Chapter 4
Distribution and Diversity of Storks in the Adjoining Areas of Chitwan National Park, Nepal

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Abstract The Barandabhar corridor forest (BCF) has a very high biodiversity and in terms of wildlife is globally significant. This study on the status of Ciconiidae (storks) in the BCF was conducted by means of direct observation along bird routes, line transects, roads, man-made tracks and riversides. A seasonal count was used to determine the actual status of the storks. Four species of the family Ciconiidae, the lesser adjutant stork (52 individuals); black stork (6); woolly-necked stork (148) and Asian open bill stork (363) were recorded during the course of this study. The population of storks was highest in the rainy season. Among the species studied, the Asian open bill stork, woolly-necked stork and lesser adjutant stork were resident in the area, whereas the black stork is migratory and only present in winter. Storks were recorded mainly around lakes and ponds (675 individuals) followed by marshy and swampy land (325), grassland (293), paddy fields (251), rivers and streams (187). The most abundant species is the Asian open bill stork, followed by the woolly-necked stork, lesser adjutant stork and black stork. All the diversity indices values showed that the Asian open bill stork was the dominant species in the study area, followed by the woolly-necked stork, lesser adjutant stork and black stork. Many wetlands inside the Chitwan National Park and the Barandabhar corridor forest dry out in summer, which directly affects the survival of these birds, as they are confined to protected areas in the dry season, when there is no water in the paddy fields. Degradation of aquatic ecosystems, overuse of pesticides in fields and overfishing of rivers and lakes using poisons and electricity, are the major threats to these species.

Keywords Storks • Corridor • Birding routes • Biodiversity • Pesticides • Threats

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4.1 Introduction

The storks, which fall under the family Ciconiidae, are the signs of the healthy wetlands. Distribution of storks in Asia and Europe ranges from India, south through Myanmar and Thailand to Laos, Cambodia, Vietnam and Peninsular Malaysia to the Greater Sundas, including Sumatra, Kalimantan, Java and Bali (Indonesia), Sabah and Sarawak (Malaysia) and Brunei. There are unconfirmed reports that some storks are under threat of extinction, like the lesser adjutant stork, black stork and white stork from Bhutan, which occurs as a vagrant east of Bali in the Lesser Sunda Islands (Nusa Tenggara), Indonesia (Birdlife International 2001). Storks have a wide distribution and are found on all continents, except Antarctica. They reach their greatest diversity in the tropical regions and show a strong preference for warmer climates, with the few species that breed in colder temperate areas migrating to warmer countries after nesting. North America has the least diversity, with the wood stork as the region's only and very marginal representative (http://www.answers.com/topic/stork?cat=technology).

Wetlands in Nepal are characterized by their diverse biological assemblages, high productivity and seasonal changes. They are shallow and largely depend on seasonal monsoon rains. Countless species of plants and animals depend on the highly productive wetlands for their survival (IUCN 2004). No wonder they are often called "the cradles of biodiversity". The wetlands also play a crucial role in flood control, storage and discharge of groundwater, microclimate regulation, retention of soil nutrients, conversion of toxins, biomass export and provision of important fish and wildlife habitats. Nepal has many different types of wetlands that range from areas of permanently flowing rivers to seasonal streams, lowland oxbow lakes, high altitude glacial lakes, swamps and marshes, paddy fields, reservoirs and ponds (Scott 1989). Birds are the most noticeable and diverse fauna in such wetlands. These areas are rich in biodiversity and regularly support more than 20,000 waterfowl during December-February (IUCN 2004). Out of the 872 species of birds in Nepal, 193 are dependent on wetlands, and of these, 180 are dependent on the wetlands of Tarai (IUCN 2004). Among them Ciconiidae are the most important bird taxon in the wetlands.

There are a number of wetland birds in Nepal, which are globally threatened. The lesser adjutant, greater adjutant, black and white storks occur in Nepal (Grimmett et al. 2000) and are listed as globally threatened species in the IUCN's Red Data Book (Birdlife International 2004; IUCN 2004). The black and white storks migrate to Nepal in winter. They are distributed throughout the southern part of Nepal, but due to habitat loss and alteration and human disturbance, these species now mainly migrate to some isolated habitats in lowland Nepal (Birdlife International 2001). They are mostly recorded in the Koshi Tappu Wildlife Reserve and its surroundings, the Chitwan National Park (CNP) and its surroundings, the Beeshazari Lake, Kapilvastu, Nawalparasi and Rupandehi districts, the Bardia National Park, the Ghodaghodi Lake and the Suklaphata Wildlife Reserve and surroundings. Currently, there is a concern about these species both internationally and in Nepal, as

there is evidence that their numbers are declining. Some studies have been carried out in the Koshi Tappu Wildlife Reserve (Fleming et al. 1984; Pokharel 1998; Baral 2004), in the Chitwan National Park (Gyawali 2003; Hungden and Clarkson 2003; Tamang 2003), the Bardia National Park and the Suklaphata Wildlife Reserve (Schaaf 1978), but this baseline study was carried out in the southern part of Nepal in order to determine the population status and distribution of Ciconiidae. Studying the current population status and distribution of Ciconiidae is necessary for developing management plans to conserve these threatened species in their natural habitats.

