ECOLOGY AND BEHAVIOUR OF LITTLE CORMORANT (*Phalacrocorax niger* Vieillot) AND NIGHT HERON (*Nycticorax nycticorax* Linnaeus) AT THE RAIGANJ WILDLIFE SANCTUARY, WEST BENGAL,

By

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1. INTRODUCTION

Mankind at present is passing through an extremely critical period. The suspicion of the environmentalists two to three decades back about severe environmental degredation is starting to surface now and is going to appear in a much bigger way if proper measures are not implemented right at this moment. The accumulation of Green-house gases due to ever increasing utilization of fossil fuels is threatening to change the face of the earth due to meltdown of polar ice caps and glaciers. The environmental scientists are rather certain that the earth is going to loose large low lying coastal areas along with a significant portion of its biodiversity. The rise of the sea-level and change in oceanic wind and current current patterns including monsoon, southern-wind and equitorial currents is going to severely affect the survival of not only resident organisms but also the migratory ones.

Most animals and plants are affected by changes in environment that influence any facets required for their survival such as habitat, food items for both adults and youngs, nestings spots-trees, predator-parasite pressure and so on. The birds in particular with very high metabolic rates are probably affected most because of their specialized requirements for survival.

There are about 8600 bird species and nearly 30000 including subspecies and geographical races of birds in the world (Ali,2002). Of which India alone accounts for more than 2100 species and subspecies (Saharia,1998). Thus we have a rich heritage of bird life which must be conserved in proper shape to be passed down to posterity.

Indian avifauna require critical study to determine how many bird taxa are there which might actually mereit species status but which currently languish in the lower rank of subspecies or even geographical races. Not much has been done on this point after Ali (2002). It may be mentioned that mainly because of burgeoning human population a large proportion of Indian birds are threatened with extinction. Among the birds regarded to have become extinct are : the Pink-headed duck, the mountain Koel and Jerdon's Courser. The Great Indian Bustard and White-winged Wood-duck have dwindled to precarious numbers. The beautiful Siberian Crane, a winter visitor to Bharatpur Sanctuary,Rajasthan, is reported to have become reduced to several individuals.

In many parts of their distribution in India in the piscivorous water birds including Little Cormorants and Night Herons come into direct conflect with establised fishery organisations who complain on loss of revenue because of these birds. Again the survival and well being of these birds is seriously threatened due to rapid process of industrialization in a massive way undertaken by both Central and State Governments throughout India. The fate of Socotra Cormorant *Phalacrocorax nigrogularis* in a Arabian Gulf following the recent Gulf War has attracted attention of environmentalists and ornithologists World over. Thus, the pollution level of some of the important Indian rivers is such that the life of the fish and fish-eating birds and animals are at a stake. Thus the cause of conservation of Indian birds have never been more urgent than at present.

The recent out break of bird influenza in South-East and South-Asian countries causing mass scale mortality enforcing culling of entire population of poultry chickens is ringing alarm for wild bird populations. However, blood samples examined for avian influenza virus from the Raiganj Wildlife Sanctuary tested negative.

The birds are not only great to watch but also are important to mankind from various accounts such as :

a) In Pest Control

Al of us know t5hat insectivorous birds thrive exclusively on insects and worms, but many others also regularly take certain amount of insects and worms in their diet. Probably because of high neutrient content in their body. The White stork is reputed as a great destroyer of locusts that ruins cultivated fields.

b) As Scavenger

Birds such as vultures, kites and crows are invaluable scavengers. The speed and thoroughness with which a flock of vultures dispose of a carrion is astounding. Vultures, however, are falling victims to their seavenging behaviour because consumption of diclofenac treated cattles causes renal failure and subsequent mortality in them. Diclofenac has been pointed out to be the primary cause of abnormally high mortality in White -backed vultures in indian subcontinent (Oaks, *et al.*, 2003).

c) As Pollination Agent

A large number of birds of diverse families are responsible for cross fertilization of flowers. In fact, many birds of there groups have specialized adaptation in structure and mechanism of their tongue and bill for the purpose of procuring honey from the base of the flower. In trying to reach the nector often the forehead and throat of the birds come in contact with the anthers. The pollen dust adheres to the feathers and it in transported to the mature stigma of the next flower visited which is thus fertilized. Ali (2002) reported that a few species of birds are responsible for pollination of sixty different species of silk-cotton trees that supply the raw materials for the match sticks. Similarly coral trees that provides shade in the tea and coffee plantations in South India are also fertilized by birds.

d) **In seed dispersal**

Birds also play an important role in the dissemination of seed over a large area. The seeds of Lantana Weeds (a plant of Mexican origin) and Laranthus, a tree-parasite belonging to the Mistletoe family are dispersed mainly by Black-headed Oriole and Sun-birds, Flower peckers and some other bird species. Bulbuls and Barbets are largely responsible for dispersal of the seeds of the sandalwood trees.

e) As food for man

Wild birds particularly wildfowls, Quails, Partridges, Egrets and species of many waterbirds are consumed by human in a mass scale particularly in winter season throughout the indian subcontinent. Similarly egges of these species are also consumed. It is suspected that egges of these species are sold in the market along with usual chicken and duck eggs.

f) Miscellaneous Uses

Feathers of certain birds such as white egrets, peacocks etc. are used in ornaments and garments in various parts of the World particularly in certain Asian and African ethnic communities.

Salim Ali reported that the Chineese consume the nest of swiftlets (*Collocalia*) made of saliva. They consider it is as a delicacy. The swiftlets live in islands off the coast of Southern Myanmer.

The excrement of the sea birds such as gannets, cormorants and pelicans are extremely rich in nitrogen and phosphorus, popularly called guanos serve as excellent fertilizer. The Government of Peru earn a handsome amount of foreign exchange by exporting guanos from the island of the coast of Peru in the paciific. In fact the guanos that accumulate in the sanctuaries inhabitet by piscivorous water birds such as Cormorants and Night Herons in India have fair potential to be used as manure in agriculture.

1.1 EXCELLENCE AND IMPORTANCE OF LITTLE CORMORANT AND NIGHT HERON

Little Cormorants are black duck-like water birds found in the South and South-East Asian countries such as :- India, Bangladesh, Pakistan, Srilanka, Thailand, Ceylon, Myanmer, Malay Peninsula to Indonesian islands. Little Cormorant, *Phalacrocorax niger* (Vieillot) has a long stiff tail, and slender compressed bill, black in colour with bill sharply hooked at the tip. It is shorter and its horny bill is less slender than Indian Shag. It is found in all types of water bodies : sea, brakish lagoons and tidal creeks. It nests in mixed colonies comprising of Night Herons,egrets, storks etc., mostly close to water bodies. Its gular skin and orbital skin is black in the non-breeding season, but purple in the breeding season ; legs and webbed feet is blackish, tinged with purple flesh-colour during breeding season.

Little Cormorants live exclusively on fish which it chases and captures mostly under water, being an expert driver and efficient swimmer.At some parts of the earth it is considered as a pest particularly at extensive fishing centers.

Night Herons on the other hand are wading, semi-terrestrial birds found in South and Central Europe ; Northern Africa and the greater part of Southern and Central Asia. It is found wherever there is suffieient water. Night Herons, *Nycticorax nycticorax* (Linnaeus) lack the characteristic necks and legs so conspicuous in other herons. During flight their necks are not s-folded like those of others but appear short and drawn in, somewhat crow-like. At rest they present a rather short, stocky appearance. This species nests in homogeneous colonies, in colonies of other waders, and, rarely, singly. Its plumage is gray and white with a distinctive black cap and two, to four long narrow white plumes that extend from the back of the head. During the breeding season, the black feathers at the head and back emit a bluish-green gloss and the legs become red or pink.

The normal call is a " Qua", " Quak". or "Quark". These calls are most often emitted in flight or from a perch.

The fish hatchery-men complained that the birds were consuming rather large amount of fish and should be declared as pests. when they nest near human settlements, they are considered as pests (Davis, 1993). So, their presence or absence is an important index of the productivity of aquatic ecosystems.

Night Herons are hunted for food. Its eggs are also reported to be stolen from the nests for human consumption.

1.2 SYSTEMATIC POSITION OF LITTLE CORMORANT AND NIGHT HERON

Class	-	Aves
Subclass	-	Neornithes
Order	-	Pelecaniformes
Family	-	Phalacrocoracidae
Sub-Family	-	Phalacrocoracinae
Genus	-	Phalacrocorax
Species	-	niger

Class	-	Aves
Subclass	-	Neornithes
Order	-	Ciconiiformes
Family	-	Ardeidae
Genus	-	*Nycticorax*
Species	-	*nycticorax*

1.2.1 Close Relatives

The genus *Phalacrocorax* includes several other common species such as : *Phalacrocorax carbo sinensis* popularly know as large cormorant having the characteristic throat and front half of face white ;*Phalacrocorax pygmaeus* (Pallas) also known as Pygmy Cormorant, found only Baluchistan ; *Phalacrocorax auritus* also called Double-crested Cormorant, and it is found in Florida ; *Phalacrocorax fuscicollis* or the Indian Shag have characteristically larger but slimmer bill.

Night Herons are also present. These are :-

a) Yellow-crowned Night Heron (*Nyctanassa violacea*).

b) White-backed Night Heron (*Gorsachius leuconotus*).

c) Malay Night Heron (*Gorsachius melanolophus)*

1.3 DISTRIBUTION OF LITTLE CORMORANT AND NIGHT HERON

Little Cormorants are found in south and southeast Asian countries i.e., India, south East Pakistan, Bangladesh, Terai region of Nepal, Srilanka, Myanmer, Malaysia and Indonesian islands.

It is absent in the Himalayas and northern Pakistan (Ali & Ripley, 1968,). However, large breeding grounds are restricted to a few suitable areas. Present breeding grounds of little Cormorants in India as evidenced from various sources (Baker,1935; Ali,1953, Ramakrishna,1990, Naik *et al.*, 1991) are summerised in Table 1.1

Unlike Little Cormorants Night Herons enjoy much larger distribution. It is found in Central and Southern Europe, North East Africa, the middle East Pakistan, India, Bangladesh, Nepal, Srilanka, Myanmer, South East Asia, China, Japan and North America.

In India it is found in different states and Andaman and Nicobar islands. It is also found in Kashmir Valley (Height 1900m.). However, large breeding grounds are restricted to a few suitable areas. Present breeding grounds of Night Herons in India as evidenced from various sources (Ali, 1953; Neginhal,1983; Naik & Parasharya, 1987; Sankhala, 1990 ; Naik *et al.*,1991; Raghunatha, 1993) are presented in Table 1.2. Breeding colonies of Little Cormorant and Night Heron in India is shown in Fig 1.1.

