



**Ecological and
Conservation
Inferences from
Monitoring a
Mixed-Species
Waterbird Breeding
Colony in
Bhitarkanika
Conservation Area,
India**



© Gopi G. V

Abstract

We present inferences from the findings of a study conducted between 2004 and 2006 in the Bhitarkanika mangroves, which harbours one of India's oldest and largest mixed-species waterbird breeding colonies. Information pertaining to breeding biology, resource partitioning, food habits and impacts due to land use changes around the breeding colony was gathered. The nest counts in the colony, which spreads over an area of less than 5 ha, during the study period were 13,704 nests on 3839 trees (2004), 11,249 nests on 3,237 trees (2005) and 11,819 nests on 4,221 trees (2006). The breeding birds in this mixed-species colony were the Asian Openbill Stork, Large Egret, Intermediate Egret, Little Egret, Cattle Egret, Grey Heron, Purple Heron, Black-crowned Night Heron, Little Cormorant, Oriental Darter and Black-headed Ibis. The Asian Openbill Stork was the most abundant species nesting in the heronry (66%), the least abundant being the Little Egret (0.8%). Five mangrove species were used for nesting: *Excoecaria agallocha*, *Heritiera fomes*, *Cynometra iripa*, *Hibiscus tiliaceus* and *Tamarix troupis*. We discuss the nest morphometry, egg morphometry, reproductive success, space use patterns and prey preference of the birds nesting in the colony. Our surveys around Bhitarkanika National Park and inside Bhitarkanika Wildlife Sanctuary revealed that more than 672 aquaculture farms dotted the periphery of the park. There was direct evidence of intake and release of saline water from and to the river/creek systems. This may have an impact on the fish population, which is the major prey base for the nesting birds in the heronry. Food abundance was found to be low adjoining the aquaculture farms thereby affecting the abundance of the forage base for the breeding birds.

Keywords : *Bhitarkanika; colonial nesting; heronry; mangroves; Odisha; waterbirds*

Introduction

Thirteen of the 26 species of colonial nesting waterbird in India breed in the Bhitarkanika mangrove ecosystem, which has been identified as an Important Bird Area (IBA) of the country (Pandav 1996, Gopi & Pandav 2007a, Gopi 2010). The Lesser Adjutant Stork *Leptoptilos javanicus* and Painted Stork *Mycteria leucocephala* form small single-species colonies and nest separately (Gopi & Pandav 2007). However, 11 resident waterbird species nest in a multi-species nesting colony (Pandav 1996, Gopi 2010), which has been identified as one of the largest congregations of breeding waterbirds in the country and as one of the five largest heronries in India (Subramanya, 1996). It harbours around 30,000 birds every year (Subramanya 1996, Chadha & Kar 1999). The breeding birds in this mixed species colony are the Asian Openbill stork (*Anastomus oscitans*), Large Egret (*Egretta alba*), Intermediate Egret (*Ardea intermedia*), Little Egret (*Egretta garzetta*), Cattle Egret (*Bubulcus ibis*), Grey Heron (*Ardea cinerea*), Purple Heron (*Ardea purpurea*), Black-crowned Night Heron (*Nycticorax nycticorax*), Little Cormorant (*Phalacrocorax niger*), Darter (*Anhinga melanogaster*) and Black-headed Ibis (*Threskiornis melanocephalus*).

Gopi G V^{1*}
and Bivash Pandav¹

¹Department of Endangered Species Management,
Wildlife Institute of India,
Post Box 18, Chandrabani, Dehradun—248001

*Email : gopigv@wii.gov.in



Heronries-in India.

Information on Indian heronries is available mainly from a few regional studies (Mahabal 1990, Nagulu & Ramana Rao 1983, Naik *et al.* 1991, Naik & Parasharya 1988], Parasharya & Naik 1990, Santharam & Menon 1991, Sharatchandra 1980, Singh & Sodhi 1986), several site-specific short-term and long-term studies (Chaudhari & Chakrabarti 1973, Datta & Pal 1990, 1993, Gee 1960, Nagulu & Ramana Rao 1983, Neelakanatan 1949, Neginhal 1983, Paulraj 1984, Raghunatha 1993, Raghunatha *et al.* 1992, Sanjay 1993, Subramanya *et al.* 1991, Subramanya & Manju 1996, Urfi 1989c, 1992, 1993a, 1993b, Vijayan 1991) and a number of site records (Abdulali 1962, Ali 1960, Baker 1935, Barnes 1886, 1891, Barooah 1991, Bates & Lowther 1952, Badshah 1963, Betham 1904, Bingham 1876, Bhat *et al.* 1992, Bolster 1923, Chhaya 1980, Daniel 1980, Hume 1881, Jamgaonkar *et al.* 1994, Packard 1903, Urfi 1992, Uttaman 1990, Wilkinson 1961). Very few studies have been carried out on the colonial waterbirds of Indian mangroves. Mukerjee (1959) studied the feeding habits of a few waterbirds in the mangrove forests of the Sunderbans. Prasad (1992) provided a report about a large, inaccessible heronry in the Krishna mangroves. Subramnaya (1996) conducted a nation-wide detailed assessment of the status, distribution and conservation of Indian heronries.

Avifaunal research in Bhitarkanika.