The main objective of this study was therefore to investigate the present status, distribution and determine the conservation needs of Ciconiidae in the Barandabhar corridor forest. The specific objectives were: (1) to determine the population status and distribution of Ciconiidae in the Barandabhar corridor forest; (2) to identify the major habitats and trends in habitat utilization by Ciconiidae; (3) to determine the present threats to Ciconiidae and suggest a strategy for the sustainable conservation of Ciconiidae and other wetland birds.

4.2 Methods

4.2.1 Study Area

The intensive study area was in and around the Barandabhar corridor forest (BCF, 84°22′30″–84°33′0″ E, 27°34′7″–27°43′30″ N – Fig. 4.1) adjacent to the northern border of the Chitwan National Park (CNP) and the Mahabharat hill forest in the north of the Chitwan Valley, which is situated in the subtropical inner Tarai lowlands of the southern central part of Nepal (85°55′–84°47′ E, 26°22′–26°46′ N). The Beeshazari Lake, which is located in the Barandabhar forest at an altitude of 256 m, is the second largest natural wetland in Nepal and was recently included among the Ramsar sites by the Nepalese government (http://www.ramsar.org/wn/w.n.nepal_3new.htm). The east-west highway divides the Barandabhar Forest corridor into two executive jurisdictions. The buffer zone forest south of the east-west highway is managed by of the Chitwan National Park (CNP), while the District Forest Office (DFO) manages the forest north of the highway.

The BCF is a habitat linking two ecosystems at significantly different altitudes: the lowland CNP and the upland Mahabharat Range. The BCF has three major habitat types: (1) sal forest- disturbed sal forest, sal forest with mixed understory and sal forest with *Shorea-Terminalia* understory; (2) successional forest – riverine forest, short grassland, open *Bombax* forest and open-wooded bush and; (3) wetlands. The riverine forest of the BCF occupies a very small area and is located mostly in the northern belt, as well as along the Khagari stream on the eastern boundary of the BCF. The flora of the riverine forest includes *Trewia nudiflora*, *Bombax ceiba*, *Mallotus philippensis*, *Litsea monopetala*, *Sapium insigne* etc. The riverine forest harbors the nesting sites for the globally threatened bird species including the giant

