Фауна і населення	Беркут	23	Вип. 1	2014	13 - 18

AVIFAUNAL DIVERSITY IN WETLANDS AROUND KEOLADEO NATIONAL PARK, BHARATPUR, INDIA

Bhumesh Singh Bhadouria, Vinod B. Mathur, K. Sivakumar

Wildlife Institute of India; Chandrabani, Dehradun, India
✉ B.S. Bhadouria, e-mail: bhumesh78@gmail.com

Abstract. Twenty-seven wetlands around Keoladeo National Park (KNP) were surveyed from 2009 to 2011. These wetlands were either on agricultural land or the dams that have been created mainly for supplying water for irrigation of the agricultural fields of surrounding areas. They ranged in distance from KNP from 4.3 to 125.82 km and area from 10 to 26,667 ha. The majority of the wetlands were from 10 to 400 ha in area. The relations of population abundance and species richness with other factors, i.e. water availability, distance and wetland size, were studied. Water availability was a very important aspect and played a crucial role for water birds. The highest bird diversity, H′ = 2.82, D = 0.084, as determined by the Shannnon-Wiener and Simpson's diversity indices, was observed at Urmila Sagar located 61.82 km from KNP, but no correlation was found between distance and species richness. Moreover, no correlation was found between distance and population abundance also.

Key words: fauna, water birds, species richness, abundance, population.

Авифаунистическое разнообразие водно-болотных угодий вокруг национального парка Кеоладео, Бхаратпур, Индия. - Б.С. Бхадурия, В.Б. Матхур, К. Сивакумар. - Беркут. 23 (1). 2014. - В окрестностях национального парка Кеоладео (штат Раджастхан на севере Индии) расположены 27 водно-болотных угодий (ВБУ). В основном это запруды, созданные для ирригации. Они расположены на расстоянии от 4,3 до 125,8 км от парка. Площадь колеблется от 10 га до 26,7 тыс. га. В большинстве случаев ВБУ небольшие – от 10 до 400 га. В 2009–2011 гг. были проведены учеты птиц. По полученным данным определялось видовое богатство ВБУ и общая численность птиц. Анализировалась связь между этими характеристиками и другими факторами – обводненность, расстояние до национального парка, площадь ВБУ и т.п. Наиболее важным фактором было наличие воды, корреляция между количеством видов, численностью птиц и расстоянием до парка не отмечена.

Ключевые слова: фауна, водные птицы, видовое богатство, обилие, численность.

1. Introduction

Worldwide there has been increasing interest in the conservation of water birds and their wetland habitats. They are under pressure due to certain environmental changes and human activities (Turner et al., 2000; Froneman et al., 2001). Wetland ecosystems are being altered and reduced at an increasing rate by human activities (Wilen, 1989). Human activities throughout the world have, however, responsible for the fragmentation of most natural biotopes (Burgess, Sharpe, 1981; Van Drop, Opdam, 1987). Over 50% of the world's wetlands have been lost since 1900 (Finlayson, Davidson, 1999) due to agricultural and urban development (Shine, Klemm, 1999). To meet increasing demands for food, natural wetlands have been converted into agricultural fields and dams that supply water for irrigation of the surrounding agricultural fields. In this situation, these agricultural wetlands have become important refuges for bird communities.

The importance of artificial wetlands has been studied by many authors who have suggested that these wetlands can provide suitable habitats for water birds (Tourenq et al., 2001; McKinstry, Anderson, 2002; Paracuellos, Telleria, 2004; Santoul et al., 2004; Okes et al., 2008; Rendon et al., 2008). In the early years, the focus was on describing the patterns of bird communities in homogenous habitats (Enemar, 1959; Blondel, 1965), but later it was understood that habitat heterogeneity, water-level fluctuations and vegetation cover may be factors influencing the occurrence, abundance and richness of species (Kaminski, Prince 1984; Wiens, 1989; Edwards, Otis, 1999; Weller, 1999).

India is estimated to have about 58.2 million hectares of wetlands (Prasad et al., 2002). Many of these wetlands are distributed around the Indo-Gangetic plains. Apart from the natural wetlands, which support 20% of the known biodiversity of India (Deepa, Ramachandra, 1999), there are many man-made wetlands such as dams and ponds, which also support floral and faunal diversity. The use of these artificial wetlands by water birds during the breeding season has been studied by Sánchez-Zapata et al. (2005). The preferences of avian communities in recently created agricultural wetlands in irrigated landscape of semi-arid areas have been studied by Moreno-Mateos et al. (2009).