Notes on the avifauna of Bhitarkanika mangroves occur at random in the literature, but an initial checklist of the birds of Bhitarkanika was drawn up in the early 1990s by Dani and Kar (1992). A detailed list with 169 species was published by Pandav (1996) Other studies include those of Nayak (2003a, 2003b), who described the ecology of the resident birds of the heronry and reported the occurrence and seasonality of eight species of kingfisher. Ambastha (2005) reported the occurrence of the Red-winged Crested Cuckoo in Bhitarkanika. The updated avifaunal checklist of Bhitarkanika includes 263 birds (Gopi & Pandav 2007a). Gopi *et al.* (2006a) reported a large congregation of Indian Skimmers (*Rynchops albicollis*) in Bhitarkanika Wildlife Sanctuary and suggested that this could be a key congregation site for Skimmers. Gopi & Pandav (2006b) published a report of a White-bellied Sea-Eagle (*Haliaeetus leucogaster*) preying on a salt-water crocodile (*Crocodylus porosus*) hatchling. Gopi & Pandav (2007b) studied the breeding biology of three stork species, *i.e.* the Lesser Adjutant Stork (*Leptoptilos javanicus*), Asian Openbill-Stork (*Anastomus oscitans*) and Painted Stork (*Mycteria leucocephala*), in the Bhitarkanika mangroves. The nesting ecology of the colonial nesting waterbirds of Bhitarkanika was studied from 2004 to 2007 (Gopi & Pandav 2007c, Gopi 2010, Gopi & Pandav 2012). The occupancy and food niche partitioning of the sympatric kingfishers were studied from January to May 2011 (Borah *et al.* 2012, Borah 2011).

The heronry in Bhitarkanika is located on an island covered with mangrove vegetation. Enhanced foraging due to the presence of abundant foraging areas in and around the heronry in terms of wetlands and agricultural fields, decreased predation due to the remoteness of the nesting site, may be the major factors in governing this large congregation of waterbirds in this colony. Considering the paucity of ecological information available on this heronry, the present study was undertaken to draw a conservation strategy.

Two critical conservation and management issues were addressed :-

- (1) The management planning and conservation of the colony are impeded by the paucity of reliable ecological information.
- (2) The current threat levels faced by the colony need to be assessed to understand the probable impacts on the breeding birds.

This study was conducted with the objectives of :-

- (1) Studying the biology of the breeding birds in the heronry.
- (2) Studying the resource use pattern, in terms of both space and food.
- (3) Determining the impacts of the land use changes around the Bhitarkanika protected area on the breeding colony.

Study Area

This study was conducted in the Bhitarkanika Conservation Area (BCA), Odisha, which encompasses three protected areas, viz., Bhitarkanika National Park, Bhitarkanika Wildlife Sanctuary and Gahirmatha Marine Sanctuary. BCA (20°04'-20°08' N, 86°45'-87°50' E) is located on the east coast of India and represents one of the finest remaining patches of mangrove forests in India (Figure 1). The Bhitarkanika mangroves are located in the deltaic region of the Brahmani and Baitarani rivers in Kendrapara District. BCA has an astounding diversity of mangroves and is rated second only to Papua New Guinea in the number of mangrove species. Bhitarkanika Wildlife sanctuary is situated near the Dhamra port and a former port, Chandabali, which is about 50 km from the city of Bhadrak. The general elevation is between 1.5 and 2 m asl, and higher grounds extend to 3-4 m asl. The sanctuary is bounded by the rivers Dhamara (to the north), Maipura (to the

south) and Brahmani (to the west) and the Bay of Bengal, in the east. The 35 km coastline from the mouth of the river Maipura to Barunei forms the eastern boundary of the sanctuary. The annual rainfall ranges from 920 to 3000 mm. The breeding colony is located inside Bhitarkanika Forest Block of the National Park. It is one of the oldest and largest mixed-species waterbird colonies in India (Subramanya 1996).

Methodology

Field Methods

Field data were collected for 3 years, i.e. from 2004 to 2006, between May and January. Prior to the onset of the south-west monsoon and the arrival of birds (probably during early June), daily visits were made to the colony. The entire colony was gridded during this initial period into 17 blocks of size 50 m × 50 m each. Five trees were randomly selected in each of these blocks and marked with paint and a cloth for ease of identification during subsequent visits in the season for monitoring. The colony was visited on alternate days for monitoring. The visits were made during the cooler parts of the day (0600 hours to 0800 hours) to avoid overheating of eggs for when they were marked and measured. The entire colony was not disturbed for more than one hour during each monitoring session. Birds left the nests when observers were within 2-5 m of a nest; however, they returned immediately once the observer moved away. Observers approached the nest along one route and left by another to minimise the chances of predators locating nests by watching the observers and birds.

The selected trees were monitored, and variables such as tree species, girth at breast height (GBH), tree height, nesting species, location of a nest in a tree (i.e., date on which nest materials were first placed in a marked tree by a nesting pair), clutch initiation date (date of laying of first egg), egg laying dates, egg measurements and clutch size (total number of eggs per nest) were recorded. Nest measurements (circumference and width) were made using a measuring tape throughout the season to document changes at various nesting stages i.e. laying, incubating, hatching and fledgling stages. The materials (twigs, leaves, grass, etc.) used for building the nests were identified up to the species level and recorded.

Once the nest building process started on a selected tree, each nest was marked using red paint and a small aluminium tag (3" × 3") tied just below a branch supporting a nest. The tags were alphanumerically coded for easy identification of the nests of different species. The monitoring of each nest was continued till the last chick fledged. We considered a young bird to be successfully fledged when it was old enough to fly across an open space to trees away from the nest. Hatching was determined to be successful in a nest even if a single egg hatched in it. The productivity was calculated as the number of chicks that survived till the fledgelings dispersed from the nest.

Behavioural observations were made to record aggression towards conspecifics, copulation duration, incubation bout duration and incubation interval time. Focal-animal sampling (Altmann 1974) was used to study the behaviour of the breeding birds. Nesting birds were selected and observed for a maximum of 4 hours per sample. All observations of duration less than 1 minute were discarded during analysis.

Annual nest counts were carried out to enumerate the total number of nests in the colony in the last week of August each year, when most of eggs had hatched. A total count of the nesting trees inside the colony was obtained by visiting and marking each tree. Parameters such as tree species, number of nests, nesting species, tree height, nest height and tree GBH were recorded. The bird species of each nest was identified by observing the species guarding the nest. If both parent birds were absent, the nest design and nest material were used as a clue to identify the species.

