

Faunal Biodiversity Survey for Baseline Assessment of Khijadiya Wildlife Sanctuary in Gujarat

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Faunal Biodiversity Survey for Baseline Assessment of Khijadiya Wildlife Sanctuary in Gujarat

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SUMMARY

As part of the Indo-German Biodiversity Programme (2012-to-2017), “Conservation and Sustainable Management of Existing and Potential Coastal and Marine Protected Areas” (CMPA) project was implemented by Ministry of Environment, Forests and Climate Change (MoEFCC), Government of India, and *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ). The present study titled “Faunal Biodiversity Surveys for Baseline Assessment at Khijadiya Wetland, in Gujarat” was carried out by Green Support Services (between 16/11/2015 to 29/07/2016) as part of the above mentioned project. The present study was to conduct detailed ecological assessment surveys of insects, fish and other aquatic species, herpetofauna, water birds, terrestrial birds & mammals of Khijadiya Wetland. The study also involved assessment of current threats to the above ecological elements, identification of economically important, identification of threatened species, and other species of conservation significance, identification of invasive species, ecological analysis of the key species interactions and ecological significance in the wetlands.

Desk review of insects suggests that no studies on insects for Khijadiya Wetland were carried out till date. We randomly sampled insects in winter (n=24) and in monsoon (n=55) seasons in agriculture fields, fresh water wetland, tree cover, saline mudflats, mangrove areas, saltpans. We report insects belonging to total 6 orders, 13 families from Khijadiya wetland. From the observed insect's specimen, we could identify 18 of them up to species levels. One of the important group of insects found in Khijadiya wetland are Odonates. The insects reported from Khijadiya wetland are known to perform variety of ecological functions in food chain in the eco-systems such as pollinators, pest, vectors, parasite, decomposers, dung feeders, prey/food for other insects and animals etc. The observed insects were occupying different feeding guilds such as omnivorous, herbivorous, saprophagus, nectorsuckers etc. Survey of fish and other aquatic animals resulted in finding 12 species belonging to 7 families from Khijadiya Wetland. This included 8 species of fish belonging to 5 families of class Osteichthyes (bony fish) and 4 species of crustaceans belonging to 2 families of class Decapoda. The lower number of fish and aquatic animals reported from Khijadiya wetland could be due to lack of fresh water in the reservoir. Majority of the fishing is carried out by local people in marine creek areas as fishing activities are prohibited in Sanctuary areas.

Study of amphibians observed 4 species of belonging to 4 genera and 2 families i.e. Bufonidae and Ranidae from Khijadiya wetland. Out of these four, the most abundant species was Indian Bullfrog (*Hoplobatrachus tigerinus*) with relative abundance of 60%. Followed by Common Indian Toad (*Duttaphrynus melanostictus*) 20%, Marbled toad (10%) and Indian Skipping frog (10%). All the four species were recorded from the wetland habitat and dry open land in surrounding area.

Survey of Reptiles at Khijadiya wetland resulted in 18 species of reptiles, belonging to 17 genera and 9 families. Total reptilian fauna comprised of 1 species of turtle, 7 species of snakes, 3 species of lizards, 3 geckos and 2 species of skinks. Occasional occurrence of annulated sea snake (*Hydrophis cyanocinctus*) during the intake of sea

water for the salt pans was recorded. The most dominant family was colubridae with six representative species. Most of the species are listed as 'Least Concerned' or Not Evaluated categories by IUCN. The most abundant species recorded was Garden Lizard with 45% abundance/ Rest all other species had similar abundance i.e. 5%. Indian Flapshell turtle has been put under the appendix II of CITES and protected under Schedule I of the WLPA (1972), due to its heavy demand due to superstitious blind beliefs. Bengal Monitor lizard also belongs to Schedule I of WLPA (1972). Most of the species are listed as 'Least Concerned' or Not Evaluated categories by IUCN.

Survey of birds was divided into study of waterbirds and terrestrial birds. The population of waterbirds was estimated on 31 January 2016 by dividing Khijadiya Wildlife Sanctuary into 4 workable zones. Experienced bird enumerators were involved to identify and count number of birds in each zone. Waterbird population estimated was low compared to previous estimation made by several agencies so far i.e. 8,199 birds. Lower number of the birds could be due to low rainfall during monsoon in 2015. During water bird estimation we reported a total of 97 waterbirds and water dependent bird species along with few terrestrial ones in Khijadiya. During our survey we reported the Khijadiya wetland supports 1% populations of only 1 species which is Common Crane. However, during good monsoon years there are records of several species are found to cross 1% mark in this wetland.

Terrestrial bird surveys using various methods such as extensive search method, random point sampling, random encounters, as well as fixed spot sampling methods in Khijadiya wetland we found total 128 species. The number of species recorded during winter were 117 where as only 78 species were reported during summer season. The overall terrestrial bird density differed significantly between two seasons [53.1 ± 3.1 (SE) birds per ha. in winter and 26.7 ± 2.2 (SE) birds per ha. in summer] due to drying of water in Sumer seasons from Khijadiya wetland. Apart from this the agriculture field also dries up during summer season and above all the migratory species are absent from this landscape during summer. The overall terrestrial bird species diversity index using Shannon Diversity Index was estimated to be 3.5 in winter ($n=24$) and 3.4 ($n=24$) in summer season in Khijadiya wetland. The Simpson Index for winter was 0.036 and 0.035 for summer suggesting no major differences in the diversity in two seasons. The species richness i.e. Margalef's Richness Index differed between two seasons as it was 9.67 in winter and 7.4 in summer season. Our survey results suggests that majority of the terrestrial birds recorded in Khijadiya Wildlife Sanctuary belongs to insectivorous birds 55.5%, followed by omnivorous birds 14.1%, carnivorous birds 13.3%, granivorous birds 12.5%, whereas frugivorous 2.3%, insectivorous 1.6% and piscivorous 0.8% birds were very few i.e. 2%.

Total 11 species belonging to 10 families of mammals were observed in Khijadiya wetland during surveys carried out in December-2015 and January-May 2016. The population estimation of some of the large and conspicuous species such as Wild Pigs and Nilgai were carried out by dividing Khijadiya Wildlife Sanctuary in to three major zones/blocks which were same as used in the bird counts. Total 145 individuals of Nilgai in winter and 96 individuals of Nilgai in summer were recorded. Relatively lower number of Nilgai found in summer could be due to their dispersal into surrounding fellow agriculture fields. The average group size of Nilgai was 5.18 ± 0.69 (SE) where as it reduced to 3.31 ± 0.35 in summer. The block counts carried out for Wild Pig population

in Khijadiya Wildlife Sanctuary reported total 68 wild pigs in winter and 109 individuals in summer.

As such the Khijadiya Wildlife Sanctuary being a protected area which is actively managed and protected by Gujarat Forest Department, there are no direct threats to any of its biodiversity component envisaged. However, constant siltation resulting in terrestrialization over the years may result in transformation of wetlands to terrestrial ecosystem followed by invasion of *Prosopis juliflora* and other alien species. It is therefore, recommended that invasion of *Prosopis juliflora* into this ecosystem should be checked and optimal mix of vegetation cover and openness of wetland shall be maintained. It will ensure higher presence of waterbirds, efficient patrolling and protection of birds and area by authorities and it should also allow visitors to observe birds for which they pay and visit this sanctuary.

BACKGROUND OF THE STUDY

Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India, and *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ) GmbH on behalf of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) are jointly implementing a project on “Conservation and Sustainable Management of Existing and Potential Coastal and Marine Protected Areas” (CMPA), of the Indo-German Biodiversity Programme between year 2012-to-2017. The project is being implemented in Gujarat, Maharashtra, Goa and Tamilnadu.

In the State of Gujarat, the project activities are implemented on the following project sites: Khijadiya Wildlife Sanctuary Jamnagar, Gosabara wetland and Madhavpur Turtle area Porbandar. In Gujarat, the project facilitates measures that result in the following outputs:

- Participatory processes for the management of areas identified for conservation of biodiversity have been implemented;
- A capacity development system for the sustainable management of coastal and marine protected areas has been made available in Gujarat;
- Relevant stakeholders are aware of – and sensitized for – the importance of conserving biodiversity in coastal and marine areas.

As part of the first output area in Gujarat, mentioned above, GIZ has commissioned several scientific and technical studies in Gujarat to assess the biodiversity, socio-economic, hydrological and climate change related parameters on the two project sites. Under this larger umbrella, the present study titled “Faunal Biodiversity Surveys for Baseline Assessment at Two Wetlands in Gujarat” was assigned to Green Support Services, based out of Gandhinagar, Gujarat. The study duration was 16/11/2015 to 29/07/2016. The main objective of the study was Characterization of faunal biodiversity of Khijadiya Wildlife sanctuary and Gosabara wetland complex to support their integrated management planning.

The scope of this survey was:

- 1) detailed desk study on the existing information, based on all possible sources of information, on the ecological characters and faunal biodiversity elements at the Khijadiya Wildlife Sanctuary
- 2) develop detailed methodology and plan for each of the element,
- 3) conduct detailed ecological assessment surveys (including diversity and population studies) over key seasons, including the following, but not limited to:; fish and other aquatic species, water birds, terrestrial birds & mammals in the nearby areas, reptiles and amphibians (herpetofauna), Insects and others,
- 4) assessment of current threats to the above ecological elements assessed,
- 5) identification of economically important species, based on current and potential use of these species by the local community,

- 6) identification of threatened species, and other species of conservation significance,
- 7) identification of invasive species of the wetland, and conduct detailed populations studies of the most significant species,
- 8) document species names in English as well as in local language,
- 9) present a detailed ecological analysis of the key species interactions and ecological significance in the wetland.

In order to accomplish the above mentioned aspects, different experts who have worked in this wetland or in the region on the respective aspects teamed up under the umbrella of Green Support Services. The study was conducted with due permissions obtained from the forest department (Annexure-II).

HOW TO USE THIS REPORT

For the convenience of the readers, this report is divided into chapters corresponding to the tasks listed under the terms of reference. Details on each task of the ToR have been presented in the corresponding heading.

DESK STUDY

We have carried out detailed desk review of wetland and fauna of wetland in our study area. Detailed desk review of insects, fish, herpetofauna, birds and mammals are given in this section as under.

WETLANDS IN INDIA AND GUJARAT

India, with its varying topography and climatic regimes, supports diverse and unique wetland habitats (Prasad et al., 2002). Jheels (lakes), Talav (ponds), dams, seasonal waterbodies, paddy fields, streams, marsh lands, coastline, mangroves, coral reefs, estuaries and large stretches of mudflats etc. contribute significantly to enrich habitat diversity, resulting in rich wetland biota, including colourful bird life. Water is a basic and primary need for all vital processes in an eco-system. Therefore, wetlands are one of the most productive ecosystems and most severely affected habitats next to tropical forests. Wetlands are important elements of a watershed because they serve as the vital link between land and water resources. Wetlands play an integral role in the ecology of a watershed. Their shallow waters, nutrients, and primary productivity are ideal for organisms that form the base of the food web upon which many species of animals depend. Wetland habitat provides the necessary food, water and shelter for amphibians, reptiles, birds and mammals (Ghadigaonkar et al. 2015).

Wetlands are considered to have unique ecological features which provide numerous products and services to humanity (Prasad et al., 2002). Ecosystem goods provided by the wetlands mainly include: water for irrigation and other purposes; fisheries; non-timber forest products and recreation. Major services include: carbon sequestration, flood control, groundwater recharge, nutrient removal, toxics retention and biodiversity maintenance (Turner et al., 2000).

Space Applications Centre (2010) estimated about 1,50,174 sq. Km (6.9% of the total geographical area of the country) of wetlands in the country, with highest share of Gujarat amongst all states in India. Of this, extent of watery-lands in Gujarat is about 34,350 sq. km (17.6% of the state's geographical area and 22.9 % of the national wetlands). In other words, about one fourth of the India's wetlands are in Gujarat. The coastal and inland wetlands of Gujarat cover 35.8 % and 6.0 % of the total wetland area respectively in India. The state recognised the value of important wetlands related to geo-morphology, ecology, flora and fauna and constituted nine Protected Areas - one national park, seven sanctuaries and one conservation reserve to preserve a total area of 13,052 sq. km. Additionally, eight wetlands of national conservation significance have been identified and notified by the Ministry of Environment Forests & Climate Change (MoEFCC), Government of India for their conservation in partnership with the local communities.

Khijadiya Wildlife Sanctuary is also one of the wetlands of national importance identified by MoEF&CC. This unique wetland area of 6.05 km² was declared as Khijadiya wildlife sanctuary in year 1981. Khijadiya is popularly known as Khijadiya Wildlife sanctuary; however, legally it is notified as Khijadiya Wildlife Sanctuary. Khijadiya wetland is known for its unique geophysical conditions and

location. It is located at 22° 31' 27" N latitude and 70° 07' 17" E longitude. It is located at about 12 km North-East of Jamnagar city. Biogeographically the area falls in Gujarat-Rajwara biotic province of Semiarid biogeographic zone 4B as per classification Rogers et al 2002. As per classification of the forest area by Champion & Seth (1968), it falls in 5/DS1-Dry Deciduous Scrub type.

This wetland is a unique manmade, coastal, freshwater wetland in semi-arid biogeographic zone in India. It came into existence due to two bunds/embankments built to arrest salinity ingress from the sea into the mainland and to prevent freshwater draining into the sea. Before Indian independence, a check dam was built for storing the waters of river Ruparel just before it entered the sea. Over the years with fresh water of the rain and river on one side and salt water of the sea on the other side, a unique area was formed.

This created a unique "Saltwater-Freshwater" ecosystem with variety of habitat types and ecosystems. This dynamic and complex wetland eco-system with diverse habitat types provides various ecological and economic services. It supports a wide variety of flora and fauna including birds including various categories of species scheduled in Red Data List of IUCN. This wetland system provides favourable breeding, feeding, roosting, and staging grounds for a great variety and density of birds during various seasons of the year. Along with the marine and fresh water habitats, there are also marshy lands, mangroves, exotic bush areas, mudflats, salt pans, creeks, forest scrub, sandy beaches, and even farmlands bordering the area. This makes the place a paradise for more than 250 species of resident and migratory birds, including globally threatened species. The sanctuary is located adjacent to the boundaries of Marine Sanctuary.

INSECTS:

Insects among the arthropods are found in extremely diverse habitats throughout the world and constitute about three quarters of all living species on earth. Insects form the largest class of Phylum arthropoda. More than 5,000 species are reported from India. They are by far most valued in conservation for their ecological roles. They are the key component in the composition, structure and function of ecosystem (Hafernik, 1992; Ricklefs et al., 1984; Wilson, 1987). They are abundant herbivores and detritivores influencing directly and indirectly elemental cycling and net productivity (Seastedt and Crossely, 1984). Distribution of insects in particular area may be regular, occasional, seasonal, persistent or sporadic. This can be determined by physical barriers like large masses of water for land insects, climatic conditions, biological barriers like food, existence of competitors and natural enemies. The sensitivity of insects to environmental conditions is proven to be useful for assessing an ecosystem conditions. Aquatic insects have been used as indicators of water quality. Ant, dung beetles and other terrestrial species have been used as indicators of success of ecosystem restoration.

According to estimates made by Z.S.I (1980), in India we have 67000 species of described insects. However the taxonomic knowledge of the group is still

inadequate, particularly with reference to national parks and sanctuaries except in southern parts of India. But, overall the diversity of insect species is very vast and unexplored (Samways 1994). No systematic studies on insect have been carried out in Gujarat barring few isolated works on certain groups. Vazirani (1968, 1977) reported studied some water insects of Gujarat whereas Prasad and Varshney (1995) studied odonates species of Gujarat. Sabnis and Amin, (1992) recorded about 250 species of insects belonging to several orders from Narmada valley in Gujarat region during the faunal survey conducted during 1990 -1992. Butterfly fauna of Jessoré sloth Bear sanctuary was carried out by Suresh et al. 2001. Parikh (2001) worked on Arthropods of Gir Protected and its surrounding ecosystem.

Fauna of arthropod pests infesting various crops of Saurashtra was reported by College of Agriculture, Gujarat Agricultural University, Junagadh (1995). Their list includes 198 species of insect pests. Insect studies in Gujarat are scanty in comparison to other Indian States (Ahir, 2005). Therefore, the need to know more about insect faunal wealth is great because of their small size and modest needs. Most insects and other invertebrates occupy ecological niches that are more numerous and smaller in dimensions (space, time and so on) and therefore more sensitive as compared to vertebrates.

Thus, studies on insects are by large scanty in Gujarat particularly for wetlands there are no substantial report available till date. Therefore, it is essential to study insect at Khijadiya Wildlife Sanctuary and fill the lacuna for this particular aspect. The purpose of survey is to give a brief overview of current insect diversity at Khijadiya Wildlife sanctuary.

FISH

Fish occupy almost all major aquatic habitats. Inland fish play critical roles in the function of their ecosystems (Dudgeon et al. 2006). For example, predatory species, such as northern pike (*Esox lucius*) have significant impacts on fish community composition (He and Kitchell 1990). Other fish species have been shown to alter the habitats in which they live, from herbivorous grass carp (*Ctenopharyngodon idella*) modifying aquatic vegetation (Wittmann et al. 2014). Fish impacts on habitat are not limited to the local scale; migratory fishes such as Pacific salmon (*Oncorhynchus* spp.) transport energy and nutrients to support distant aquatic and terrestrial food webs (Wipfli and Baxter 2010). When functioning properly, inland ecosystems provide many valuable services to people (i.e., provisioning, regulating, supporting, and cultural services; e.g., detoxification of wastes, management of infectious diseases).

Inland fishes account for approximately 40% of all fish species and 20% of all vertebrate species (Helfman et al. 2009). Biodiversity of inland fishes, at both species and population levels, also confers important benefits. When people rely upon functioning ecosystems for their basic needs, natural disasters and other disturbances to those ecosystems can be devastating. Natural ecosystems that recover quickly from such disturbances have resilience. Ecosystems with high species richness exhibit increased resilience (Downing and Leibold 2010), highlighting the importance of diverse inland fish communities. However, species

assemblages are not the only factor moderating the impacts of disturbance on fish populations. A diversity of biologically relevant characteristics among fish populations of the same species (e.g., alternate life histories) also has been shown to improve resilience to perturbations (Schindler et al. 2010). Biodiversity confers benefits to aquaculture as well. Genetic diversity within species provides the building blocks for selective breeding and stock improvement, and enables the creation of transgenic fishes, such as genetically modified Atlantic salmon (*Salmosalar*) that grow more quickly and require less food than non-modified fish (Gjedrem 2000). The central role of inland fish in aquatic ecosystems makes them good indicators of ecosystem change. Inland fish are used as warnings for current and impending impacts on human well-being from environmental change. Beyond overfishing, aquatic ecosystems are faced with both direct and indirect anthropogenic influences that may have undesirable consequences. Threats from eutrophication, flow modification, destruction or degradation of habitat, and invasion by exotic species place 65% of freshwater habitats at risk (Dudgeon et al. 2006; Vorosmarty et al. 2010). The large scope of these threats arises because inland aquatic habitats are in close proximity to a variety of anthropogenic activities (e.g., agriculture, deforestation and hydropower) and because aquatic habitats integrate environmental influences throughout a watershed (Allan 2004).