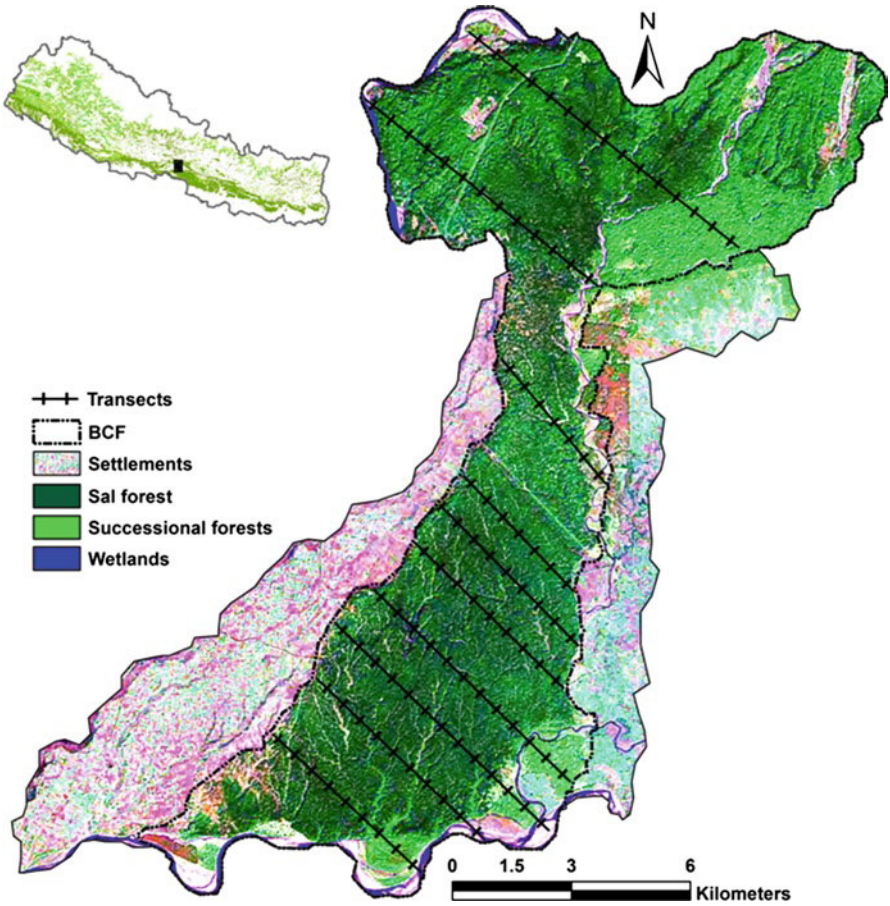


Fig. 4.1 Study area: the Barandabhar corridor forest and location of transects

hornbill (*Buceros bicornis*), and the lesser adjutant stork (*Leptoptilos javanicus*). There is large tracts sal (*Shorea robusta*) forest in the BCF, which extend up to the foothills of the Mahabharat range. Disturbed sal forest occurs along the entire length of the edge of the western side as well as the northern section of the BCF (Bhojad). *Shorea robusta* is the dominant species, also associated with species such as *Terminalia tomentosa*, and *Cleistocalyx operculatus*. The BCF, which is relatively rich in tree diversity, includes 24 species from 17 families. The southern area up to the east-west highway, under the jurisdiction of the Department of National Parks and Wildlife Conservation (DNPWC), is a relatively undisturbed habitat compared to the area north of the east-west highway, which is under DFO jurisdiction.

Sal forests dominating the BCF contain 22 species of mammals including tiger, common leopard, rhinoceros, Asian elephant, sloth bear, wild boar, sambar deer, spotted deer, hog deer, barking deer and 280 species of birds including giant hornbill, hill myna and storks. It is a critical habitat for many species of migratory

birds (e.g., Siberian crane), aquatic birds, and mugger crocodile. More than 45 species of amphibians and reptiles, including frogs, toads, lizards, pythons and crocodiles are found in the Barandabhar corridor forest (KMTNC 2003). Wildlife often takes shelter in the BCF during flooding and fires in the National Park (IUCN 2004). During periods of food scarcity in the National Park, short grasses such as *Imperata cylindrica*, *Cyperus* species, *Digitaria ciliaris*, *Bulbostylis barbata*, and *Eragrostis tenella* in the BCF provide food for ungulates (KMTNC 2003).

Migratory birds use this area as a stop-off point (stepping stone) on the way to their ultimate destination (IUCN 2004). Previously, wetland habitat of BCF was a paradise for residential and migratory birds, but due to the invasion of exotic species, the number of birds has dramatically declined. Weeds, water hyacinths, and other invasive plant species have covered most of the surface of the Beeshazari lake. In addition, dams of the lake are often flooded, which reduces the biological value of the lake (Baral 1996). A total of four species of the family Ciconiidae (lesser adjutant stork, *Leptoptilos javanicus*; black stork, *Ciconia nigra*; woolly-necked stork, *Ciconia episcopus* and Asian open bill stork, *Anastomus oscitans*) are found in the BCF. Among them, the Asian open bill stork and the lesser adjutant stork are residential in the area, whereas the black stork and woolly-necked stork are winter migrants (Baral 1996).

4.2.2 Population Status, Distribution and Diversity of Storks

Total counts were used to determine the number of storks in different habitats. The birds were counted and studied in different wetland habitats of the BCF mostly during the morning and evening, periods of highest bird activity. For the total counts of storks, the bird routes, such as riversides, roads and man made tracks were used. Most of the wetlands and paddy fields around the study area were observed during the study period.

Transect counts were used to check the total counts. Altogether, there were ten transects of 3.2–7.8 km long and 0–300 m wide, depending upon the visibility in each of the different habitats of the storks. Photographs of storks and their habitats were used for identification and determining distribution in different parts of the BCF.

4.2.3 Identification of Key Habitats and Habitat Utilization Trends

The total counts and transects were also used to identify of habitats and habitat utilization by Ciconiidae. The habitats were classified and their preferred use by the storks recorded. The degree of habitat utilization by storks was determined by direct observation in the forest and at wetlands.

4.2.4 Identification of the Threats to Storks and Documentation of the Conservation Strategy

The threats to storks were determined by field studies, personal communication with local people and consultation with concerned authorities. The dissolved oxygen (DO- mg/l) in the water was also determined by the Winkler method in the rainy, winter and summer seasons (Winkler 1888). The number of local people, tourists and livestock encroachment of stork habitats were also investigated by direct counts. The identified threats and their management implications were used in compilation of a sustainable conservation strategy for storks in the study area.

4.2.5 Data Analysis

The data were analyzed using Microsoft Excel 2003. The diversity indices for storks were determined using *Past* (http://folk.uio.no/ohammer/past/download.html) software. The diversity indices were calculated following methods outlined by Harper (1999):

Dominance: $D = \sum \left(\frac{n_i}{n} \right)^2$, where n_i is the number of individuals of taxon *i*.

Shannon-Wiener index: $H = -\sum \frac{n_i}{n} \ln \left(\frac{n_i}{n} \right)$, where n_i is the number of individuals of taxon *i*.

Simpson index: $SI = 1 / D$

Evenness: $E = \frac{e^H}{S}$, where *S* is the number of taxa and *H* as above.

Equitability: $J = \frac{H}{\ln S}$ where H is as above and S is the number of taxa.

The Shannon-Wiener index is one of several diversity indices used to measure diversity in categorical data. It is simply the information entropy of the distribution, treating species as symbols and their relative population sizes as the probability. The Shannon-Wiener index is maximized, when each species is present in equal numbers.

