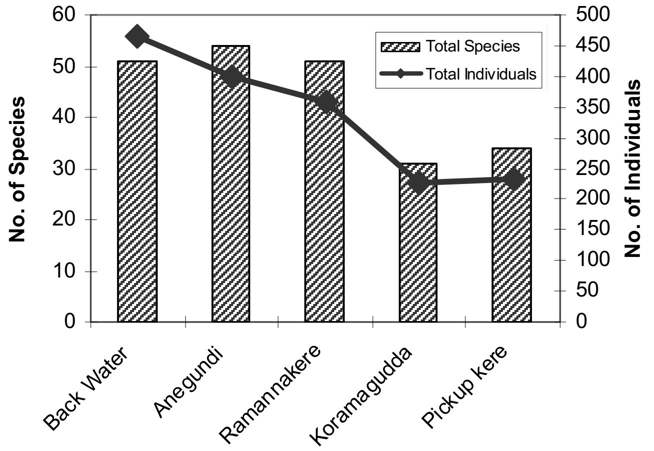

Fig. 2 Diagramatic representation of mean species richness for all the vegetation layers in different wetlands.

complete drawdown and should be able to manipulate water levels with a precision of 5 to 7 cm.

- Actions such as deepening, removing decaying vegetation and leaf lifer during the dry period (this may provide a refuge or macro invertebrates or plants that lack desiccation resistant life-stages, Nicolet *et al.* 2004) often have a damaging effect on these fragile ecosystems.
- Particular attention should be paid to the presence of uncommon species (Colfinson *et al.* 1995; Nicolet *et al.* 2004).
- Conservation actions should focus on a number of small wetlands which provide a variety of different microhabitats and therefore a diversity of species.

Management may fail because of inadequate or inaccurate information, imprecise water control, colonization, and modification by nuisance species, or even political or public pressure to terminate or modify management techniques or goals (Fredrickson 1985). Therefore, it seems reasonable to reserve active management for wetlands known to be degraded and created wetlands.

In order to implement the management plans in an area, increasing public awareness is necessary. Therefore, management measures should include actions to publicize the conservation value of wetlands.

In this particular ecobiological study a simple and comprehensive typology approach is suggested including a combination of hydromorphologic and water quality parameters that characterize the different types of wetlands. However, the conservation of the wetlands is very important and appropriate political and managerial measure should be immediately taken to avoid potential ecological degradation.

REFERENCES

Ahmed SH, Singh AK (1993) Winter liminology. A comparison of physical, chemical and biological characteristics in two temperate lakes during ice cover. *Hydrobiologia* **304**, 221-234

Ali S, Rao GR, Mesta DK, Sreekantha Mukri VD, Chandran MDS, Gururaja KV, Ramachandra TV (2007) *Ecological Status of Sharavathi Valley wildlife Sanctuary*, Sahyadri conservation Series 1, Prism Books Pvt. Ltd., Chennai, 5 pp

Angelibert SP, Marty R Cereghino, Giani N (2004) Seasonal variations in the physical and chemical characteristics of ponds: Implications for biodiversity conservation. *Aquatic Conservation* **14**, 439-456

APHA (1998) *Standard Methods for the Examination of Water and Waste Water* (20th Edn), APHA, AWWA and WEF N.W, Washington DC

APHA (2005) *Standard Methods for the Examination of Water and Waste Water* (21st Edn), APHA, AWWA and WEF N.W, Washington DC

Asthana DK, Asthana M (2003) *Environment Problems and Solutions*, S. Chand and Co., Ramnagar, New Delhi, 369 pp

Banakar AB, Kiran BR, Puttaiah ET, Purushothama, Manjappa S (2005) Hydrochemical characteristics of surface water in Chandravalli pond near Chitradurga. *International Journal of Environment and Pollution* **25**, 249-253

Bird Life International (2002) *Bird Life International and the Ramsar Convention – A Guide* (2nd Edn), Bird Life International, 36 pp

BIS (1998) Indian drinking water Standard specification. Bureau of Indian Standards, New Delhi, pp 171-178

Bray RH, Kurtz LT (1945) Determination of total organic and available forms of phosphate in soils. *Soil Science* **59**, 39-45

Chabrek RH (1976) *Management of Wetlands for Wildlife Habitat Improvement in Estuarine Processes I*, Wiley M (Ed), Academic Press, New York, 226 pp