We used the number of items of prey consumed to determine the food habits of the nesting birds. We collected a total of 1422 regurgitated samples from the 11 species of birds and broadly classified these as insects, molluscs, fish, amphibians and snakes, lizards and frogs etc. Regurgitated boluses from the nesting birds were collected by standing under a nest for a while with a large cloth. The chicks regurgitated food when they were alarmed by predators or human beings. Two views have been expressed to explain this behaviour. Regurgitation serves as an antipredatory device to lure predators away by causing them to consume the regurgitated food instead of killing the nestlings (Kushlan 1978). Also, the regurgitation makes nestlings more mobile so that they can easily escape from the predators (Owen 1955). The sizes of the prey items consumed were measure to analyse the data for differences in the food habits of nesting species and siblings in the same nest.

In order to determine the land use change impact on prey abundance, 272 1m x 1m quadrats were laid in the agricultural fields to understand the impacts of aquaculture farms on the prey base of the nesting birds, particularly Asian Openbill Storks. Fifty percent of the quadrats were laid within 50 m from the periphery of a farm, and 50% of the quadrats were laid at least 2 km from a farm. The number of apple snails (*Pila globosa*) encountered in each quadrat was counted, and the

dry weight was measured later at the base camp to determine the biomass. Later, the prey items from all the sampling points were averaged to obtain a mean value. The results were expressed as the number of prey items and the biomass (dry weight) of the prey items in each quadrat.

Analytical Methods

The length (L) and breadth (B) of each egg were measured to the nearest 0.1 mm using a digital vernier caliper for morphometric studies. Later, the volumes of the eggs were calculated using the formula $V = 0.51 \times L \times B^2$ (Hoyt 1979). To understand the association among nesting species in the heronry Pearson's Chi-square Statistic # $P > 0.05$ (indicating spatial independence of nests) was carried out. Differences between sampling points close to aquaculture farms and those far away from aquaculture farms were analysed using a repeated measures of ANOVA after $\log_e(x - 1)$ transformations. All statistical analyses were carried out using the SPSS 8.0 statistical package. Unless indicated otherwise, errors presented in the text are the standard deviation of mean (1 SD).

Results

Our study showed a strong relation between the nesting activity of the colonial nesting waterbirds and the south-west monsoon. The nest enumeration carried out in the colony between 2004 and 2006 indicates that there were 13,704 nests on 3839 trees in 2004, 11,249 nests on 3,237 nest trees in 2005 and 11,819 nests on 4,221 trees in 2006.

Five species of mangrove tree were used by the birds in the colony for nesting. These were *Excoecaria agallocha*, *Heritiera fomes*, *Cynometra iripa*, *Hibiscus tiliaceus* and *Tamarix troupii*. The largest number of nests (79.6%) was recorded on *E. agallocha*, followed by *H. fomes* (17.4%), *C. iripa* (2.2%) and *H. tiliaceus* (0.9%). Only two nests were found on *T. troupii*. *E. agallocha* was the most numerous species in the colony, and it occupied the central area. *H. fomes* was the tallest and stoutest tree species in the colony. Asian Openbill Storks preferred to nest in *E. agallocha* trees. Continued nesting of Openbills has damaged the top portions of the trees, resulting in stunted growth of *E. agallocha* in the heronry. This in turn has given the heronry a saucer shape.

Eleven of the 26 colonially nesting waterbirds bred in the colony. The nesting species, in decreasing order of abundance, in this colony are the Asian Openbill Stork, Large Egret, Little Cormorant, Intermediate Egret, Purple Heron, Night Heron, Grey Heron, Black-headed Ibis, Oriental Darter, Cattle Egret and Little Egret. Asian Openbill Storks accounted for nearly 66% of all the nests counted in the colony, and Little Egrets had the least number of nests (0.6%). Cattle Egrets nested in 2004 and abandoned the colony in 2005 and 2006, the reason, however, could not be ascertained.

On examination of the materials used for building the nests, dry and green twigs of the following species were found: *E. agallocha*, *H. fomes*, *H. tiliaceus*, *T. troupii*, *C. iripa*, *Salvadora persica*, *Salacia prinoides*, *Avicennia officianalis* and *Ceriops decandra*. In one instance (Oriental Darter), green leaves of *Phoenix paludosa* were found. There was a significant increase in the amount of nest material and size as breeding progressed, i.e. from the laying stage to the hatching and fledgling stages. Nest materials were added by both parents till the chicks fledged in all the species so that there was enough space for the growing chicks in the nest.

The herons and egrets took 8-10 days to initiate a clutch, while the cormorant and Darter took 15-18 days to initiate a clutch. Asian Openbill Storks displayed delayed clutch initiation (30 days after nest initiation) in 2004, and this late initiation was presumably due to the delay in the onset of the monsoon that year. The clutch size varied between 2.5 eggs and 6 eggs per clutch across all species. The largest mean clutch size was that of the Black-headed Ibis, followed by the Oriental Darter and Night Heron. The Large Egret had the lowest clutch size, with a mean of less than 3 eggs per clutch. Incubation started with the laying of the first egg. The Black-headed Ibis and Little Egret had the shortest mean incubation durations (18 and 19 days, respectively), while the Oriental Darter and Asian Openbill Stork had the longest mean incubation durations (28 and 26 days, respectively). The productivity, in terms of hatching and fledgling success, was very low, less than 50% for most species, and only the Purple Heron and Darter had a comparatively high reproductive success, with more than 50% of the eggs surviving till the fledgling stage.

The success rate was found to be independent of the hierarchical order (order of eggs laid) except in the case of the Purple Heron and Oriental Darter. For both the species, the older egg/chick had greater probability of success. Analysis of the relationship between clutch size and hatching success revealed nothing significant for all the birds, except the Oriental Darter and Purple Heron, for which there was negative significance (lower success rate with greater clutch size). The Black-headed Ibis displayed strong dissociation from the other colonial species, except the Large and Intermediate egrets, and tended to nest in sub-colonies in the heronry. There was little evidence of the Grey Heron and Purple Heron nesting together, and a similar trend was also seen between the Night Heron and Cattle Egret. The Darter was dissociated from the Little Cormorant and Intermediate, Little and Cattle egrets.