The Simpson's diversity index is another one of a number of diversity indices, used to measure of diversity. In ecology, it is often used to quantify the biodiversity of a habitat. The Simpson index represents the probability that two randomly selected individuals in the habitat belong to the same species.

Dominance, evenness and equitability are other indices of biodiversity, calculated based from the Shannon-Wiener index or from the Simpson index. Equitability and evenness are equal to the Shannon-Wiener index "normalized" by the number of species and dominance is the reciprocal value of the Simpson's index.

4.3 Results

4.3.1 Population Status, Distribution and Diversity of Storks

A total of four species of storks were recorded in the study area. Among them, the lesser adjutant stork and the black stork are globally threatened species. The woolly-necked stork and the Asian open billed stork were the commonest storks in the BCF (Fig. 4.2). In comparison with the global population, the population of the lesser adjutant stork is very low (Fig. 4.3). The population of storks was highest in the rainy season, followed by the autumn, winter and summer seasons. The winter migratory black stork (listed in the protected birds of Nepal, National Parks and Wildlife Conservation act 2029) is by far the rarest species (only 6 individuals altogether). The globally threatened lesser adjutant stork is also rare: 52 individuals were observed during the study, all the records were from wetland in the Barandabhar corridor forest.

The seasonal diversity indices (the Shannon and Simpson indices) of storks were high in winter, followed by those for the summer, autumn, and rainy seasons (Table 4.1). The dominance value for storks was high in the rainy season, followed by the autumn, summer and winter seasons. The species equitability and evenness values for storks were high in the summer season, followed by the rainy, winter and autumn seasons. The comparative diversity indices (the Shannon and Simpson

Simal (*Bombax ceiba*) offers nesting sites for storks and other birds (Photo by BP Bhattarai)

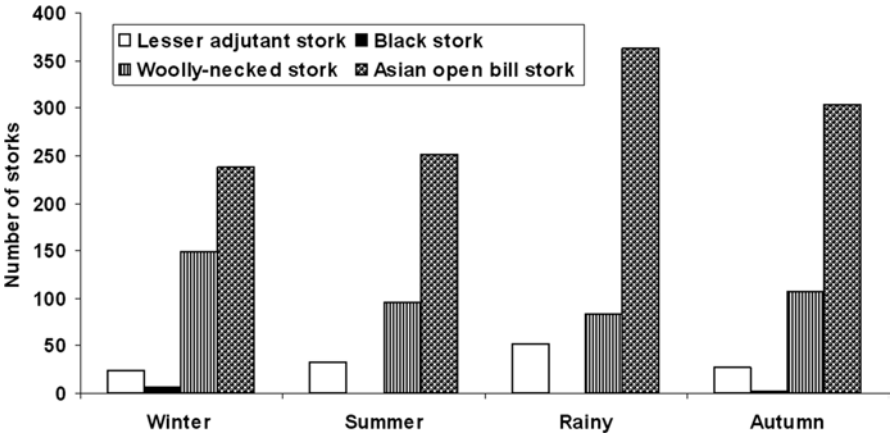
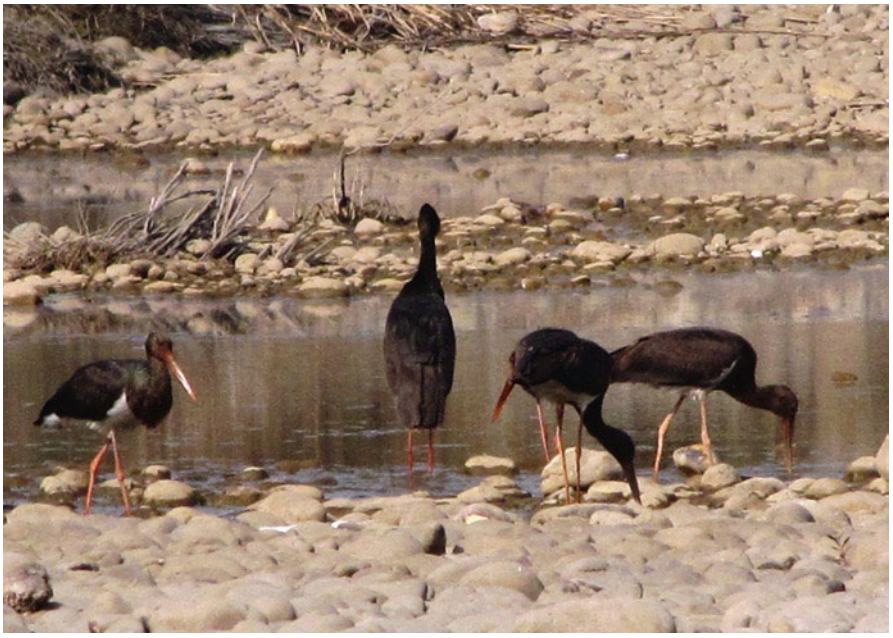


Fig. 4.2 Population status of the four species of storks in the BCF



Black stork (*Ciconia nigra*): a winter visitor bird in the lowlands of Nepal (Photo by BP Bhattarai)