Fish respond directly to some environmental stressors such as toxic and thermal pollution, flow regime change, and climate change (Dudgeon et al. 2006). Around the globe, inland fish populations and species assemblages often indicate changes in nutrient inputs to their watersheds (Ludsin et al. 2001). Inland fishes respond to many aquatic and terrestrial environmental changes throughout their watersheds, making them valuable bioindicators of ecosystem health.

Inland waters are defined by the Food and Agriculture Organization of the United Nations (FAO) as lakes, rivers, streams, canals, reservoirs, and other land-locked waters (FAO 2014). While inland is generally synonymous with freshwater, inland waters do include land-locked saline water bodies such as the Caspian Sea (FAO 2014). Inland waters comprise approximately 0.01% of the total volume of water on earth. Inland fishes reside in these waters. They comprise approximately 40% of all fish species and 20% of all vertebrate species. However, the difficulty in assessing aquatic biodiversity, particularly in developing countries and remote areas, suggests that inland fishes are more diverse than the reported estimates (Cooke et al. 2012). Additionally, 65% of inland habitat is classified as moderately or highly threatened by anthropogenic stressors (Vorosmarty et al. 2010), so populations may be extirpated even before they are documented. Inland fish species are present in almost every inland ecosystem on earth. These inland fishes also serve as indicators of ecosystem function and ecosystem change (Allan 2004).

The Indian subcontinent, occupying a position at the confluence of three biogeographic realms, viz., the Palaearctic, Afro-Tropical and Indo-Malayan, exhibits a great variety of ecological habitats harboring rich ichthyo faunal diversity. The contribution to the global fish community is about 3500 species and out of which there are 2500 species recorded in the subcontinent. The Indian species represent about 8.9% of the known fish species of the world. In

the world's biological resources, India is one of the 17 mega biodiversity hot spots contributing with 60-70 % and having third rank in the world in total fish production with the contribution of 11.72% of total global fish biodiversity (Kumar, 2012). Out of the total 2500 species from India, 930 species are freshwater inhabitants. Devi and Indra (2012) in an annual report by Zoological Survey of India have reported 667 species grouped under 12 orders, 35 families and 149 genera.

An annual report by Zoological Survey of India, Devi and Indra, 2012 reports about 120 freshwater fishes are found in Gujarat state. According to books by authors A.D. Dholakia (Fisheries and Aquatic Resources of India, 2005), M. I. Patel and N. D. Chhaya (Field key to fishes of Gujarat, 1979), a total of 96 freshwater fishes are present in the state of Gujarat. The other major literature resource available for freshwater fishes indicates work done by Goswami and Mankodi (2010) and Gohil and Mankodi (2013) on Nyari-II reservoir and Mahi River where they found fifteen and twenty six species of fishes respectively.

In case of Gujarat, the fishermen community mostly deals with marine fishes as they find a large exposure area of catch in respect to the freshwater fishes so there is very less document or biodiversity work available for freshwater fishes in this state.

HERPETOFAUNA

Herpetofauna include amphibians and reptiles. Reptiles and amphibians occupy a diverse range of habitats and microhabitats, found from deserts to grasslands, from forests to oceans and from hills to our own houses. About 9,596 known species of reptiles and 6,000 species of amphibians are known worldwide, of which, 518 reptiles and 314 amphibians inhabit India and 107 reptilian species and 22 amphibian species occur in Gujarat (Vyas 2007). Reptiles and amphibians (collectively called herpetofauna) constitute important elements of biotic components of various ecosystems because they occupy various niches (like arboreal, aquatic, terrestrial and fossorial). There are more than 6,000 currently recognized species of extant amphibians, with representatives present in virtually all terrestrial and freshwater habitats, but absent from the coldest and driest regions, and from the most remote oceanic islands. The number of recognized species of amphibians has grown enormously in recent years, with a nearly 50% increase between 1985 and 2004 (Frost 1985, 2004) and an increase in species numbers of 25% in the years between 1992 and 2003 (Köhler et al. 2005). This unprecedented growth largely reflects an increase in collecting work in previously remote locations, a significant growth of active herpetological communities in a few mega diverse countries, and the application of complementary techniques, such as molecular genetics, to support more traditional taxonomic methods.

Amphibians are ecological indicators and in recent decades there has been a dramatic decrease in their populations. Many species are now threatened or extinct. Amphibians are the least amongst the vertebrates and comprise nearly 6.6% of the total vertebrate life on the earth. Total number of species in the world has been estimated around 3,140 and in India 214 species are known. However

Dinesh et al. (2011) has mentioned 314 species of amphibians in India. According to IUCN criteria 57% of the amphibians in India are 'threatened' (Vasudevan et al., 2001).

Reptiles are diverse in south Asia with approximate 632 species belonging to 185 genera and 25 families. India harbors 456 species of reptiles belonging to 25 families and 4 orders including 3 species of Crocodilia, 31 of Testudines, 178 of lizards and 244 species of serpents.

In Gujarat, a number of studies have been carried out on reptiles in the post independence era (Acharya 1949; Kapadia 1951; Sharma 1982; Gayen 1999) adding about 48 species of reptiles (Vyas 2000). Excluding the protected areas Vyas (1993) studied the snakes of the Gujarat State. A total of 107 species of reptiles belonging to 21 families were reported by Vyas (2000). Naik et al. (1993) gave a comprehensive account of the amphibian distribution in Gujarat. They gave distribution of about 15 species of amphibians in the state; however the majority of their inferences were confined to the collections presented at BNHS and / or ZSI. Pandey and Teli (2005) gave a detailed account on the birds and mammals of Khijadiya Sanctuary, but did not provide any details on the herpetofauna of the area. The studies emphasizing on the importance of the herpetofauna in the wetlands and wetland complex are rare with reference to Gujarat and requires detailed ecological studies.

BIRDS

Khijadiya is a unique wetland which is a saline and freshwater eco-system covered over area of 6.05 km². Before independence, a check dam was built for storing the waters of river Ruparel just before it entered the sea. Over the years with fresh water of the rain and river on one side and salt water of the sea on the other side, a unique area was formed. On the other side of the bund large creeks flowing from the Gulf of Kutch are located. These creeks supports mangroves and other marine vegetation while on land side of the sanctuary inland vegetation like *Prosopis juliflora*, *Salvadora*, *Acacia* and others are found profusely. The sanctuary is located at the watershed of Ruparel River and Kalindri at the North East coastal region of Jamnagar district in the Gulf of Kutch and has a very special and unique ecosystem.

Very few studies have been carried out on Khijadiya and its biodiversity, major being "Ecology and biodiversity of Khijadiya Wildlife sanctuary and its environs" 2005 by Pandey and Teli from Gujarat Ecological Education and Research Foundation. This study is a comprehensive study of major floral and faunal taxa thriving in Khijadiya Wildlife Sanctuary. This study reported total 189 species of birds of which 117 were waterfowl and 72 terrestrial birds. The official website of Gujarat Forest Department has reported more than 220 species of birds in a relatively very small area of Khijadiya Wildlife Sanctuary. Pathak et al. (2013) carried out a study of nesting of Black-necked Stork in Sikka to Jodiya coastal belt of Jamnagar district along with Khijadiya Wildlife Sanctuary for two breeding seasons. Apart from biodiversity and species related research studies, there are several notes on sightings of birds have been published in local and national

newsletters. After an overall study conducted by Pandey and Teli (2005) no major study to characterization of biodiversity of Khijadiya Wildlife Sanctuary is carried out till date. In this context the present study is carried out after almost a decade (10 years).

Since waterbirds and terrestrial birds are studied using different methodology, we divided study of birds into two separate parts i.e. study of water birds and study of terrestrial birds.

MAMMALS

Management and conservation of any ecosystem requires information on species assemblages as well as reliable estimates of population sizes of its major components such as birds, mammals etc. As per revised and updated checklist of Indian Mammals (Nameer, 2008), India is providing habitat to 417 mammals species. Zoological Survey of India (ZSI 2004) has reported 12 Orders, 33 Families, 68 Genera and 101 Species from Gujarat. The only study report on Khijadiya Wildlife Sanctuary by Pandey and Teli 2005 has reported total 7 species of mammals in Khijadiya Wildlife Sanctuary. There are numerous techniques being used for survey of mammals. Due to differential detection probability coupled with their habits such as diurnal and nocturnal, it is difficult to use one approach to study all mammals in any eco-system. Therefore, suitable techniques are required to be used for studying mammals in heterogeneous landscapes such as wetland.

DETAILED METHODOLOGY

During study, following methodology was developed and used for each of the component of the study such as Insects, Fish, Herpetofauna, Birds and Mammals.

DETAILED METHODOLOGY FOR INSECTS

Class insecta is considered as the largest class of arthropoda. Identification of insects is fundamentally not different from Identification and quantitative analysis of birds, mammals, fishes and amphibians. However, their size, lifecycle and drastic change in appearance and habits throughout their life cycle make it difficult to identify (Borror and white 1970). For many species rich insect taxa it is monumental task to collect all species from a site. Moreover, it is a far from trivial exercise to know what proportion of a site's fauna has been sampled as a function of collecting efforts and methods (Brown and Feener 1995, Colwell and Coddington 1994, McGowan 1996). Each stage of lifecycle of an insect varies in their size, shape, colour, food, habitat and behavior. The lifecycle stages of different insects differ from few months to several years. Some insects even take 17 years (Cicada) to accomplish their lifecycle. Therefore to obtain an accurate population data one requires at least two to three years of intensive sampling efforts. Therefore with given time and efforts in the current study, we inventorized a checklist of insects up to family, orders and species of insects of the Khijadiya Wildlife Sanctuary. Following methodology was used for studying insects in Khijadiya Wildlife Sanctuary.

A reconnaissance survey was conducted in December 2015 through the entire stretch of the study sites to select the habitats and sampling sites. Initially we used stratified random sampling approach for studying insects in the study area. Six broad habitat types were selected for Khijadiya Wildlife sanctuary and its surrounding area for insect observations. The random sampling was carried out at total 24 sites in winter and 55 sites in monsoon (Table-2.1). The selection of sites was based on general and specific criteria such as type of vegetation, proximity to water body and/or road etc. six sites were selected at Khijadiya wildlife sanctuary. The random sampling was carried out at total 56 sites in winter and 108 sites in monsoon using various methods such as beating umbrella, litter shifting, bark scarapping, sweep net, strainers etc. (Table-2.1). Insect captured were identified with slandered reference book up to family level and release back to their natural habitat. Photographs were also taken which helped to identify certain well known insects till species level. The actual filed survey schedule, date-wise is provided in Annexure-I.

However, these sampling efforts did not provide us data that would extract meaningful population or diversity estimates. Therefore, we relied on qualitative methods to inventorize family, orders and species richness of insect groups in the Khijadiya Wildlife Sanctuary area. In order to study insects following popular methods were used Insect collection was done with following methods:

Table-2.1: Sampling efforts in different habitats and season during the study.

No	Habitat	Sample points	
		Winter	Monsoon
1	Fresh water area	4	10
2	Tree cover/ Vegetation	4	11
3	Saline Mudflat	3	9
4	Mangrove Area	5	9
5	Saltpan	2	6
6	Agriculture Fields	6	10
	Total	24	55

Sweep net: Sweep net was used for capturing flying insects and also insects found on vegetation. This method was mainly used studying large size and flying insects such as butterflies, mayflies, odonates etc.

Beating Umbrella: This method was used to gather insect fauna from taller vegetation such as tree canopy, shrub etc. During this method an umbrella is held upside down and the tree canopy is bitten gently with a stick to collect insects. The insects fallen in umbrella are collected in vials and identified.

Litter sifting: In order to study ground dweller and foliage feeder insects from the litter we used this method. The litter is shifted or lifted from the ground to expose the insects beneath.

Bark scraping: This method is especially used to studying borers and insects hiding under the bark of the trees. The bark of tree is gently scraped to expose and collect the insects.

Strainers: In order to study aquatic insects, we used strainers. Flowing and static waters from different depth were strained to collect insects.

Light trap: Light traps, were arranged to attract certain insects. Light sources like halogen lamps were used. Light traps are widely used to survey nocturnal moths and other nocturnal insects.

Direct photography: During study insects were photographed in their natural habitats without disturbing them. Macro SLR lenses were used to take good quality pictures of insects which were further used for identification with help of standard reference books.

DETAILED METHODOLOGY FOR FISH

The contract required detailed ecological study including diversity and population studies, however, there were several limitations related to non availability of water (except a small puddle) in Khijadiya Wildlife Sanctuary during sampling periods. The sampling therefore, was possible only in marine creek areas adjacent to Khijadiya Wildlife Sanctuary but not in its main wetland. Main wetland was in the form of a small puddle, where we could find only one species after several efforts. Moreover, during summer most freshwater parts of the sanctuary area were excavated. Therefore, there were no fish species present in that freshly excavated area with fresh rain water in next monsoon. Therefore, we relied on qualitative method to study the species richness of fish and associated fauna in the study area. Following methodology and steps were followed and adopted during the field work.

Our team visited in and around Khijadiya wetland and interviewed fishermen and selected sites based on the information of fishing in the entire Khijadiya wetland complex. After site selection, we visited sites as per discussion with fishermen at a proper time where there is a possibility of receiving marine fish fauna for assessment. During the sites visits we conducted meetings with local fishermen and interviewed them for their fishing activities per day, season and on yearly basis. We collected the specimens according to their availability of catch collected by fishermen. We also collected the specimen by manually fishing using mosquito net in all the sites. We photographed the water source, fishing techniques and most importantly the specimens to preserve the actual color of the fish and their morphology. We collected samples, which ever required, and preserved them in plastic bottles containing 70% ethanol (Kumar and Hasan, 2015) and brought back to the laboratory and were properly identified using standard identification keys (Day, 1878; Froese and Pauly, 2017). The actual field survey schedule, date-wise, is provided in Annexure-I.

DETAILED METHODOLOGY FOR HERPETOFAUNA

The contract required detailed ecological study including diversity and population studies, however, there were several limitations related to low abundance and detection probability of herpetofauna in the study area. During our survey efforts with great difficulties we encountered few herpetofauna species. Therefore, such low detection probability was a limitation for not conducting systematic population and diversity studies. Moreover, actual population assessment techniques call for intensive effort using capture-mark-recapture techniques or a complete census over one or more years (David *et al.* 2013). Population counts typically involve a series of surveys, with the peak count of each species being used (David *et al.* 2013). Peak counts are difficult to defend statistically, as they do not take account of variations in detectability from site to site. They can therefore be misleading (David *et al.* 2013). Therefore, with given low detection probability along with time and efforts, we carried out simple surveys i.e. presence absence surveys to inventories the herpetofauna of Khijadiya Wildlife Sanctuary, the methodology was divided into following three parts.

Direct Search Method: In this method, we selected total 3 general broad habitat types viz. Wetland area and its fringes, wetland roads and surrounding dry wastelands and agriculture lands in immediate surroundings to assess the herpetofauna of the study area. These areas were randomly and intensively searched. All the habitats were repeated twice in a day i.e. once during the morning 7 to 11 am and during night 9 pm to 1 am. Total number of field work days scheduled for this site was 8 man days. Therefore, 4 days sampling was carried out in winter season and another 4 days sampling was carried out by two persons (total 8 man days) in monsoon season. The actual field survey schedule, date-wise, is provided in Annexure-I. The main reason for this was to inventories the nocturnal fauna also. Uniform efforts were made in all habitats during surveys in day and night hours. All the species encountered were identified and photographed using Nikon D70 / D90 DSLR cameras. Relative abundance of the species was estimated based on the number of individuals occurred within the sampling area.

Indirect evidences: Both the wetlands were searched thoroughly to check the indirect evidences of the herpetofauna such as skin, body parts etc.

Water Straining: Straining of flowing as well as stagnant water was also carried out during monsoon season; however no amphibian or reptile was encountered in this method.

Consultation with the local experts: Local experts and naturalists, who visit the area frequently, were consulted and data was obtained from them regarding the presence and absence of various herpetofauna species.

Calculations of Relative Abundance: Relative abundance of herpetofauna was calculated using method described by Michael (1986) with following formula.

Relative Abundance RA

$$= \left(\text{Total population of the } \frac{\text{species}}{\text{Total}} \text{ population of community} \right) * 100$$

DETAILED METHODOLOGY FOR WATERBIRDS

Waterbirds have been defined as “species of bird that are ecologically dependent on wetland. Waterbirds are well-known indicators of the quality of certain types of wetlands. A powerful tool which makes use of this characteristic is the so-called 1% criterion, whereby any site which regularly holds 1% or more of a waterbird population qualifies as a wetland of international importance under the Ramsar Convention on Wetlands (Wetlands International 2010). Waterbird Population Estimates by Wetlands International (2006) is widely used for calculating 1% geographic populations of waterbirds across the world (Li et al, 2009). It is also used by BirdLife International in the identification of Important Bird Areas (IBAs) in wetlands throughout the world. Various approaches can be employed to assess Waterbirds species composition and abundance over an area of interest, from total counts of all individuals present (a complete census) to sampling strategies that provide population estimates that can be extrapolated over the entire study area.

Population Estimate: We used complete census method by dividing entire wetland into different workable/accessible zones and counting/estimating waterbird species within each zone. The goal of a complete census is to conduct a total count of all the birds present over a specified area to obtain an unbiased estimate of abundance without statistical inferences or underlying assumptions. A reliable census is conditional on the assumption that all individuals present in an area can be recorded; therefore, censuses are most useful for conspicuous species occupying discrete and well-defined open landscapes and habitats. Some situations in which a reliable census may be possible include complete counts of waterbirds frequenting open wetlands. Experienced counters can accurately estimate 10, 20, 50, 100 or more birds almost instantaneously, and scan through flocks counting in these units with a tally counter. A complete census is more practical when targeted at large and conspicuous species especially where there are active networks of participants to undertake the work. This kind of approach is promoted for periodic waterbird census by organizations such as Wetlands International/IUCN etc.

Due to lack of rain Saurashtra during 2015 monsoon, Khijadiya wetland had very little or no freshwater in its major part but, saltpan and saline tidal creek had marine water as usual. However, the waterbird estimation was carried out in entire wetland as there were some wetland dependent birds roosting in open dry wetland parts of Khijadiya, whereas saltpan and tidal influenced area of Khijadiya wetland had waterbird populations. Water bird estimation was carried out twice in Khijadiya wetland i.e. primary estimation was carried out on 25-26 December, 2015 where as final estimation was carried out on 31 January 2016. Entire wetland was divided into four major parts based on accessibility, and convenience as following (Map-2.1).

Zone-1: Saltpan & Mangrove areas

Zone-2: Open Dry wetland in Part-II

Zone-3: Wetland near Khijadiya

Zone-4: Wetland towards Vibhapar

Waterbird Species Richness: During each field visits to Khijadiya Wildlife sanctuary we recorded the sightings of the waterbirds in different habitats i.e. freshwater, marine creek, mangrove, saltpan etc. These sightings were used to prepare a comprehensive checklist of waterbird species reported in the Khijadiya Wildlife Sanctuary and its surrounding areas.

Map-2.1: Waterbird estimation zones in Khijadiya during January 2016.



DETAILED METHODOLOGY FOR TERRESTRIAL BIRDS

In order to study bird diversity and abundance in Khijadiya wetland, we employed three methods i.e. 1) Random point count method, 2) Area Search Method or extensive search using roads and 3) Fixed spot sampling. The terrestrial bird surveys were carried out on in winter (December) 2015 and in Summer March-April 2016. During these surveys, Dr. Chittranjan, our team members, and some of the expert local birdwatchers were involved in sampling efforts. Total 3-5 birdwatchers other than the expert were trained in sampling efforts prior to actual sampling carried out in the field. Data were recorded and analysis was carried out to get preliminary results for Khijadiya wetland. Different methods and efforts made are described as under. The methodology used are easy to repeat which would provide basic and most important information for managers i.e. species richness, species density, and diversity of terrestrial birds.