The Asian Openbill Stork, Little Cormorant, Black-headed Ibis, Little Egret and Cattle Egret showed a preference for nesting on *E. agallocha*, whereas the Oriental Darter, Grey Heron, Purple Heron and Night Heron showed a preference for *H. fomes*. The Black-headed Ibis, Little Cormorant, Darter, Intermediate Egret, Little Egret and Cattle Egret tended to avoid nesting on *H. tiliaceus* in the colony. Analysis of the vertical alignment of the nests did not support the body mass-nest height hypothesis, which postulates a direct positive correlation between body weight and nest height in colonial waterbirds. There was a significant radial zonation of species in the heronry, with Asian Openbill Storks preferring to nest in the central portion of the heronry (KW $\chi^2 = 8.54$, $P < 0.05$), whereas Darter and Grey Heron nests were observed more towards the periphery of the heronry (KW $\chi^2 = 6.40$, $P < 0.05$). On the other hand, the nests of the Little Egret (KW $\chi^2 = 11.11$, $P < 0.05$), Purple Heron (KW $\chi^2 = 11.53$, $P < 0.05$) and Night Heron (KW $\chi^2 = 10.61$, $P < 0.05$) were found to have clumped distributions, being restricted to certain blocks of the heronry.

Analysis of 1422 regurgitated samples collected from chicks of varying ages of all the species revealed that most species prefer fish as the main prey (Table 1). However, >99% of the diet of Asian Openbill Storks was composed of Apple Snails (*Pila globosa*). The Little Egret, Little Cormorant and Black-headed Ibis had significant proportions of prawns and shrimps in their diet. On a couple of instances, Little Egret digits were found in samples regurgitated by Night Heron chicks, suggesting that Night Herons may prey or scavenge on other birds nesting in the colony. Water snakes (*Enhydryis enhydryis*, Dog-faced Water Snake (*Cerberus rynchops*) were preferred by the Purple Heron followed by the Night Heron, Grey Heron and Little Cormorant. A few aquatic insects (mostly water beetle larvae) were found in the diets of the Black-headed Ibis, Night Heron and Intermediate and Little egrets (Figure 2).

Discussion

The nesting activity in the colony coincided with the south-west monsoon in all the years monitored. The breeding seasons of birds are generally known to be highly dependent on the monsoon as the improved availability of water increases the food availability of the birds (Ali & Ripley 1968 and Thomson, 1950). All the storks, herons and egrets that breed in India breed just after the monsoon (Ali 1996). Strong seasonal peaks in food resources may limit breeding to a single season of the year and cause synchronized breeding of the population. Large colonies are formed to exploit the abundant food resources (Emlen & Demong 1971).

There were significant changes in the nest profile at various stages. The Asian Openbill Stork, Grey Heron, Black-headed Ibis, Large Egret, Little Cormorant, Intermediate Egret and Little Egret had a less than 50% success rate, and the Purple Heron and Oriental darter had a more than 50% success rate. The Asian Openbill had a delayed clutch initiation date compared to the other species in 2 years, probably because of the delay in the onset of the monsoon in both years (Gopi & Pandav 2007). The Black-headed Ibis and Little Egret had the shortest incubation periods, and the Oriental Darter and Asian Openbill had the longest incubation periods. The Night Heron and Large Egret had the smallest clutches, and the White Ibis and Oriental Darter had the largest clutches. The success rate was independent of the hierarchical order, except the Purple Heron and Oriental Darter, for which there was a significant relation between the hierarchical order and hatching success. Slagsvold *et al.* (1984) postulated that birds laying relatively small last eggs demonstrate the brood reduction strategy and those laying large last eggs fit the "nest failure" model. With the Oriental Darter and Purple Heron, there was negative significance (the greater the clutch size, the lower the success rate), and for the other species, no significant relation was found between the clutch size and hatching success. A significance difference was observed between the growth rates of older and younger chicks, with older chicks showing a better growth rate compared with the younger chicks.

It was observed that the Asian Openbill Stork, Large Egret, Intermediate Egret, Little Cormorant and Little Egret were associated more frequently than they would be expected at random. There was a significant avoidance trend between the Grey heron and Purple Heron and between the Oriental Darter and Asian Openbill Stork. Interestingly, the Black headed Ibis was observed to nest away from most of the species within the heronry, forming sub-colonies on its own. Frederick and Callopy (1989) found strong differences between the nesting chronologies of four species (*Casmerodius albus*, *Egretta tricolor*, *Egretta caerulea*, *Edocimus albus*) in Florida. Maxwell and Kale (1977) and Jenni (1969) found that nests of *Egretta thula* and *Bulbulcus ibis* were situated at an average nest height of 2.04-2.59 m. The findings of this work support the notion that species that overlap temporally in breeding segregate vertically in nest placement within the colony. Our analysis of the vertical alignment of the nests shows that though there was vertical alignment of nests, there was no support for the body mass-nest height hypothesis, which postulates a direct positive correlation between body weight and nest height in colonial waterbirds. Earlier studies by Anderson *et al.* (1979), suggested vertical stratification partitions resources and thereby reduces competition among coexisting species. There was a significant radial zonation of species in the heronry, with the Asian Openbill Storks preferring the central portion of the heronry and

Oriental Darter and Grey heron nests being found more towards the periphery of the heronry. On the other hand, the nests of the Little Egret, Purple Heron and Night Heron had a clumped distribution, being restricted to certain blocks of the heronry. These patterns might have been responsible for reducing interspecific aggression and thereby enhancing interspecific resource partitioning. Competition may be reduced through a strategy of fine-scale temporal and spatial segregation in the use of habitats among species with similar feeding habits (Murray 1971, Hill & Lein 1989).