Wetlands around Keoladeo National Park (KNP), which is a World Heritage Site and a Ramsar Site, were selected for the present study. Most of the wetlands are natural depressions that have been converted into dams and ponds that supply water to agricultural fields. Over the last decade, KNP has not received the required quantity of water (550 million cubic feet) because of erratic rainfall. Consequently, the population of water birds and the number of species have decreased, and no heronry has been formed during drought periods. In this paper we analyse the bird communities of these wetlands.

2. Material and Methods

2.1. Study Area

KNP (27° 8′ to 27° 12′ N and 77° 30′ to 77° 34′ E), with an extent of 2873 ha, lies at the edge of the Gangetic plain, near the margin of the Thar desert, in a depression at the junction of the Gambhir and Banaganga rivers (Fig. 1).

KNP has a climate with hot summer and a cold winter. The mean maximum temperature ranges from 20.9 °C, in January, to 47.8 °C, in May, while the minimum mean temperature varies from 6.8 °C, in December, to 26.5 °C, in June. The mean annual precipitation is 743 mm, with rain falling on an average of 39 days per year, mainly during the monsoon, in July and August.

More than 350 species of bird have been recorded in KNP, with a high diversity of migratory birds during winter. Indeed, KNP is known as «Birders Paradise» as the park lies on the Central Asian Flyway of the Asia Pacific Global Migratory Flyway. It is a wintering ground for a large number of migra-

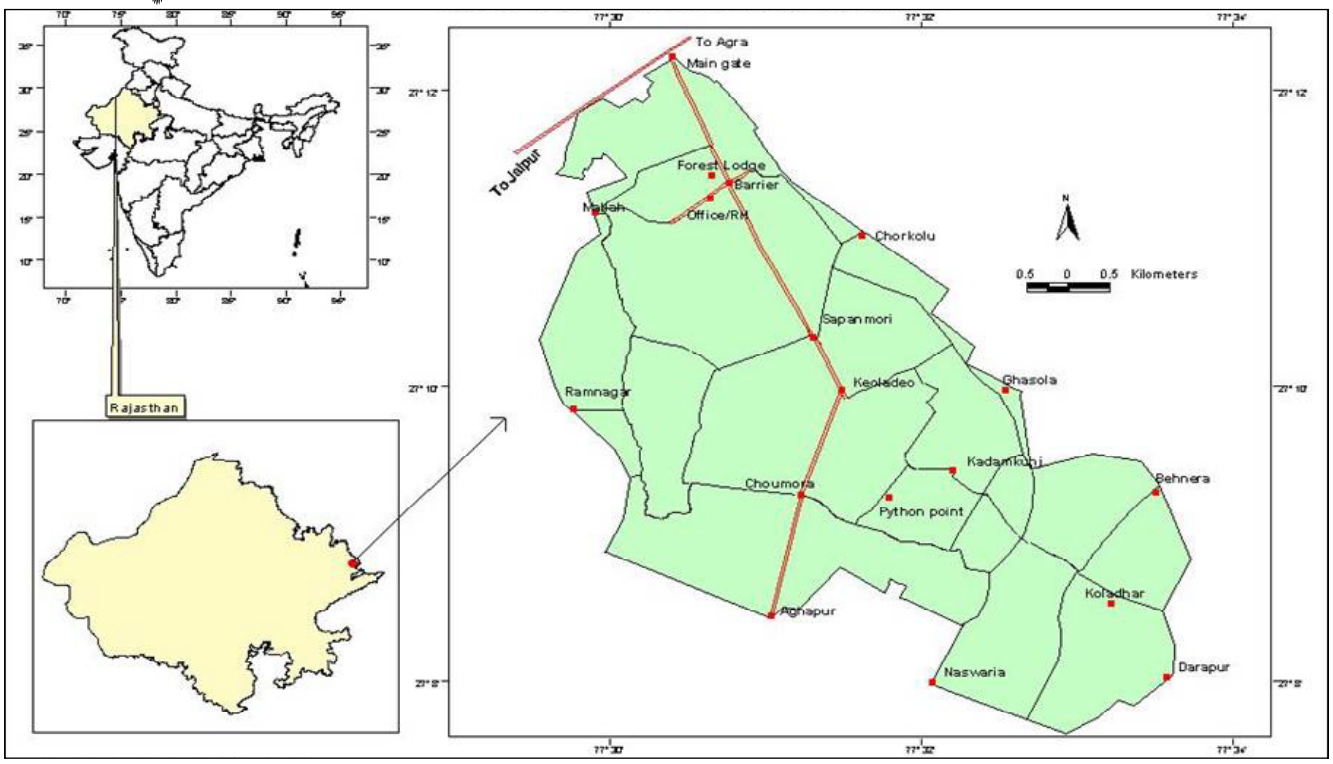

Fig. 1. Block map of Keoladeo National Park.