Random Point Count: method was used to quantify the density of various terrestrial birds in study area. Sampling is carried out at random locations in the study area. All the species found in a fixed 30 mtrs radius plot are recorded for not more than 4 minutes. This quick window sampling in different locations enables us to correctly report the bird species present in the habitat. We sampled at 36 random points in Khijadiya in winter and 24 points in summer (Map-2.2 a & b). The data collected are used to obtain quantitative estimates of bird species diversity and density etc.

Extensive Search Method: is a qualitative method being used for improving the total species richness for each site in totality. In this method we slowly drive through the roads and look for birds and their calls. We identify birds based on

their calls, colour etc. using binoculars and standard reference books. The species checklist for each site is prepared based on this method. Total 160 km in Khijadiya in winter and 180 km in summer were covered through drives on the roads in order to report the bird species seen during this period.

Fixed Spot Sampling: is a qualitative method which was used for improving checklist from different habitats. This method involved standing at one location for 10 minutes and reporting all the bird species seen from the pre-identified spot. The spots are identified based on different habitats in order to cover all types of habitats present in the site. Total 5 such fixed locations were chosen in Khijadiya wetland (Map-2.3). The bird species were seen during these efforts were recorded and used for improving information on species richness in the overall sites. Since study area is primarily a wetland, we restricted our sampling efforts to wetland peripheries, roads, and on land forms present inside wetlands.

Map-2.2a: Random Point Count sampling locations in Khijadiya Wildlife sanctuary.



Biodiversity Estimation:

We estimated α - diversity of terrestrial bird species within Khijadiya wetland complex. We used Shannon–Wiener diversity index, Shannon and Wiener (1949), Simpson Diversity Index, Simpson (1949), and Margalef's Index (Margalef, 1958). Following are details of the biodiversity indexes we calculated for terrestrial birds of Khijadiya wetland. We calculated these indices using XL spreadsheet as well as a online tool (www.alyoung.com) for quick and easy calculation of various biodiversity indices. Details of each of the indices are given as under.

Map-2.2 b: Random Point Count sampling locations in Khijadiya Wildlife sanctuary.



Map-2.3: Locations of fix spot sampling in Khijadiya Wildlife sanctuary.



Shannon Wiener Diversity Index: It is the most preferred index among the other diversity indices. The index values are between 0.0 – 5.0. Results are generally between 1.5 – 3.5, and it exceeds 4.5 very rarely (Kocataş 1992). The values above 3.0 indicate that the structure of habitat is stable and balanced; the values under 1.0 indicate that there are pollution and degradation of habitat structure.

$$H' = -\sum [(n_i / N) \times (\ln n_i / N)]$$

H'=Shannon Diversity Index

n_i = Number of individuals belonging to i species

N= Total number of individuals.

Simpson's index: The Simpson's index used is $D=1/\sum(p_i)^2$ where, "p_i" proportion of "ith" species and is calculated as "n_i/N", where, "n_i" is the number of individuals in "ith" species and "N" is the total number of individuals in the sample but the form of the index used in the present study is:

$$D=\sum[n_i(n_i-1)/N(N-1)]$$

N_i= the number of individuals in "ith" species

N= the total number of individuals in the sample

Margalef Diversity Index: It is a measure of species richness. It has no limit value and it shows a variation depending upon the number of species.

$$d = (S-1) / \ln N$$

d=Margalef Diversity Index

S= Total number of species

N= Total number of individuals

DETAILED METHODOLOGY FOR MAMMALS

During our mammal diversity survey in Khijadiya, we initially used several techniques such as transect method, camera trap method for studying their diversity and density in these wetlands. However, due to their very low abundance, differential activity periods and clustered distributions these methods did not work. Since the presence of mammalian species is low affecting probability of their sightings, in the study areas, it was difficult to estimate their population using line transect method. More importantly, it was also difficult to accommodate the sightings of nocturnal and diurnal animals in the study. Therefore, we used following approaches to study their species richness and abundance in these ecosystems.

Random Observations: This method involves preparation of a qualitative check list of mammals based on direct and indirect observations during field work in the study area. We used all the direct and indirect observations on the presence of mammal species during each field visits.

Specific Habitat Search: search efforts were also made in various different micro habitats to gather direct and indirect evidences such as various signs of important habitat specific mammal species in the study area. This includes looking for signs such as footprints, dens, diggings, scrap marks, droppings etc. The micro habitats, where likelihood of animals is higher such as shady trees, waterholes, dense and undisturbed bushes etc. were surveyed intensively during the survey in the study area. This survey has helped us in identifying various mammal species, their behavior and characteristics. For mammal inventory, both direct sightings and indirect evidences (like dung, scats, pellets, foot prints, nests, dens etc.) were accounted.

Howling Surveys: Some of the canids that utilise howls to communicate, the response rate to simulated vocalisations has been used as an index of relative abundance (e.g., Wenger and Cringan 1978; Okoniewski and Chambers 1984; Fuller and Sampson 1988). Howling surveys typically employ recorded vocalisations, although human imitation can be used.

We tried to survey presence of their numbers in these wetland eco-system and their surrounding areas. Dr. Bharat Jethva specializes in vocal simulating howling of Indian Wolf and Jackals produced howling calls from elevated points. After each howling calls, we waited for 10 minutes to listen to the responses. Howling surveys were made from specific elevated locations from these wetlands between 8:30 to 10:00 PM. Surveys were conducted over 7 nights using the vocalisation response to estimate their abundance. These surveys were helpful in determining presence and absence of canid species and also estimating their numbers to some extent.

Block Counts: As mentioned earlier, it was difficult to estimate population of mammals in these wetland eco-systems. Therefore, we used block count method to estimate population of some of the conspicuous diurnal mammals in Khijadiya Wildlife Sanctuary. In this method entire Sanctuary area was divided into various workable zones based on their accessibility and manpower available with us.

Interview Surveys: There are several mammals species which are very shy or have seasonal occurrences in the landscapes. In order to accommodate such species we also interviewed local cattle herders, fishermen, forest personals, local naturalists and other local people who we encountered in and around study area. Total 30 individuals in Khijadiya Wildlife Sanctuary were interviewed for confirming the presence of various mammals they might be aware of. We showed them photographs of various animals to confirm their identifications and knowledge.

Camera Trap Surveys: In order to detect nocturnal animals, we carried out camera trap surveys in Khijadiya Wildlife Sanctuary. During our field surveys, we laid camera traps at 6 strategic locations (trails, dense bushes, roads, waterholes) in Khijadiya Wildlife Sanctuary for two times in winter and summer seasons. However, due to low abundances of nocturnal mammals, we did not find any mammals in camera trap.

DETAILED ECOLOGICAL ASSESSMENT SURVEYS

Since detailed desk review and methodology are provided in the previous sections, this section provides results of the study carried out on each of the component of the study i.e. study of insects, fish, herpetofauna, birds and mammals.

SURVEY OF INSECTS

Wetland of India is studied for their avian biodiversity, floral diversity, lithology etc., but very few serious attempts have been made to study Insect biodiversity of different wetlands of India. Even though insects play a major role for wetland ecosystem by providing their valued services as pollinators, herbivorous, defoliators, food for other animals and many more. However, no studies have been conducted for insect biodiversity of wetlands of Gujarat.

Khijadiya Bird Sanctuary is one of the well-known wetlands of Saurashtra; Gujarat. One of the most favorite places for migratory birds and other water birds Khijadiya Wildlife sanctuary is growing its popularity among the bird watchers, nature lovers and ecologists. Therefore it has becomes a crucial of know and record the present status of faunal diversity and its seasonal variation. Thus, present study was conducted as part of the project to discover the faunal biodiversity of Khijadiya Wildlife sanctuary.

GENERAL OBSERVATIONS

During winter visits at Khijadiya Wildlife sanctuary Mantidea was represented by family: Mantidae. Presence of order Neuroptera was confirmed by lots of antlion larva pits they belong to family: Myrmeleontidae. Four families from Order: Coleoptera were recorded from different habitat; family: Scarabaeidae, family: Tenebrionidae, family: Meloidae and Family: Anthicidae. The most diverse order during this season was order: Lepidoptera Four different families of butterflies were sited Papilionidae, Pieridae, Lycaenidae and Nymphalidae. Order: Diptera was represented by family: Mucidae and family: Culicidae. Family Apidae from order Hymenoptera; one more family from this order; Formicidae was also noticed (Figure-3.1).

Monsoon observations were completely different from those of winter (Figure-3.2). In this season Order Odonata, order Orthoptera, order Coleoptera, order Lepidoptera and order Diptera and order Hymenoptera were the major Insect representatives. Order Odonata was present around the fresh water area and family: Libellulidae. Family: Acrididae of order Orthoptera was also recorded. Four different families of order: Coleoptera were present during monsoon season Carabidae, Scarabaeidae, Tenebrionidae, Anthicidae. Anthiasexguttata beetle from family carabidae were sighted near the agricultural fields, which is a wingless, flightless large black beetle with 6 big round white spots on elytra. The insect ejaculates glandular fluid when trapped, which serves as a means of protection. Family Tenebrionidae and their occurrence were observed throughout the study area. They were mostly found under the dung, stones and dead wood. Order: Lepidoptera was also recorded by four different families;

Pieridae, Nymhalidae, Sphingidae, Noctuidae. Of which two families; Sphingidae and Noctuidae are moth families which were observed during night collection.

During monsoon visit there was addition of family in order: Diptera, beyond Mucidae and Culcidae family: Asilidae was also present. Family: Formicidae was the only representative for order: Hymenoptera.

Though some order representatives were common during both the seasons still less insect diversity and less insect activities were observed during winter visit. Lots of honey bees were seen on and around salvadora blooms. Ant lion larva pits were observed all throughout the road in huge number. These were the two most evident and striking observations of winter season.

CHECKLIST OF INSECT FOR KHIJADIYA WILDLIFE SANCTUARY

Class: Insecta

1. Order: Odonata

Suborder: Anisoptera

- i. Family: Libellulidae
Brachythemis comtaminata (Fabricius, 1793)

2. Order: Orthoptera

- ii. Family: Acrididae

3. Order: Mantidea

- iii. Family: Mantidae

4. Order: Neuroptera

- iv. Family: Myrmeleontidae

5. Order: Coleoptera

- v. Family: Carabidae
Anthia sexguttata
- vi. Family: Scarabaeidae
Gymnopleurus miliaris
Copris numa
- vii. Family: Tenebrionidae
Rytinota impolita
Platynotus perforatus
- viii. Family: Meloidae
Mylabris pustulata
- ix. Family: Anthicidae
- 6. Order: Lepidoptera
- x. Family: Papilionidae
Papilio polytes (Linnaeus)
- xi. Family: Pieridae
Catopsilia pyranthe (Linnaeus)
Colotis amata (Fabricius)
Colotis vestalis (Butler)
Ixias marianne (Cramer)
- xii. Family: Lycaenidae
Catochrysops Strabo (Fabricius)
- xiii. Family: Nymphalidae
Danaus genutia (Cramer)
Danaus chrysippus (Linnaeus)
Hypolimnas misippus (Linnaeus)
- xiv. Family: Sphingidae
- xv. Family: Noctuidae
- 7. Order: Diptera
- xvi. Family: Mucidae
Musca domestica (Linnaeus)
- xvii. Family: Asilidae
- xviii. Family: Culicidae
- 8. Order: Hymenoptera
- xix. Family: Formicidae
- xx. Family: Apidae
Apis indica (Fabr.)

Figure-3.1: Composition of insect families in Khijadiya Wildlife Sanctuary during winter 2015.

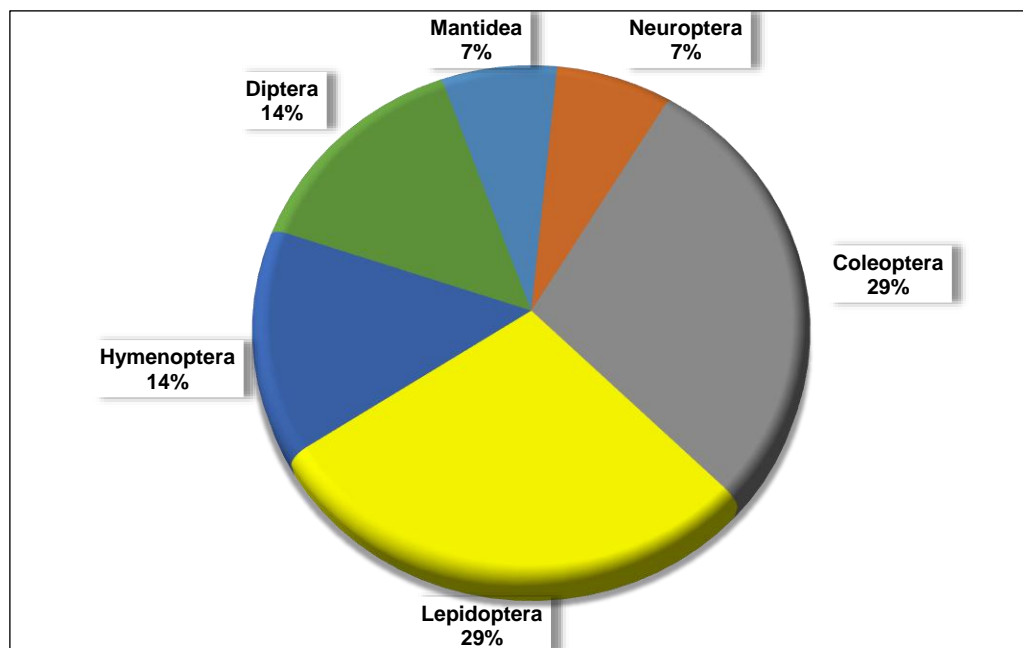
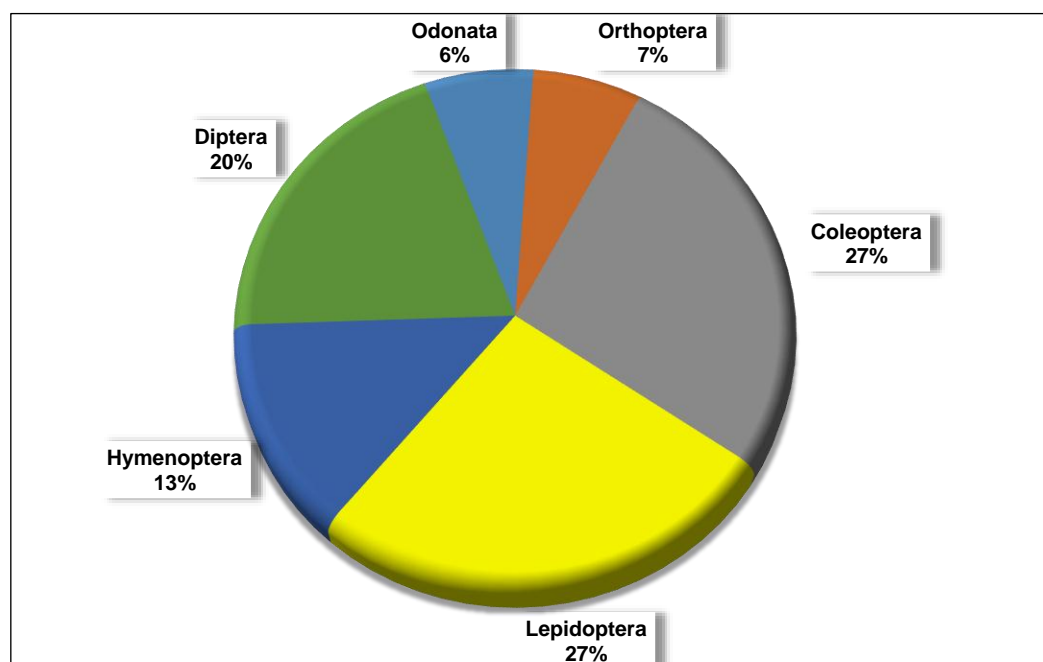


Figure-3.2: Composition of insect families in Khijadiya Wildlife sanctuary during monsoon 2016.



DISCUSSION AND CONCLUSION:

We observed total 8 orders and 20 families of insects from Khijadiya Wetland. From the observed insect's specimen, we could identify 18 of them up to species levels. Present study has made an effort to evaluate insect species richness in the Khijadiya Wildlife sanctuary. One of the important group of insects found in Khijadiya Wildlife Sanctuary are Odonates. They spend major part of their life cycle in fresh water ecosystem. Their trophic position and sensitivity to environmental degradation allow odonates to function as indicators of ecosystem quality (Westfall & May, 1999; Stewart & Samways, 1998; Clark & Samways, 1996; Samways et al., 1996; Takamura, 1996; Watson et al., 1982). Odonates are more and more recognized as indicator of a healthy aquatic ecosystem in recent years and are often termed as the bio-indicators of the aquatic ecosystem (Clark & Samways 1996). Among odonates dragonflies are considered as a potential bio control agents of mosquitoes (Sathe & Bhusnar, 2010; Mitra, 2002). Being predator during larval and adult stage plays important role in invertebrate food chain. Due to lack of fresh water in Khijadiya Wildlife Sanctuary the odonates species were very few. In other word lower number of species of odonates also indicated the low availability of water in the study area. It is recommended that further study of odonates diversity shall be carried out for long term in Khijadiya Wildlife Sanctuary as the present study could not give true representative diversity of odonates due to lack of water during the study period.

Order Mantidea was represented by family Mantidae which feed exclusively on living insects, seize s in a vise-like grip. This group has excellent ability to camouflage with the surrounding. Occurrence of this group was observed during winter when food is the maximum. Family Mymeleontidae often included in the list of beneficial insects, no doubt because they prey upon ants, a common pest to humans. During the winter season this insect was the most dominating throughout the road side of the study area ,lose and dry soil and good availability of food source at Khijadiya creates from order neuroptera was the sole representative. Antlions are quite favorable condition for antlion larvae for making their conical pit and trapping other insects for their food.

Being the most diverse group of insect, order coleoptera is represented by total 5 families and 6 species. Family carabidae well-known both taxonomically and ecologically and are also used as different kind of indicators studies because of their sensitivity to slightest habitat alteration. The majority insects of this family are carnivorous but some forms are herbivorous. Family Scarabaeidae are essential component of forest ecosystem. They do valuable work in quickly mixing raw manure with soil which may increase the rate of nutrient cycling. Scarabids play a major role pastures and grass biomes removing vertebrate feces of many domestic and wild ungulates. Presence of ungulates at the study area is helping these beetles to proliferate and sustaining them. Family Tenebrionidae (darkling beetle) is one of the families which occurred throughout the study area irrespective of seasons. Adults of this family are generally herbivorous and few species are known to feed on decaying or dead plant material. They are known to occupy niche of carabidae in arid region but at study area they also captured niche of scarabidae beetles. This could be one reason of their dominance over these two families at Khijadiya. Family Meloidae (Blister beetle): This group of beetles contains cantharidin, a substance capable of

creating blistering on skin. Adults are plant feeders and are pest if present beyond the threshold number, whereas larvae of this beetles are beneficial, they usually feed on eggs of grass hopper and eggs of bee. Presence of this group indicates that the study area is providing shelter as well as food for this beetles during immature as well as an adult stage. Family Anthicidae (Ant like flower beetle) beetles were minute and resemble ants. They occur in foliage, under stones, logs, debris and on ground. Their presence at study area indicates sustainable condition for these insects.