Collinson NH, Biggs J, Corfield A, Hodson MJ, Walker D, Whitefield M, Williams PJ (1995) Temporary and permanent ponds. An assessment of the effects of drying out on the conservation value of aquatic macroinvertebrate communities. *Biological Conservation* **74**, 125-133

Copeland C, Zinn JA (2008) Wetlands: An overview of issues. 25 pp. Available online: http://www.nationalaglawcenter.org/assets/crs/RL33483.pdf

Das AC, Baruah BK, Baruah D, Sengupta S (2002) Study on wetlands of Guwahati city-1 water quality of pond and Beels. *Pollution Research* **21**, 511-513

Donald MK (2001) *Applied Wetlands Science and Technology* (2nd Edn), Lewis Publishers, Washington DC, pp 296-297

Dwivedi BK, Pandey GC (2002) Physico-chemical factors and algal diversity of two ponds (Jinja Kund and Magubara pond), Faizabad, India. *Pollution Research* **21**, 361-370

Eitam A, Noren C, Blastein L (2004) Microturbellarian species richness and community similarity among temporary pools: Relationships with habitat properties. *Biodiversity and Conservation* **13**, 2107-2117

Fredrickson LH (1985) Managed wetland habitats for wildlife: why are they important? in Water impoundments for wildlife: A habitat management workshop. General technical report NC-100, US. Department of Agriculture, Forest Service, North Central Forest Experimental Station, 1

Fredrickson LH, Taylor TS (1982) Managed and seasonality flooded impoundments for wildlife. US Fish and Wildlife Service Resources Publication, 148 pp

Gaston KJ, Spicer JI (2004) *Biodiversity*: *An Introduction* (2nd Ed), Blackwell Publishing Science, Oxford University Press, 208 pp

Gentry AH (1988) Tree species richness of upper Amazon forests. *Proceedings of the National Academy of Sciences USA* **85**, 156-159

Ghavzan NJ, Gunale VR, Trivedy RK (2006) Limnological evaluation of an urban fresh water river with special reference to phytoplankton. *Pollution Research* **25**, 259-268

Grillas P, Gaulthier P, Yavercovski N, Perennou C (2004a) *Mediterranean Temporary Pools: Issues Relating the Conservation Functioning and Management* (Vol I), Station Biologique de la Tour du Valat, Le Sambuc, Arles, France, pp 63-70

Groot RS, Wilson MA, Boumans RMJ (2002) A typology for the classification description and valuation of ecosystem functions goods and services. *Ecological Economics* **41**, 393-408

Hegde GR, Bharathi SG (1985) Comparative phytoplankton ecology of fresh water ponds and lakes of Dharwad, Karnatka state, India. In: *Proceedings of the National Symposium of Pure and Applied Limnology. Bulletin of the Botanical Society* **32**, 24-29

Herrick JE (2000) Soil quality: An indication for sustainable land management. *Applied Soil Ecology* **15**, 75-83

IUCN (1992) *Protected Areas of the World. Review of National Systems* (Vol 4), *WCMC, Cambridge and IUCN Commission on National Parks and Protected Areas.* IUCN, Gland, Switzerland

Jeevan Rao K, Shantaram MV (1995) Nutrients changes in agricultural soils due to application of garbage. *Indian Journal of Environmental Health* **34 (4)**, 265

Johnsingh AJT (1983) Large mammalian prey-predators in Bandipur. *Journal of Bombay natural History Society* **80**, 1-57

Kadlec JA (1960) The effect of drawdown on the ecology of a waterfowl im-

Table 12 Number of individuals that represents plant species among different wetlands in Lakkavalli range of Bhadra Wildlife Sanctuary.