Рис. 1. Размещение национального парка Кеоладео.

tory waterfowl that breed in the Palaearctic region. Due to its rich avian biodiversity value, the park has been declared as both a Ramsar Site and a World Heritage Site. Populations of both migratory and resident water birds have been declining in the region due to a prolonged drought and a scarcity of water in its reservoirs. Birds known to reside within KNP have been moving to the nearby wetlands as less water has become available in the park (Mathur et al., 2009). Detailed information is not available on usage of these wetlands by birds. Twenty-seven wetlands were identified for this study (Fig. 2). They are located at distances ranging from 4.3 to 125.8 km from KNP and are never interconnected by ecological corridors.

2.2. Water Bird Census

Water birds were counted over a period of 3 years, from 2009 to 2011. The counting was done between 12^{00} and 17^{00} hours, using binoculars and telescopes. Surveys began near wetlands, where most of the surface area and edge of the water were visible. All the birds present were identified and counted (Bibby et al., 1993). Birds were located by walking along the edge of the wetland. They were identified to species level by consulting Ali (1996), Ali and Ripley (1986) and Bhusan et al. (1993). The bird species richness at each site was determined as the total number of species observed (Ludwig, Reynolds, 1988). The total number of individuals of each species was recorded to calculate the species diversity (H′) using the Shannon-Wiener diversity index (Krebs, 1999).

2.3. Data Analysis

The GPS locations of all the wetlands were obtained and the distance of each wetland from KNP calculated using an online distance calculator. The relationships between dependent and independent variables were determined using simple linear correlation. The mean and standard deviation were calculated using an Excel worksheet.

3. Results

The wetlands' characteristics, such as size, water availability and holding capacity, are presented in Table 1. Water was available throughout the year in nine wetlands. In 11 wetlands, water was available for 4–8 months, and the remaining seven wetlands were dry during the survey period. Water availability is a very important aspect of a wetland ecosystem and plays a crucial role in the assemblage of water birds there. It can be seen that the area of the wetlands ranged from 10 to 26,667 ha (M = 1980.8, SD = 5622.7), but most of them were in the range from 10 to 400 ha.

The GPS locations of the wetlands and their calculated distances from KNP are presented in Table 2. The wetlands are located 4.3–125.82 km (M = 53.25, SD = 34.35) from KNP, and their extent ranges from 10 to 26,667 ha (M = 1980.8, SD = 5622.7).

3.1. Species Composition, Diversity and Evenness and Bird Abundance

The species richness and bird abundance of each wetland were calculated. The Shannon-Wiener and Simpson's diversity indices were used to determine the species diversity of each wetland (Table 3).