1.4 OBJECTIVES OF THE PRESENT STUDY

Although Large populations of various Cormorant and Night Heron species occur in this subcontinent ; only very few longterm studies on them are known. The objectives of the present work is to study the ecology and behaviour of Little Cormorant and Night Heron at the Raiganj Wildlife Sanctuary. These two species live on limited food items and have rigid nesting requirements. These species are greatly affected by habitat destruction and similar other constraints thus warranting precise systematic observations on the ecology and behaviour to evaluate their actual status.

The specific objectives of the present work on Little Cormorant and Night Herons are :-

1. To ascertain the food composition and food preference
2. To study the nesting and reproductive behaviour
3. To study the parental behaviour and nestling success
4. To study the human interference at the sanctury, cyclonic storms and management.

Table 1.1 : Known breeding / nesting sites of Little Cormorant in India

Name of the site	State	District	Source
Neelapattu	Andhra Pradesh	Nellore	Nagulu and Rao (1983)
Ethirapattu	Andhra Pradesh	Nellore	Ramakrishna (1990)
Southern Gulf Kutch Heronries	Gujarat	Jamanagar	Naik *et al* (1991)
Ranganathittu Bird Sanctuary	Karnataka	Mysore	Ali (1943); Sharatchandra (1990)
Gudvi Bird Sanctuary	Karnataka	Shimoga	Ragunatha (1993)
Keoladeo National Park	Rajasthan	Bharatpur	Ali (1952); Sankhala (1990)
Vedanthangal	Tamilnadu	Chengai-Anna	Baker (1935); Santharam & Menon (1991)
Chitrangudi Heronry	Tamilnadu	Ramanathapuram	Ragunatha (1993)
Vettangudi Patti	Tamilnadu	Ramanathapuram	Ragunatha (1993)
Raiganj Wild life Sanctuary	West Bengal	Uttar Dinajpur	Present study
Lakhimpur Swamp	Assam	Lakhimpur	Baker (1935)
Luna Village	Gujarat	Kuchchh	Thiwari (1993)
Pabitora Wildlife Sanctuary	Assam	Morigoan	Lahkar (1999)
Kolkata Zoological Garden	West Bengal	Kolkata	Baker (1929)
Adina Forest	West Bengal	Malda	Personal observation

Table : 1.2 : Known breeding / nesting sites of Night Heron in India

Name of the site	State	District	Source
Ranganathittu Bird Sanctuary	Karnataka	Mysore	Ali (1943) Neghinhal (1983)
Keoladeo National Park	Rajasthan	Bharatpur	Baker (1935) Ali (1953) Soni (1992)
Southern Gulf of Kutch Heron	Gujarat	Jamanagar	Naik *et al.* (1991)
Ghoga Town	Gujarat	Bhavnagar	Naik & Parasharya, (1987)
Gudvi Bird Sanctuary	Karnataka	Shimoga	Raghunatha (1993)
Bhitarkannika Wildlife Sanctuary	Orissa	Cuttack	Subramanya (1996)
Raiganj Wildlife Sanctuary	West Bengal	Uttar Dinajpur	Present study
Kolkata Zoological Garden	West Bengal	Kolkata	Baker (1929)
Adina Forest	West Bengal	Malda	Personal observation

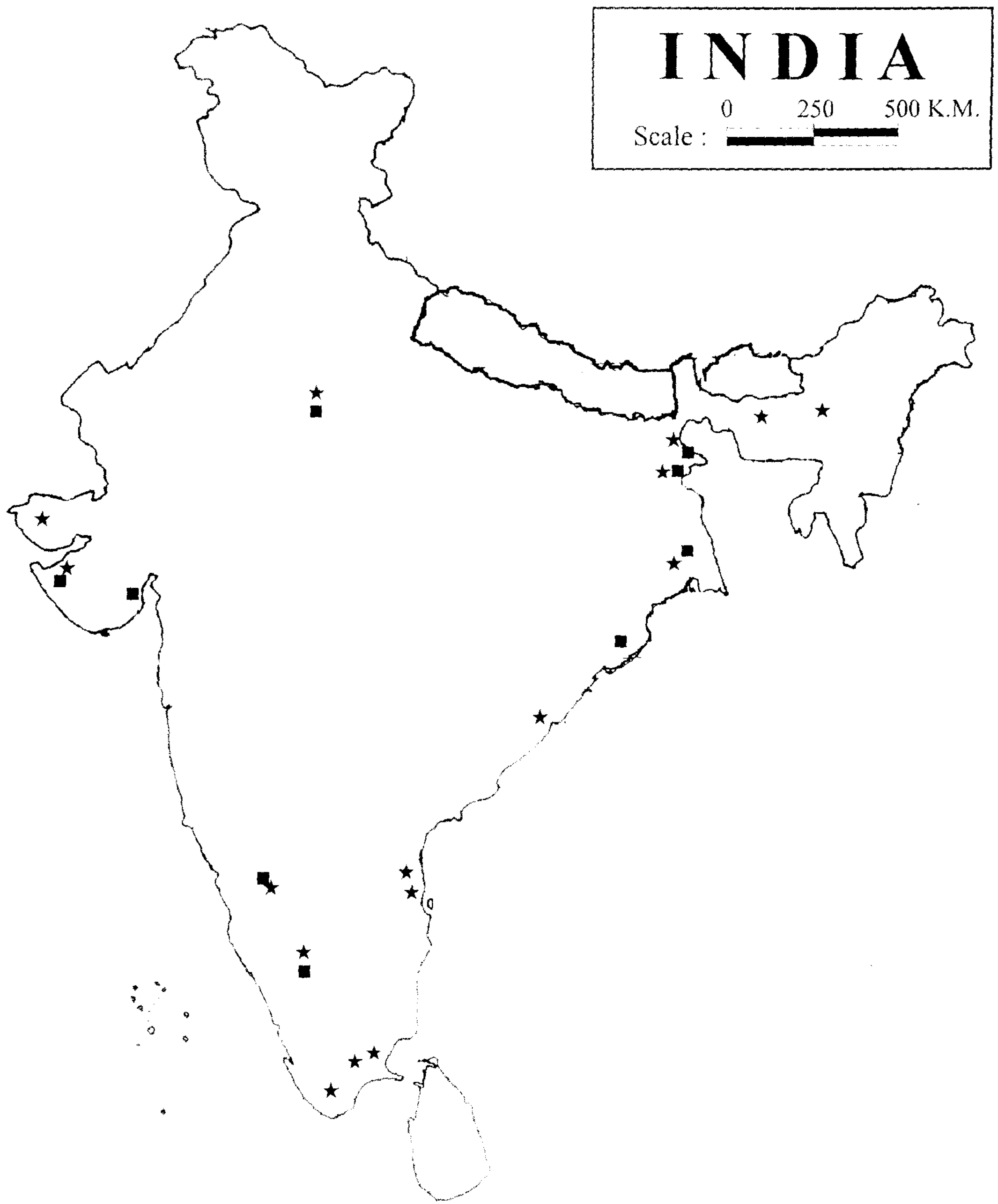


Fig. 1.1 Breeding colonies of Little Cormorant (★) and Night Heron (■) in India.

2. LITERATURE REVIEWED

Not much is known on the behavioural aspects of Little Cormorants and Night Herons, Mukherjee's (1975) works on Water-birds including Little Cormorant and Night Heron, Gross (1923), Noble, Wurm and Schmidt(1938), Maxwell and Putnam's (1968) work on Black-crowned Night Heron are noteworthy. Most other works on these species and its kins are rather patchy and stray observations. Report of this kind, however, are not few in number and despite lack of details their contribution in the present study is very important.

Information on Little Cormorants past and present distribution in India was gathered from the works of Baker (1929), Ali (1953), Ali and Ripley (1969), Naik *et al.* (1991), Ragunatha (1993), Subramanya (1996), Lahkar (1999).

Similarly information about Night Herons past and present distribution in India was gathered from the works of Baker (1935), Wolford *et al.* (1971), Ali and Ripley (1987), Raghunatha (1993), Subramanya (1996). Different aspects of morphology of Little Cormorant and Night Heron have been discussed by Baker (1929), Gill (1940), Ali and Ripley (1968), Ganguli (1975), Davis (1993), Mukherjee (1995).

Data on feeding of Little Cormorant are available from the studies of Lack (1945), Mukherjee (1975, 1995), Ali and Ripley (1987). Some information on feeding of Night Herons are available from the studies of Wetmore (1920), Gross (1923), Baker (1929), Ali and Ripley (1968), Mukherjee (1975), Hancock and Elliott (1978), Parasharya (1982), Davis (1993).

Only few components of breeding of Little Cormorant was discussed by Baker (1928), Ali and Ripley (1968). Kortlandt's (1995) works on breeding of large cormorant are, however, noteworthy. Breeding of Black-crowned Night Heron was discussed by Bailey (1915), Gross (1923), Baker (1929), Noble Wurm and Schmidt (1938), Noble and Wurm (1942), Ali and Ripley (1968), Custer *et al.* (1983), Soni (1992), Davis (1993), Schjorring *et al.* (2000). Particulars of nesting habitat and differents aspects of nesting of Little Cormorant have been discussed by Baker (1929), Ali and Ripley (1968), Ali (2002). Some aspects of Nesting habitat and different aspects of nesting of Night Herons have been discussed by Gross (1923), Baker (1929), Gill(1940), Ali and Ripley (1968), Ganguli (1975), Custer *et al.* (1983), Soni (1992), Davis (1993), Mukherjee (1995), Ali (2002) . Different aspects of egg, clutch and incubation of Little Cormorant and its kins are available from the works of Baker (1929), Ali and Ripley (1968), Barett (1986).

Some aspects of egg, clutch and incubation of Night Heron and its kin are available from the works of Gross (1923), Baker (1929), Gill (1940), Ali and Ripley (1968), Ganguli (1975), Braithwaite and Clayton (1976), Custer *et al.* (1983), Davis (1993), Ali (2002). Parental care and growth of young of Little Cormorant was discussed by Ali and Ripley (1968).

Aspects of parental care and growth of youngs of Night Heron has been discussed by Gross (1923), Ali and Ripley (1968), Parson and Burger (1981), Ali (2002). Other studies on Little Cormorant and Night Heron on different aspects of foraging and breeding of various Cormorant and Night Heron species of the world were made by Snow (1960), Custer *et al.* (1978), Watts (1988).

Some aspects of mating was also discussed for some other species of Cormorants by Potts *et al.* 1980 ; Boekelhelde and Ainley 1989 ; Kortlandt 1995 ; Bregnballe 1996 ; Schjorring *et al.*, 1999,2000 and on Night Herons by Braithwaite and Clayton, 1976 ; Hancock and Elliot, 1978, Chuan-Chiung ,2000.