Order Lepidoptera (Butterflies) was represented by four families and their occurrence was affected by the seasonal variations. Lepidopterans are considered flagship species for insect conservation. Larvae are mostly phytophagous and many are serious pests. During winter *Salvadora* blooming was major cause for attracting more different varieties of butterflies. Nine species of butterflies from four different families were observed at Khijadiya wildlife sanctuary during studies.

Family Apidae (Honey bees) was one more dominating family from order Hymenoptera by number of individuals as wells. *Salvadora* flowering was the main source for nectar collection for these insects. Ants were another hymenopteran representative from family Formicidae. Ants play a major role in soil turnover and also serve as food for many other groups of animals. Their occurrence at Khijadiya shows availability of host insects, which may be due to increased floristic diversity.

Three families of order Diptera were recorded at Khijadiya. Family Muscidae and the most commonly sighted species *Musca domestica* during winter season. This species is considered as cosmopolitan pest and are carrier of many harmful microorganisms commonly associated with human activities. Family: Asilidae (Robber flies or Grass flies) was observed during monsoon season. It is predacious and attacks variety of insects. Presence of Family: Culicidae was also noticed after sunset.

Insects representative of major groups of food chain/niches were observed (Table-3.1) suggesting functional and self-sustained ecosystem of Khijadiya Wildlife Sanctuary. Less human interference/anthropological activities might help these insect communities play their role of maintenance of the equilibrium of the ecology of this protected area. Thus, the study provides overview of insects of Khijadiya Wildlife sanctuary. It also provides baseline data for upcoming researchers and will give wide scope of further investigations.

Table-3.1: Ecological roles of insect families recorded from the study area.

Order	Family	General Ecological Role	
		larva	Adult
Odonata	Libellulidae	Predator	Predator
Orthoptera	Acrididae	Pest	Pest
Mantidea	Mantidae	Predator	Predator
Neuroptera	Mymeleonidae	Predator	
Coleoptera	Carabidae	Predator	Predator
	Scarabaeidae	Root, dung and decaying material feeders	Dung feeders and decomposers
	Tenebrionidae	Omnivorous	Omnivorous
	Meloidae	Parasitic	Herbivorous
	Anthicidae	Omnivorous, predator and fungus feeder	Omnivorous
Lepidoptera	Papilionidae	Herbivorous	Nectorsuckers Pollinators
	Pieridae	Herbivorous	Nector suckers Pollinators
	Lycaenidae	Herbivorous few carnivorous	Nector suckers Pollinators
	Nymphalidae	Herbivorous	Nector suckers Pollinators
	Sphingidae	Herbivorous	Nector suckers
	Noctuidae	Herbivorous	Nector suckers Pollinators
Diptera	Mucidae	Saprophagus	saprophagus
	Asilidae	Predator	Predator
	Culicidae	Microorganisms available in water	Vector
Hymenoptera	Formicidae	Fed by adult	omnivorous
	Apidae	Fed by adult	Nector suckers Pollinators

Plate-3.1: Insects recorded in the Khijadiya Wildlife Sanctuary during study.



Plate-3.2: Insects recorded in the Khijadiya Wildlife Sanctuary during study.



SURVEY OF FISHES

FISH SPECIES RICHNESS

We have collected and identified fish and associated fauna from the creek area where fishing activity was going on. We have identified five species from samples and all fauna are marine as collected from creeks (Table-3.2). We have visited Khijadiya wetland during winter and monsoon but water was not available hence no fishing has been done in freshwater part of Khijadiya Wetland. From literature survey Pandey and Teli, 2005 have recorded 9 species from Khijadiya wetland (Table-3.3).

An overall result of the survey conducted in and around the Khijadiya wetland and literature survey for the documentation of the fish and associated fauna is listed below accordingly (Table-3.3). The list also includes the family to which it belongs, their common and local or vernacular names, the IUCN category to which they belong. Also the IUCN status of each species has been mentioned. A total of 4 numbers of species of fishes and associated fauna belong to the category of Least Concern, 6 species are Not Evaluated and data has not been found for 2 species.

Table-3.2: List of fishes and associated fauna recorded at Khijadiya wetland.

Sr. No.	Scientific Name
1	<i>Metapenaeus kutchensis</i>
2	<i>Mugil cephalus</i>
3	<i>Puntius sarana</i>
4	<i>Boleophthalmus dussumieri</i>
5	<i>Mugilidae</i> (Boi)

Table-3.3: List of fishes and associated fauna of Khijadiya wetland listed from literature survey.

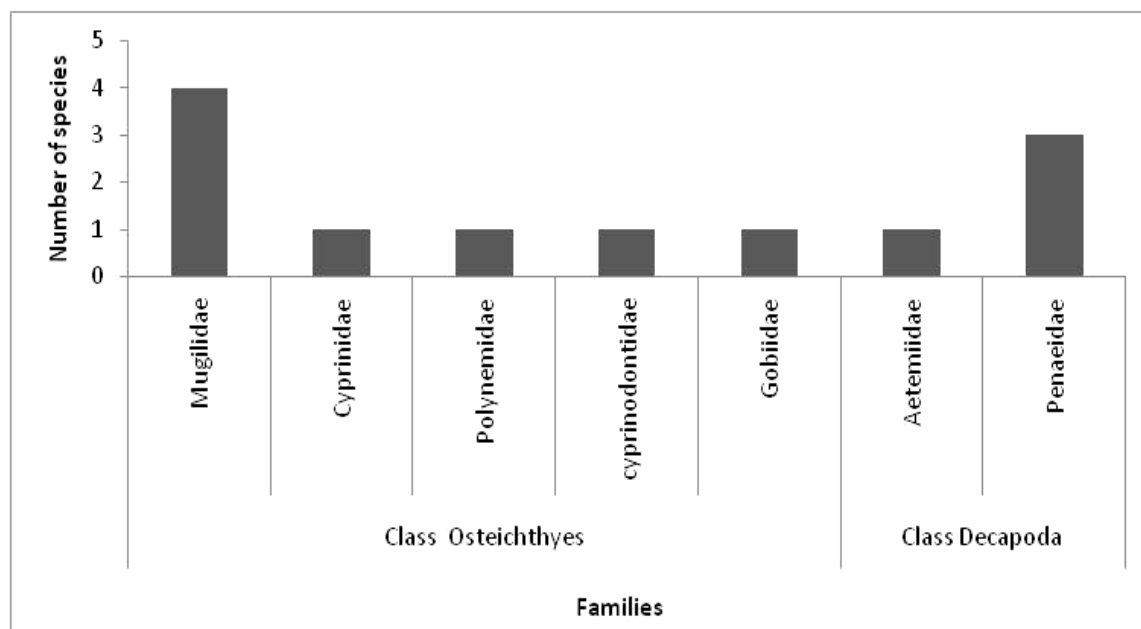
Sr. No.	Scientific Name
1	<i>Boleophthalmus dussumieri</i>
2	<i>Eleutheronematetractylum</i>
3	<i>Cyprinidondispar</i>
4	<i>Mugil salinatus</i>
5	<i>Mugil oligolepus</i>
6	<i>Artemiasalina</i>
7	<i>Metapenopsiskutchensis</i>
8	<i>Metapenaeusattinis</i>

9

*Parapenopsisscolptilis***FISH & OTHER SPECIES CLASSIFICATION**

Out of the total 12 fauna found 8 species belongs to class Osteichthyes (bony fish) while 4 species belongs to class Decapoda (Shrimp and Prawn). Among class Osteichthyes 4 species belong to the family of Mugilidae and families such as Gobiidae, Polynemidae, Cyprinodontidae and Cyprinidae have 1 species each. Among class Decapoda 3 species belongs to family Penaeidae and 1 species belong to family Artemiidae (Figure-3.3, Table-3.4).

Figure-3.3: Number of fish species recorded in Khijadiya Wildlife Sanctuary.

**FISHING ACTIVITY IN KHIJADIYA WETLAND**

Total 10-12 families of Koli communities living at Khijadiya salt village are involved in fishing activity. They are only collected fish for their food while they are going for labor or as a driver for living expenses. They perform Hook line and cast net for fishing (Plate-3.3). They collect 1-2 kg fish per person per hour. During our field visit we found four people active in fishing. The fishing is not done inside the freshwater area. However, they do fishing in the areas of marine creeks etc. which are not part of Khijadiya Wildlife Sanctuary.

Table-3.4: Comprehensive list of fishes and associated aquatic fauna with primary details.

Sr. No.	Scientific Name	Family	Common name	Local name	IUCN status
1	<i>Boleophthalmus dussumieri</i>	Gobiidae	Mudskipper	Levti	NE
2	<i>Eleutheronematetradactylum</i>	Polynemidae	Bastard mullets	Rawas	NE
3	<i>Cyprinidondispar</i>	Cyprinodontidae	Arabian pupfish	-	LC
4	<i>Mugil salinatus</i>	Mugilidae	-	-	-
5	<i>Mugil oligolepis</i>	Mugilidae	Grey Mullet	Mullet	NE
6	<i>Artemiasalina</i>	Artemiidae	Brine Shrimp		LC
7	<i>Metapenopsiskutchensis</i>	Penaeidae			
8	<i>Metapenaeusattinis</i>	Penaeidae	Shrimp	Jhinga	NE
9	<i>Parapenopsiscolptilis</i>	Penaeidae	Shrimp	Jhinga	NE
10	<i>Mugil cephalus</i>	Mugilidae	Flathead grey mullet	Boi	LC
11	<i>Puntius sarana</i>	Cyprinidae	Greenstripe barb	-	LC
12	<i>Mugilidae (Boi)</i>	Mugilidae	Grey mullet	Boi	-

Plate-3.3: Fishing practices by local people in creek area around Khijadiya Wildlife Sanctuary.



FISH SPECIES DESCRIPTIONS

Details of some of the important fish and crustacean faunal species are given below.

Puntius sarana (Hamilton, 1822)



Species Identification

Puntius sarana (Hamilton, 1822)

Common name

Puntius sarana (Froese and Pauly, 2017)

Local name

Olive barb

Dhebri

***Mugil cephalus* Linnaeus, 1758**



Species Identification

Mugil cephalus Linnaeus, 1758

Common name

Mugil cephalus (Froese and Pauly, 2017)

Local name

Flathead grey mullet

Boi

***Mugilidae* (Boi)**



Species Identification

Identified up to family: Mugilidae

Common name

Mugilidae species (Froese and Pauly, 2017)

Local name

Mullet

Boi

***Boleophthalmus dussumieri* Valenciennes, 1837**



Species Identification	<i>Boleophthalmus dussumieri</i> Valenciennes, 1837
Common name	<i>Boleophthalmus dussumieri</i> (Froese and Pauly, 2017)
Local name	Mudskipper
	Levta

***Metapenaeus kutchensis* George, George & Rao, 1963**



Scientific name	<i>Metapenaeus kutchensis</i> George, George & Rao, 1963
Common name	Prawn
Local name	Jinga

SURVEY OF HERPETOFAUNA

AMPHIBIANS SPECIES RICHNESS

At Khijadiya, a total 4 species of Amphibians belonging to 4 genera and 2 families *i.e.* Bufonidae and Ranidae were recorded (Table-3.5). All the four species were directly sighted on transects. Out of these four, the most abundant species was Indian Bullfrog (*Hoplobatrachus tigerinus*) with relative abundance of 60%. All the four species were recorded from the wetland habitat. Indian Bullfrog (*Hoplobatrachus tigerinus*) was recorded from the moist agriculture land also. As described earlier, all the four species are one of the most common food for the heronry birds in Gujarat (Vyas and Parasharya, 2016) and serves as great food source for the newly hatched chicks of the heronry birds. However the proliferation of the two frog species purely depends on the water availability and moisture content of the soil.

Table-3.5: Amphibian species recorded from Khijadiya Wildlife Sanctuary.

Sr. No	Common Name	Scientific Name	IUCN Status	WLPA Schedule
Family Bufonidae				
1	Common Indian Toad	<i>Duttaphrynus melanostictus</i> (Schneider, 1799)	LC	Sch-IV
2	Marbled Toad	<i>Duttaphrynus stomaticus</i> Lütken, 1864	LC	Sch-IV
Family Dicroglossidae				
3	Indian Skipping frog	<i>Euphlyctis cyanophlyctis</i> (Schneider, 1799)	LC	Sch-IV
4	Indian Bullfrog	<i>Hoplobatrachus tigerinus</i> (Daudin, 1803)	NE	Sch-IV

AMPHIBIANS RELATIVE ABUNDANCE

Relative abundances of amphibians were calculated using the observations made during the field (Table-3.6). Out of these four, the most abundant species was Indian Bullfrog (60%) followed by Common Indian Toad (20%), Marbled toad (10%) and Indian Skipping frog (10%). All the four species were recorded from the wetland habitat and cultivated agriculture fields in surrounding area.

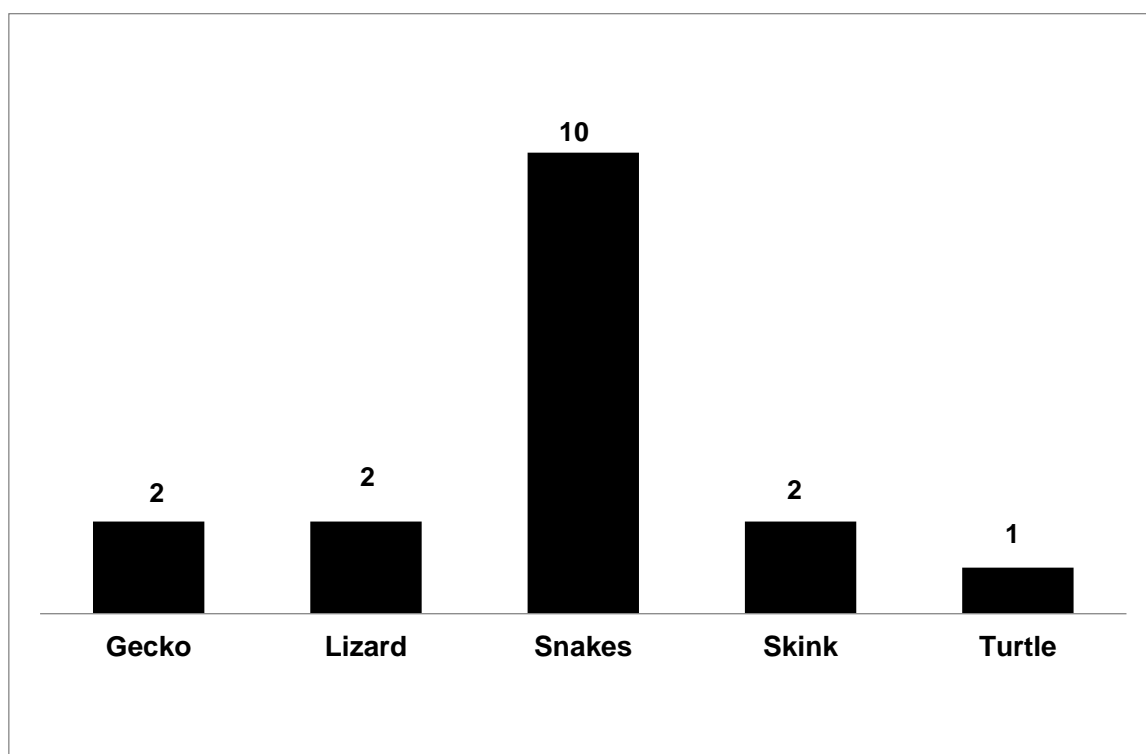
Table-3.6: Relative abundance of the Amphibian species at Khijadiya Wildlife Sanctuary

No	Species	Scientific Name	Habitat			Total	RA
			Wet land	Dry waste land	Cultivated		
1	Indian Bullfrog	<i>Hoplobatrachus tigerinus</i>	20	0	4	6	60.0
2	Common Indian Toad	<i>Duttaphrynus melanostictus</i>	8	0	0	2	20.0
3	Indian Skipping frog	<i>Euphlyctis cyanophlyctis</i>	4	0	0	1	10.0
4	Marbled Toad	<i>Bufo stomaticus</i>	4	0	0	1	10.0

REPTILES SPECIES RICHNESS

A total of 18 reptile species belonging to 17 genus and 9 family were recorded from the wetland and its surrounding environs of Khijadiya (Table-3.7, Table-3.8 & Figure-3.4). Out of these 18 species two species viz. Indian flapshell and Bengal monitor lizard are protected under Schedule I of the WLP – 1972, due to its heavy trade in black magic as well as for domestic consumption. Occasional occurrence of annulated sea snake (*Hydrophis cyanocinctus*) during the intake of sea water for the salt pans was recorded. The most dominant family was colubridae with six representative species.

Figure-3.4: Number of reptilian species in each representative group.



REPTILE RELATIVE ABUNDANCE

Relative abundances of amphibians were calculated using the observations made during the field visits (Table-3.7). Out of 18 species of reptiles, 12 species were sighted directly during field sampling. Garden Lizard was one of the most encountered and had highest relative abundance (45%) compared to all other species which were sighted only once during field visits having similar relative abundance i.e. 5% (Table-3.7). This could be due to their naturally low abundance as well as shy, nocturnal, and secretive behaviours. Maximum sightings were reported from Agriculture field and their boundaries followed by open dryland followed by wetland and creek areas in Khijadiya Wildlife Sanctuary.







Table-3.7: Relative abundance of Reptile species at Khijadiya Wildlife Sanctuary

No	Species Name	Habitat			Encounters	Relative Abundance (%)
		Wet land	Dry waste land	Culti vated		
1	Yellow-green House Gecko	0	1	0	1	5
2	Brooke's Gecko	0	1	0	1	5
3	Bengal Monitor lizard	0	0	1	1	5
4	Garden lizard	2	2	5	9	45
5	Indian Cobra	0	0	1	1	5
6	Indian Rat snake	0	0	1	1	5
7	Buff striped keelback	1	0	0	1	5
8	Sawscaled viper	0	1	0	1	5
9	Annulated Seasnake	1	0	0	1	5
10	Indian flapshell	1	0	0	1	5
11	Bronze skink	0	1	0	1	5
12	Spotted supple skink	0	0	1	1	5

Table-3.8: Species inventory of reptiles recorded at Khijadiya.