3.2. Species Richness and Population: Relationship with Distance and Area

The results indicate that there is no relationship between

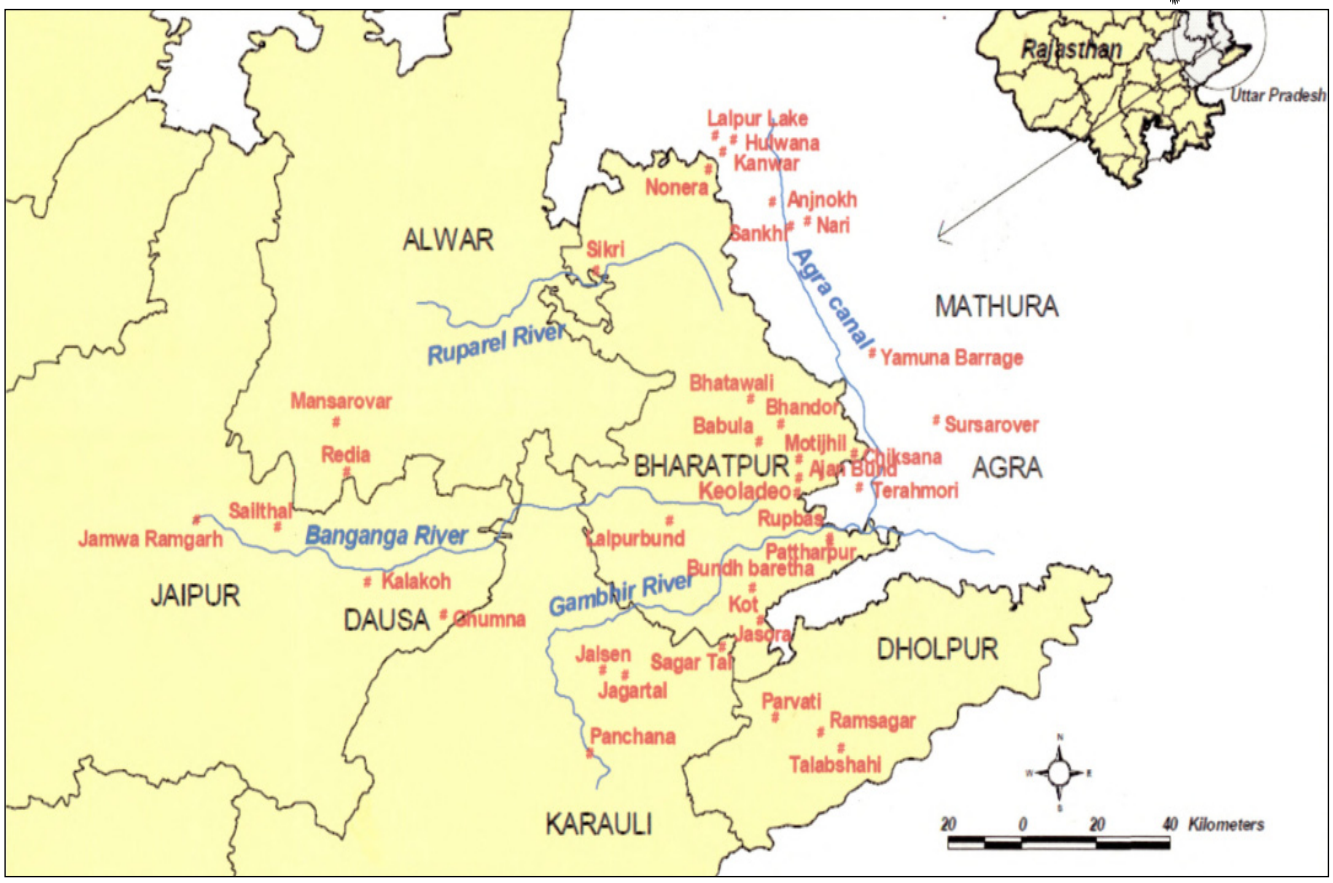

Fig. 2. Locations of the wetlands selected for the study.
Рис. 2. Размещение водно-болотных угодий, выбранных для исследований.

species richness and distance (Fig. 3). The highest species richness (Shannon-Wiener diversity index H′ = 2.82, D = 0.084) was recorded at Urmila Sagar, which is located 61.82 km from KNP. The species eveness at Urmila Sagar was 0.759.

No relationship was found also between distance and total population (Fig. 4). The highest population of birds was found at Bundh Baretha, which is 36.3 km from KNP. The second highest population was recorded at Parvati Dam, which is located 61.73 km from KNP. We found 41 species at this wetland, but the largest bird population is supported at Bundh Baretha, where 30,529 birds were recorded.

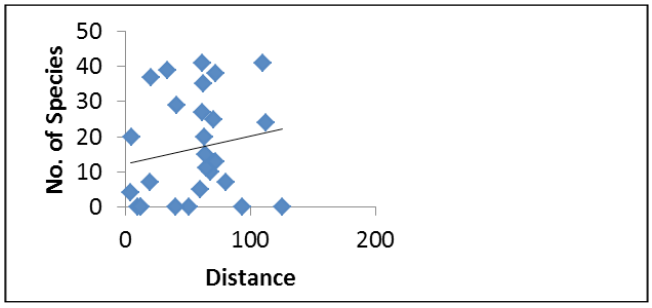

Fig. 3. Relationship between species richness and distance.
Рис. 3. Связь между видовым богатством и расстоянием ВБУ от национального парка.

3.3. Relationship of Wetland Size with Species Richness and Total Population

No relationship was found of the size with species richness and population (Fig. 5, 6). The wetlands selected for this study ranged in size from 10 to 26,667 ha, with mean area 1980.8 ha (SD = 5622.7).