3. STUDY AREA

3.1 LOCATION

The study was carried out at Raiganj Wildlife Sanctuary and its adjacent areas (Fig.3.1). Actually breeding biology and a part of feeding ecology was done at the sanctuary but data on foraging was mainly collected at different feeding grounds within 10 km. radius of the sanctuary. The sanctuary is located in the district of Uttar Dinajpur, 2 km. northwest of district town Raiganj and is 174 km. (by road) south of North Bengal University, Siliguri, West Bengal, India. National Highway No. 34 runs by its southern border and connects Raiganj and Siliguri. The sanctuary lies on the co-ordinates of 25 ^{0}37^{l} north Latitude and 88^{0} 08^{l} east longitude. Mean sea level (RL) is 32 meter. Location of Raiganj Wildlife Sanctuary in relation to West Bengal in shown in Fig 3.2, Fig 3.3.1. and Fig 3.3.2.

3.2 ESTABLISHMENT OF SANCTUARY

The sanctuary is under the Kulik Beat, Karandighi Forest Range, Raiganj Social Foresty Division. Though birds started to visit the sanctuary since 1962 it was only in the year 1971 when the first step was taken to protect the birds and record related information by the timely initiative of Mr. B.N.De, IFS, the then Conservator of Forests, Central Circle.

In order to consider the feasibility of creating a new bird sanctuary in and around Raiganj F.R.H. under Bhattadhighi and Soharoi Mouzas a resolution was taken by the Wildlife Board in its meeting on 23.08.1975 (agenda item no. 10 of the 6th meeting). The resolution was then forwarded to the DFO, Malda by the Chief Wildlife Warden (vide no. 3086/CWLW/2!-125 dt. 28.10.75). subsequently, a detailed report with maps was also submitted to the DFO, Malda in reference to his query (no. 1874/28-42 dt. 08.11.75).

Eventually an amount of Rs. 75,000/- was alloted to carry out preliminary works towards the establishment of the proposed sanctuary during the financial year of 1976-77. In this process at last, in 1985 the area around the nesting zone was declared as "Raiganj Wildlife Sanctuary" vide notification no. 1901-Fer/11B-88 dt 11.04.1985). Raiganj Wildlife Sanctuary is popularly known as "Kulik Bird Sanctuary".

3.3 AREA

The sanctuary covers an area of 321.23 acres. Actually this tiny reserved area was formed cumulating several vested and private land with the existing forest portion. Thus it developed from (i) Forest range (Soharoi 139.85 acres & Bhattadighi 171.41 acres) of 311.26 (ii) Vested land transformed on 27.01.1977 (Abdulghata 1.42 acres & Soharoi 0.24 acres) of 1.66 acres (iii) Private land by acquisition on 23.02.1977(Soharoi 6.13 acres, Bhattadighi 0.83 acres & Abdulghata 1.32 acres) of 8.28 acres, and (iv) Vested land transformed on 03.05.1977 (Abdulghata) of 0.03 acres. Out of this 321.23 acres the present nesting area spans over only about 36 acres comprising Plot nos.1077,1078,1079,1080,1158,1159,1202 & 1226 in Mouza Soharoi, J.L. No. 106.

It is also mentioned that proposal for acquisition of private land about 12.74 acre is sent to the Conservator of Forests, Social Forestry, North Circle, Siliguri (Memo No. 243/8-2 dt. 05.03.2004).

3.4 BOUNDARY DESCRIPTION

The river Kulik delimits its northern and eastern boundary. The NH-34 runs along its southern boundary and its western end is marked by the Eco-tourism Park and the farm of the State Sericulture Department.

3.5 METEOROLOGY

3.5.1 Seasons

The seasonal cycle of Raiganj is marked with three distnict seasons : the summer (March to May), prolonged monsoon (June to September) and the winter (Mid-November to February) ; punctuated with a short autumn (October to Mid-November) between monsoon and winter.

3.5.2 Rainfall

This area records a good amount of rainfall. Figure 3.4 presents the average monthly precipitation that were recorded at Model Seed Farm, Raiganj, 2 km. northeast of the sanctuary, during last 10 years (1997-2006). The average annual rainfall over this period was 2081.38 mm ; of which 78.83% precipitated during the monsoon. The pre-monsoon and post monsoon months i.e. May and October respectively also show a good amount of rainfall, 179.59 mm. and 141.59 mm. respectively.

3.5.3 Temperature

The average daily maximum and minimum temperature, recorded during the study period, are presented in Fig. 3.5. Temperature attains the culmination point in May (average ; max 33.50^0 C, min 22.87^0 C) and the lowest in January (average max 23.75^0 C, min 10.12^0 C). During this period the highest and lowest recorded temperature were 39^0 C (on 15th May,2004) and 4.7^0 C (on 23rd January,2003).

3.5.4 Relative Humidity

Relative humidity in this area is very high. The mean maximum relative humidity during the study period remained almost stable at an higher value with a slight decrease during the summer months (Fig.3.6). Whereas, the mean minimum relative humidity flunctuated at a greater extent throughout the year. Difference of maximum and minimum relative humidity attains the highest order in March(41.96%) which drops down to only 21.40% in September.

3.6 RIVER AND WATERBODIES

This sanctuary is placed in a curvature of the river Kulik(Kulik R.) which delimits the the northern and eastern boundary of the sanctuary. The Kulik R. also regulates the water condition of the sanctuary as it is connected directly or indirectly with canals and ditches which pass through the sanctuary (Fig. 3.1). During periods of heavy shower this river usually over flows and inundates a major portion of the sanctuary. Thus the sanctuary is on the flood plains of the Kulik R. During the study period flood struck the sanctuary on two occassions (1998,1999, 2002) with maximum manifestation during 1999 When even the highest land area of the sanctuary was under 0.3 m. in water and major parts were inundated by more than 1.0 meter deep water.

The main creek which is also the deepest runs through the heart of the sanctuary in a horse-shoe pattern. Except at its two tips the major portion of the creek is 2 m deep and water is retained throughout the year. This canal is indirectly connected with the Kulik R. through another perennial canal which runs through the northern part of the sanctuary in east-west direction. Apart from these two main canals and some other canals and ditches boarders the southern extremity of the sanctuary (Fig 3.1). Though these canals and ditches become confluent with the Kulik R. during monsoon the northern and southern canals become connected by another canal which persist only upto November. Water-logging during monsoon is a common feature of the western part of the sanctuary as it is a low land with some waterholes. All these canals and ditches serve as a handy source of water and fish to the birds of the sanctuary throughout their breeding season.

3.7 GEOLOGY

This region is a part of the great alluvial plain of India which originally was a fore-deep between the peninsula (i.e. the Decan) and the Himalayas. This depression gradually converted into the plains by the process of alluviation. The deposition of this alluvium commenced after the final phase of Siwaliks and has continued all through the Pleistocene upto the present.

3.8 SOIL

The soil of Raiganj Wildlife Sanctuary is mostly loamy type with colour varying from yellowish-grey to grey. This small area is unique in its highly varied nature of soil which may be a function of differential deposition of faeces of birds. Soil is highly acidic in nature and in some cases acidity is of very much high degree. High concentration of phosphorus and low concentration of potassium are two other characteristic soil features of this area. The results analysis of soil samples taken from 5 spots of the sanctuary is presented in Table 3.1.

In general the gangetic riverine soil of the region outside the sanctuary is rich in calcium and bases and vary from sandy, loam or silty clay which is acidic in nature in most cases.

3.9 VEGETATION

The Vegetation in part is an outcome of the 1955 plantation programme.Thus instead of any particular forest type, here we find a mosaic of different types of vegetation. Some of the local tree species grow here in close association with many other species which are rather uncommon to this region. On the whole it forms a tropical semievergreen type of forest. The tree species which are common to this sanctuary are shown in Table 3.2. There are 30 major tree species of which three species viz. Jarul, Hijal and Arjun are predominant (36.7%, 17.2% & 11.8% respectively).

3.10 FAUNA

Due to its small size and because it is a plantation forest a large variety of wildlife is not expected to thrive here. A number of reptiles, birds and mammals, which are in general common in this region and found in the sanctuary. Most of these animals are visitors.

3.10.1 Terrestrial Animals

Reptiles : The Bengal monitor , *Varanus bengalensis* (Daudin), which is also a good swimmer, is the most common reptile of the sanctuary. Among snakes Indian rat snake, *Ptyas korras* (Schlegel) and Indian Cobra, *Naja naja* (Linn), snake, *Enhydris enhydris* are common.

Birds : Almost all the bird species which are common to this region were found to this sanctuary from time to time. However, the four other nesting bird species which breed almost at the same time with the Little Cormorant and Night Heron are Open-bill stork, *Anastomus oscitans* (Boddaert) ; Large egret, *Egretta alba* (Linnaeus), Median egret, *Egretta intermedia* (Linnaeus), Little egret, *Egretta garzetta* (Linnaeus). Recently a small population of Indian Pond Heron (*Ardeola grayii*) is also found to nest in the sanctuary.

Mammals : Only three non-domestic mammals i.e. Indian Gray Mongoose, *(Herpestes edwardsi* Geoffroy), the Bengal Fox (*Vulpes bengalensis*) and Jungle Cat (*Felis chaus*) are found here but their number is limited.