Lesser adjutant stork (*Leptoptilos javanicus*) (Photo by BP Bhattarai)

Nesting sites of the Asian open bill stork (*Anastomus oscitans*) nearby the Beeshazari lake (Photo by BP Bhattarai)

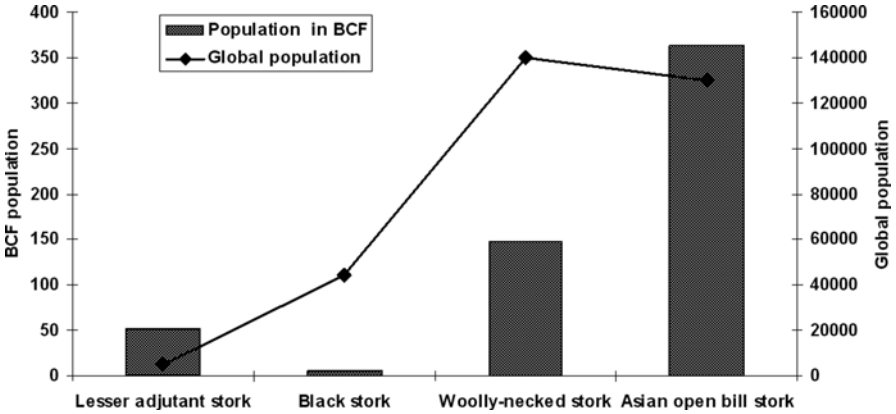


Fig. 4.3 Population status of storks in the BCF compared with their global population size (http://www.birdlife.org/datazone/)

Table 4.1 Seasonal numbers and diversity indices of storks in the BCF

	Seasons			
Name of storks	Winter	Summer	Rainy	Autumn
Lesser adjutant stork	24	32	52	27
Black stork	6	0	0	2
Woolly-necked stork	148	95	83	107
Asian open bill stork	238	251	363	303
Total	**416**	**378**	**498**	**439**
Dominance	0.46	0.51	0.57	0.54
Shannon index	0.91	0.83	0.76	0.80
Simpson index	0.54	0.49	0.43	0.46
Equitability	0.66	0.75	0.70	0.57
Evenness	0.62	0.76	0.72	0.55

indices) of each of the stork species reveal that the diversity of occurrence of the Asian open bill stork was the highest, followed by the woolly-necked stork, lesser adjutant stork and black stork (Table 4.2). Diversity of occurrence of the black stork was low, because it is a winter migrant in this area. This species was not recorded during the summer and rainy seasons. The species evenness and equitability values for the Asian open bill stork were higher than those for the other species; they were followed by the values for the woolly-necked stork, lesser adjutant stork and black stork. All the diversity indices indicate that the Asian open bill stork is the most abundant species in the study area.

The distribution of storks was mainly confined to wetlands, such as the Beeshazari lake system, marshy and swampy lands, short grasslands and rivers in the study area. The Beeshazari lake system was found to be the most restricted and isolated habitat for the storks (Fig. 4.4) and there are very few habitats for storks in this area.

Table 4.2 Comparison of diversity indices of storks in the BCF

	Diversity indices			
Name of storks	Shannon index	Simpson index	Evenness	Equitability
Lesser adjutant stork	1.34	0.72	0.95	0.96
Black stork	0.56	0.37	0.88	0.81
Woolly-necked stork	1.36	0.74	0.98	0.98
Asian open bill stork	1.37	0.74	0.99	0.99