The size of most wetlands was in the range from 10 to 400 ha. Two of others were 800 ha in area, and rest were in the range from 2900 to 26,667 ha. The area of the most diverse wetland, Urmila Sagar, is about 2900 ha.

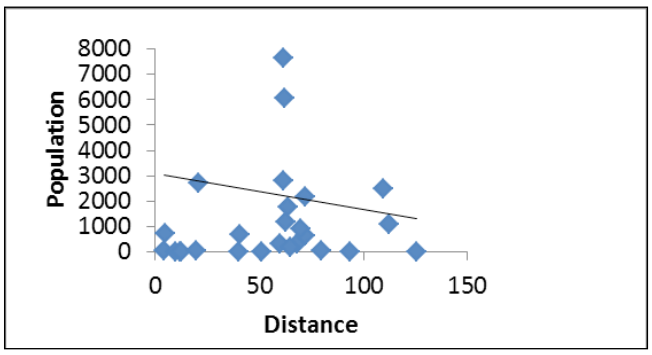

Fig. 4. Relationship between population and distance.
Рис. 4. Связь между численностью птиц и расстоянием ВБУ от национального парка.

Table 1

The water availability and sizes of the wetlands Наличие воды и размеры водно-болотных угодий

Wetland	Water availability												Area (ha)
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	
Abua Nagla													200
Ajan Dam													120
Babula	DRY												250
Bhandor	DRY												250
Bundh Baretha													120
Chambal													300
Chiksana Bundh													810
Ghumna	DRY												50
Gir Raj Canal													300
Indrolia													NA
Jagar Bundh													100
Jalsen	DRY												40
Jasora	DRY												200
Kalakho	DRY												100
Kot													14,497
Leathri													300
Mansarovar													800
Nonera													10
Pachna Dam													140
Parvati													26,667
Ram Sagar													5600.3
Redia Bundh													80
Roopbas Bundh													20
Saithal	DRY												400
Talab-e-Shahi													410.12
Urmila Sagar													2900
Vishronde Ka Taal													200

4. Discussion

The present study was conducted with the objective of evaluating the species richness and abundance of water birds using these man-made wetlands, which have been created for irrigation. These wetlands are the roosting, feeding and breeding places of water birds. Similar findings have been reported by Múrias et al. (2002), Ma et al. (2004), Paracuellos, Telleria (2004), Santoul et al. (2004). We tried to identify factors responsible for birds migrating to these wetlands and to correlate the species richness and bird abundance with the distance of the wetland from KNP and the area of the wetland. Many studies that have tried to determine the most important features responsible for selection of habitats by water birds have not been successful (Murkin et al., 1997), and the influence of season on habitat selection has been poorly investigated (Froneman et al., 2001). The diversity of some wetlands was found to be high from the Shannon-Wiener and Simpson's indices. Urmila Sagar, Redia Bundh, Bundh Baretha, Nonera and Abua Nagla were the five areas with the highest species richness. Almost all the wetlands hold water throughout the year, except Nonera, where water is available for up to 8 months in a year. Studies have demonstrated that the bird abundance is best predicted by water level fluctuations. Ringelman and Longcore (1982), Froneman et al. (2001), Paszkowski and Tonn (2000) have reported that larger wetlands can provide more microhabitats and hence attract a larger number of species. However, Hudson (1983) and Garay et al. (1991) have reported that smaller wetlands maintain a higher water bird density and diversity compared with larger ones.

During our survey, a rare albino Oriental White Ibis (*Threskiornis melanocephalus*) was observed at Talab-e-Shahi, which is located 62.24 km from KNP. We spotted what was probably the same bird at KNP after a gap of a few days. This suggests that the local movements of birds, as well as

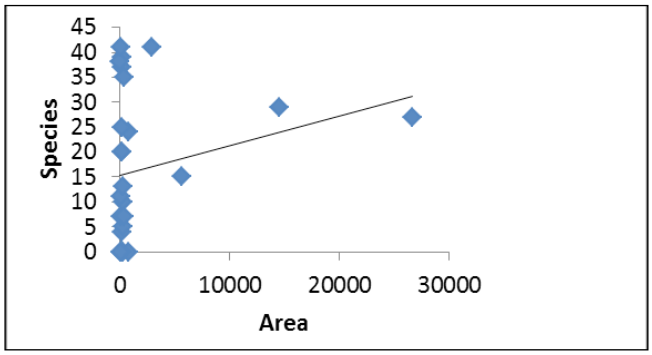

Fig. 5. Relationship between area and species richness.
Рис. 5. Связь между площадью ВБУ и видовым богатством.