Plant species	Family	Habit	Mavinahalla kere	Anegundi kere	Ramannana kere	Korama Guddada kere	Pickup kere
Acacia concinna	Mimoseae	C		7			
Acacia instia	Mimoseae	T	4				
Ageratum conyzoides	Asteraceae	H	3			2	
Albizzia lebbeck	Mimoseae	T		5			
Albizzia procera	Mimoseae	T	1				
Allophyllus cobbe	Sapindaceae	S		16	15		
Alocasia sp.	Araceae	H					1
Alseodaphne semicarpifolia	Lauraceae	T			6		
Alstonia scholaris	Apocynaceae	T			1		
Anogessus latifolia	Combretaceae	T	22				
Antidesma ghaesemblia	Euphorbiaceae	T		3			
Ardesia solanaceae	Myrsinaceae	S		5			
Argeria nervosa	Convolvulaceae	C					2
Artocarpus lakoocha	Moraceae	T			2		1
Asparagus racemosus	Liliaceae	C			21	5	
Aspidopteris cordata	Malpighiaceae	C	1				
Bauhenia racemosa	Papilionaceae	T	2				
Bauhinia sp.	Caesalpiniaceae	T		2			
Bombax ceiba	Malvaceae	T		2		2	
Braynia retusa	Euphorbiaceae	S			5		
Butea monosperma	Papilionaceae	T		7			
Butea parviflora	Papilionaceae	C		8			
Caesalpinia mimosoides	Caesalpiniaceae	S		12			
Cansjera rheedii	Opiliaceae	S		5			
Carallia brachiata	Rhizoporaceae	T			4		
Careya arborea	Myrtaceae	T	5	11			8
Caseria tomentosa	Flacourtiaceae	S			1		
Cassia fistula	Caesalpinaceae	T	17	7	13	1	2
Cassia mimusoides	Caesalpinaceae	H	7				
Cassia sp.	Caesalpinaceae	S	4				
Cassia tora	Caesalpinaceae	H	8				
Centella asiatica	Umbelliferae	H		2			
Chromolina oderata	Asteraceae	H		22	4	20	22
Cinnamomum malabathrum	Lauraceae	T			21		
Cissus raphanda	Vitaceae	C			1		
Cleome viscosa	Capparaceae	H				18	11
Clerodendron viscosum	Verbinaceae	S		9	1	3	
Crotolaria sp.	Fabaceae	H	3	2			
Cryptolepis buchanani	Asclapiadaceae	C	6		18		5
Curculigo orchioides	Palmae	T	9		2		
Curcuma sp.	Zingiberaceae	H	5				
Cyclea peltata	Menispermaceae	C			21	5	
Cynodon dactylon	Graminae	H	2				
Dalbergia latifolia	Papilionaceae	T	18	15	12		
Dellinia pentagyna	Dilliniaceae	T			15	7	9
Dendrocalamus strictus	Graminae	T	15				3
Desmodium triquetrum	Papilionaceae	H		5	14		6
Dioscorea bulbifera	Dioscoriaceae	C		8	1		
Dioscorea pentaphylla	Dioscoriaceae	C		5			
Diospyros buxifolia	Ebenaceae	T					4
Diospyros montana	Ebenaceae	T	9				
Diploclisia glaucansis	Menispermaceae	C		5			
Drynaria quersifolia	Polypodiaceae	H		2			
Elephantophus scaber	Asteraceae	H	12				
Embelia tsjerium -cottam	Myrsinaceae	C	15				
Emblica officinale	Euphorbiaceae	T	12	7		8	
Ficus callosa	Moraceae	T			9		5
Ficus hispida	Moraceae	T		2			
Ficus racemosa	Moraceae	T		8	4	2	
Ficus tsjehela	Moraceae	T		1			
Flacourtia indica	Flacourtiaceae	T	1				
Flemingia sp.	Fabaceae	H	2				
Glochidion sp.	Euphorbiaceae	T					4
Grewia tilifolia	Teliaceae	T		11	1	8	13
Gynura nitida	Asteraceae	H					12
Helicteres isora	Sterculiaceae	S				5	5
Heliotropium indica	Boraginaceae	H	6			9	
Hippocratea sp.	Hippocrataceae	C		1			
Holarrhina antidysentrica	Apocynaceae	S	12				
Homonoia riparia	Euphorbiaceae	H		14			
Hopea ponga	Dipterocarpaceae	T				10	

Table 12 (Cont.)