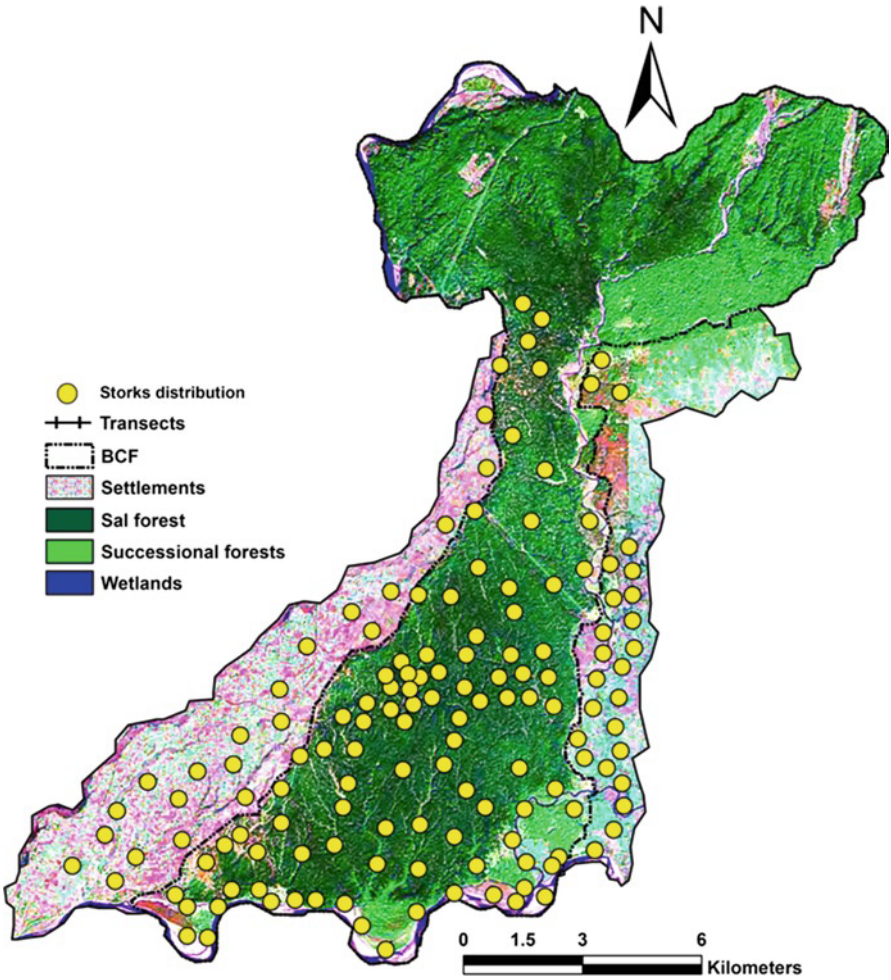


Fig. 4.4 Distribution of storks in the Barandabhar corridor forest and adjoining areas

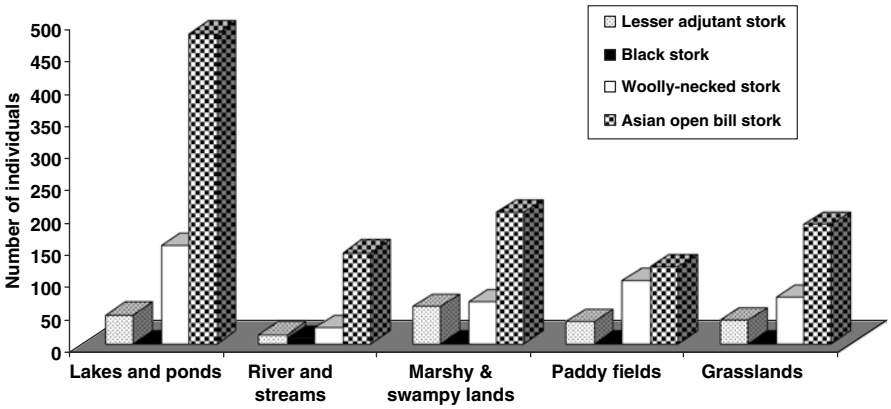


Fig. 4.5 Habitat utilization by storks in the BCF

4.3.2 Key Habitats and Habitat Utilization

Wetlands (the Beeshazari lake system; the Rapti, Budhi Rapti and Khageri rivers; marshy and swampy areas in the forest and short grasslands) were important habitats for storks in the study area. Storks were mainly found in and around lakes and ponds followed by marshy and swampy lands, grasslands, paddy fields, river and streams (Fig. 4.5). The black stork is a migrant in this area and was recorded along the Rapti river. The lesser adjutant stork preferred mostly marshy and swampy lands, followed by lakes and ponds, grasslands and paddy fields. The woolly-necked stork preferred lakes and ponds followed by paddy fields, grasslands, marshy and swampy lands, rivers and streams. Asian open bill storks were mainly confined to lakes and ponds followed by marshy and swampy lands, grasslands, rivers and streams and paddy fields.

4.3.3 Threats to Storks

4.3.3.1 Habitat Disturbance and Destruction

The numbers of storks were very low mainly because of habitat destruction and disturbance. The wetlands in the BCF are decreasing in size and quality for birds because of natural eutrophication. I recorded three darters (snake bird), trapped in the dense mat of water hyacinth and *Leersia hexandra*, which subsequently died of suffocation. Because of the dense growth of the water hyacinth, most of the wetlands (mainly lakes and ponds) look like grasslands. The water level was very low in the associated lakes of the Beeshazari Lake (e.g., Shorahazar and Satrahazar lakes) and wetlands in the forest. The level of dissolved oxygen in the water was also very low in Beeshazari lake (3.2 mg/l in the rainy season, 2.8 mg/l in the winter