3.10.2 Aquatic Animals

Though the canals and ditches are small and shallow at most parts they support a good number of molluscs and fishes which are as follows:

Molluscs : *Bellamya bengalensis, B. dissimilis* and *Dymnea luteola*

Fishes : *Channa punctatus, C. gachua, Ophicephalus punctatus, Labeo rohita, L. bata, Catla catla, Cirrhinus mrigala, Puntius ticto, Belone cancila,Rhynchobdella aculeata, Mastocembelus armatus, Heteropneustes fossilis, Anabas testudins , Clarias batrachus, Colisa lalius, Mystus vittatus*, *Paleomon sp.*, and *Wallago attu.*

Table 3.1 : Soil characteristics of different regions of Raiganj Wildlife Sanctuary

Sl. No.	Sample Collection Spot	Month of Year	Parameters			
			Org. Carbon %	P^H	Ec.mmho / cm^2	Ave. P_2O_5 Kg/ha
1.	Low area of island under nesting tree. No herbs or any other plants present.	April	0.97 (H)	5.0 (SA)	0.74 (N)	665 (VH)
		December	0.85 (H)	4.4 (A)	0.68 (V)	388 (H)
2.	High area of island nesting tree. No herbs or any other plants present.	April	0.60 (M)	5.3 (SA)	0.56 (N)	609 (VH)
		December	0.59 (M)	4.7 (A)	0.80 (V)	280 (H)
3.	Low area of Island under nesting tree. Few herbs are present.	April	1.05 (VH)	5.4 (SA)	0.60 (N)	171 (VH)
		December	0.85 (H)	4.5 (A)	0.62 (V)	440 (H)
4.	Middle area between two nesting trees where some herbs are present.	April	1.35 (VH)	6.7 (N)	0.46 (N)	>1000 (VH)
		December	0.65 (M)	4.7 (A)	0.28 (V)	350 (H)
5.	Near Rest House outside island where plants are present.	April	0.60 (M)	6.3 (SA)	0.04 (N)	119 (VH)
		December	0.42 (L)	7.0 (N)	0.13 (V)	122 (H)

H = High, VH = Very High, N = Normal, SA = Slightly Acidic, M = Medium, L = Low

Table 3.2 : Tree species of the sanctuary

Sl No.	Common name of the trees	Scientific Name
1	Jarul	*Lagerstroemia flosregnae*
2	Hijal	*Barringtonia acutangula*
3	Arjun	*Terminalia arjuna*
4	Chitim	*Alstonia scholaris*
5	Sisso	*Dalbergia sissoo*
6	Kadam	*Anthocephalus cadamba*
7	Pithali	*Treuia nudiflora*
8	Eucalyptus	*Eucalyptus globulus*
9	Tunt	*Morus alba*
10	Gokul	*Ailanthus grandis*
11	Dumur	*Ficus cunia*
12	Sirish	*Albizzia lebbek*
13	Simul	*Bombax malabaricum*
14	Sal	*Sorea robusta*
15	Aswatha	*Ficus reliqiosa*
16	Jackfruit	*Artocarpus intergrifolia*
17	Nim	*Azadirachta Indica*
18	Coconut	*Cocos nucifera*
19	Mehogony	*Swietenia mehogoni*
20	Banian	*Ficus bengalensis*
21	Bamboo	*Bamboosa sp.*
22	Sheora	*Streblus asper*
23	Jigni	*Lannea caromandelica*
24	Akashmoni	*Acacia moriliformis*
25	Subabul	*Leucina leucocephala*
26	Lichu	*Litchi chinensis*
27	Bakul	*Mimosops elengi*
28	Karanj	*Pongamia pinnata*
29	Guava	*Pisidium guajava*
30	Amlaki	*Emblica officinalis*

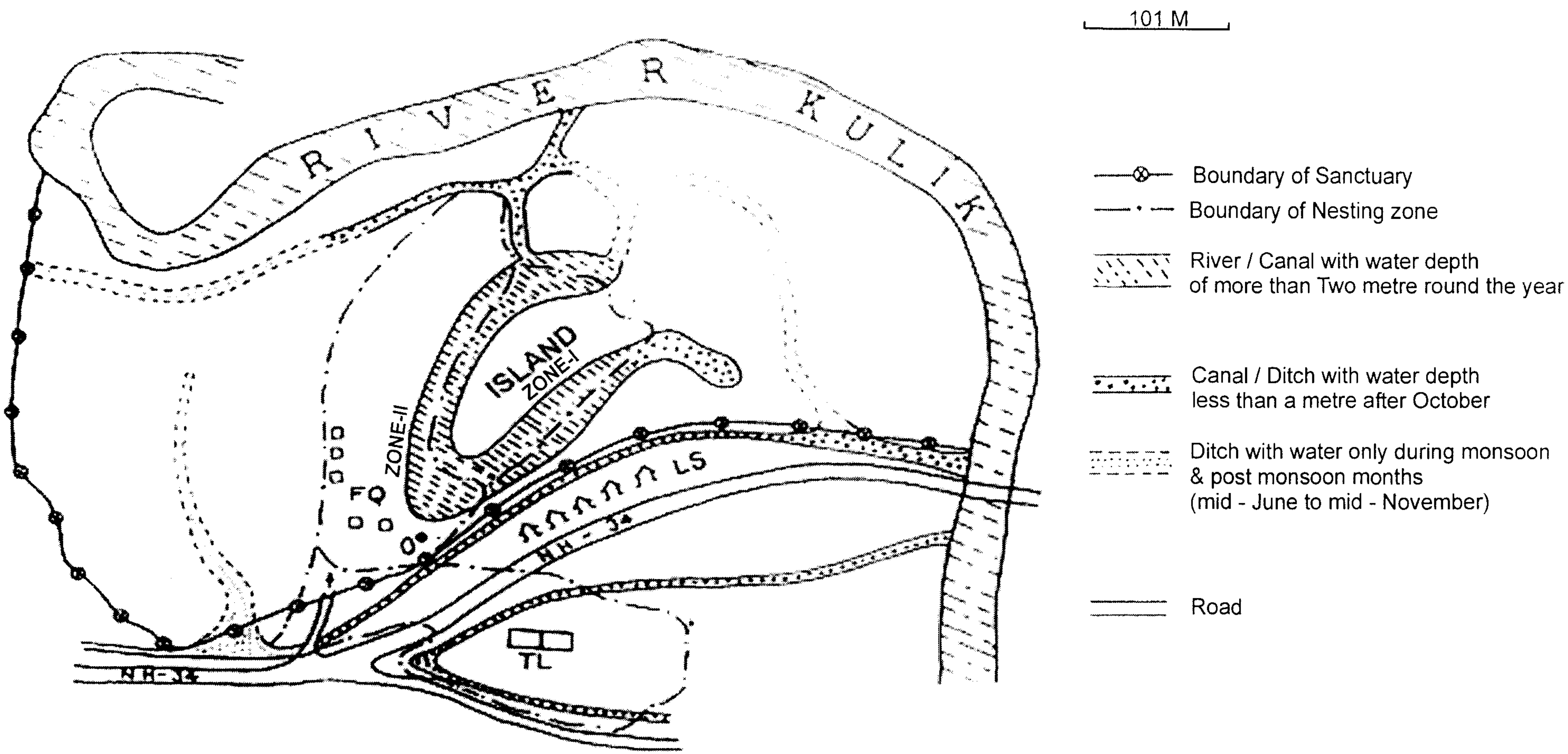


Fig. 3.1 : Map showing boundary and waterbodies of Raiganj Wildlife Sanctuary

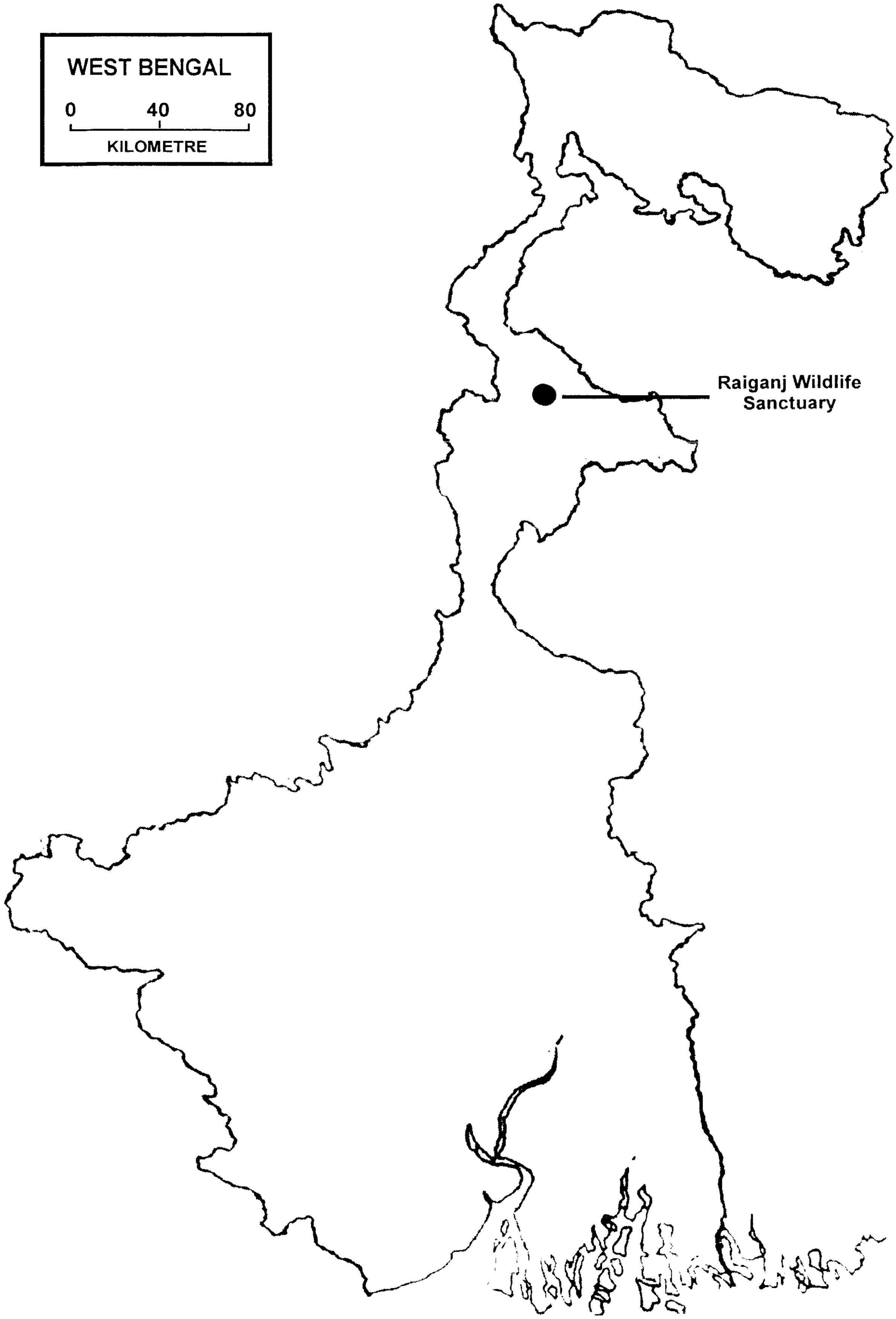
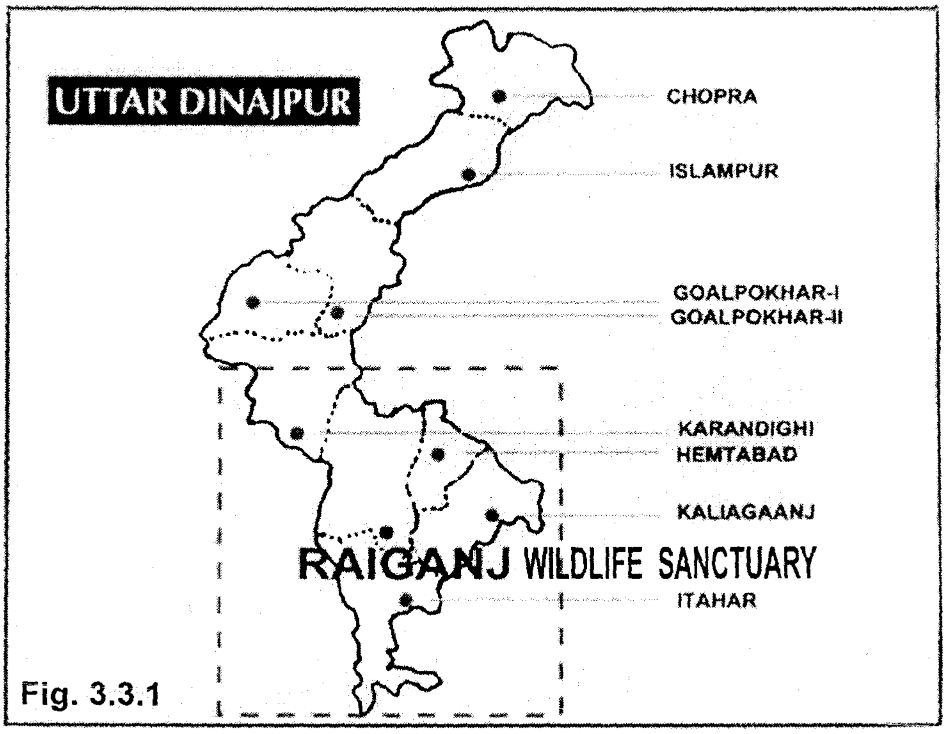