All the birds showed a strong preference for fish except the Asian Openbill, which fed exclusively (99.7%) on Apple Snails. Crabs were strongly preferred by the White Ibis and Little Cormorant. The White Ibis had significant proportion of prawns and shrimps in its diet. The Night Heron displayed evidence of preying/scavenging on birds (Little Egrets were found in 17 regurgitated samples). Water snakes (*Enhydryis enhydryis*) were preferred by the Purple Heron, followed by the Night Heron, Grey Heron and Little Cormorant. Insects (mostly water beetle larvae) were largely preferred by the White Ibis, Little Cormorant, Intermediate Egret and Little Egret. Aquaculture farms are increasing over the past decade all along the Indian coastal belt. Bhitarkanika is no exception, and our surveys around Bhitarkanika National Park and inside Bhitarkanika Wildlife Sanctuary showed that there were more than 672 farms dotting the periphery of the park. Direct evidence was found of intake and release of saline water from and to the river systems. These could have an impact on the fish population, which is the major prey base for the nesting birds in the heronry. The food abundance was low in the areas adjoining the aquaculture farms, thereby affecting the abundance of the forage base for Asian Openbill Storks. Since the period of reproduction is a time of a high demand for energy (Drent & Dann 1980), the availability of suitable foraging sites will directly influence the colony location, colony size and reproductive parameters. Future attempts to manage this colony should consider paying attention to reducing the threats in the adjacent agricultural landscapes, where the breeding birds forage during the nesting season.

Current Status (2014) of the Breeding Colony in Bhitarkanika :

Only two species now breed in this mixed-species colony as nine of the 10 species that breed in this colony have shifted to a nearby location (Matuadia), less than 1 km away, in Bhitarkanika Forest Block, across Suajore Creek. As of now, only the Asian Openbill storks and Intermediate egrets nest in this colony. A census carried out in August 2014 in this colony near Suajore Creek revealed a total of 13457 Asian Openbill Stork nests and 24 Intermediate egret nests. A new colony has formed amidst the *Excoecaria agallocha* and *Avicinea officinalis* mangrove patches, where a total of 10 species breed. A total of 6303 nests, with 1671 nests of Asian openbill storks, 1073 nests of Large egrets, 612 nests of Intermediate egrets, 170 nests of Little egrets, 536 nests of Purple heron, 290 nests of grey herons, 561 nests of Black crowned night herons, 290 nests of Oriental darter, 168 nests of Black headed Ibis and 932 nests of Little cormorants were counted during the census carried out in August 2014 in the colony at the Matha Adia area.

Source: Bijay Kumar Das, Research Assistant, Bhitarkanika National Park

Table 1. Number of regurgitated boluses analysed

Species	Number of regurgitated boluses
Asian Openbill Stork	468
Grey Heron	74
Intermediate Egret	95
Large Egret	223
Little Cormorant	227
Little Egret	43
Black-crowned Night Heron	41
Oriental Darter	44
Purple Heron	176
Black-headed Ibis	31
Total	1422



Fig 1 : Map of Bhitarkanika Wildlife Sanctuary

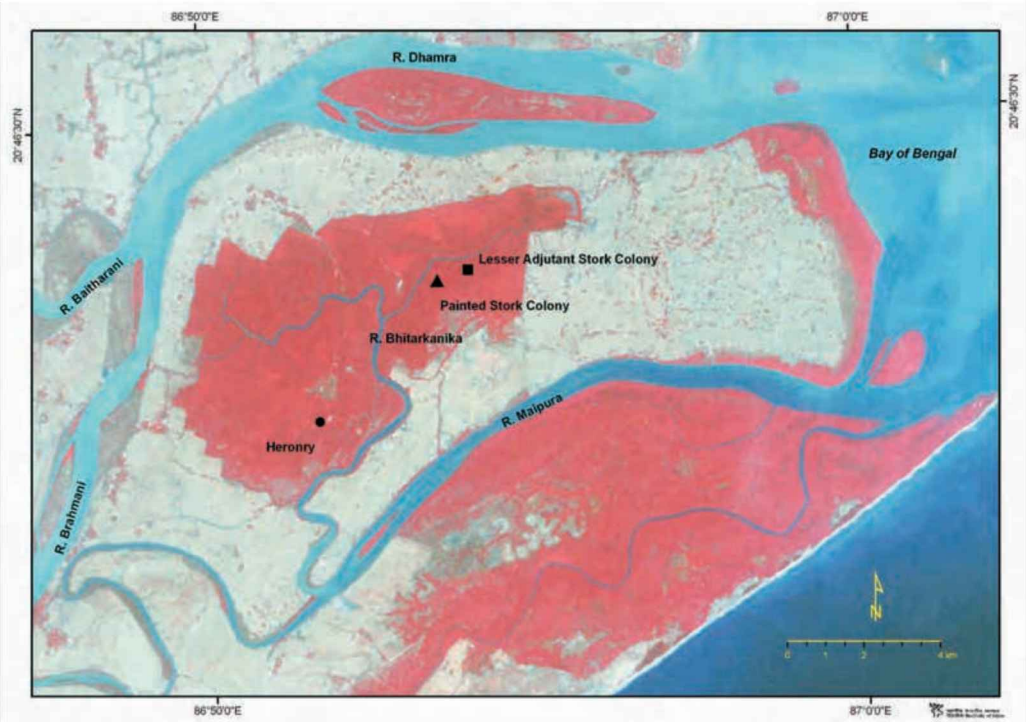
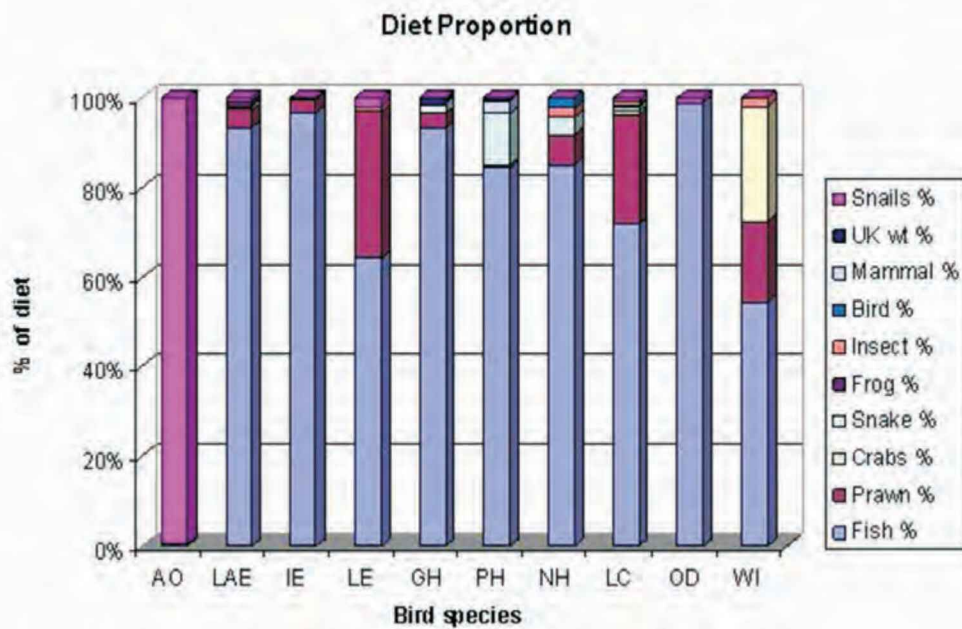