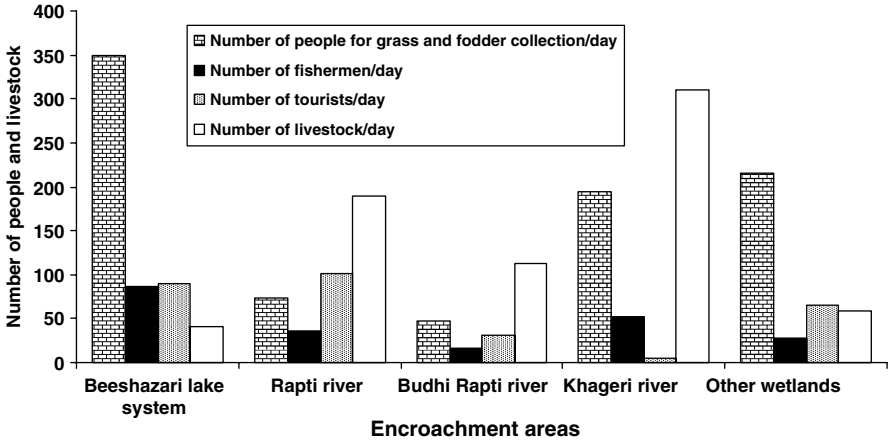


Fig. 4.6 Human and livestock encroachment in the study area

season and 3.8 mg/l in the summer season). Human and livestock encroachment on the forest, mainly of grasslands in the forest, was so high that it could change the population and behavior of the grassland dependent storks by decreasing the size of the feeding and breeding habitats. I have observed, on average, 880 people per day collecting grass, fodder and firewood; 219 fishing, collecting snails and other wetlands products; 292 foreign tourists and 712 domestic animals in and around the wetlands. Of the fishermen and other people collecting wetland products, 86 were doing so from the Beeshazari lake, 36 from the Rapti river, 17 from the Budhi Rapti river, 52 from the Khageri river and 28 from other wetlands in the forest (Fig. 4.6). Some of them, mostly the young collected eggs and young of birds in the study area, mainly in the Beeshazari lake area and along the side of the Khageri river.

4.3.3.2 Vulnerability to Pesticides and Inorganic Fertilizers

Local people in the adjoining area are applying liquid and powder pesticides along with fertilizers to their fields (pers. comm.). Their fields are located in the higher elevations of the study area and pesticides and fertilizers easily dissolve in water and are carried down to the wetlands (Khageri, Rapti and Budhi Rapti river). The Khageri canal is the major source of the chemical threats to Beeshazari lake system as it is the major source of water for the Beeshazari Lake. The farmers apply 5,000 l of liquid and 40 metric tons of powdered pesticides per year in the Chitwan district. Fertilizers (Urea, D.A.P., potash, etc.) are also heavily used in this district. There are a total of 62 authorized societies and suppliers in Chitwan, of which 20 are in Bharatpur and 10 in Ratnanagar municipalities (DADO 2002). Local people are applying more and more fertilizers and pesticides every year, in order to get higher yields. The percentage of organic fertilizers applied continuously declines (pers. comm.) with the increase in the use of inorganic fertilizers.

4.4 Discussion

Unlike previous studies, which focused on the species level (Gyawali 2003; Hungden and Clarkson 2003; Tamang 2003), the present study is mainly focused on the family level (Ciconiidae), in order to study their status, distribution, and develop a conservation database for the long-term survival of these threatened birds. The number of stork individuals recorded in the BCF during the study was very low, compared with previous studies in this area (Baral 1996; BirdLife International 2001; Tamang 2003) and also with the global average (lesser adjutant stork: 5,000 individuals, black stork: 44,000; woolly necked stork: 140,000, Asian open bill stork: 130,000 individuals – Bird Life International 2004 and http://www.birdlife.org/datazone/).

Previously, black storks were recorded as occurring in the Beeshazari lake system (Baral 1996), but I only observed them around the Rapti river, which indicates that the habitat of these migratory birds is now more restricted. This is probably because of the recent eutrophication of the Beeshazari lake system. Eutrophication greatly affects the population status and structure of wetland dependent birds like storks (Masifwa et al. 2001). The populations of storks are mainly confined to the Beeshazari Lake and its associated parts because of the scarcity of wetland habitats in other parts of the study area. During the rainy season, storks were recorded in all the wetlands and paddy fields, but in other seasons they were mostly observed along rivers and in the Beeshazari lake system due to lack of wetlands and paddy fields outside the forest.

The dramatic decline in wetland-dependent bird populations might be due to the scarcity of food (Inskipp and Inskipp 1991) and decrease in the number of wetlands (e.g., lakes associated with Beeshazari lake and other wetlands in the forest), because large numbers of local people are collecting fish, snails and other wetland products by hand, and by diverting the flow of water and by poisoning fish. The practice of killing fish by poisoning is common in the water system of Chitwan (Dahal 1999), but mainly confined to the Khageri canal and rivers in the study area. Such practices destroy the local habitats and directly affect species along with their food chains, including storks.

Storks are large and conspicuous; they are a favourite and easy target for bird hunters and their body parts, mainly the bills, are sold in shops in Kathmandu as medicine (Sapkota 2002). On the other hand, the disturbances of their habitat in the forest and/or in the protected areas (Baral 2005), these birds search paddy fields for food. The application of pesticides and fertilizers to the fields results in the storks being poisoned and, in the long term, a disastrous change in their gene pool and a lower reproductive success.