Sr. No	Common Name	Scientific Name	IUCN Status	WLPA Schedule
Family Gekkonidae				
1	Yellow-green House Gecko	<i>Hemidactylus flaviviridis</i> Ruppell, 1835	LC	NA
2	Brooke's Gecko	<i>Hemidactylus brookii</i> Gray, 1845	NE	NA
Family Varanidae				
3	Bengal Monitor lizard	<i>Varanus bengalensis</i> (Daudin, 1802)	LC	I
Family Agamidae				
4	Garden lizard	<i>Calotes versicolor</i> (Daudin, 1802)	NE	NA
Family Lacertidae				
5	Indian fringe finger lizard	<i>Acanthodactylus cantoris</i> Günther, 1864	LC	NA
Family Elapidae				
6	Indian Krait	<i>Bungarus caeruleus</i> (Schneider, 1801)	NE	IV
7	Indian Cobra	<i>Naja naja</i> (Linnaeus, 1758)	NE	II
8	Annulated Seasnake	<i>Hydrophis cyanocinctus</i> Daudin, 1803	LC	IV
Family Colubridae				
9	Indian Rat snake	<i>Ptyas mucosa</i> (Linnaeus, 1758)	NE	II
10	Common Wolf snake	<i>Lycodon aulicus</i> (Linnaeus, 1758)	LC	IV
11	Buff striped keelback	<i>Amphiesma stolatum</i> (Linnaeus, 1758)	NE	IV
12	Checkered keelback	<i>Xenochrophis piscator</i> (Schneider, 1799)	LC	II
13	Indian Trinket	<i>Coelognathus helena</i> (Daudin, 1803)	NE	IV
14	Common Kukri	<i>Oligodon arnensis</i> (Shaw, 1802)	NE	IV
Family Viperidae				
15	Sawscaled viper	<i>Echis carinatus</i> (Schneider, 1801)	NE	IV
Family Trionychidae				
16	Indian flapshell	<i>Lissemys punctata</i> (Lacépède, 1788)	LC	I
Family Scincidae				
17	Bronze skink	<i>Eutropis macularia</i> (Blyth, 1853)	NE	NA
18	Spotted supple skink	<i>Lygosoma punctata</i> Gmelin 1799	NE	NA

Plate-3.4: Photographs of various amphibians and reptiles present in Khijadiya Wildlife Sanctuary.

<p>Common Indian Toad</p>  A photograph of a Common Indian Toad (Anaxyrus indicus) resting on a rocky, uneven ground. The toad has a brownish-orange body with darker, mottled patterns.	<p>Marbled Toad</p>  A photograph of a Marbled Toad (Anaxyrus marmoratus) resting on a sandy, reddish-brown ground. The toad has a greenish-brown body with prominent white and black marbled patterns.
<p>Indian Bullfrog</p>  A photograph of an Indian Bullfrog (Hoplobatrachus tigerinus) resting on a wet, rocky surface. The frog has a large, brown body with a lighter, mottled pattern.	<p>Indian Skipping frog</p>  A photograph of an Indian Skipping frog (Zadokionigrum) resting on a reddish-brown, sandy ground. The frog has a yellowish-brown body with dark spots.
<p>Brookes Gecko</p>  A photograph of a Brookes Gecko (Gehyra brookesi) resting on a light-colored, textured surface. The gecko has a brownish body with a lighter, mottled pattern.	<p>Bengal Monitor Lizard</p>  A photograph of a Bengal Monitor Lizard (Varanus bengalensis) resting on a rocky, uneven ground. The lizard has a brownish body with a lighter, mottled pattern.

SURVEY OF BIRDS

Birds are an important component of biotic community of any ecosystem. They respond quickly to changing in habitat thus, birds are good bioindicators of habitat quality, productivity, and stability of any ecosystem (Pertti Koskimies, 1998; Roché et al. 2010). The information on diversity and their abundance helps in conservation and management of threatened and endangered bird species. The alteration in habitats may cause changes in avian abundance and diversity.

About 1300 species of bird i.e. About 13 % of the world's bird (Grimmett *et al.* 1998) are recorded from Indian subcontinent. India ranks third in having a large number of threatened and rare species (Dandapat et al. 2010). Khijadiya Wildlife Sanctuary being a unique freshwater-saltwater eco-system, the diversity birds is also unique in a small area. Total more than 300 species of birds are recorded from Khijadiya a small area of 6.05 km². The birds of Khijadiya Wildlife Sanctuary can be broadly divided into terrestrial and waterbirds.

STUDY OF WATERBIRDS

WATERBIRD POPULATION ESTIMATE

The population of waterbirds estimated on 31 January 2016 in Khijadiya Wildlife Sanctuary in freshwater, marine water creeks, mangrove and mudflats are given as under. Waterbird population estimated in 4 different zones of Khijadiya wetland was low compared to previous estimation made by several agencies so far i.e. 8,199 birds in (Table-3.9, Table-3.10). During waterbird estimation we reported a total of 96 waterbirds and water dependent bird species along with few terrestrial ones in Khijadiya (Table-3.11). Waterbird population was reported to be 3655 birds during primary survey in December-2015. However, during final survey in January-2016 we reported total 8199 birds present in the Khijadiya Wildlife sanctuary. During our survey we reported the Khijadiya wetland supports 1% populations of only 1 species which is Common Crane. However, during good monsoon years there are records of several species are found to cross 1% mark in this wetland. These species are Demoiselle crane, Great White Pelican, Greater Flamingo, Lesser Flamingo; Black tailed Godwit, Oriental Darter etc.

Table-3.9: Zone wise number and percentage of estimated waterbirds in Khijadiya wetland during 31 January 2016.

Zone	Zone-1	Zone-2	Zone-3	Zone-4	Total
Numbers	2039	2171	468	3521	8199
Percentage	24.87	26.48	5.708	42.94	100

During our survey we observed that cranes, shorebirds, gulls & Terns, made majority of the population of waterbirds in the Khijadiya Wildlife Sanctuary (Figure-3.5).

Figure-3.5: Major bird groups and their population recorded in Khijadiya Wildlife Sanctuary during winter.

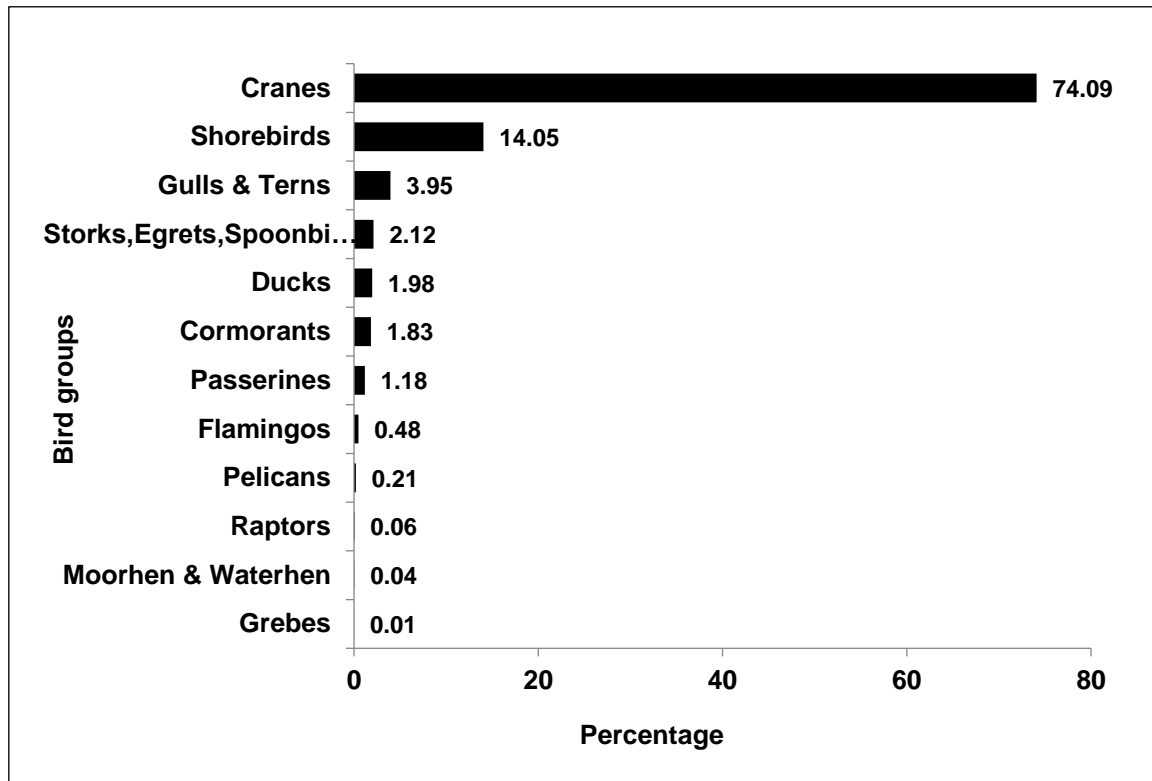


Table-3.10: Details of Waterbirds population estimates and sightings in Khijadiya wetland.

No	Name of Bird	Scientific Name of Bird	HABIT		CONSERVATION STATUS		Final Counts January-2016				
			Habit	Migratory status	IUCN STATUS	WPA Schedule	zone-1	zone-2	zone-3	zone-4	Total
1	Black-headed Gull	<i>Larus ridibundus</i>	A	M	LC	IV	15				15
2	Black-headed Ibis	<i>Threskiornis melanocephalus</i>	A	R	NT	IV		5	1	5	11
3	Black-necked Stork	<i>Ephippiorhynchus asiaticus</i>	A	R	NT	IV	2				2
4	Black-tailed Godwit	<i>Limosa limosa</i>	A	M	NT	IV	75				75
5	Black-winged Stilt	<i>Himantopus himantopus</i>	A	R	LC	IV	74				74
6	Broad-billed Sandpiper	<i>Limicola falcinellus</i>	A	M	LC	IV	1				1
7	Brown-headed Gull	<i>Larus brunnicephalus</i>	A	M	LC	IV	6				6
8	Caspian Tern	<i>Hydroprogne caspia</i>	A	M	LC	IV	2				2
9	Cattle Egret	<i>Bubulcus ibis</i>	A	R	LC	IV	15	15	14	11	55
10	Common Crane	<i>Grus grus</i>	A	M	LC	IV	0	2100	450	3500	6050
11	Common Greenshank	<i>Tringa nebularia</i>	A	M	LC	IV	3				3
12	Common Kingfisher	<i>Alcedo atthis</i>	A	R	LC	IV	3	2			5
13	Common Moorhen	<i>Gallinula chloropus</i>	A	R	LC	IV	1				1
14	Common Redshank	<i>Tringa totanus</i>	A	M	LC	IV	7				7
15	Common Sandpiper	<i>Actitis hypoleucos</i>	A	M	LC	IV	3				3
16	Common Snipe	<i>Gallinago gallinago</i>	A	M	LC	IV	1				1
17	Common Swallow	<i>Hirundo rustica</i>	T	M	LC	IV	40				40
18	Common Teal	<i>Anas crecca</i>	A	M	LC	IV	25				25
19	Curlew Sandpiper	<i>Calidris ferruginea</i>	A	M	LC	IV	1				1
20	Dalmatian Pelican	<i>Pelecanus crispus</i>	A	M	VU	IV	2				2
21	Demoiselle Crane	<i>Grus virgo</i>	A	M	LC	IV	20	5			25
22	Eurasian Curlew	<i>Numenius arquata</i>	A	M	NT	IV	4				4
23	Eurasian Spoonbill	<i>Platalea leucorodia</i>	A	R	LC	I	10				10
24	Eurasian Thick-knee	<i>Burhinus oedicnemus</i>	A	R	LC	IV	2	2			4
25	Glossy Ibis	<i>Plegadis falcinellus</i>	A	R	LC	IV	2				2

No	Name of Bird	Scientific Name of Bird	HABIT		CONSERVATION STATUS		Final Counts January-2016				
			Habit	Migratory status	IUCN STATUS	WPA Schedule	zone-1	zone-2	zone-3	zone-4	Total
			A	R	LC	IV	21				21
27	Great Thick-knee	<i>Esacus recurvirostris</i>	A	R	LC	IV	1				1
28	Great White Egret	<i>Casmerodius albus</i>	A	R	LC	IV	4				4
29	Great White Pelican	<i>Pelecanus onocrotalus</i>	A	M	LC	IV	15				15
30	Greater Flamingo	<i>Phoenicopterus ruber</i>	A	R	LC	IV	37				37
31	Greater Sand Plover	<i>Charadrius leschenaultii</i>	A	M	LC	IV	2				2
32	Green Sandpiper	<i>Tringa ochropus</i>	A	M	LC	IV	4				4
33	Grey Heron	<i>Ardea cinerea</i>	A	R	LC	IV	2				2
34	Grey Plover	<i>Pluvialis squatarola</i>	A	M	LC	IV	1				1
35	Gull-billed Tern	<i>Sterna nilotica</i>	A	M	LC	IV	22				22
36	Heuglin's Gull	<i>Larus heuglini</i>	A	M	LC	IV	1				1
37	Indian Black Ibis	<i>Pseudibis papillosa</i>	A	R	LC	IV	2	15			17
38	Clamorous Reed-warbler	<i>Acrocephalus stentoreus</i>	A	R	LC	IV	25				25
39	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>	A	R	LC	IV	2	2			4
40	Indian Pond-heron	<i>Ardeola grayii</i>	A	R	LC	IV	15	4			19
41	Intermediate Egret	<i>Mesophoyx intermedia</i>	A	R	LC	IV	2	1			3
42	Kentish Plover	<i>Charadrius alexandrinus</i>	A	M	LC	IV	15				15
43	Lesser Crested Tern	<i>Sterna bengalensis</i>	A	M	LC	IV	5				5
44	Lesser Flamingo	<i>Phoenicopterus minor</i>	A	R	LC	IV	2				2
45	Lesser Sand Plover	<i>Charadrius mongolus</i>	A	M	LC	IV	10				10
46	Little Cormorant	<i>Phalacrocorax niger</i>	A	R	LC	IV	125				125
47	Little Egret	<i>Egretta garzetta</i>	A	R	LC	IV	1				1
48	Little Grebe	<i>Tachybaptus ruficollis</i>	A	R	LC	IV	1				1
49	Little Ringed Plover	<i>Charadrius dubius</i>	A	M	LC	IV	1				1
50	Little Stint	<i>Calidris minuta</i>	A	M	LC	IV	15				15
51	Marsh Sandpiper	<i>Tringa stagnatilis</i>	A	M	LC	IV	7				7
52	Northern Shoveller	<i>Anas clypeata</i>	A	M	LC	IV	10				10
53	Osprey	<i>Pandion haliaetus</i>	T	M	LC	I	1	1			2

No	Name of Bird	Scientific Name of Bird	HABIT		CONSERVATION STATUS		Final Counts January-2016				
			Habit	Migratory status	IUCN STATUS	WPA Schedule	zone-1	zone-2	zone-3	zone-4	Total
54	Painted Stork	<i>Mycteria leucocephala</i>	A	R	NT	IV	36	5			41
55	Pallas's Gull	<i>Ichthyaetus ichthyaetus</i>	A	M	LC	IV	1				1
56	Peregrine Falcon	<i>Falco peregrinus</i>	T	M	LC	IV	1				1
57	Red-wattled Lapwing	<i>Vanellus indicus</i>	A	R	LC	IV	14	14	3	5	36
58	River Tern	<i>Sterna aurantia</i>	A	R	NT	IV	15				15
59	Ruff (M) and Reeve (F)	<i>Philomachus pugnax</i>	A	M	LC	IV	150				150
60	Sanderling	<i>Calidris alba</i>	A	M	LC	IV	25				25
61	Spot-billed Duck	<i>Anas poecilorhyncha</i>	A	R	LC	IV	2				2
62	Spotted Redshank	<i>Tringa erythropus</i>	A	M	LC	IV	1				1
63	Temminck's Stint	<i>Calidris temminckii</i>	A	M	LC	IV	2				2
64	Western Marsh Harrier	<i>Circus aeruginosus</i>	A	M	LC	IV	2				2
65	Western Reef-heron	<i>Egretta gularis</i>	A	R	LC	IV	7				7
66	Whimbrel	<i>Numenius phaeopus</i>	A	M	LC	IV	1				1
67	Whiskered Tern	<i>Chlidonias hybrida</i>	A	M	LC	IV	7				7
68	White-breasted Waterhen	<i>Amaurornis phoenicurus</i>	A	R	LC	IV	2				2
69	White-throated Kingfisher	<i>Halcyon smyrnensis</i>	A	R	LC	IV	17				17
70	Wire-tailed Swallow 2	<i>Hirundo smithii</i>	T	R	LC	IV	2				2
71	Wood Sandpiper	<i>Tringa glareola</i>	A	M	LC	IV	6				6
72	Yellow Wagtail	<i>Motacilla flava</i>	A	M	LC	IV	8				8
73	Yellow-wattled Lapwing	<i>Vanellus malarbaricus</i>	A	R	LC	IV	2				2
	Unidentified ducks						125				125
	Unidentified gulls						130				130
	Unidentified shorebirds						700				700
	Unidentified terns						120				120
							2039	2171	468	3521	8199

Table-3.11: Checklist of all waterbirds recorded from Khijadiya Wildlife Sanctuary during the study period.

No	Name of Bird	Scientific Name of Bird	Migratory status	Feeding Guild	Conservation Status	
					IUCN Status	WPA Schedule
1	Asian Openbill	<i>Anastomus oscitans</i>	R	C	LC	IV
2	Bar-tailed Godwit	<i>Limosa lapponica</i>	M	C	NT	IV
3	Black-crowned Night Heron	<i>Nycticorax nycticorax</i>	R	C	LC	IV
4	Black-headed Gull	<i>Larus ridibundus</i>	M	P	LC	IV
5	Black-headed Ibis	<i>Threskiornis melanocephalus</i>	R	C	NT	IV
6	Black-necked Grebe	<i>Podiceps nigricollis</i>	M	P	LC	IV
7	Black-necked Stork	<i>Ephippiorhynchus asiaticus</i>	R	C	NT	IV
8	Black-tailed Godwit	<i>Limosa limosa</i>	M	C	NT	IV
9	Black-winged Stilt	<i>Himantopus himantopus</i>	R	C	LC	IV
10	Broad-billed Sandpiper	<i>Limicola falcinellus</i>	M	C	LC	IV
11	Brown-headed Gull	<i>Larus brunnicephalus</i>	M	P	LC	IV
12	Caspian Tern	<i>Hydroprogne caspia</i>	M	P	LC	IV
13	Cattle Egret	<i>Bubulcus ibis</i>	R	C	LC	IV
14	Comb Duck	<i>Sarkidiornis melanotos</i>	R	O	LC	IV
15	Common Coot	<i>Fulica atra</i>	R	O	LC	IV
16	Common Crane	<i>Grus grus</i>	M	O	LC	IV
17	Common Greenshank	<i>Tringa nebularia</i>	M	C	LC	IV
18	Common Kingfisher	<i>Alcedo atthis</i>	R	C	LC	IV
19	Common Moorhen	<i>Gallinula chloropus</i>	R	O	LC	IV

No	Name of Bird	Scientific Name of Bird	Migratory status	Feeding Guild	Conservation Status	
					IUCN Status	WPA Schedule
20	Common Redshank	<i>Tringa totanus</i>	M	C	LC	IV
21	Common Sandpiper	<i>Actitis hypoleucos</i>	M	C	LC	IV
22	Common Snipe	<i>Gallinago gallinago</i>	M	C	LC	IV
23	Common Teal	<i>Anas crecca</i>	M	O	LC	IV
24	Curlew Sandpiper	<i>Calidris ferruginea</i>	M	C	LC	IV
25	Dalmatian Pelican	<i>Pelecanus crispus</i>	M	P	VU	IV
26	Demoiselle Crane	<i>Grus virgo</i>	M	O	LC	IV
27	Dunlin	<i>Calidris alpina</i>	M	C	LC	IV
28	Eurasian Curlew	<i>Numenius arquata</i>	M	C	NT	IV
29	Eurasian Oystercatcher	<i>Haematopus ostralegus</i>	M	C	NT	IV
30	Eurasian Spoonbill	<i>Platalea leucorodia</i>	R	C	LC	I
31	Eurasian Thick-knee	<i>Burhinus oedicephalus</i>	R	C	LC	IV
32	Glossy Ibis	<i>Plegadis falcinellus</i>	R	C	LC	IV
33	Great Cormorant	<i>Phalacrocorax carbo</i>	R	P	LC	IV
34	Great Crested Grebe	<i>Podiceps cristatus</i>	R	P	LC	IV
35	Great Thick-knee	<i>Esacus recurvirostris</i>	R	C	NT	IV
36	Great White Egret	<i>Casmerodius albus</i>	R	C	LC	IV
37	Great White Pelican	<i>Pelecanus onocrotalus</i>	M	P	LC	IV
38	Greater Flamingo	<i>Phoenicopterus ruber</i>	R	O	LC	IV
39	Greater Sand Plover	<i>Charadrius leschenaultii</i>	M	C	LC	IV
40	Green Sandpiper	<i>Tringa ochropus</i>	M	C	LC	IV