Plant species	**Family**	**Habit**	**Mavinahalla kere**	**Anegundi kere**	**Ramannana kere**	**Korama Guddada kere**	**Pickup kere**
Hydnocarpus pentadra	Flacourtiaceae	T			8		2
Ichinocarpus fruitiscence	Apocynaceae	C	3				
Ipomea sp.	Convolvulaceae	C	4				
Ixora coccinea	Rubiaceae	S				11	
Jasminum sp.	Oleaceae	C			3		
Kydia calycina	Malvaceae	T		2	2	2	
Lagestroemia flosregini	Lythraceae	T		7			
Lagestroemia lanceolata	Lythraceae	T	20		1	12	6
Lannea coramandalica	Anacardiaceae	T			12		
Lantana camara	Verbinaceae	S					8
Leea talbotii	Leeaceae	S	15	1		3	
Macaranga peltata	Euphorbiaceae	T			19		12
Mallotus phillippinensis	Euphorbiaceae	T	5	3	4		9
Memecylon umbellatum	Melastomaceae	T				7	
Meyna laxiflora	Rubiaceae	T	8	12	2	2	4
Michelia champaca	Magnoliaceae	T			2		
Mimosa pudica	Mimoseae	H	20			13	9
Mitragyna parviflora	Rubiaceae	T	4		14		
Murraya koenegii	Rutaceae	T			2		
Musenda frondosa	Rubiaceae	C			2		
Narvelia zeylanica	Rananculaceae	C		1			
Nothopegia racemosa	Anacardiaceae	T		2			
Ochlandra rheedi	Graminae	S	2				
Olea dioca	Oleaceae	T			1		
Pavetta tomentosa	Rubiaceae	S		1			
Persea macrantha	Lauraceae	T			17		4
Polygonum glabrum	Polygonaceae	H		14			
Polygonum sp.	Polygonaceae	H					4
Pongamia pinnata	Papilionaceae	T		7			
Pterocarpus marsupium	Fabaceae	T		6			
Randia dumentorum	Rubiaceae	T	14	21	2		
Rauvolfia serpentina	Apocynaceae	H			1	2	
Rubus moluccanus	Rosacear	S	5				
Santalum album	Santalaceae	T				5	
Sapindus laurifolia	Sapindaceae	T		1			
Schlichera oleosa	Araliaceae	T	8	7			5
Securinuga leucopyurus	Euphorbiaceae	S	2				
Sida acuta	Malvaceae	H	5				
Sida rhomboideae	Malvaceae	H	21				8
Smilax zeylanica	Smalacaeae	C				1	
Solanum sp.	Solanaceae	S	2				
Stachytarpeta indica	Verbinaceae	H	13				
Sterculia guttata	Sterculiaceae	T		6	8		
Strereospermum personatum	Bignoniaceae	T		4	7		7
Syzygium cumuni	Myrtaceae	T			7	8	
Taebernmontana heyniana	Apocynaceae	T			5		
Tamarindus indica	Fabaceae	T	2				
Tectona grandis	Verbinaceae	T	21	28		16	10
Terminalia bellarica	Combretaceae	T		8	16	11	
Terminalia paniculata	Combretaceae	T	21	18	15	13	13
Terminalia tomentosa	Combretaceae	T	18		2	12	14
Thespesia lampas	Malvaceae	T		2			
Trema orientalis	Urticaceae	T			5		2
Trewia nudiflora	Euphorbiaceae	T		5			
Triumfetta rhomboidea	Malvaceae	H		9			
Urena lobata	Malvaceae	S		9	4		
Ventilago maderaspatensis	Rhamnaceae	S	13				
Volvulopsis nummularia	Convolvulaceae	H	14				
Xanthium stromarium	Asteraceae	H	11				
Zanthoxylum rhetsa	Rutaceae	T			3		2
Zizyphus oenoplia	Rhamnaceae	S	12			2	
Zizyphus rugosa	Rhamnaceae	S		15	4		

C = climber, H= herb, S = shrub, T = tree

poundment, Michigan Department Conservation Report, 2276 pp

Karanth KU (2002) Nagarahole: limits and opportunities in wildlife conservation. In: Terborgh J, van Schaik C, Davenport L, Rao M (Eds) *Making Parks Work: Strategies for Preserving Tropical Nature*, Island Press, Washington, DC, pp 189-202

Khapekar RR, Deshpande SV (2007) Phytoplankton composition and assessment of pollution status of Naik Lake, Nagpur (MS). *Aquatic Biology* **22 (2)**, 21-26

Knighton MD (1985) Vegetation management in water impoundments: water level control, in water, impoundments for wildlife: A habitat management workshop. Knighton MD (Ed) *General Technical Report NC-100*, U.S. Department of Agriculture, Forest service North Central Forest Experiment Station, St. Paul, MN, 39 pp

Manjappa K (1999) Fish and fisheries of Hemavathi River, Karnataka. *The IVth Indian Fisheries Forum Proceedings*, 24-28 Nov Kochi, Kerala, pp 389-391

Mishra SM, Pani S, Bajpai A, Bajpai AK (2001) Assessment of tropic status by using Nygaard index with reference to Bhoj wetlands. *Pollution Research* **20**, 147-153

Nagarathna, Hosamani SP (2002) Impact of *Microcystis aeruginosa* Kutz bloom on the water quality parameters. *Pollution Research* **21**, 59-61