Fig 2 : Diets of different breeding birds in the heronry





© Gopi, G.V

All the nesting species in the Bhitarkanika heronry build "platform nests". Grey heron built the largest nest size in contrast to little cormorant building the smallest nest with few sticks in them.



© Gopi, G.V

Oriental Darter fledgelings in a nest, age 10-20 days. The difference in age between siblings of the same nest is due to the phenomenon of hatching asynchrony.





Purple Heron fledgelings in a nest, age 2-7 days. The difference in age between siblings of the same nest is due to the phenomenon of hatching asynchrony.



© Gopi G. V

Most of the birds from the nesting colony are commonly seen foraging in the paddy fields adjoining the sanctuary (personal observation). Paddy fields in this area are rapidly being converted to shrimp ponds, thus reducing the foraging areas available for the breeding birds.



© Gopi G. V

Ecological and Conservation Inferences from Monitoring a Mixed-Species Waterbird Breeding Colony in Bhitarkanika Conservation Area, India

References

- Abdulali, H. (1962). An ornithological trip to the Gulf of Kutch. *Journal of the Bombay Natural History Society*. 59: 655–658.
- Ali, S. (1960). "Flamingo city" revisited: Nesting of rosy pelican (*Pelecanus onocrotalus* Linnaeus) in Rann of Kutch. *Journal of Bombay Natural History Society* 57: 412–415.
- Ali, S. & Ripley, S.D. (1968). *Handbook of the Birds of India and Pakistan Together with Those of Nepal, Bhutan and Ceylon. I. Divers to Hawks*. Oxford University Press, Oxford.
- Ali, S. (1996) *The Book of Indian Birds*. (12th ed.). New Delhi: BNHS & OUP.
- Altmann, J (1974). Observational study of behavior: sampling methods. *Behaviour* 48:227-267.
- Ambastha, K.(2005). Records of Red-winged Crested Cuckoo *Clamator coromandus* from Bhitarkanika National Park, Orissa., *Indian Birds*, 1:5
- Anderson, S.H., H.H. Shugart & T.M. Smith (1979). Vertical and temporal habitat utilization within a breeding bird community. Pp. 203-216. In: Dickson, J.D., R.N. Conner, R.R. Fleet, J.A. Jackson and J.C. Kroll (Eds): *The Role of Insectivorous Birds in Forest Ecosystems*. Academic Press, New York.
- Badshah, M.A. (1963). Breeding colony of Painted Storks. *Peacock* 3: 15–17.
- Baker, E.C.S. (1935). *The Identification of Birds of the Indian Empire*. Vol. 4. Taylor and Francis, London.
- Barnes, H.E. (1886). Birds nesting in Rajputana. *Journal of the Bombay Natural History Society*. 1: 38–62.
- Barnes, H.E. (1891). Nesting in western India. *Journal of the Bombay Natural History Society* 6: 130–153.
- Barooah, D. (1991). Greater Adjutant Storks nesting in Upper Assam. *Newsletter for Birdwatchers* 31(1&2): 11.
- Bates, R.S.P & Lowther, E.H.N. (1952). *Breeding Birds of Kashmir*. Oxford University Press, London. 367 pp.
- Betham, R.E. (1904). Notes on birds nesting from Poona. *Journal of the Bombay Natural History Society* 15: 709–712.
- Bhat, H.R., Jacob, P.G. & Jamgaonkar, A.V. (1992). Observations on a breeding colony of Painted Stork *Mycteria leucocephala* (Pennant) in Anantapur Dist., Andhra Pradesh. *Journal of the Bombay Natural History Society* 88: 443–445.
- Bingham, C.T. (1876). *Anastomus oscitans*. *Stray Feathers* 4: 212–214.
- Bolster, R.C. (1923). Notes on the breeding season of the Painted Stork (*Pseudotalus leucocephalus*). *Journal of the Bombay Natural History Society* 29: 561.
- Borah, J. (2011). Foraging-Niche Partitioning Among The Sympatric Species Of Kingfishers In Bhitarkanika Mangroves, Orissa. M.Sc. dissertation. Saurashtra University, Rajkot, India.
- Borah, J., Ghosh, M., Harihar, A., Pandav, B. & Gopi, G.V. (2012). Food-niche partitioning among sympatric kingfishers in Bhitarkanika Mangroves, Odisha. *Journal of the Bombay Natural History Society* 109(1&2): 71–77.
- Brown, C.R. & Bomberger Brown, M.R. (1987). Group living in cliff swallow as an advantage in avoiding predators. *Behavioral Ecology and Sociobiology* 21: 97–107.
- Chada, S. & Kar, C.S. (1999). *Bhitarkanika: Myth and Reality*. Natraj Publisher, Dehradun. 388 pp.
- Chaudhari, A.B. & Chakrabarti. (1973). Wildlife biology of Sunderbans forests: A study of the birds of Sunderbans, with special reference to the breeding of Openbill Stork, Little Cormorant and Large Egret. *Science Culture* 39: 8–16.
- Chhaya, Y.H. (1980). Breeding colony of waterbirds near Seelaj. *Newsletter for Birdwatchers* 20(4): 12–13.
- Crook, J. H. (1965). The adaptive significance of avian social organizations, Symp. Zool. Soc. Lond. 14:181-218
- Dani, C.S. and C.S. Kar. (1999). Conservation of sea turtles and environmental relationship of arribadas of olive ridley *Lepidochelys olivacea* (Eschsholtz, 1829) in relation to Bhitarkanika mangrove ecosystem of Orissa coast. In: Bhitarkanika - The Wonderland of Orissa, pp. 98-120. Nature & Wildlife Conservation Society of Orissa, Bhubaneswar.
- Daniel, P. (1980). Koodankulam heronry. *Hornbill* 4: 3.
- Datta, T. And Pal, B.C. (1990). Space partitioning in relation to nesting among six bird species in the heronry at Kulik Bird sanctuary, West Bengal. *Environmental Ecology* 8: 86–91.
- Datta, T. And Pal, B.C. (1993). The effect of human interference on the nesting of Openbill Stork *Anastomus oscitans* at the Raiganj Wildlife Sanctuary, India. *Biological Conservation* 64: 149–154.
- Del Hoyo, J., Elliott, A, And Sargatal, J. (eds.) (1992). *Handbook of the Birds of the World*. Vol 1. Lynx Edicions, Barcelona.
- Drent, R.H. And Dann, S. (1980). The prudent parent: Energetic adjustments in avian breeding. *Ardea* 68: 225–252.
- Emlen, J.T And Demong, N.J. (1971). Adaptive significance of synchronized breeding in a colonial bird: A new hypothesis. *Science* 188: 1029–1031.
- Frederick, P.C And M.W. Collopy (1989). The nesting success of five species of wading birds (Ciconiiformes) in relation to water conditions in the Florida Everglades. *Auk* 106:625-634.
- Gee, E.P. (1960). The breeding of Grey or Spotbilled Pelican (*Pelecanus philippensis philippensis* Gmelin). *Journal of the Bombay Natural History Society* 57: 245–251.