No	Name of Bird	Scientific Name of Bird	Migratory status	Feeding Guild	Conservation Status	
					IUCN Status	WPA Schedule
41	Grey Heron	<i>Ardea cinerea</i>	R	C	LC	IV
42	Grey Plover	<i>Pluvialis squatarola</i>	M	C	LC	IV
43	Gull-billed Tern	<i>Sterna nilotica</i>	M	P	LC	IV
44	Heuglin's Gull	<i>Larus heuglini</i>	M	P	LC	IV
45	Indian Black Ibis	<i>Pseudibis papillosa</i>	R	C	LC	IV
46	Indian Clamorous Reed-warbler	<i>Acrocephalus stentoreus</i>	R	I	LC	IV
47	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>	R	P	LC	IV
48	Indian Pond-heron	<i>Ardeola grayii</i>	R	C	LC	IV
49	Intermediate Egret	<i>Mesophoyx intermedia</i>	R	C	LC	IV
50	Jack Snipe	<i>Lymnocyptes minimus</i>	M	C	LC	IV
51	Kentish Plover	<i>Charadrius alexandrinus</i>	M	C	LC	IV
52	Lesser Crested Tern	<i>Sterna bengalensis</i>	M	P	LC	IV
53	Lesser Flamingo	<i>Phoenicopterus minor</i>	R	O	NT	IV
54	Lesser Sand Plover	<i>Charadrius mongolus</i>	M	C	LC	IV
55	Lesser Whistling-duck	<i>Dendrocygna javanica</i>	R	O	LC	IV
56	Little Cormorant	<i>Phalacrocorax niger</i>	R	P	LC	IV
57	Little Egret	<i>Egretta garzetta</i>	R	C	LC	IV
58	Little Grebe	<i>Tachybaptus ruficollis</i>	R	P	LC	IV
59	Little Ringed Plover	<i>Charadrius dubius</i>	M	C	LC	IV
60	Little Stint	<i>Calidris minuta</i>	M	C	LC	IV
61	Little Tern	<i>Sterna albifrons</i>	M	P	LC	IV

No	Name of Bird	Scientific Name of Bird	Migratory status	Feeding Guild	Conservation Status	
					IUCN Status	WPA Schedule
62	Marsh Sandpiper	<i>Tringa stagnatilis</i>	M	C	LC	IV
63	Northern Pintail	<i>Anas acuta</i>	M	O	LC	IV
64	Northern Shoveller	<i>Anas clypeata</i>	M	O	LC	IV
65	Oriental Darter	<i>Anhinga melanogaster</i>	R	P	NT	IV
66	Pacific Golden Plover	<i>Pluvialis fulva</i>	M	C	LC	IV
67	Painted snipe	<i>Rostratula benghalensis</i>	R	C	LC	IV
68	Painted Stork	<i>Mycteria leucocephala</i>	R	C	NT	IV
69	Pallas's Gull	<i>Ichthyaetus ichthyaetus</i>	M	P	LC	IV
70	Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>	R	O	LC	IV
71	Pied Avocet	<i>Recurvirostra avosetta</i>	M	C	LC	IV
72	Pied Kingfisher	<i>Ceryle rudis</i>	R	C	LC	IV
73	Purple Heron	<i>Ardea purpurea</i>	R	C	LC	IV
74	Purple Swampphen	<i>Porphyrio porphyrio</i>	R	O	LC	IV
75	Red-wattled Lapwing	<i>Vanellus indicus</i>	R	C	LC	IV
76	River Tern	<i>Sterna aurantia</i>	R	P	NT	IV
77	Ruddy Shelduck	<i>Tadorna ferruginea</i>	M	O	LC	IV
78	Ruddy Turnstone	<i>Arenaria interpres</i>	M	C	LC	IV
79	Ruff (M) and Reeve (F)	<i>Philomachus pugnax</i>	M	O	LC	IV
80	Sanderling	<i>Calidris alba</i>	M	C	LC	IV
81	Slender-billed Gull	<i>Larus genei</i>	M	P	LC	IV
82	Spot-billed Duck	<i>Anas poecilorhyncha</i>	R	O	LC	IV

No	Name of Bird	Scientific Name of Bird	Migratory status	Feeding Guild	Conservation Status	
					IUCN Status	WPA Schedule
83	Spotted Redshank	<i>Tringa erythropus</i>	M	C	LC	IV
84	Temminck's Stint	<i>Calidris temminckii</i>	M	C	LC	IV
85	Western Reef-heron	<i>Egretta gularis</i>	R	C	LC	IV
86	Whimbrel	<i>Numenius phaeopus</i>	M	C	LC	IV
87	Whiskered Tern	<i>Chlidonias hybrida</i>	M	P	LC	IV
88	White-breasted Waterhen	<i>Amauornis phoenicurus</i>	R	O	LC	IV
89	White-throated Kingfisher	<i>Halcyon smyrnensis</i>	R	C	LC	IV
90	Wire-tailed Swallow 2	<i>Hirundo smithii</i>	R	I	LC	IV
91	Wood Sandpiper	<i>Tringa glareola</i>	M	C	LC	IV
92	Woolly-necked Stork	<i>Ciconia episcopus</i>	R	C	VU	IV
93	Yellow Bittern	<i>Ixobrychus sinensis</i>	R	C	LC	IV
94	Yellow Wagtail	<i>Motacilla flava</i>	M	O	LC	IV
95	Yellow-legged Gull	<i>Larus cachinnans</i>	M	P	LC	IV
96	Yellow-wattled Lapwing	<i>Vanellus malarbaricus</i>	R	C	LC	IV

R=Resident, M=Migratory; C=Carnivore, P=Piscivore, O=Omnivore, I=Insectivore; LC=Least Concerned, NT=Near Threatened, VU=Vulnerable; IV= Schedule-IV, I= Schedule-I as per Wildlife Protection Act.

WATERBIRD SPECIES RICHNESS

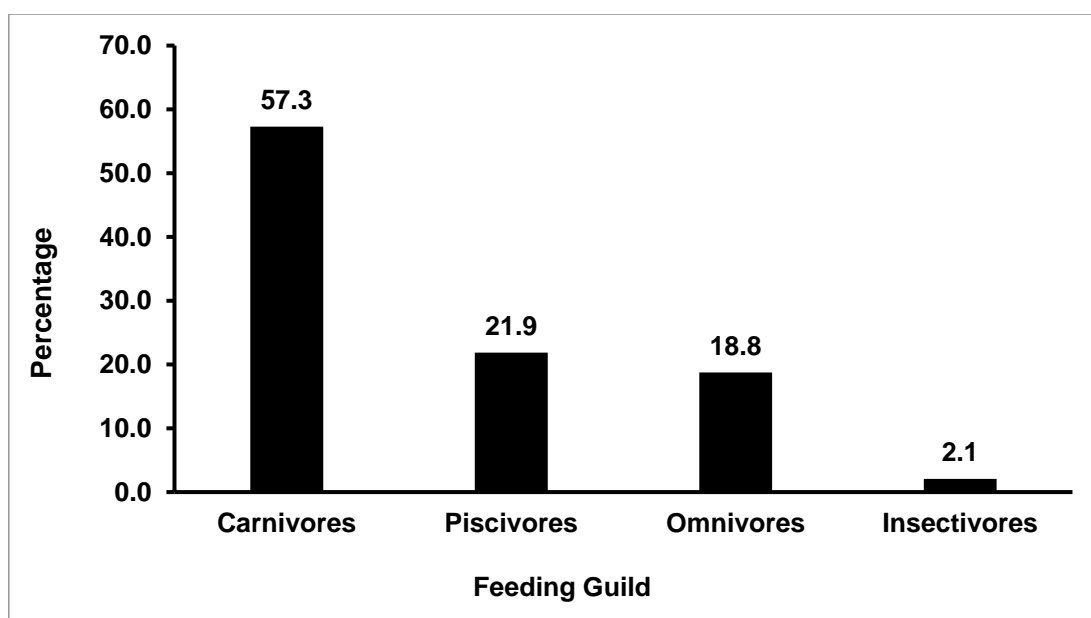
During the course of entire study, total 96 waterbirds and water dependent bird species were sighted in Khijadiya Wildlife Sanctuary (Table-3.11).

- It was observed that total 50 species of waterbirds were migratory whereas 46 species were resident Indian species.
- Of total 96 species of waterbirds great majority of the species i.e. 86.5 % were found to be Least Concerned, 11.5% species were Near Threatened and 2.1% species was Vulnerable according to IUCN categories.
- Of total 96 waterbird species, we found only 1 species belonging to Schedule-I of Wildlife Protection Act where as great majority i.e. 95 species belong to Schedule-IV of Wildlife Protection Act.

FEEDING GUILD DISTRIBUTION

The feeding guild of the waterbird showed that there were more carnivorous species i.e. 57.3%, Piscivorous 18.8%, Omnivorous 18.8% and Insectivorous were 2.1% (Figure-3.6).

Figure-3.6: Feeding guilds of waterbirds of Khijadiya Sanctuary.



From the aforesaid results it is evident that despite low rainfall the species feeding on higher trophic levels i.e. secondary consumers (carnivores, piscivorous insectivore) were higher than that of primary consumers (herbivores) in Khijadiya Wildlife Sanctuary. This could be due to variety of habitats present in this unique freshwater and saltwater wetland eco-system. This productive wetland system supports both freshwater and marine waterbirds.

IMPORTANT WINTER ROOSTING HABITATS

Khijadiya Wildlife sanctuary is well known to host large congregation of two species of Cranes i.e. Common Crane and Demoiselle Crane. Even without water these species were found to roost in Khijadiya Wildlife sanctuary (Zone-2, 3, 4) during winter in 2015-16. These species move into surrounding agriculture fields and small wetland in the periphery of Khijadiya Wildlife sanctuary during early morning to late evening hours. Vast open flat land of Khijadiya Wildlife sanctuary provides safe roosting space for Common Crane and Demoiselle cranes. Based on our repeated observations, we identified major winter roosting sites of Common Cranes in Khijadiya Wildlife sanctuary (Map-3.1).

Map-3.1: Major Common Crane winter roosting sites in Khijadiya Wildlife sanctuary.



IMPORTANT FEEDING HABITAT

Intertidal mudflats present in north of Khijadiya Wildlife Sanctuary have ecological linkages with marine sanctuary and its eco-system. This mudflat form integral part of the marine creek- mangrove ecosystem. These mudflats are highly productive areas which, together with other intertidal habitats, support large numbers of predatory birds and fish. They provide feeding and resting areas for internationally important populations of migrant and wintering waterfowl, and are also important nursery areas for variety of crustaceans, molluscs, crabs, worms etc.

STUDY OF TERRESTRIAL BIRDS

TOTAL SPECIES RICHNESS

During terrestrial bird surveys using various methods such as extensive search method, random point sampling, random encounters, as well as fixed spot sampling methods in Khijadiya Wildlife sanctuary we found total 128 terrestrial bird species (Table-3.12). The number of species recorded during winter were 117 where as only 78 species were reported during summer season. The less number of species reported during summer could be due to higher temperature, high wind speed and lack of food and water in Khijadiya Wildlife Sanctuary.

OVERALL BIRD DENSITY

The overall density of terrestrial birds in Khijadiya Wildlife Sanctuary during winter was estimated to be 53.1 ± 3.1 (SE) birds per ha. and 26.7 ± 2.2 (SE) in summer season. The overall bird density goes down almost to half during summer season due to various reasons i.e. migratory birds are absent during summer which contributes substantially to the bird population of Khijadiya Wildlife Sanctuary.

SPECIES SPECIFIC DENSITY

Total 50 bird species were recorded during the sampling efforts in winter and summer seasons. Density of each of the species recorded is given in Table-3.13. During winter density of some species were as follow Rosy starling 7.96 bird/ha., Red-vented Bulbul 4.42 bird/ha., House sparrow 3.93 bird/ha. Large grey babbler 3.54 bird/ha., however, rest of the birds showed low densities in the study area (Table-3.13). During summer the density of local resident birds was higher as they congregate in the area. Most of the local bird species were found in good density in Khijadiya Wildlife Sanctuary (Table-3.13).

SPECIES DIVERSITY

The overall species diversity index using Shannon Diversity Index (Shannon and Wiener, 1949) was estimated to be 3.5 in winter ($n=24$) and 3.4 in summer ($n=24$). Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon index increases as both the richness and the evenness of the community increase. However, the higher value of Shannon Diversity Index clearly suggests that terrestrial bird diversity is very high in Khijadiya during both winter and summer seasons. Relatively lower diversity of terrestrial birds in wetland eco-systems is naturally justified as the majority of the area is wetland or dry area in the Sanctuary. The Simpson Index for winter was 0.036 and 0.035 for summer suggesting no major differences in the diversity in two seasons. The species richness (Margalef's Richness Index) however, differed between two season as it was 9.67 in winter and 7.4 in summer season.

Table-3.12: Checklist of all Terrestrial birds recorded from Khijadiya Wildlife Sanctuary during the study period.

No.	Name of Bird	Scientific Name of Bird	Feeding Guild	Migratory status	IUCN STATUS	WPA Schedule	Season	
							Winter	Summer
1	Ashy Drongo	<i>Dicrurus leucophaeus</i>	Ins	R	LC	IV	1	
2	Ashy Prinia	<i>Prinia socialis</i>	Ins	R	LC	IV	1	1
3	Ashy-crowned Sparrow Lark	<i>Eremopterix grisea</i>	Gran	R	LC	IV	1	1
4	Asian Koel	<i>Eudynamys scolopacea</i>	Omn	R	LC	IV		1
5	Asian Palm Swift	<i>Cypsiurus balasiensis</i>	Ins	R	LC	IV	1	
6	Asian Paradise-flycatcher	<i>Terpsiphone paradisi</i>	Ins	R	LC	IV	1	
7	Bank Myna	<i>Acridotheres ginginianus</i>	Omn	R	LC	IV	1	
8	Barn Swallow	<i>Hirundo rustica</i>	Ins	M	LC	IV	1	
9	Barred Buttonquail	<i>Turnix suscitator</i>	Gran	R	LC	IV	1	
10	Bay backed shrike	<i>Lanius vittatus</i>	Ins	R	LC	IV	1	1
11	Baya Weaver	<i>Ploceus philippinus</i>	Ins	R	LC	IV	1	1
12	Black Drongo	<i>Dicrurus macrocercus</i>	Ins	R	LC	IV	1	1
13	Black Kite	<i>Milvus migrans</i>	Carn	R	LC	IV	1	1
14	Black Redstart	<i>Phoenicurus ochruros</i>	Ins	M	LC	IV	1	
15	Black-headed Bunting	<i>Emberiza melanocephala</i>	Gran	M	LC	IV	1	
16	Black-rumped Flameback	<i>Dinopium benghalense</i>	Ins	R	LC	IV	1	1
17	Black-shouldered Kite	<i>Elanus caeruleus</i>	Carn	R	LC	IV	1	
18	Blue-cheeked Bee-eater	<i>Merops persicus</i>	Ins	R	LC	IV	1	1
19	Bluethroat	<i>Cyanecula svecica</i>	Ins	M	LC	IV	1	
20	Brahmini kite	<i>Haliastur indus</i>	Carn	R	LC	IV	1	1
21	Brahminy Starling	<i>Sturnus pagodarum</i>	Omn	R	LC	IV	1	1
22	Brown Rock-chat	<i>Oenanthe fusca</i>	Ins	R	LC	IV		1
23	Chestnut-bellied Sandgrouse	<i>Pterocles exustus</i>	Gran	R	LC	IV		1
24	Chestnut-shouldered petronia	<i>Gymnoris xanthocollis</i>	Omn	R	LC	IV	1	1
25	Citrine Wagtail	<i>Motacilla citreola</i>	Ins	M	LC	IV	1	
26	Clamorous Reed Warbler	<i>Acrocephalus stentoreus</i>	Ins	R	LC	IV	1	1
27	Collared Scops Owl	<i>Otus bakkamoena</i>	Carn	R	LC	IV	1	
28	Common Babbler	<i>Argya caudata</i>	Ins	R	LC	IV	1	1

No.	Name of Bird	Scientific Name of Bird	Feeding Guild	Migratory status	IUCN STATUS	WPA Schedule	Season	
							Winter	Summer
29	Common Chiffchaff	<i>Phylloscopus collybita</i>	Ins	M	LC	IV	1	
30	Common Hoopoe	<i>Upupa epops</i>	Ins	R	LC	IV	1	1
31	Common Iora	<i>Aegithina tiphia</i>	Ins	R	LC	IV	1	1
32	Common Kestrel	<i>Falco tinnunculus</i>	Carn	M	LC	IV	1	
33	Common Myna	<i>Acridotheres tristis</i>	Omn	R	LC	IV	1	1
34	Common Quail	<i>Coturnix coturnix</i>	Omn	R	LC	IV	1	
35	Common Stonechat	<i>Saxicola torquatus</i>	Ins	M	LC	IV	1	
36	Common Tailorbird	<i>Orthotomus sutorius</i>	Ins	R	LC	IV	1	1
37	Common Woodshrike	<i>Tephrodornis pondicerianus</i>	Ins	R	LC	IV	1	1
38	Coppersmith Barbet	<i>Megalaima haemacephala</i>	Frug	R	LC	IV	1	1
39	Crested Lark	<i>Galerida cristata</i>	Gran	R	LC	IV	1	1
40	Desert Wheatear	<i>Oenanthe deserti</i>	Ins	M	LC	IV	1	
41	Dusky Crag Martin	<i>Hirundo concolor</i>	Ins	R	LC	IV	1	1
42	Eurasian Collared Dove	<i>Streptopelia decaocto</i>	Gran	R	LC	IV	1	1
43	Eurasian Cuckoo	<i>Cuculus canorus</i>	Ins	R	LC	IV		1
44	Eurasian Golden Oriole	<i>Oriolus oriolus</i>	Ins	R	LC	IV	1	1
45	Eurasian Wryneck	<i>Jynx torquilla</i>	Ins	M	LC	IV	1	
46	European Roller	<i>Coracias garrulus</i>	Ins	M	LC	IV	1	
47	Forest Wagtail	<i>Dendronanthus indicus</i>	Ins	M	LC	IV	1	
48	Greater Coucal	<i>Centropus sinensis</i>	Omn	R	LC	IV	1	1
49	Greater Short-toed Lark	<i>Calandrella brachydactyla</i>	Gran	M	LC	IV	1	
50	Greater Spotted Eagle	<i>Aquila clanga</i>	Carn	M	LC	IV	1	
51	Green Bee-eater	<i>Merops orientalis</i>	Ins	R	LC	IV	1	1
52	Grey francolin	<i>Francolinus pondicerianus</i>	Gran	R	LC	IV	1	1
53	Grey Wagtail	<i>Motacilla cinerea</i>	Ins	M	LC	IV	1	
54	Grey-breasted Prinia	<i>Prinia hodgsonii</i>	Ins	R	LC	IV	1	1
55	Grey-headed Canary Flycatcher	<i>Culicicapa ceylonensis</i>	Ins	M	LC	IV	1	
56	House Crow	<i>Corvus splendens</i>	Omn	R	LC	IV	1	1
57	House Sparrow	<i>Passer domesticus</i>	Gran	R	LC	IV	1	1