Narayana J, Somashekar RK (2003) Distribution ecology of protozoan in relation to water quality in river Cauvery, Karnataka, India. In: Kumar A (Ed) *Ecology and Ethology of Aquatic Biota*, Daya Publishing House, New Delhi, pp 283-293

Nicolet P, Biggs J, Fox G, Hodson MJ, Reynolds C, Whitefield M, Williams P (2004) The wetland plant and macroinvertebrates assemblages of temporary ponds in United Kingdom and Wales. *Biological Conservation* **120**, 261-278

Patrick R, Reimer CW (1975) The diatoms of the US. Philadelphia. *Academy of Natural Sciences* **2**, 213 pp

Patrick R, Reimer RW (1966) The diatoms of the US. Philadelphia. *Academy of Natural Sciences* **1**, 688 pp

Prescott GW (1962) *Algae of the Western Great Lakes Area*, Dubuque, IA, McGraw Hill, 977 pp

Payne NF (1992) *Techniques for Wildlife Habitat Management of Wetlands*, McGraw Hill, New York, 549 pp

Ramakrishnaiah M, Rao D, Sukumara SK, Das AK (2000) Ecology and fish yield potential of selected reservoirs of Karnataka. *Central International Fish Society of India Bulletin* **94**, 41

Rath GC (1999) *Proceedings of 86th Session*, Indian Science Congress, Chennai, 28 pp

Rhazi MP, Grillas A, Charpentier, Medail F (2004) Experimental management of Mediterranean temporary pools for conservation of the rare quillwort "Isoetes setacea". *Biological Conservation* **118**, 675-684

Rundle WD, Fredrickson LH (1981) Managing seasonally flooded impoundments for migrant raisl and shorebirds. *Wildlife Society Bulletin* **9**, 80

Sathisha AM (2007) Survey and documentation of bryophytes in Bhadra wildlife sanctuary, Karnataka. PhD thesis, Kuvempu University, 23 pp

Serrano Laura, Luis, Serrano (1996) Influence of groundwater exploitation for urban water supply on Temporary ponds from the Donana National park (Spain). *Journal of Environmental Management* **46**, 229-238

Sharma BK, Kaur H (1994) Soil and noise pollution, Goel Publishing House, Meerut, 18 pp

Smith GM (1950) *The Freshwater Algae of the United States*, McGraw Hill, New York, 719 pp

Sukumaran PK, Das AK (2005) Limnology and fish production efficiencies of selected reservoirs of Karnataka. *Indian Journal of Fish* **52 (1)**, 47-53

Suresh Kumar (2002) *An Introduction to Algae*, Campus Books International, New Delhi, pp 243-245

Tas B, Gonulol A (2007) An ecologic and taxonomic study on phytoplankton of a shallow lake, Turkey. *Journal of Environmental Biology* **28**, 439-445

Tiwari A, Chauhan SVS (2006) Seasonal phytoplankton diversity of Kitham lake, Agra. *Journal of Environmental Biology* **27**, 35-38

Tonapi GT (1980) Cited from Fresh water animal of India ecological approaches), Oxford and IBH Publishing Co., New Delhi 341 pp

Venkateshwarlu M, Shanmugham M, Mallikarjun HR (2002) The fish fauna of Bhadra reservoir, Western Ghats. *Journal of Aquatic Biology* **17**, 9-11

Venkateshwarlu M, Somashekar DS, Jothi Srigowri, Ashashree HM (2005) *Proceedings of State Level Seminar on Biodiversity and Conservation*, Haveri, pp 22-25

Walkley A, Black CA (1934) An examination of the determination soil organic matter under a proposed modification of the chromic acid titration method. *Soil Science* **37**, 29-38

Weller MW (1987) *Freshwater Marshes: Ecology and Wildlife Management* (2nd Edn), University of Minnesota Press, Minneapolis, MN, 165 pp

Wetlands International (2002) *Water Bird Population Estimates* (3rd Edn), Wetlands International Global Series, Wageningen, The Netherlands, 12 pp

Whitton BA, Potts M (2000) *The Ecology of Cyanobacteria*, Kluwer Academic Publishers, The Netherlands, pp 233-255

Wilson KA (1968) Fur production and southeastern coastal marshes. *Proceedings of Marsh Estuary Management Symposium* **1**, 149 pp

Wilson MV, Shmida A (1984) Measuring beta diversity with presence absence data. *Journal of Ecology* **72**, 1055-1064