- Gopi, G.V., A.K.Jena & Pandav, B. (2006a). Bhitarkanika Wildlife Sanctuary (Orissa), a key congregation area for India Skimmer (*Rynchops albicollis*). *Birding Asia* 5(5): 78.
- Gopi, G.V., Pandav, B., & A.K.Jena (2006b). White bellied sea eagle (*Haliaeetus leucogaster*) preying on salt water crocodile (*Crocodylus porosus*). *Indian Birds* 2 (6): 171.
- Gopi, G.V. (2008). Bagagahana: The hidden paradise of Bhitarkanika. *Hornbill* 3: 29–31.
- Gopi, G.V. (2010). Nesting Ecology of Colonial Waterbirds at Bhitarkanika Mangroves, Orissa. Ph.D. dissertation submitted to Saurashtra University, Rajkot, India. 120 pp.
- Gopi, G.V. & Bivash Pandav. (2007a). Conservation of avifauna of Bhitarkanika mangroves, India. *Zoosprint* 22(10): 2839–2847.
- Gopi, G.V. & Pandav, B. (2007b). Observations on breeding biology of three stork species in Bhitarkanika mangroves, India. *Indian Birds* 3(2): 45–50.
- Gopi, G.V. (2007c). Bhitarkanika: A breeding haven. *Sanctuary Asia* XXVII(2): 48–51
- Gopi, G.V. & Pandav, B. 2012. Ecology of a near-threatened colonial waterbird Black-Headed Ibis *Threskiornis melanocephalus* at Bhitarkanika mangroves, Odisha. *Journal of the Bombay Natural History Society* 109(1&2): 101–110.
- Hill, B.G & Lein, M. R (1989). Territory overlap and habitat use of sympatric chickadees. *Auk*, 106, p. 259 – 268.
- Hoyt, D. (1979). Practical methods of estimating volume and fresh weight of bird eggs. *Auk*, 96: 73–77.
- Hume, A.O (1881). Our Indian pelicans. *Stray Feathers*, 10: 487–502.
- Jamgaonkar, A.V., Jacob P.G., Rajagopal, S.N. & Bhatt, H.R. (1994). Records of new breeding colonies of Painted Storks *Mycteria leucocephala* in Karnataka. *Pavo* 32: 59–62.
- Jenni, D.A. (1969). A study on the ecology of four species of herons during the breeding season at Lake Alice, Alachua County, Florida. *Ecological Monographs* 39: 245–270.
- Kushlan, J.A. (1978). Feeding ecology of wading birds. Pp. 242–297 in: *Wading Birds* (eds. Sprunt, A. et al.). National Audubon Society, New York.
- Lack, D. (1954). *The Natural Regulation of Animal Numbers*. Clarendon Press, Oxford.
- Lack, D. (1968). *Ecological Adaptations For Breeding Birds*. Methuen, London.
- Mahabal, A. (1990). Heronries in Raigad District, Maharashtra: A preliminary survey. *Journal of the Bombay Natural History Society* 87: 137–138.
- Maxwell, G.R & Kale, W. (1977). Breeding biology of five species of herons in coastal Florida. *Auk* 94: 689–700.
- Mukerjee, A.K. (1959). Pakhiral, Sajnakhali: An introduction to a bird sanctuary in Sunderbans. *Journal of the Bengal Natural History Society* 30: 161–165.
- Murray, Jr B.G (1971). The ecological consequences of interspecific territorial behavior in birds. *Ecology*, 52, p.414–423.
- Nagulu, V. & Ramana Rao, J.V. (1983). Survey of south Indian pelicanries. *Journal of the Bombay Natural History Society* 80: 141–143.
- Naik, R.M., Murthy, M.S., Mansuri, A.P., Rao, Y.N., Parvez, R., Mundkur, T., Krishnan, S., Faldu, P.J. & Krishna, T.S.V.R. (1991). WWF-India Sponsored Project on Coastal Marine Ecosystems and Anthropogenic Pressures in the Gulf of Kachh. Final report. Department of Biosciences, Saurashtra University, Rajkot, Gujarat, India.
- Naik, R.M & Parasharya, B.M. (1988). Impact of the food availability, nesting habitat destruction and cultural variations of human settlements on the nesting distribution of a coastal bird, *Egretta gularis*, in western India. *Journal of the Bombay Natural History Society* 84: 350–360.
- Nayak, A. (2003a). Seasonal diversity of kingfishers in Bhitarkanika National Park, Orissa. *Indian Forester* 13(12): 1559–1563.
- Nayak, A. (2003b). *Preliminary Field Guide to the Birds of Bhitarkanika*. Mangrove Forest Division (Wildlife), Rajnagar, Orissa.
- Neelakantan, K.K. (1949). A south Indian pelicanry. *Journal of the Bombay Natural History Society* 48: 656–666.
- Neginhal, S.G. (1983). The birds of Ranganathittu. *Journal of the Bombay Natural History Society* 79: 581–593.
- Owen, D.F. (1955). The food of the heron *Ardea cinera* in the breeding season. *Ibis* 97: 276–295.
- Packard, H.N. (1903). Notes on the breeding of certain herons, etc. in southern India. *Journal of the Bombay Natural History Society* 15: 138.
- Pandav, B. (1996). Birds of Bhitarkanika mangroves, eastern India. *Forktail* 12: 7–17.
- Parasharya, B.M & Naik, R.M. (1990). Ciconiiform birds breeding in Bhavnagar City, Gujarat: A study of their nesting and plea for conservation. Pp. 429–445 in *Conservation in Developing Countries: Problems and Prospects* (eds. Daniel, J.C. & Serrao, J.S.). Oxford University Press, Bombay.
- Paulraj, S. (1984). Studies on Vedanthangal Bird Sanctuary. Project report, final part. Tamil Nadu Forest Department, Madras.