No.	Name of Bird	Scientific Name of Bird		Migratory status	IUCN STATUS	WPA Schedule	Season	
							Winter	Summer
58	House Swift	<i>Apus affinis</i>	Ins	R	LC	IV	1	1
59	Indian Bushlark	<i>Mirafr erythroptera</i>	Gran	R	LC	IV		1
60	Indian Nightjar	<i>Caprimulgus asiaticus</i>	Ins	R	LC	IV		1
61	Indian Peafowl	<i>Pavo cristatus</i>	Omn	R	LC	IV	1	1
62	Indian Robin	<i>Saxicoloides fulicata</i>	Ins	R	LC	IV	1	1
63	Indian Roller	<i>Coracias benghalensis</i>	Ins	R	LC	IV	1	1
64	Indian Silverbill	<i>Lonchura malabarica</i>	Gran	R	LC	IV	1	1
65	Isabelline Shrike	<i>Lanius isabellinus</i>	Ins	M	LC	IV	1	
66	Jungle Babbler	<i>Turdoides striata</i>	Omn	R	LC	IV	1	1
67	Jungle Prinia	<i>Prinia sylvatica</i>	Ins	R	LC	IV	1	1
68	Laggar Falcon	<i>Falco jugger</i>	Carn	R	LC	IV	1	
69	Large Grey Babbler	<i>Argya malcolmi</i>	Omn	R	LC	IV	1	1
70	Large-billed Crow	<i>Corvus macrorhynchos</i>	Omn	R	LC	IV	1	
71	Laughing Dove	<i>Streptopelia senegalensis</i>	Gran	R	LC	IV	1	1
72	Lesser Whitethroat	<i>Sylvia curruca</i>	Ins	M	LC	IV	1	
73	Long-tailed Shrike	<i>Lanius schach</i>	Ins	R	LC	IV	1	1
74	Marshall's iora	<i>Aegithina nigrolutea</i>	Ins	R	LC	IV	1	1
75	Montagu's Harrier	<i>Circus pygargus</i>	Carn	M	LC	IV	1	
76	Oriental Honey-buzzard	<i>Pernis ptilorhyncus</i>	Carn	R	LC	IV	1	1
77	Oriental Magpie Robin	<i>Copsychus saularis</i>	Ins	R	LC	IV	1	1
78	Oriental Skylark	<i>Alauda gulgula</i>	Gran	R	LC	IV		1
79	Oriental White-eye	<i>Zosterops palpebrosus</i>	Ins	R	LC	IV	1	1
80	Orphean Warbler	<i>Sylvia hortensis</i>	Ins	M	LC	IV	1	
81	Osprey	<i>Pandion haliaetus</i>	Pisci	R	LC	I	1	
82	Paddyfield Pipit	<i>Anthus rufulus</i>	Ins	R	LC	IV	1	1
83	Paddyfield Warbler	<i>Acrocephalus agricola</i>	Ins	M	LC	IV	1	
84	Pallid Harrier	<i>Circus macrourus</i>	Carn	M	NT	IV	1	
85	Peregrine Falcon	<i>Falco peregrinus</i>	Carn	R	LC	IV	1	
86	Pied Bushchat	<i>Saxicola caprata</i>	Ins	R	LC	IV	1	

No.	Name of Bird	Scientific Name of Bird	Feeding Guild	Migratory status	IUCN STATUS	WPA Schedule	Season	
							Winter	Summer
87	Pied Crested Cuckoo	<i>Clamator jacobinus</i>	Ins	M	LC	IV		1
88	Plain Prinia	<i>Prinia inornata</i>	Ins	R	LC	IV	1	1
89	Purple Sunbird	<i>Cinnyris asiaticus</i>	Nect	R	LC	IV	1	1
90	Purple-rumped Sunbird	<i>Nectarinia zeylonica</i>	Nect	R	LC	IV	1	1
91	Rain Quail	<i>Coturnix coromandelica</i>	Omn	R	LC	IV		1
92	Red Collared Dove	<i>Streptopelia tranquebarica</i>	Gran	R	LC	IV	1	1
93	Red-rumped Swallow	<i>Hirundo daurica</i>	Ins	R	LC	IV	1	
94	Red-throated Flycatcher	<i>Ficedula parva</i>	Ins	M	LC	IV	1	
95	Red-vented Bulbul	<i>Pycnonotus cafer</i>	Omn	R	LC	IV	1	1
96	Red-wattled Lapwing	<i>Vanellus indicus</i>	Ins	R	LC	IV	1	1
97	Rock Pigeon	<i>Columba livia</i>	Gran	R	LC	IV	1	1
98	Rose-ringed Parakeet	<i>Psittacula krameri</i>	Frug	R	LC	IV	1	1
99	Rosy Starling	<i>Sturnus roseus</i>	Ins	M	LC	IV	1	
100	Rufous Treepie	<i>Dendrocitta vagabunda</i>	Omn	R	LC	IV	1	1
101	Rufous-tailed Lark	<i>Ammomanes phoenicurus</i>	Gran	R	LC	IV	1	1
102	Sand Lark	<i>Calandrella raytal</i>	Omn	R	LC	IV	1	1
103	Sand Martin	<i>Riparia riparia</i>	Ins	R	LC	IV		1
104	Shikra	<i>Accipiter badius</i>	Carn	R	LC	IV	1	1
105	Short-toed Snake Eagle	<i>Circaetus gallicus</i>	Carn	R	LC	IV	1	1
106	Singing Bushlark	<i>Mirafr cantillans</i>	Omn	R	LC	IV		1
107	Small Minivet	<i>Pericrocotus cinnamomeus</i>	Ins	R	LC	IV	1	1
108	Southern Grey Shrike	<i>Lanius meridionalis</i>	Ins	R	LC	IV	1	1
109	Spotted Owlet	<i>Athene brama</i>	Carn	R	LC	IV	1	1
110	Sykes's Lark	<i>Galerida deva</i>	Omn	R	LC	IV	1	1
111	Sykes's Nightjar	<i>Caprimulgus mahrattensis</i>	Ins	R	LC	IV	1	
112	Tawny Pipit	<i>Anthus campestris</i>	Ins	M	LC	IV	1	
113	Tickell's Blue Flycatcher	<i>Cyornis tickelliae</i>	Ins	R	LC	IV	1	1
114	Western Marsh Harrier	<i>Circus aeruginosus</i>	Carn	M	LC	I	1	
115	White-browed Wagtail	<i>Motacilla maderaspatensis</i>	Ins	R	LC	IV	1	1

No.	Name of Bird	Scientific Name of Bird	Feeding Guild	Migratory status	IUCN STATUS	WPA Schedule	Season	
							Winter	Summer
116	White eared bulbul	<i>Pycnonotus leucotis</i>	Frug	R	LC	IV	1	1
117	White Wagtail	<i>Motacilla alba</i>	Ins	M	LC	IV	1	
118	White-eyed Buzzard	<i>Butastur teesa</i>	Carn	R	LC	IV	1	
119	White-throated Fantail	<i>Rhipidura albicollis</i>	Ins	R	LC	IV	1	1
120	Wire-tailed Swallow	<i>Hirundo smithii</i>	Ins	R	LC	IV	1	1
121	Yellow Wagtail	<i>Motacilla flava</i>	Ins	R	LC	IV	1	
122	Yellow-crowned Woodpecker	<i>Dendrocopos mahrattensis</i>	Ins	R	LC	IV	1	1
123	Yellow-wattled Lapwing	<i>Vanellus malarbaricus</i>	Ins	R	LC	IV	1	
124	Zitting Cisticola	<i>Cisticola juncidis</i>	Ins	R	LC	IV	1	
125	Isabeline Wheatear	<i>Oenanthe isabellina</i>	Ins	M	LC	IV	1	
126	Graceful Prinia	<i>Prinia gracilis</i>	Ins	R	LC	IV	1	
127	Red-necked Falcon	<i>Falco chicquera</i>	Carn	R	LC	IV	1	
128	Variable Wheatear	<i>Oenanthe picata</i>	Ins	M	LC	IV	1	

R=Resident, M=Migratory; Gran =Granivorous, Carn=Carnivore, Pesci=Piscivore, Omn=Omnivore, Ins=Insectivore; LC=Least Concerned, NT=Near Threatened, VU=Vulnerable; IV= Schedule-IV, I= Schedule-I as per Wildlife Protection Act.

Table-3.13.: Bird species density recorded in Khijadiya Wildlife Sanctuary during winter and summer.

No	Species	Winter		Summer	
		Density/ha.	SE	Density/ha.	SE
1	Ashy Prinia	0.59	0.10	NR	NR
2	Ashy-crowned Finch-lark	1.47	0.25	7.96	0.88
3	Asian Koel	NR	NR	3.54	0.00
4	Bay-backed Shrike	NR	NR	3.54	0.00
5	Black Drongo	0.69	0.11	4.04	0.51
6	Black Redstart	0.49	0.08	NR	NR
7	Black-rumped Flameback	NR	NR	3.54	0.00
8	Black-winged Kite	NR	NR	3.54	0.00
9	Common Babbler	0.69	0.11	7.58	1.80
10	Common Hoopoe	0.49	0.08	NR	NR
11	Common Myna	2.46	0.41	6.49	1.09
12	Common Tailorbird	0.39	0.07	3.54	0.00
13	Crested Lark	0.69	0.11	3.54	0.00
14	Eurasian Collared-dove	0.88	0.15	4.04	0.51
15	Greater Coucal	0.49	0.08	3.54	0.00
16	Grey Francolin	2.06	0.34	5.90	1.18
17	Grey Wagtail	0.29	0.05	NR	NR
18	House Crow	1.97	0.33	3.54	0.00
19	House Sparrow	3.93	0.66	5.90	1.18
20	House Sparrow	NR	NR	NR	NR
21	Indian Clamorous Reed-warbler	NR	NR	4.42	0.88
22	Indian Peafowl	1.08	0.18	NR	NR
23	Indian Robin	0.39	0.07	3.54	0.00
24	Indian Roller	0.49	0.08	3.54	0.00
25	Indian Roller	NR	NR	NR	NR
26	Indian Silverbill	1.18	0.20	3.54	0.00
27	Jungle Babbler	0.79	0.13	7.08	3.54
28	Large Grey Babbler	3.54	0.59	11.80	3.12
29	Laughing Dove	0.39	0.07	5.31	1.77
30	Little Green Bee-eater	2.56	0.43	3.54	0.00
31	Long-tailed Shrike	0.29	0.05	3.54	0.00
32	Oriental Magpie-Robin	0.59	0.10	3.54	0.00
33	Oriental White-eye	2.46	0.41	7.96	2.65
34	Paddyfield Pipit	NR	NR	4.72	1.18
35	Pied Bushchat	0.39	0.07	NR	NR
36	Purple Sunbird	0.59	0.10	5.31	1.02
37	Purple-rumped Sunbird	NR	NR	3.54	0.00
38	Red-rumped Swallow	NR	NR	3.54	0.00
39	Red-vented Bulbul	4.42	0.74	4.87	0.65
40	Red-wattled Lapwing	1.47	0.25	3.54	0.00

No	Species	Winter		Summer	
		Density/ha.	SE	Density/ha.	SE
41	Rock Pigeon	2.95	0.49	3.54	0.00
42	Rose-ringed Parakeet	0.88	0.15	4.42	0.88
43	Rosy Starling	7.96	1.33	NR	NR
44	Rufous Treepie	NR	NR	7.08	0.00
45	Sand Lark	NR	NR	5.31	1.77
46	Shikra	0.39	0.07	3.54	0.00
47	White-throated Fantail	NR	NR	5.31	1.77
48	White-throated Kingfisher	0.20	0.03	5.31	1.77
49	Wire-tailed Swallow	NR	NR	7.08	0.00
50	Yellow-throated Sparrow	2.26	0.38	6.37	0.71

FEEDING GUILDS OF TERRESTRIAL BIRDS

A feeding guild can be defined as “a group of species that exploits the same class of environmental resources in the same way (Root 1967). Avian feeding guilds have been suggested as a suitable indicator to monitor all components and interactions of an ecosystem (Ghazoul and Hellier 2000). Guild categorization among birds emphasizes upon functional component of community in an ecosystem (Wilson 1999). The wetland is used by a diverse number of bird species for foraging, nesting and roosting due to their heterogeneity of microhabitats and available rich food resources. Terrestrial bird community was categorized into following feeding guilds.

Grainivorous: Feeds on grains

Frugivorous: Feeds on fruits

Insectivorous: Feeds on insects

Herbivorous: Feeding on young shoots, roots, leaves and sprouts of vegetation.

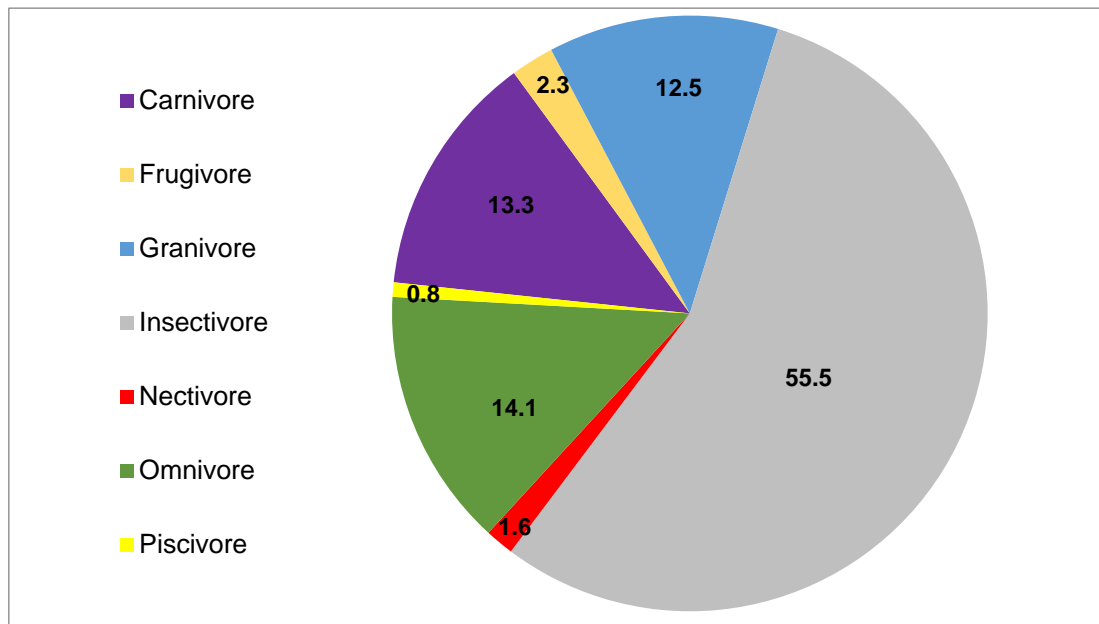
Omnivorous: Feeding on all types of food including vegetable matter, fruit, insects and other animal matter.

Carnivorous: Feeds animal matter such as fish, amphibians, reptiles, birds and small mammals.

Nectivorous: Feeds on nectar of flowers

Khijadiya is biologically very productive wetland and it provides feeding grounds for a diverse range of resident and migratory birds. Our survey results suggests that majority of the terrestrial birds recorded in Khijadiya Wildlife Sanctuary belongs to insectivorous birds 55.5%, followed by omnivorous birds 14.1%, carnivorous birds 13.3%, granivorous birds 12.5%, whereas frugivorous 2.3%, insectivorous 1.6% and piscivorous 0.8% birds were very few i.e. 2% (Figure-3.7). This composition of birds is typical of highly productive wetland ecosystems.

Figure-3.7: Feeding guild wise distribution of terrestrial birds in Khijadiya Wildlife sanctuary.



SURVEY OF MAMMALS

SPECIES RICHNESS OF MAMMALS

Mammal surveys carried out in and around in Khijadiya wetland in December-2015 and January-May 2016. During our field surveys, we reported total 11 species from 10 families of mammals through direct sightings in Khijadiya Wildlife Sanctuary (KWS) (Table-3.14).

POPULATION ESTIMATES OF NILGAI & WILD PIG

It was feasible to get total counts of some of the large and conspicuous species such as Wild Pigs and Nilgai in open and small landscape of KWS. We therefore, divided KWS in to three major zones/blocks (Map-3.2) which were same as used in the bird counts. These total counts were made by different teams walking and scanning entire zone area and using binoculars and spotting scopes between 4:30 to 6:30 PM in winter and summer seasons. This timing was finalized based on our observations on their relative numbers in KWS area during morning, afternoon and evening hours. We found that during winter and summer seasons, these animals are found to take refuge in KWS. During day time, their numbers are highest during evening hours as they are found to rest in open areas in bigger herds. It was observed that due to presence of crops in the surrounding agriculture fields, they are chased away by farmers during day time. However, during night hours they venture again into agriculture fields.

Map-3.2: Zones/blocks for population estimation of Wild Pig & Nilgai in Khijadiya Wildlife sanctuary.



POPULATION OF NILGAI

During block counts for Nilgai population carried out in KWS we reported total 145 individuals in winter and 96 individuals in summer in three zones (Table-3.15). Relatively lower number of Nilgai found in summer could be due to their dispersal into surrounding fellow agriculture fields. During winter due to presence

of corps in the agriculture fields farmers chase them away and therefore, they are found to congregate in the KWS. The population structure of Nilgai suggests that their breeding was post-monsoon and foaling was in winter season as the number of juveniles in the population was higher during winter season (Table-3.15, Figure-3.8).

Table-3.14: Mammals species reported in Khijadiya Wildlife sanctuary through various methods.