Fig. 3.2 : Location of Raiganj Wildlife Sanctuary in relation to West Bengal



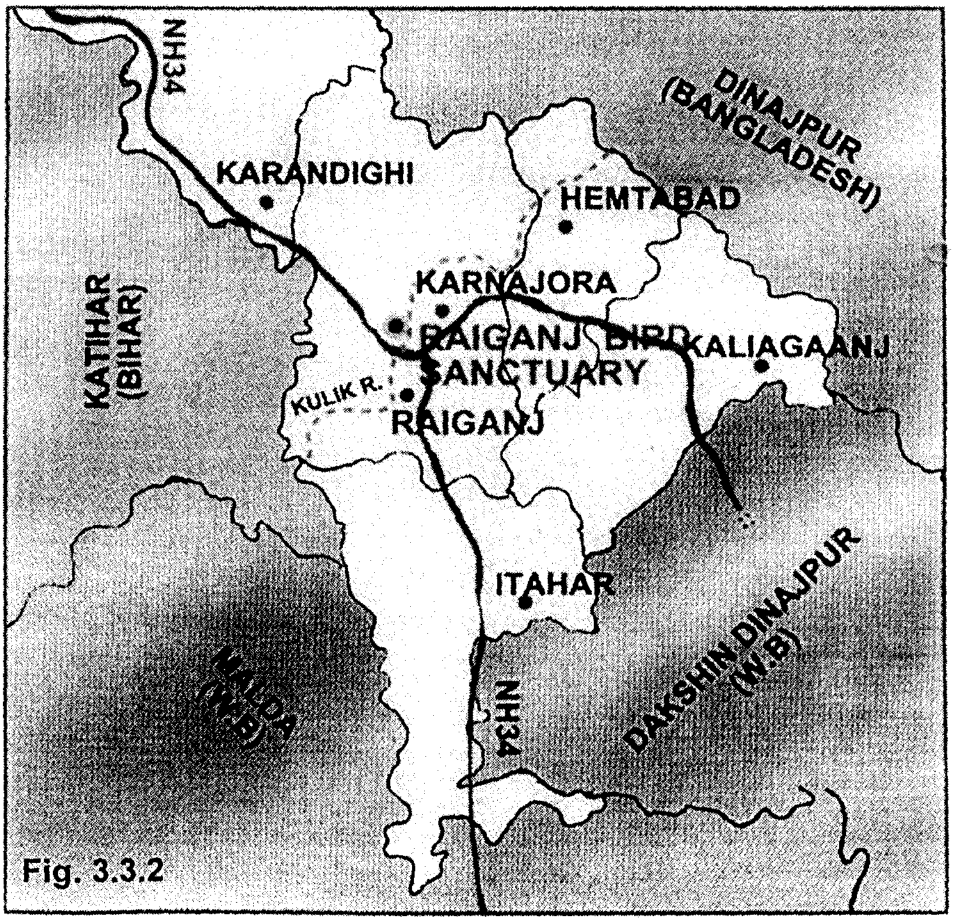


Fig. 3.3.1 and Fig. 3.3.2 : Map showing Raiganj Wildlife Sanctuary in Uttar Dinajpur

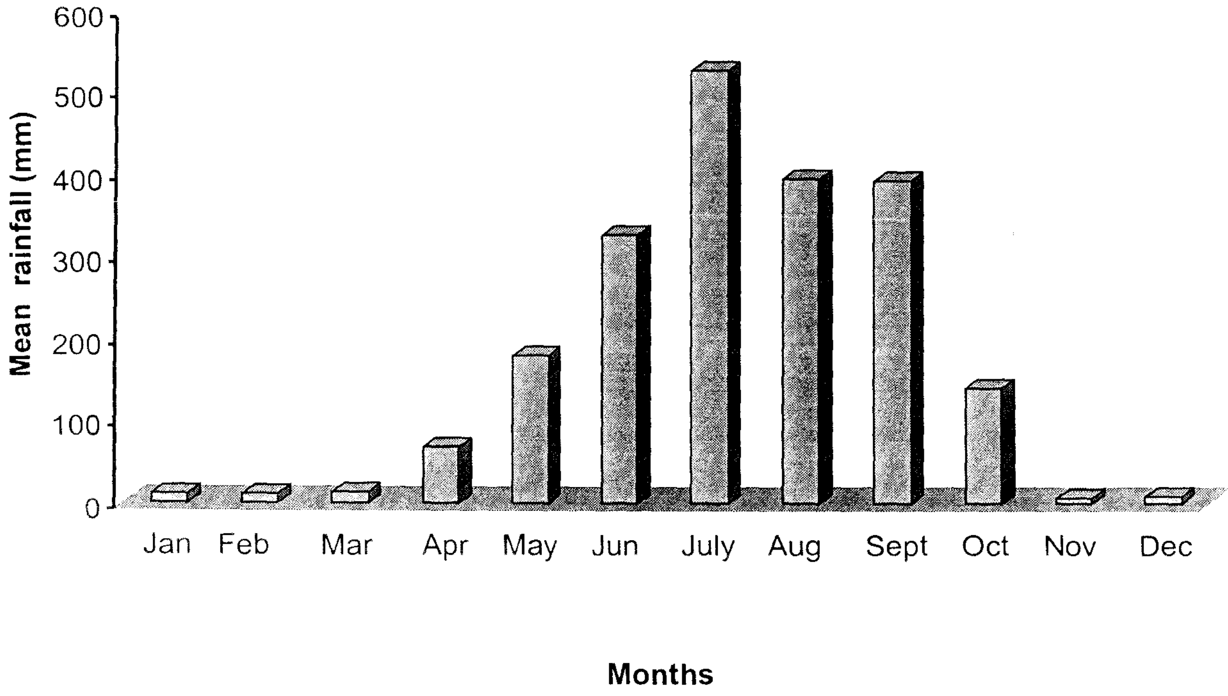


Fig. 3.4 Mean monthly rainfall.

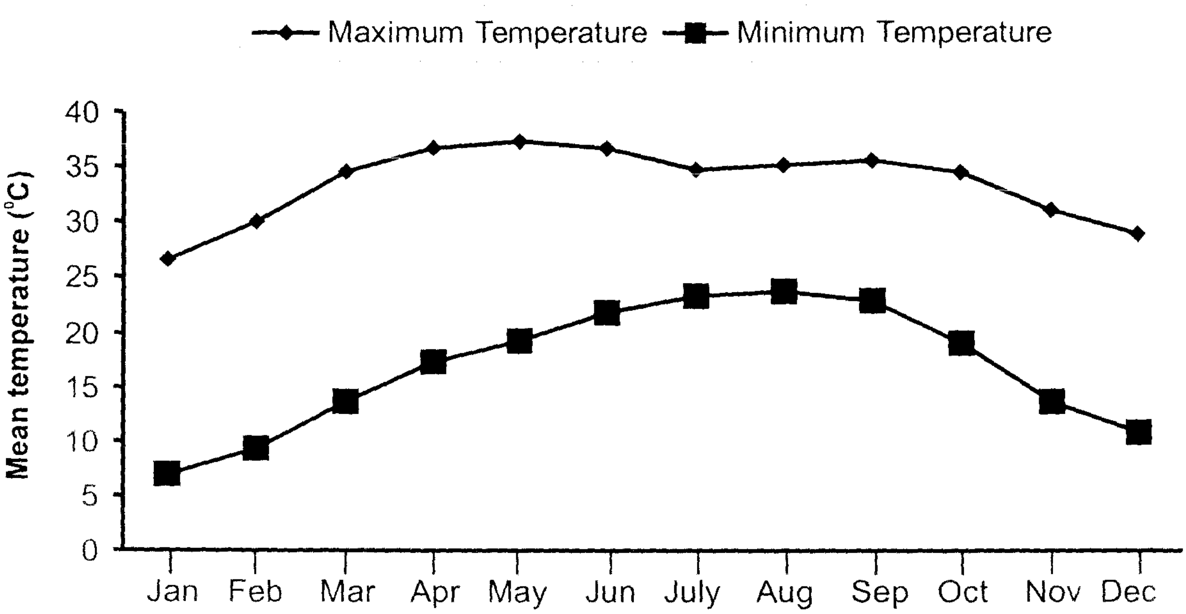


Fig. 3.5 Mean monthly minimum and maximum temperature

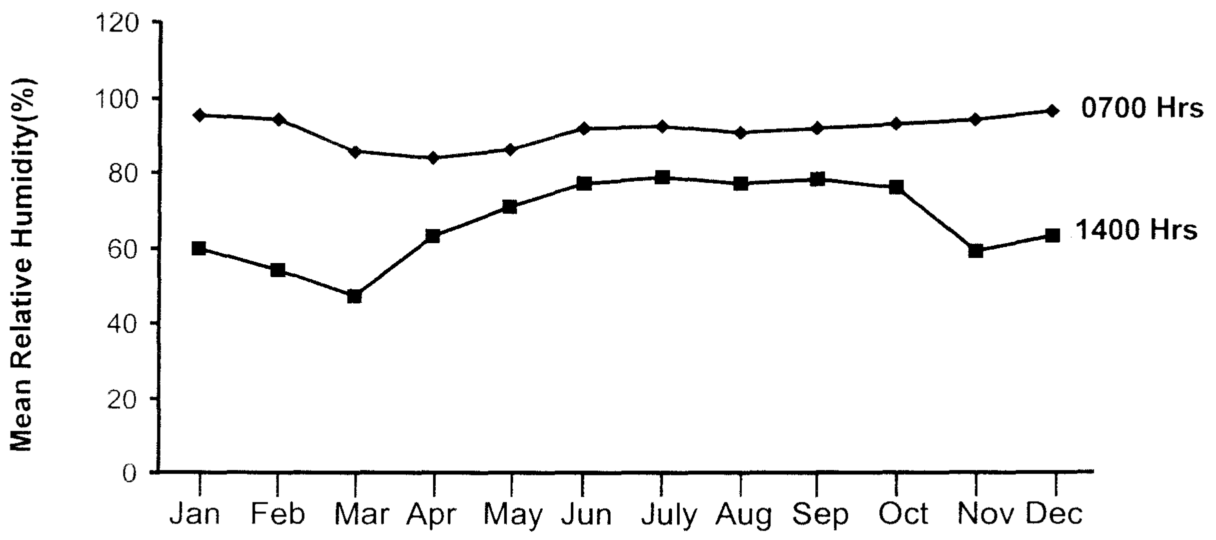


Fig. 3.6 Mean monthly relative humidity at 0700 hr and 1400 hr.