their habitat use, need to be assessed more intensively. The present study provides some basic information that can be used in preparing a comprehensive landscape-level conservation plan for conserving the avifaunal diversity of this region. The prolonged drought in and around KNP may be a factor forcing several migratory species to move to the neighbouring wetlands. Hence, these wetlands are playing a crucial role in the conservation of the avifauna of this region, especially during droughts. The current land-use patterns of this region could well be posing an added threat to these wetlands. Some of these wetlands should be declared as community or conservation reserves after conducting nature education programmes and subsequently receiving inputs from the local people.

Acknowledgment

This study is a part of the project «Building Partnerships to Support UNESCO's World Heritage Program in India». We thank the Director, Wildlife Institute of India, for providing support under the UNF-UNESCO project.

REFERENCES

Ali S. (1996): The Book of Indian Birds. Bombay Natural History Society, Oxford University Press, Mumbai.

Ali S., Ripley S.D. (1986): Handbook of the Birds of India and Pakistan. Vol. V. Oxford University Press, London.

Bhusan B., Fry G., Hibi A., Mundkur T., Prawiradilaga D.M., Sonobe K., Usui S. (1993): A Field Guide to the Water Birds of Asia. Wildlife Society, Japan.

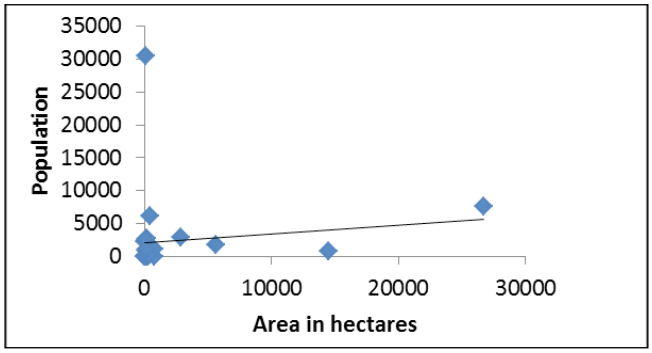

Fig. 6. Relationship between area and population.
Рис. 6. Связь между площадью ВБУ и численностью птиц.

Table 2

GPS location and distances from KNP of the wetlands
Координаты и расстояние водно-болотных угодий от парка

Wetland	GPS location	Distance (km)
KNP	27° 10′ 08″ N, 077° 31′ 24″ E	0
Abua Nagla	27° 20′ 0.8″ N, 77° 37′ 28.1″ E	20.85
Ajan Dam	27° 07′ 53.1″ N, 077° 30′ 44.4″ E	4.3
Babula	NA	NA
Bhandor	NA	NA
Bundh Baretha	26° 53′ 51.8″ N, 77° 22′ 20.4″ E	33.63
Chambal	26° 39′ 28.1″ N, 77° 54′ 16.1″ E	68.2
Chiksana Bundh	27° 10′ 57.8″ N, 77° 38′ 51.4″ E	12.38
Ghumna	26° 50′ 32.3″ N, 76° 38′ 55.8″ E	93.87
GirRaj Canal	27° 12′ 24.3″ N, 77° 32′ 46.8″ E	4.78
Indrolia	NA	60
Jagar Bundh	26° 43′ 17.4″ N, 77° 05′ 52.1″ E	65.18
Jalsen	26° 43′ 28.0″ N, 77° 38′ 46.8″ E	50.87
Jasora	NA	40
Kalakho	27° 02′ 03.3″ N, 76° 15′ 37.2″ E	125.82
Kot	26° 48′ 39.9″ N, 77° 25′ 42.6″ E	40.85
Leathri	27° 47′ 24.2″ N, 77° 18′ 28.3″ E	72.2
Mansarovar	27° 14′ 31.5″ N, 76° 23′ 28.9″ E	112.16
Nonera	27° 47′ 24.2″ N, 77° 18′ 24.2″ E	72.2
Pachna Dam	26 °43′ 28.0″ N, 77° 01′ 14.9″ E	70.12
Parvati	26° 36′ 59.8″ N, 77° 27′ 22.0″ E	61.73
Ram Sagar	26° 35′ 48.9″ N, 77° 35′ 35.2″ E	63.93
Redia Bundh	27° 07′ 12.5″ N, 76° 24′ 51.6″ E	109.79
Roopbas Bundh	27° 00′ 08.1″ N, 77° 35′ 12.9″ E	19.56
Saithal	27° 01′ 46.1″ N, 76° 15′ 39.5″ E	80
Talab-e-Shahi	26° 37′11.9″ N, 77° 38′ 53.7″ E	62.24
Urmila Sagar	26° 39′15.3″ N, 77° 45′ 36.9″ E	61.82
Vishronde Ka Taal	26° 39′ 42.7″ N,77° 48′ 10.9″ E	62.79

Bibby C., Burgess N., Hill D. (1993): Bird Census Techniques. Academic Press Limited, London.