132 pp.

- Prasad, S.N. (1992). An ecological reconnaissance of Mangals in Krishna estuary: Plea for conservation. In: *Tropical Ecosystems: Ecology & Management* (eds. Singh, K.P. & Singh, J.S.). Wiley Eastern Ltd., New Delhi.
- Perrins, C. M., And T. R. Birkhead (1983). *Avian ecology*. Blackie, Glasgow.
- Raghunatha, V. (1993). An Ecological Study of Waterbirds at Gudvi Bird Sanctuary. Final report of the study sponsored by the Conservation Corps Volunteer Programme. WWF-India, New Delhi.
- Raghunatha, V., Subramanya, S., Shyamlal, L., Lokesh, R. & Vasudeva, R. (1992). A preliminary survey of Gudvi Bird Sanctuary. *My Forest* 28: 265–274.
- Rosenzweig, M.L. (1981). A theory of habitat selection. *Ecology* 62: 327–335.
- Sanjay, G.S. (1993). An Ecological Study of Birds at Kokkare Bellur. Final report of the study sponsored by the Conservation Corps Volunteer Programme, WWF-India, New Delhi.
- Santharam, V. and Menon, R.K.G. (1991). Some observations on the water bird populations of the Vedanthangal bird sanctuary. *Newsletter for Birdwatchers* 31(11&12): 68.
- Sharatchandra, H.C. (1980). Studies on the breeding biology of birds and pesticide residues at Ranganthittu Bird Sanctuary in Mandya District, Karnataka. *Journal of Agricultural Sciences* 14: 264.
- Singh, N. & Sodhi, N.S. (1986). Heronries and the breeding population density of the Cattle Egret, *Bulbulcus ibis coromandus* (Boddaert): during (1985), in Tehsil Kharar of the Ropar District (Punjab). *Pavo* 23: 77–84.
- Slagsvold, T. (1984). Clutch size variation of birds in relation to nest predation: on the cost of reproduction. *Journal of Animal Ecology* 53:945–953.
- Subramanya, S. (1996). Distribution, status and conservation of Indian heronries. *Journal of the Bombay Natural History Society* 98: 459–486.
- Subramanya, S., Kartikeyan, S. & Prasad, J.N. (1991). Ranganathittu: Flood havoc and aftermath. *Newsletter for Birdwatchers* 31(9&10): 5–7.
- Subramanya, S & Manju, K. (1996). Saving Spotbilled Pelican: A successful experiment. *Hornbill* 2: 25.
- Thomson, A. L. (1950). Factors determining the breeding seasons of birds: an introductory review. *Ibis* 92: 173–184
- Urfi, A.J. (1989). Breeding and habitat selection patterns of Painted Storks *Mycteria leucocephala* in Delhi Zoological Park heronries. *Water Study Group Bulletin* 57: 26. (Abstract)
- Urfi, A.J. (1992). The significance of Delhi zoo for water bird conservation. *International Zoo News* 39: 13–16.
- Urfi, A.J. 1993a. Heronries in the Delhi region of India. *Oriental Bird Club Bulletin* 17: 19–21.
- Urfi, A.J. (1993b). Breeding patterns of Painted Storks (*Mycteria leucocephala* Pennant) at Delhi zoo, India. *Colonial Waterbirds* 16: 95–97.
- Uttaman, P.K. (1990). Breeding of egrets in Kerala. *Journal of the Bombay Natural History Society* 87: 139.
- Vijayan, V.S. (1991). Keoladeo National Park Ecology Study (1980–1990), Final report. Bombay Natural History Society, Bombay.
- Wilkinson, M.E (1961). Pelicanry at Kundakulam, Tirunelveli District. *Journal of the Bombay Natural History Society* 58: 514–515.
- Wittenberger, J.F. & Hunt, Jr. G.L. (1985). The adaptive significance of coloniality in birds. Pp. 1–78 in: (eds. Farner, D.S. & King, J.R.) *Avian Biology*, Vol. 8. Academic Press, San Diego.



© Gopi G. V

Ecological and Conservation Inferences from Monitoring a Mixed-Species Waterbird Breeding Colony in Bhitarkanika Conservation Area, India