Plate 3.1

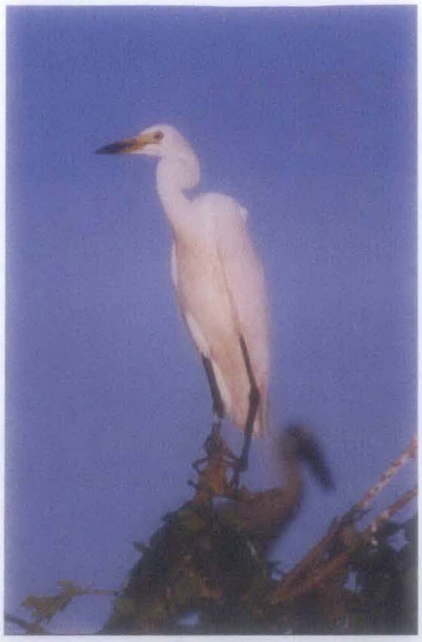
Tongue- shaped island, Zone-1 of the nesting area surrounded by canals in the sanctuary.

Plate 3.2

A Bengal Monitor resting in the sanctuary

Plate 3.3

Open-bill Storks the most dominant species in the sanctuary both in size and number.



(A)
Large Egret perched on the top canopy of a Jarul tree.

(B)
Medium Egret displaying its beautiful white ornamental feathers.

(C)
Little Egret attending its nestling comfortably resting in the nest.

Plate 3.4 (A,B,C) White Egrets in the sanctuary

Plate : 3.5 Birds in the island (Zone 1) of the sanctuary

Plate : 3.6 Bare soil (without any plant) under a nesting tree because of its highly acidic nature caused by the liquid defecates containing nitrogenous wastes excreted by the adult and nestlings.

4. GENERAL METHODS FOR OBSERVATION

4.1 INTRODUCTION

Study of animal behaviour in the wild requires patient observation from suitable spots with minimum interfence to animal life. Ethological approach demands study of animal behaviour in natural conditions in one hand and experimental study on the other. The investigator collects data on basic facts which can be tested by experiments and as a result the facts and theories obtained become more precise and accurate (Scott,1958). Thus modern behavioural study attains a special height with proper integration of observation of animal behaviour in natural habitats and the application of evolutionary theory to this behaviour with simple experiments which can be carried out in the field. Nevertheless, many questions about behaviour may be answered through simple but precise careful observations without experimental interferences. So, the most important thing in the study of behaviour is to record data systematically and precisely. Though technical innovations like microprocessors, portable tape recorders, digital camera, radiotransmitters, etc. Precision still appears to be a function of researcher's patience, devotion and intelligent resolution. It is possible to attain considerable accuracy with the aid of less sophisticated instruments like binocular, still-camera, stop-watch, etc. It is often necessary to correlate the observed behavioural data to time of the day, season, temperature, railfall, humidity and other environmental variables which need to be measured with precision instruments.

In order to record behaviour systematically two basic sampling procedures viz. 'instantaneous sampling' and 'continuous sampling' were followed. The details of these methods are described in specific section.

4.2 SELECTION OF THE STUDY AREA

Little Cormorants and Night Herons are common water birds in India and are found near waterbodies in many parts of the plains of West Bengal. Besides a few smaller breeding populations in parts of the District Dakshin Dinajpur, Malda, Murshidabad, Coochbehar and Kolkata Zooligical Garden; Little Cormorants and Night Herons mostly breed in large breeding colony at the Raiganj Wildlife Sanctuary.

Although the Raiganj Wildlife Sanctuary encompasses a rather small area, in the course of a little more than several decades it has established itself as a successful breeding ground of these populations. The main reasons which determined selection of the sanctuary as the study site are :

(i) **The richness of breeding population**

Both the number of breeding Little Cormorants and Night Herons and number of other breeding waders are quite high in the sanctuary. This colony provides one of the largest congregations of waterbirds in the world.

(ii) **Stability**

The steady yearly turnover indicates its stability which reflects the richness of natural resources of this area.

(iii) **Easy accessibility**

It is easily accessible, particularly in comparison to the other areas of West Bengal. The huge feeding ground around the sanctuary further makes observation easier particularly on foraging.

(iv) **Diversity**

Within its small span this sanctuary exhibits considerable diversity in physical structure and vegetative physiognomy.

4.3 STUDY PERIOD

The present study was conducted in the field for about eleven years from June 1996 to December 2005. It covers a total of 7920 bird hours. In each month the study was interrupted for a period of 5 to 7 days for consultation and other such purposes at the department. Number of hours/day that could be employed to observations varried at different periods during the course of eleven years study due to obvious reasons. Occasionally the help of field assistant was utilized.

4.4 DAILY OBSERVATION SCHEDULE

Observations were made in all hours of a day. However, daily routine observations was divided in two main shifts, i.e. the morning shift (0600 to 1000 hrs.) and the afternoon shifts (1600 to 1830 hrs.), when the birds were more active. Attempts were taken so as to maintain an equitable distribution of observation hours at various parts of the day. Besides one day-long observation was taken in a week. Though it was the basic pattern, departure from this pattern was frequent and observations were made at any hours of the day whenever feasible. 16 wholenight observations (2100 to 0530 hrs.) were also made during the fullmoons in the months of May-June. Observations on foraging was made solely during day time during the nesting phase following the same schedule.

4.5 MODE OF OBSERVATION

General movements of the birds were recorded mostly from two types of observation spots the elevated spots and ground spots. The first category included a 10 m high bamboo 'Machan' suitably built in the island, another bamboo 'Machan' (platform on a tree) built on a tall tree in the island, a 11m high observatory in the Sanctuary, roof-tops of the rest house and Forest office and from adjacent trees without nests. Of the four ground spots one is situated in the island and three were on the side of the canal. At the start of the season the birds were apprehensive of the observer (myself) but with the advancement of the season birds become havituated to my presence. Data were, however, recorded only on resumption of normal behaviour of the birds in all cases. Besides this general schedule of observation nest inspections were also made for various purposes with a higher frequency during the later part of the breeding season. Efforts were taken to complete inspection as quickly as possible in a way so as to make negligible disturbance to the birds and nestlings. Details of these observations will be discussed later in specific chapters.

Observations on foraging were made from ground sports. Sometimes a paddle boat and country boats were used to get closer of the birds. Most of the observations were made from a distance of 20 to 40m. Recording data from a distance of more than 60m was avoided.

4.6 EQUIPMENT USED

Observations were made with the aid of field binoculars (SAMSUNG, 7-15 x 35 with Zoom). Photographs were taken with a still camera (Olympus 700xB, Lens : 38-70 mm. f 5.6/9.6), and a digital camera Coloplix(6.2 mega pixel), Hong Kong, Japan. Some of the behaviour patterns were recorded with a movie camera which were analysed at later a period in Computer Monitor or TV Screen. Stopwatch (GEM License, Hanhert, West Germany) was used to record time. Slide Calipers, spring balance and a plastic scale were used to measure various parameters of eggs, youngs and adults. Tree heights and Nest heights were taken by a 50m cloth measuring tape and stick meter. A powerful sprayer was used to spray colour to mark the birds.

For capturing birds a nylon net was used. Thirty four adults of Little Cormorant and forty adults of Night Heron and two hundred hatchlings of each species were indicidually marked with locally made engraved leg bands. A paddle boat is used to enter into the island (Zone 1) of the sanctuary.

4.7 METHODS IN RECORDING BEHAVIOUR

Observational data were tabulated in the data sheets prepared separately for different behaviour patterns and where necessary, for specific individual or pair. When previously prepared data sheets were not appropriate for some actual situations, recordings were made on a separate note-book simply pointing major events which were analysed in details immediately after the study period . In the field, note-books were also used to account descriptive aspects of quantitative data recorded in data-sheets which were checked on return to the camp. Occassionally a combination of these basic methods were used as required under specific situation.

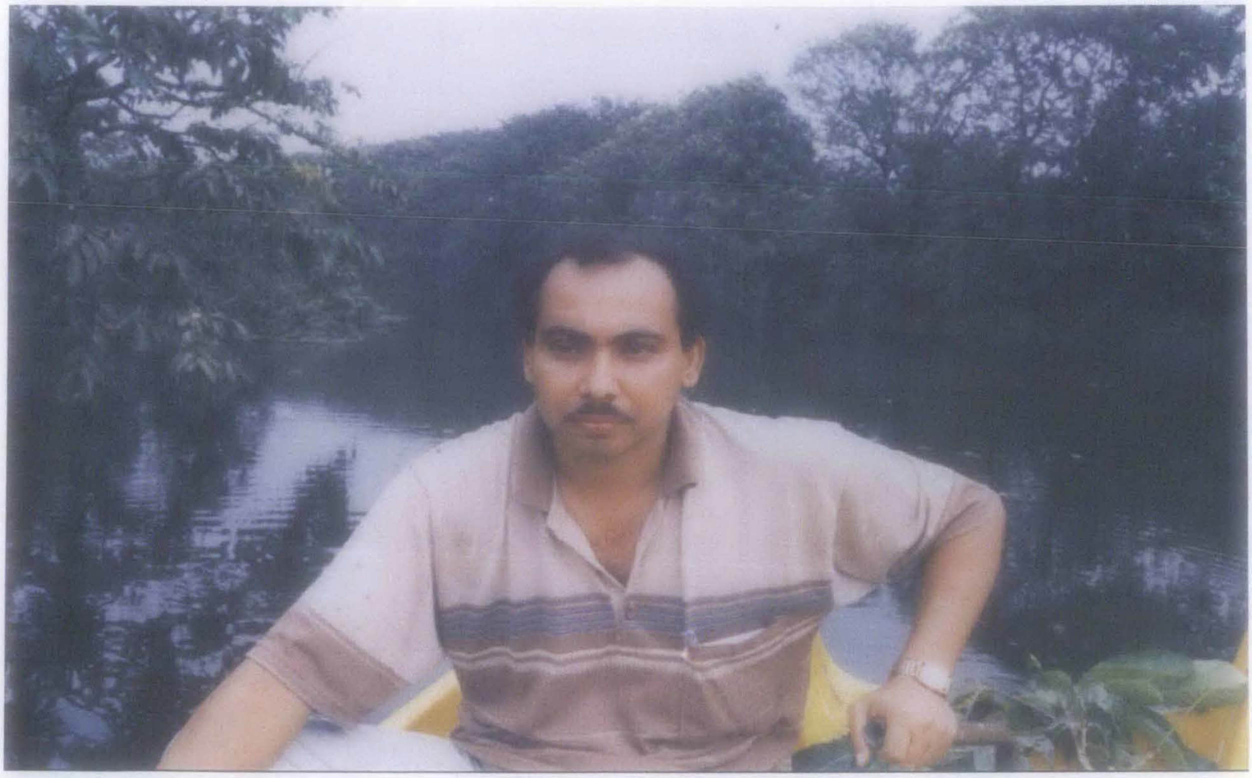


Plate 4.1 The author proceeding to the island, Zone-1 of the nesting area in the sanctuary in a paddle boat.