Blondel J. (1965): Étude des populations d'oiseaux dans une garrigue méditerranéenne: description du milieu, de la méthode de travail et exposé des premiers résultats obtenus à la période de reproduction. - Terre et Vie. 112: 311-341.

Burgess R.L., Sharpe D.M. (1981): Forest Island Dynamics in Man Dominated Landscapes. Springer Verlag, New York.

Deepa R.S., Ramachandra T.V. (1999): Impact of urbanization in the interconnectivity of wetlands. Paper presented at the National Symposium on Remote Sensing Applications for Natural Resources: Retrospective and Perspective (XIX–XXI 1999), Indian Society of Remote Sensing, Bangalore, India.

Edwards N., Otis D. (1999): Avian communities and habitat relationships in South Carolina piedmont beaver ponds. - Amer. Midland Nat. 141: 158-171.

Enemar A. (1959): On the determination of the size and composition of a passerine bird population during the breeding season. - Vår fågelwärld. Suppl. 2: 1-114.

Finlayson C.M., Davidson N.C. (eds.) (1999): Global Review of Wetlands Resources and Priorities for Wetland Inventory. Wetlands International, the Netherlands.

Froneman A., Mangnall M.J., Little R.M., Crowe T.M. (2001): Water bird assemblages and associated habitat characteristics of farm ponds in the Western Cape, South Africa. - Biodiv. Conserv. 10: 251-270.

Table 3

Species richness, abundance and diversity of the wetlands
Видовое богатство, обилие и разнообразие птиц водно-болотных угодий

Name of wetland	Total population	Average population	Species richness	Shannon diversity index (H′)	Simpson's index (D)	Equitability index
Abua Nagla	2703	73.05	37	2.234	0.162	0.619
Ajan Dam	66	16.50	4	1.048	0.387	0.756
Bundh Baretha	29,447	755.10	39	2.147	0.222	0.586
Chambal	315	31.50	10	1.927	0.163	0.837
Jagar Bundh	166	15.09	11	1.501	0.313	0.626
Gir Raj Canal	739	36.95	20	2.005	0.191	0.669
Indrolia	340	68.00	5	0.468	0.785	0.291
Kot	700	24.14	29	2.720	0.112	0.808
Lithere	659	50.69	13	2.036	0.162	0.794
Mansarovar	1107	46.12	24	1.700	0.324	0.535
Nonera	2190	57.63	38	2.372	0.131	0.652
Pachna Dam	921	36.84	25	2.372	0.132	0.737
Parvati	7646	283.20	27	0.903	0.628	0.274
Ram Sagar	1757	117.10	15	1.621	0.269	0.599
Redia	2484	60.59	41	2.473	0.128	0.666
Roopbas	30	4.286	7	1.263	0.359	0.649
Saithal	60	8.57	7	1.291	0.333	0.663
Suronth	2169	61.97	35	1.903	0.297	0.535
Talab-e-Shahi	6048	172.80	35	2.044	0.257	0.575
Urmila Sagar	2815	68.66	41	2.820	0.085	0.759
Vishonda Bundh	1178	58.90	20	2.013	0.180	0.672

Garay G., Johnson W., Franklin W. (1991): Relative abundance of aquatic birds and their use of wetlands in the Patagonia of southern Chile. - Revista Chilena de Historia Natural. 64: 127-137.

Hudson M.S. (1983): Waterfowl production on three age classes of stock ponds in Montana. - J. Wildlife Manag. 47: 112-117.

Kaminski R., Prince H. (1984): Dabbling duck-habitat associations during spring in delta marsh, Manitoba. - J. Wildlife Manag. 48: 37-50.

Krebs C. (1999): Ecological Methodology. Second edition. Benjamin/Cummings, Addison Wesley, Menlo Park, California.