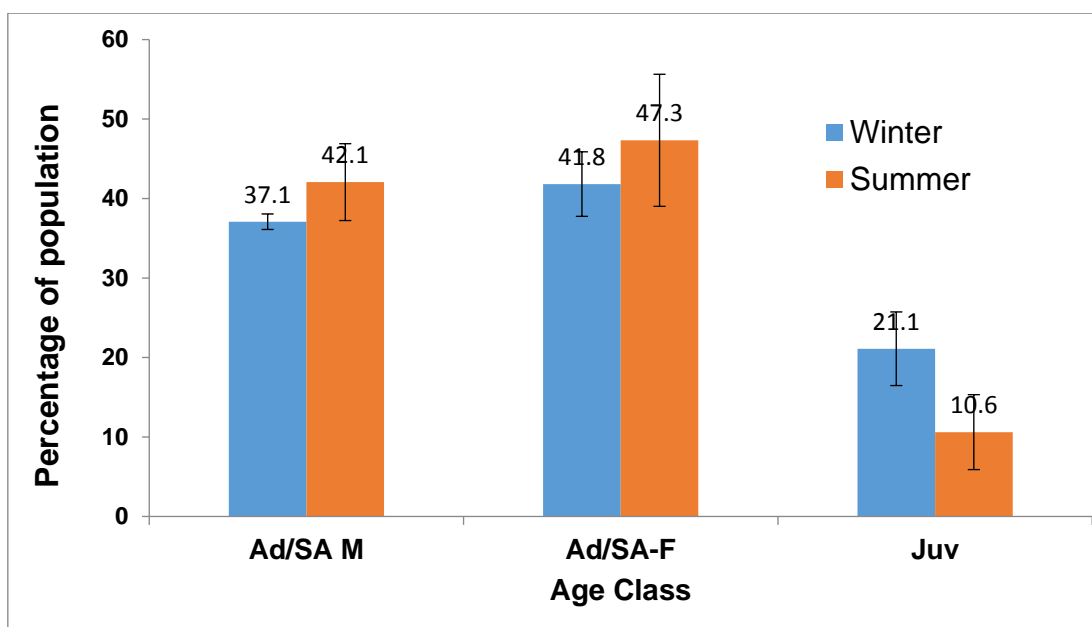
Sr. No	Common Name	Scientific Name	IUCN status	WPA (1972)	Observed using method*
Family: Felidae					
1	Jungle Cat	<i>Felis chaus</i>	LC	Sch-II	1
Family: Canidae					
2	Indian Wolf	<i>Canis lupus pallipes</i>	EN	Sch-I	5
3	Indian Fox	<i>Vulpes bengalensis</i>	LC	Sch-II	1,2
4	Jackal	<i>Canis aureus</i>	LC	Sch-II	1,3
Family: Herpestidae					
5	Common Mongoose	<i>Herpestes edwardsii</i>	LC	Sch-IV	1,2
Family: Bovidae					
6	Blue Bull	<i>Boselaphus tragocamelus</i>	LC	Sch-III	1,4,5,6
Family: Suidae					
7	Indian Wild Pig	<i>Sus scrofa</i>	LC	Sch-III	1,4,5,6
Family: Leporidae					
8	Indian Hare	<i>Lepus nigricollis</i>	LC	Sch-IV	1,2
Family: Sciuridae					
9	Fivestriped Squirrel	<i>Funambulus pennantii</i>	LC	Sch-IV	1
Family: Muridae					
10	Indian Gerbil	<i>Tatera indica</i>	LC	Sch-IV	2
Family: Pteropodidae					
11	Indian Flying fox	<i>Pteropus giganteus</i>	LC		1
Family: Vespertilionidae					
12	Indian Pygmy Pispistrelle	<i>Pipistrellus mimus</i>	LC	Sch-IV	1
Family: Rhinopomatidae					
13	Lesser mouse-tailed bat	<i>Rhinopoma hardwickii</i>	LC	Sch-IV	1
14	Greater mouse-tailed bat	<i>Rhinopoma microphyllum</i>	LC	Sch-IV	1

* Methods 1=Random Observations, 2= Specific Habitat Search, 3 =Howling Surveys, 4= Block Counts, 5= Interview Surveys, 6= Camera trap surveys

Table-3.15: Zone wise population of Nilgai in Khijadiya Wildlife sanctuary in December 2015.

Season	Zone-1	Zone-2	Zone-3	Total
Winter	44	34	67	145
Summer	39	21	36	96

Figure-3.8: Population structure of Nilgai in Khijadiya Wildlife Sanctuary during winter and summer seasons.



AVERAGE GROUP SIZE OF NILGAI IN KWS

The average group size of Nilgai was 5.18 ± 0.69 (SE) where as it reduced to 3.31 ± 0.35 in summer in KWS.

POPULATION ESTIMATE OF WILD PIG

The block counts carried out for Wild Pig population in KWS reported total 68 wild pigs in winter and 109 individuals in summer in three zones (Table-3.16).

Table-3.16: Population Wild Pigs in Khijadiya Wildlife sanctuary in December 2015.

Season	Zone-1	Zone-2	Zone-3	Total
Winter	18	23	27	68
Summer	54	24	31	109

PEOPLE'S PERSPECTIVE

In order to improve checklist of mammals, and understand the perspective of local community towards biodiversity, we interviewed several local nature photographers, naturalists and the farmers and cattle herders from the surrounding area of the KWS. According to farmers of the surrounding area of KWS, Nilgai and Wild Pigs are major species that raid their crops of groundnut and sorghum etc. During winter the farmer have to invest more time and efforts to protect their crop particularly in the immediate surroundings of the Khijadiya Wildlife Sanctuary. Khijadiya Wildlife Sanctuary provides much needed shelter and water to the population of Nilgai and Wild Pigs. Dense *Prosopis juliflora* thickets along with freshwater availability within protected area provide undisturbed refuge to these two species. In other words, these two species have their source populations within Khijadiya Wildlife Sanctuary area which constantly disperses in to surrounding unprotected areas of the region.

CURRENT THREATS TO THE ECOLOGICAL ELEMENTS

As such the Khijadiya Wildlife Sanctuary being a protected area which is actively managed and protected by Gujarat Forest Department, there are no direct threats to any of its biodiversity component envisaged.

TERRESTRIALIZATION

Wetlands are known to be transitional eco-system which keeps on changing due to ecological changes that it undergoes. If not understood the salient processes such as autogenic terrestrialization (Batzer & Sharitz 2014), succession, eutrophication, siltation, erosion, sediment load, etc. it can convert itself into a terrestrial eco-system over a period of time. Therefore, in order to gain continuous services and benefits of a wetland eco-system, proper understanding of wetland eco-system and its scientific management is crucial for this sanctuary area. Khijadiya Wildlife Sanctuary is primarily a set of two wetland eco-systems i.e. marine (mangrove, intertidal) and freshwater. Though, over the years this eco-system has been managed and protected by forest department, it has undergone several changes as following.

SILTATION OF FRESH WATERBODY

The fresh water habitat/area of Khijadiya Wildlife Sanctuary has reduced its water holding capacity due to siltation over the years (discussion with local forest staff). Reduced freshwater area supports lower biota. During our study on we observed that due to lack of fresh water very few number and species of waterbirds were recorded in Khijadiya Wildlife Sanctuary. Different waterbirds require different depths of water. The differential microhabitat requirements of waterbirds can be met with providing them with a gradient of depths in a freshwater wetland. Khijadiya Wildlife Sanctuary like many famous wetlands of India is also manmade wetland which requires appropriate and proactive management interventions to sustain its benefits. It is therefore, recommended that optimal desiltation of freshwater part be carried out in Khijadiya Sanctuary and its influenced area. Desiltation shall be carried out to increase waterscape with varied depths such as deep water to be maintained up to 1-2 meter and shallow water up to 10 cm. with utmost care so that the saline water table is not touched.

INVASION OF PROSOPIS JULIFLORA

As a result of siltation and other autogenic processes, and constant seed dispersal by Nilgai and Wild Pigs, *Prosopis juliflora*, has grown out of proportion and considerable area is under this invasive species. Vegetation along the road has increased due to growth of *Prosopis juliflora* to the extent that the visibility of birds, visitors and managers has reduced drastically. Dense vegetation on road and dense growth of *Prosopis juliflora* from the southern part of the sanctuary areas form a close vegetative fence around fresh waterbodies. Such closed waterbodies are less likely to be favoured by most of the waterbirds as they are known to utilize open wetlands which maintain relatively higher visibility/escape distances. The invasion of *Prosopis juliflora* is also encroaching in the open wetland areas as well as open land which are used by many waterbirds and water dependent birds for roosting and feeding.

It is therefore, recommended that invasion of *Prosopis juliflora* into this eco-system shall be checked and optimal mix of vegetation cover and openness of wetland shall be maintained. It should be done to ensure presence of waterbirds, it shall allow patrolling and protection of birds and area by authorities and it should also allow visitors to observe birds for which they pay and visit this sanctuary.

Apart from above mentioned ecological and environmental issues, there are administrative issues that concerns mostly lack of staff & infrastructure, tourist behavior and direct disturbance to birds and constant monitoring and protection of this Sanctuary efficiently. These issues shall be solved by authority and appropriate actions shall be taken by government so that the sanctuary is preserved for its best values. It is also recommended that Khijadiya Wildlife Sanctuary shall be maintained for conservation of wetland biodiversity than the terrestrial biodiversity. Therefore, the management practices shall be oriented more towards wetland management than the terrestrial eco-system.

IDENTIFICATION OF ECONOMICALLY IMPORTANT SPECIES

The task given refers to 'identification of economically important faunal species at Khijadiya Wetland based on current and potential use of these species by the local community'.

The economically important species includes mostly freshwater and marine fish species that are reported in section 3.2. Most of the fish and crustaceans are edible and fishermen consume them. However, total 5 marine fishery species reported from Khijadiya and surrounding marine creek areas are economically important which are listed below.

- i. *Metapenaeus kutchensis*
- ii. *Mugil cephalus*
- iii. *Puntius sarana*
- iv. *Boleophthalmus dussumieri*
- v. *Mugilidae* (Boi)

However, according to our knowledge, Khijadiya wetland being a Wildlife Sanctuary, there were no faunal species from Khijadiya Wildlife Sanctuary were currently being utilized by local community. Therefore, apart from above mentioned marine fishery species no other faunal species were considered economically important species from this wetland.

IDENTIFICATION OF THREATENED AND OTHER SPECIES OF CONSERVATION SIGNIFICANCE

As per our primary survey we identified threatened species as per IUCN Red list categories and also as per Wildlife Protection Act 1972.

During our survey we found Woolley necked Stork and Dalmatian Pelican in Khijadiya Bird Sanctuary which are considered as Vulnerable i.e. Threatened as per IUCN redlist categories. We also found total two species of reptiles and 9 species of birds falling in to Schedule-I of Wildlife Protection Act 1972 (Table-6.1). Apart from these species no other important species of higher conservation significance were found in Khijadiya Wildlife Sanctuary.

Table-6.1: Threatened and Schedule-I species found in Khijadiya Wildlife Sanctuary.

Faunal Class	Threatened Species			WPA Schedule-I species
	CR	EN	VU	
Fish	Nil	Nil	Nil	Nil
Amphibians	Nil	Nil	Nil	Nil
Reptiles	Nil	Nil	Nil	Bengal Monitor lizard Indian flapshell
Birds	Nil	Nil	Dalmatian Pelican Woolley necked Stork	Eurasian Spoonbill
				Osprey
				Western Marsh Harrier
				Montagu's Harrier
				Pallid Harrier
				Black Kite
				Brahmini kite
				Black-shouldered Kite
				Indian Peafowl
Mammals	Nil	Nil	Nil	Nil

Therefore, Khijadiya Wildlife Sanctuary supports total 13 species of higher conservation significance.

IDENTIFICATION OF INVASIVE SPECIES OF WETLAND

As per definition of Invasive species by **Convention on Biological Diversity-**

"An invasive alien species (IAS) is a species that is established outside of its natural past or present distribution, whose introduction and/or spread threaten biological diversity"

In order to confirm the status and distribution of the identified species in the present study, we referred to various literature, books and websites. We referred to Fauna of Gujarat Part-I (ZSI 2001) Fauna of Gujarat Part-I (ZSI 2004), for confirming the status and distribution of majority of the species observed in the present study. Apart from these, we also reviewed status and distribution of identified species on IUCN redlist website (<http://www.iucnredlist.org>), Birdlife International Website (<http://datazone.birdlife.org>) etc. to reconfirm the status and distribution of the species observed in the present study.

After careful review of literature and websites, we found that none of the identified species. All the species are native to Indian region and no introduced species of fauna were recorded from Khijadiya Wetland.

ECOLOGICAL SIGNIFICANCE OF THE WETLAND

Key Species Interaction

Detailed scientific analysis of key species interactions would require large data sets of several repeat seasons on feeding, breeding and habitat use etc. The present study was scheduled for one year duration only therefore, the required data set was not available to carryout meaningful key species interaction. Based on primary observations and general species information we provide a qualitative matrix of species interactions (Table-9.1).

Ecological Significance of the Khijadiya Wildlife Sanctuary

- Based on our observations and survey results as well as literature survey we conclude that Khijadiya Wildlife Sanctuary is a unique and important wetland for conservation of biodiversity representative of both marine and freshwater eco-systems.
- Apart from variety of ecological functions that this wetland could be performing, the most important one is the habitat it provides to the great diversity of migratory and resident birds for their feeding, roosting, resting and breeding (resident) waterbirds.
- Sanctuary regularly supports breeding of two local resident and Near Threatened bird species i.e. Black-necked Stork and Oriental Darter. Therefore, the sanctuary is equally important for conservation of local bird species and migratory species.
- This Sanctuary has been supporting 1% population of several migratory and resident birds. Some of them are even categorized by IUCN as Near Threatened and Vulnerable species such as Lesser Flamingo, Greater Flamingo, Common Crane, Demoiselle Crane, Great White Pelican, Dalmatian Pelican, Black Tailed Godwit, Painted Stork, Black-headed Ibis.
- Sanctuary fulfils several criteria for being designated as Ramsar Site. Due to its ornithological assemblage, this Sanctuary has become one of the favourite destinations for birdwatchers which yield economic benefits to the government and local people.

Table-9.1: Key species interaction qualitative analysis.

Species	Species Characteristics				Sanctuary Habitats			Species role & interactions in Ecosystem			
	Habit	Habitat	Activity	Niche	Breed ing	Feedi ng	Roost ing/re sting	Trophic	Interaction with plants	Interaction with animals	Impacts in ecosystem
Nilgai	Herbivore	Dense Prosopis	Diurnal	Generalist	Yes	Partial	Yes	Primary Consumer	feeds on Prosopis pods/ causes crop damage in surrounding agriculture area	No natural predators in eco-system. Sometime hunted by dogs	Negative, Promotes invasive plant growth. Also affects socio-economic of farmers in peripheral area
Wild pig	Omnivore	Dense bushes	Diurnal	Generalist	Yes	Yes	Yes	Primary & secondary Consumer	feeds on Prosopis pods/ plant roots/ causes crop damage in surrounding agriculture area	No natural predators in eco-system. Sometime hunted by dogs	Negative, Promotes invasive plant growth. Also affects socio-economic of farmers in peripheral area
Black necked stork	Piscivore	open mudflats	Diurnal	Specialist	Yes	Yes	Yes	Secondary consumer	Uses tall Prosopis trees for nesting	feeds on fishes/ crabs/ mollusks	Positive, Nutrient cycling in food web. Important tourist attraction
Honey bees, Ants	Nectivores, Pollen feeder	Trees/plants	Diurnal	Specialist	Yes	Yes	Yes	Primary Consumer	Feeds on nector and promotes pollination	competes with nectivore birds, becomes food for other birds	Positive, Important pollinators
Cranes	Omnivore	open wetland	Diurnal	Specialist	NO	Yes	Yes	Primary Consumer	Feeds on roots, tubers, groundnut, cereals,	Becomes food for carnivores such as Jungle cat, Jackals etc.	Positive, Nutrient cycling in food web and important tourist attraction
Water birds	Omnivore	open wetland	Diurnal	Specialist	NO	Yes	Yes	Primary Consumer	Feeds on fish, algae, insects, crabs	Becomes food for carnivores such as Jungle cat, Jackals etc.	Positive, Nutrient cycling in food web and important tourist attraction
Terrestrial birds	Granivore/ Insectivore/ Carnivore	Trees, Open scrubland, dense vegetation	Diurnal/ Nocturnal	Specialist	NO	Yes	Yes	Primary Consumer	Feeds on fish, algae, insects, crabs	Becomes food for carnivores such as Jungle cat, Jackals etc.	Positive, Nutrient cycling in food web and important tourist attraction
Insects	Herbivore/ Omnivore	variety of microhabitat		Generalists & specialists	Yes	Yes	Yes	Pri & Secon Consumers	Feed on plants, leaves, pollen, etc	Becomes food for birds and animals	Positive, Nutrient cycling and important role in food web

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Annexure-I

Details of field visits carried out by various experts for biodiversity sampling.

No	Start Date	End Date	Days	Person/ Expert	Expertise/Sampling
Insects Sampling					
1	24/12/2015	26/12/2015	3	Dr. Kiran Ahir	Insects Sampling
2	9/2/2016	10/2/2016	2	Mayurdan Gadhvi	Insects Sampling
3	6/3/2016	9/3/2016	3	Ms. Rajal Pathak	Insects Sampling
4	13/8/2016	14/8/2016	2	Dr. Kiran Ahir	Insects Sampling
Fish & other Aquatic Fauna Sampling					
1	30/1/2016	31/1/2016	2	Mayurdan Gadhvi	Fish & Aquatic animals
2	28/5/2016	29/5/2017	2	Mayurdan Gadhvi	Fish & Aquatic animals
3	29/7/2016	31/7/2016	3	Mayurdan Gadhvi	Fish & Aquatic animals
4	13/8/2016	16/8/2016	4	Mayurdan Gadhvi	Fish & Aquatic animals
Herpetofauna Sampling					
1	3/12/2015	3/12/2015	1	Dr. Virag Vyas	Herpetofauna sampling
2	30/7/2016	31/7/2016	2	Dr. Dishant & Vinodbhai	Herpetofauna sampling
3	30/7/2016	31/7/2016	2	Mr. Vinod Gajjar	Herpetofauna sampling
Terrestrial birds & Mammals					
1	24/12/2015	27/12/2015	3	Dr. Chittaranjan Dave	Terrestrial birds & Mammals
2	6/3/2016	9/3/2016	3	Dr. Chittaranjan Dave	Terrestrial birds & Mammals
3	6/3/2016	9/3/2016	5	Dr. Bharat Jethva	Terrestrial birds & Mammals
4	28/5/2016	1/6/2016	4	Dr. Bharat Jethva	Terrestrial birds & Mammals
Waterbird & Team Leader (Assistance in other taxa sampling)					
1	3/12/2015	3/12/2015	1	Dr. Bharat Jethva	Waterbirds & TL
2	24/12/2015	27/12/2015	3	Dr. Bharat Jethva	Waterbirds & TL
3	30/1/2016	31/1/2016	2	Dr. Bharat Jethva	Waterbirds & TL
4	6/3/2016	9/3/2016	5	Dr. Bharat Jethva	Waterbirds & TL
5	29/4/2016	4/5/2016	5	Dr. Bharat Jethva	Waterbirds & TL
6	13/8/2016	15/8/2016	2	Dr. Bharat Jethva	Waterbirds & TL
7	4/11/2016	8/11/2016	5	Dr. Bharat Jethva	Waterbirds & TL

About the Study

The study is part of the overall scientific and technical studies in Gujarat that the CMPA project supported towards effective and sustainable management of coastal and marine protected areas. Faunal biodiversity surveys for Baseline Assessment at Khijadiya Wildlife Sanctuary in Gujarat were conducted by a team of experts from the Green Support Services, during 2015 -16. The study presents the results of the characterization of faunal biodiversity of Khijadiya Wildlife sanctuary. The results are intended to support the effective management planning of this wetland, which is suitable for being designated as the wetland of International Importance.

The CMPA Project

The Project “Conservation and Sustainable Management of Coastal and Marine Protected Areas” (CMPA) is a project of the Indo-German technical cooperation. It is funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and implemented by the Ministry of Environment, Forests and Climate Change (MoEFCC), Government of India, and the *Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of BMUB*.

Established to support the achievement of the Aichi targets of the Convention on Biological Diversity, the Project’s overall goal is to contribute to conservation and sustainable use of biodiversity in selected areas along the coast of India. Taking into consideration the economic importance of the coastal zone for large segments of the population, the Project’s approach is people-centered, thus ensuring the support for conservation by those depending on coastal ecosystems.

Faunal Biodiversity Survey for Baseline Assessment of Khijadiya Wildlife Sanctuary in Gujarat

August 2017