5. PHYSICAL FEATURES

5.1 INTRODUCTION :

To account behaviour patterns from a biological point of view and to analyse their significance it is necessary to evaluate particular trait from various considerations such as : age, sex, prior experience and many other parameters. While many animals including birds exhibit clear cut sexual dimorphism, many others are monomorphic. It is a difficult problem to detect sex of a monomorphic bird in the field. Though banding and different other types of marking make the problem a little bit easier ; large scale observation in the field always demands some morphological differentiating cues to distinguish different age and sex classes.

Though Baker (1929); Ali and Ripley (1968) highlighted some of the physical features of Little Cormorants and Night Herons not much is mentioned about useful age and sex differentiation characterristics of these species. In this chapter I have endeavoured to discuss some of the features of different age-sex classes of the species'.

5.2 METHODS :

Every year adults captured by net and nestlings prior to fledging were banded after measuring different physical parameters. On recapturing in subsequent years their physical parameters were measured again colour patterns, gap between bills, some specific behaviour etc. were used to determine the age structure of unmarked birds. A number of birds were colour marked with textile dyes and status of these marked birds were detected secondarily from their physical and behavioural characteristics. For each of these colour marked birds a identify card was maintained where the specific marking pattern was sketched for future identification. However, this second method is less precise and is operative for only one season.

5.3 RESULTS AND DISCUSSIONS

5.3.1 Age

It is not possible to detect the actual age of an individual bird with certainty unless marking is made prior to fledging. Although in some bird species it is possible to correlate different physical features with the age of the individual, no such procedures, are available for these species. For convenience three main divisions were recognised on the basis of age : fledgling, yearling and adult. Here I am furnishing some of the morphological distinctions of these three age classes which are easily detectable in the field.

5.3.2 Morphological features

5.3.2.1 Morphological features of Little Cormorant

5.3.2.1.1 Adult

Breeding Plumage

Black overall with (Bluish or greenish sheen) deep blue or blue-green gloss ; scapulars, inner secondaries, wing coverts, except the least, dark silvery grey with black edges. A short crest on occipit and nape and a few scattered silky white feathers and plumes on the fore-crown and sides of the head and neck.

Non-breeding plumage

Crest and white feathers in the head disappear and throat becomes white.

Bare Parts

Iris : Green

Orbital skin and gular skin : Black in the non-breeding season. Purple in the breeding season.

Bill : Stout horny-brown, blackish at the tip and livid purple at the bare. Compressed bill sharply hooked at the tip.

Legs : Legs and feet blackish, tinged with purple flesh-colour at breeding season.

5.3.2.1.2 Fledgling

Plumage : Neck is deep black, wings are with metallic black and fore-head brown in colour.

Bare Parts

Iris : Black

Orbital skin and naked lores : Light brown

Bill : Light brown upper bill scalloped with black at certain spots. Lower bill brown.

Legs : Black

5.3.2.1.3 Yearling

Plumage

Neck is deep black. Breast is also black. Wings are black with brownish sheen. The back with paler scalloping. Tail light black. Throat and abdomen paler. Only center of abdomen is white. Feathers of flanks and breast fringed with brownish white.

Bare Parts

Iris : Light brown scalloped with whitish

Orbital skin and naked lores : Light brown or fleshy with line upto eye on both sides.

Bill : Upper bill is brown with blackish base, lower portion of lower bill is whitish but upper portion is black.

Legs : Black with lighten edges.

5.3.2.2 Morphological features of Night Herons

5.3.2.2.1 Adult

Plumage : Crown, nape and crest, back and scapulars black glossed with green : above the lores, forehead and supercilium white ; two or three very long, narrow pure white feathers from the nape ; chin, throat, fore-neck, centre of breast, abdomen and under tail-coverts white ; reminder of plumage pale ashy vinous-grey, palest on the neck, darkest on the wing-quills and tail.

Bare Parts

Iris : Blood red

Orbital skin and naked lores : Yellowish green

Bill : Horny bill has arching mandible and narrow gap between the two bills. Tip portion of upper bill is acutely curved. During breeding season upper bill is black with greenish black at base and lower portion of lower beak is redish.

Legs : Legs and feet dull green. During the breeding season legs and feet lemon-yelow, (slight redish yellow) or orange red.

5.3.2.2.2. Fledglings

Plumage : Dorsal body is brownish black with deep brown spots. Below slightly whitish at the abdomen. Head with brownish black and white threads extended from each plumage. Neck portion with brownish spots. Brown chest and belly streaked with buff and white. Tails are brownish black with slight brown sports at the end of the tail feather. Wings and back darker brown with less extensive white spots on upper wings and a dark cap.

Bare parts

Iris : Yellow or Amber

Orbital skin and naked lores : Blakish with reddish brown.

Bill : Upper beak is redish brown. Lower beak is brownish. Yellow at the base. Tip of the upper beak is slightly curved and hoocked.

Legs : Dull greyish with greenish yellow prominant claw.

5.3.2.2.3. Yearlings

Plumage : Down sparse, crown with stiff and erect ; down absent from parts of head, hind-neck and belly ; down reddish-brown above, white on thighs.

Bare Parts

Iris_: Greyish or golden yellow

Bill : Greyish

Legs : Legs and feet greyish-green.

Apart from these rather easily recognizable morphological features the age-groups also differ in measurements of some external body parts and weight. Though range of some of the measurements overlap to some extent, particularly among yearlings and adults ; some other characteristics such as body and bill length differ significantly in all three groups (Table 5.1 and 5.2).

5.3.3 Sex

Sexes are alike in both the species. Distinctive morphological features seem to be absent. In general males appear bigger than the females (Coulter *et al.*, 1989). Besides body size some other external parts such as the length of the body, bill, wings, tarsus and tail are larger in males than the females (Table 5.3 and 5.4). However, no attempt was made to sex the birds depending on external morphology.

The age-group differentiation on the basis of morphological characteristics are more easier and effective than dimorphic characteristics. However, the age-group characteristics also has some obvious limitations as it lacks data for the different age classes of adults and presents only a generalised feature.

In general the external differences between the sexes is indeed very marginal. However, in some cases, particularly at the later part of season, larger females have been found to mate with smaller males. Probably these were the deserted females who mated with younger males. Despite these shortcomings body size, bill characteristic indices along with behavioural features are more effective in practice than any other cues.

Table 5.1 : Measurements of different physical parameters in three age classes of Little Cormorants

Physical Parameters	Fledgling	Yearling	Adult
Body weight (gm)	498 (490-515)	580 (560-595)	640 (620-700)
Body length (cm)	38 (34-41)	47 (42-53)	62 (55-70)
Bill length (mm)	36 (32-42)	49 (45-54)	57 (55-64)
Wing length (mm)	190 (180-200)	210 (195-220)	221 (215-228)
Tarsus length (mm)	35 (30-38)	41 (40-43)	47 (45-50)
Tail length (mm)	80 (75-84)	99.5 (98-102)	139 (133-146)

The figure in parentheses indicate range

Table 5.2 : Measurements of different physical parameters in three age classes of Night Herons

Physical Parameters	Fledgling	Yearling	Adult
Body weight (gm)	470 (452-484)	510 (485-530)	725 (625-900)
Body length (cm)	41 (38-43)	47 (44-51)	62 (52-72)
Bill length (mm)	53 (50-57)	62 (60-66)	72 (67-80)
Wing length (mm)	256 (250-276)	283 (280-298)	304 (298-320)
Tarsus length (mm)	59 (54-62)	65 (60-70)	81 (75-85)
Tail length (mm)	45 (40-51)	75 (70-82)	100 (96-115)

The figure in parentheses indicate range

Table 5.3 : Measurements of different physical parameter in adult male and female of Little Cormorant

Physical Parameters	Male	Female
Body weight (gm)	652.34 (590-680)[a]	620.62 (570-650)
Body length (cm)	58.2 (52.0-65.0)	52.8 (48-60)
Bill length (mm)	47 (41-51)	38.5 (35-42)
Wing length (mm)	212 (195-220)	195 (187-210)
Tarsus length (mm)	45 (43-48)	42 (37.5-44)
Tail length (mm)	143.8 (139-147)	136.7 (133-138.5)

a = Range of the parameter in parenthesis

Table 5.4 : Measurements of different physical parameters in adult male and female of Night Heron

Physical Parameters	Male	Female
Body weight (gm)	720 (690-745)[a]	650 (625-680)
Body length (gm)	65.8 (61-72)	58.7 (52-62.3)
Bill length (mm)	74 (67-80)	68 (63-75)
Wing length (mm)	298 (290-320)	292 (280-305)
Tarsus length (mm)	81.3 (75-90)	76.2 (74-80)
Tail length (mm)	106.5 (100-112)	99.4 (94-105)

a = Range of the parameter in parenthesis

Plate 5.1 An adult Little Cormorant with open bill perching on a branch of Jarul tree