The wetlands of Nepal have suffered greatly from invasive alien plant species, primarily the water hyacinth *Eichhornia crassipes*, which is a native of Brazil, but has become widespread globally (Gopal 1987). This is also true for the wetlands in the study area, e.g., the Beeshazari lake and its associated lakes. The volume of water in the Shorahazar and Satrahazar lakes, which are the main lakes in the Beeshazari lake system, is very low due to the heavy organic matter produced by the

dense mat of invasive plant species. In addition, the dense layer of water hyacinth prevents light penetrating into the water, and even traps diving birds (e.g., darter, kingfishers), causing a decline in their populations (Tamang 2003). Water hyacinth was first reported in Nepal in 1966 and is now widely distributed in most of the Tarai-protected areas, ranging from 75 m to 1,500 m (Tiwari et al. 2005). This species a major problem everywhere in South Asia (Gopal and Krishnamurthy 1993) and has caused more damage to Nepal's aquatic habitats than any other invasive, alien species (Inskipp and Inskipp 1991). The species has a high growth and reproductive rates and the free-floating mats have an adverse effect on wetland biodiversity. The enormous expanse of water hyacinth significantly reduced the open water area and caused a rapid decline in the number of wetland birds such as storks, darter and cormorants. The abundance of water hyacinth not only reduces the quantity of water, but also reduces the level of dissolved oxygen in the water (Gopal 1987), which might influence the dynamics of the benthic community that could negatively affect birds like storks. This invasive weed can also greatly reduce invertebrate communities as it reduces the level of dissolved oxygen in the water (Butchart 1998; Masifwa et al. 2001). Nevertheless, management of the water hyacinth is difficult, due to its extremely high growth rate and potential adverse effect on other ecosystem components (Gopal 1987).

Water hyacinth – consequence of natural eutrophication – Beeshazari Lake (Photo by BP Bhattarai)

The oxygen concentration in the water of the Beeshazari lake is very low, which affects the distribution of invertebrates, which in turn adversely affects the waterfowl and storks that feed on a wide range of invertebrates and small fish.

Agrochemicals present another threat (Pokharel 1998; Gyawali 2003) to many wetlands in Nepal. The feeding habitats of birds are being converted into agricultural land or used for the development of infrastructure. Changes in agricultural practices are taking place throughout the country. Farmers have shifted from traditionally grown crops to cash crops, such as paddy and wheat. Since storks depend on paddy fields, the change in agricultural practices might seriously affect them. Several threats, such as habitat loss, human and livestock disturbance and hunting (Shakya 1995; Pokharel 1998; BirdLife International 2001; Gyawali 2003) are the major threats for the sustainable conservation and management of storks and their habitat.

4.5 Conservation Strategy

Despite increased efforts to raise public awareness of the importance of birds and wildlife, the local people still do not understand and appreciate the value of conserving birds and wildlife. Large numbers of people are involved in the collection of bird food such as fish, snails etc., for their own use (Fig. 4.3). We need to provide them with an alternative ways of satisfying their needs. These might include establishment of fishponds outside the forest, providing biogas, agro-forestry, and some of their daily needs, such as forage for their livestock, firewood, thatch grass and traditional medicines.

The local people dependent on these wildlife habitats are low caste Chepang, Darai, Bote, Majhi, and Tharu communities. The majority of these people are illiterate and do not know anything about wildlife conservation and its importance (personal communication with people in the study area). These people are unknowingly using wildlife habitats as if part or a member of the forest ecosystem, so that their adverse effect on wildlife increases. Local people are using more and more fertilizers and pesticides to increase the production of their crops, which indirectly affects wetland-dependent birds, like storks. Others are heavily dependent on forest resources for survival, which could be addressed by income generation programs, which in turn will enhance the conservation of birds as well as the biodiversity of the region. Thus the low avifauna conservation awareness of the people living close to bird habitats is one of the most serious challenges for conservation agencies. Extensive conservation awareness programs targeted at these people are of primary importance.

4.6 Conclusions

The present study revealed that the migratory black stork is very rare, the lesser adjutant stork is rare, the woolly-necked stork is common and the Asian open bill stork is the most abundant species of the family Ciconiidae in the study area. All the

diversity indices values for storks showed that the open bill stork is the most abundant species in the study area. The majority of the open bill storks were recorded around the Beeshazari lake. River banks, the Beeshazari lake and paddy fields are the most important habitats for storks in Chitwan. The major threats faced by Ciconiidae are disturbance of their habitats, food scarcity and excessive use of agrochemicals in the fields. The area and quality of the wetlands are decreasing due to eutrophication and human encroachment. Human encroachment (fishermen, hunters, large numbers of tourists), livestock pressure and collection of natural products like fish and snails from the habitat of storks needs to be reduced by means of conservation awareness programs and alternative ways of providing the daily needs of local people. Farmers should be encouraged to reduce their dependence on fertilizers and pesticides and use organic manure and biological control. Many wetlands and lakes in the Chitwan National Park and the Barandabhar corridor forest dry out during the summer. This drying out of wetlands directly affects the survival of birds, as they are then confined to protected areas since there is no water in the paddy fields. Therefore, it is necessary to pump in water into the paddy fields and other dried wetlands, in order to increase the survival rate of these wetland-dependent birds. Regular monitoring of storks is essential for their sustainable conservation.

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