Ludwig J.A., Reynolds J.F. (1988): Statistical Ecology. John Wiley and Sons, New York.

Ma Z., Li B., Zhao B., Ping K., Tang,S., Chen J. (2004): Are artificial wetlands good alternatives to natural wetlands for waterbirds? A case study on Chongming Island, China. - Biodiv. Conserv. 13: 333-350.

Mathur V.B., Sivakumar K., Singh B., Anoop K.R. (2009): A Bibliographical Review for Identifying Research Gap Areas: Keoladeo Ghana National Park, A World Heritage Site. Wildlife Institute of India, Dehradun.

McKinstry M.C., Anderson S.H. (2002): Creating wetlands for waterfowl in Wyoming. - Ecological Engineering. 18: 293-304.

Moreno-Mateos D., Pedrocchi C., Comín F.A. (2009): Avian communities' preferences in recently created agricultural wetlands in irrigated landscapes of semi-arid areas. - Biodiv. Conserv. 18: 811-828.

Múrias T., Cabral J.A., Lopes R., Marques J.C., Goss-Custard J. (2002): Use of traditional salines by waders in the Mondego estuary (Portugal): a conservation perspective. - Ardeola. 49: 223-240.

Murkin H.R., Murkin E.J., Ball J.P. (1997): Avian habitat selection and prairie wetland dynamics: a 10-year experiment. - Ecol. Appl. 7: 1144-1159.

Okes N.C., Hockey P.A.R., Cumming G.S. (2008): Habitat use and life history as predictors of bird responses to habitat change. - Conserv. Biol. 22: 151-162.

Paracuellos M., Telleria J.L. (2004): Factors affecting the distribution of a water bird community: the role of habitat configuration and bird abundance. - Waterbirds. 27: 446-453.

Paszkowski C., Tonn W. (2000): Community concordance between the fish and aquatic birds of lakes in northern Alberta, Canada: the relative importance of environmental and biotic factors. - Freshwater Biology. 43: 421-437.

Prasad S.N., Ramchandra T.V., Ahalya N., Sengupta T., Kumar A., Tiwari A.K., Vijayan V.S., Vijayan L. (2002): Conservation of wetlands of India – a review. - Tropical Ecology. 43:173-186

Rendon M.A., Green A.J., Aguilera E., Almaraz P. (2008): Status, distribution and long-term changes in the water bird community wintering in Doñana, south-west Spain. - Biol. Conserv. 141: 1371-1388.

Ringelman J., Longcore J. (1982): Movements and wetland selection by brood-rearing black ducks. J. Wildlife Manag. 46: 615-621.

Sánchez-Zapata J.A., Anadón J.D., Carrete M., Giménez A., Navarro J., Villacorta C., Botella F. (2005): Breeding waterbirds in relation to artificial pond attributes: implications for the design of irrigation facilities. - Biodiv. Conserv. 14: 1627-1639.

Santoul F., Figuerola J., Green A.J. (2004): Importance of gravel pits for the conservation of waterbirds in the Garonne river floodplain (southwest France). - Biodiv. Conserv. 13: 1231-1243.

Shine C., Klemm C. (1999): Wetlands, Water and the Law: Using Law to Advance Wetland Conservation and Wise Use. IUCN, Gland.

Tourenq C., Bennets R.E., Kowalski H., Vialet E., Licchesi J.-L., Kayser Y., Isenmann P. (2001): Are rice fields a good alternative to natural marshes for waterbird communities in the Camargue, southern France? - Biol. Conserv. 100: 335-343.

Turner R.K., Van den Berg J.C.J.M., Soderqvist T., Barendregt A., Van der Straaten J., Maltby E., Van Ierland E.C. (2000): Ecological-economic analysis of wetlands: scientific integration for management and policy. - Ecol. Economics. 35: 7-23.

Van Dorp D., Opdam P.F.M. (1987): Effects of patch size, isolation and regional abundance on forest bird communities. - Landscape Ecology. 1: 59-73.

Weller M.W. (1999): Wetland birds: Habitat Resources and Conservation Implications. Cambridge University Press, Cambridge, UK.

Wiens J.A. (1989): The ecology of bird communities: foundations and patterns. Cambridge University Press, New York.

Wilen B.O. (1989): Status and Trend of Inland Wetlands and Deepwater Habitats in the conterminous United States: Freshwater Wetlands and Wildlife. CONF-8603101. DOE symposium series no. 61 (Sharitz R.R. and Gibbons J.W., eds.). 719-727.