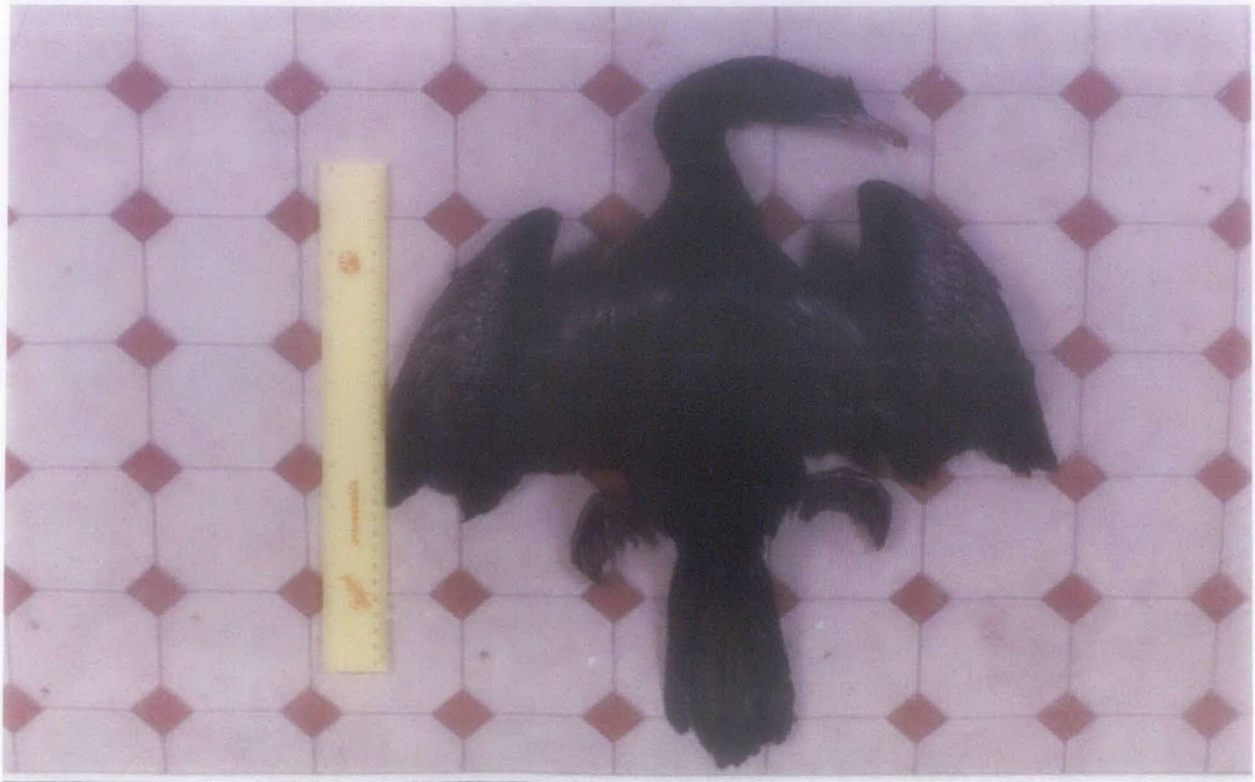


Plate 5.2 Measurement of body length of a Little Cormorant

Plate 5.3 Measurement of bill length of a Little Cormorant

Plate 5.4
Measurement of tail feather of a Little Cormorant

Plate 5.5 An adult Night Heron with splendid plume on the crown

6. ECOLOGICAL AND BEHAVIOURAL ASPECTS OF FOOD AND FEEDING OF LITTLE CORMORANT (*PHALACROCORAX NIGER*) AND NIGHT HERON (*NYCTICORAX NYCTICORAX*)

6.1 INTRODUCTION

Food and foraging behaviour is one of the most important aspects in the life of an animal. Mac Arthur and Pianka (1966) introduced a model on "Optimal foraging theory", in essence it states that animals conciously or unconciously endeaviour to maximize net energy gain per unit feeding time. However, net energy gain is not the only issue associated with foraging pattern or foraging strategy. Animals may choose to take less energy food items leaving high energy food items aside because of palatability of the item concerned. Foraging behaviour of animals is heavily influenced by season, prey-density and conflicting demands (Cerri and Fraser, 1983) from other behavioural activities such as aggression(Medeiros *et al*,2000), reproduction (Krebs, 1978 ; Nur, 1987), parental and so on. For example, it may be stated that most parent birds get little to eat for themselves during the parental phase when they are busy feeding the nestlings almost throughout the day. Thus time invested on feeding behaviour also varies depending on various other requirements in avian life.

Again, various authors such as Darling (1938); Fisher (1954) ; Crook (1965); Lack (1968) observed that birds which feed in flocks and breed in colonies greatly benefit in locating food sources and in reducing risk of predation (Gadgil and Ali, 1974). Roosts and breeding colonies may act as "information centers", wherein unsuccessful birds follow successful ones to better feeding sites (Ward and Zahavi, 1973 ; Krebs 1974). In this connection it may be stated that multispecies prey complexes often are exceedingly profitable. When these complexes are associated with particular easily locatable microhabitat such as ponds, pools and puddles and partially dried out canals then such habitats serve as excellent foraging centers for both Little Cormorants and Night Herons.

This chapter attempts to discuss and analyse behavioural ecology of feeding of Little Cormorants and Night Herons specifically on :

1. Traditional foraging grounds
2. Distance of foraging grounds
3. Time of foraging
4. Food items based on observations and stomach content, and techniques of food capture both in the breeding and non-breeding season.

6.2 METHODS

Observations on foraging were made from January 1998 to December 2005. A major portion of the observations were made during the breeding season and only a minor portion during the non-breeding season. A total of 1480 hours of observations were made on this aspect. The usual observation schedule was 0600 to 0900 hrs. and 1500 to 1800 hrs. However, on occasions observations were made throughout the whole day particularly on weekends.

Data included field observations as well as those obtained from the examination of regurgitatates of the adults at the sanctuary. Because of this queer habit of vomitting out of their stomach content on the least provocation, it was possible to analyse the food items without sacrificing or injuring the birds. However, during the course of the study period extending over seven years the stomach contents of sixteen morbid (due to malnutrition, disease or injury) and five dead adult birds were analyzed in order to substantiate data obtained from observations. Food items supplied by the parents to their youngs were also collected. Such collections were quite easy because just-fed youngs regurgitated almost all the food when alarmed. The food samples were identified, weighed and preserved in different percentages of formaldehyde, depending on their nature.

Field observation data were taken by 'focal sampling' and 'instantaneous scan sampling' (Altmann, 1974) and also by continuous observations. Each focal bird was followed for as long as it was in sight, but not longer than 15 minutes. After each observation period another focal bird was chosen. Observations were made with the help of a field binocular (SAMSUNG, 7-15 x 35 with Zoom), a Tape recorder (Philips) and a Stopwatch.

6.3 RESULTS AND DISCUSSION

6.3.1. Traditional foraging grounds

Little Cormorants and Night Herons traditionally forage at certain water bodies year after year.Only some of this water bodies are perennial most others partially or completely dry out in the non-breeding season. For example, rivers and canals may dry up at certain parts of their stretch ; some pools and puddles, submerged cultivated lands, swamps etc. may completely dry up in the dry non-breeding season. While some deep, large ponds ; parts of rivers and canals and even certain ditches are perennial but there is a definite reduction in surface area in the non-breeding season.

Table 6.1. shows the traditional foraging grounds along with their total surface area in the breeding and non-breeding season and distance from the sanctuary. It is observed that there is a reduction in the surface area in all categories of water bodies except ponds in the non-breeding season. This is because the birds visited several distant perennial ponds in the non-breeding season in order to compensate dried out foraging grounds not visited earlier. It is also seen that the range of distance of water bodies foraged increases considerably in all categories during the non-breeding season. Most feeding sites, however, were within the 10 km. radius of the sanctuary.

In otherwords the birds tended to forage close to the sanctuary in the breeding season when they had to find food not only for themselves but also for their nestlings. In the breeding season area of the water bodies increased by more than 56% in comparison to non-breeding season. The dried up waterbodies and some low-lyaing land areas around the sanctuary filled up to the brim in the monsoon. Thus, there was a significant increase in size of waterbodies in the breeding season which provided enough food materials for both the adults and the nestlings. It was not necessary for the parent birds to forage at distant waterbodies leaving the nest and nestlings unattended for a long time.

Further, it was observed that shallow water bodies such as submerged cultivated lands, swamps and marshes were solely foraged by Night Herons. Other water-bodies were foraged by both the avian species. However, the Little Cormorant tended to forage more in deep water bodies such as perennial ponds, rivers, canals etc.

6.3.2. Distance of foraging grounds from sanctuary

6.3.2.1. Feeding in non-breeding season

Both Little cormorants and Night Herons are in the habit of forming single and mixed species communal roosts which were small (5-20 individuals) in size. However, they also foraged in groups. An fifteen member group of Little Cormorant and a eight member group of Night Heron was observed in an area about 8.5 Km and 7 Km away from the sanctuary. In a 10 Km radius around the sanctuary twelve such groups (6-10 individuals) of Little Cormorants and five groups (10-15 individuals) of Night Herons were found during the study period.

Group movements were oriented centering mainly perennial ponds and rivers in Little Cormorants but perennial swamps, marshes, ponds and ditches in case of Night Herons. During this period they not only foraged at these water bodies but they also spent the whole day and night in nearby trees. As a result some waterbodies become heavily depleted of their resources after supporting the groups over three early months of the dry season and can no longer support the group at the driest part of the season. Consequently, the groups were forced to leave the place in search of better foraging grounds.

6.3.2.2 Feeding in breeding season

In the early phase of the breeding season (upto mid-August) all the birds of both the species whether paired or unpaired, considerably restrict their foraging activities. During the early and mid-hatchling phase they mostly forage in waterbodies inside the sanctuary and adjacent ones within about 2 km radius of the sanctuary. As chick development progresses the requirement for food increases rather dramatically and the water bodies inside and those close to the sanctuary are no longer sufficient to meet the requirements adequately. The parents in the later phases of chick development and at the fledgling stage forage over much longer areas outside the sanctuary. It may be pointed out that nest attendance and foraging distance are governed by two major factors i.e. protection requirement of chick and amount of feed needed. In essence when the chicks are young the parents need to attend them for much linger periods but the requirement for food is small that can be procured from adjacent water bodies. On the otherhand, in the late phases the parents need to attend the nest only for short whiles and thus they get sufficient time to forage in distant water bodies in order to collect increased amounts of feed required by the grown up chicks. In the late phase the birds were even found to feed at distances of 5 km from the sanctuary.

6.3.3. Time of foraging

6.3.3.1 During non-breeding season

Most animals feed or forage at some particular periods which depends not only on the counteracting demands of other vital activities or to avoid competition from other species but also on the availability of feed species and their temporal activity patterns.

Little Cormorant is a diurnal bird. It usually takes five principal meals on an average during the day-time. On the other hand, Night Heron is nocturnal and mainly forage throughout the night and in the twilight hours.

Although the Little Cormorants feed throughout the day most frequent feeding were observed at five periods of the day i.e. Phase-I 6.00 - 7.30 ; Phase II 9.00 to 10.30, Phase- III 11.30-13.00 ; Phase- IV 14.00 -15.30 and Phase -V 16.00 -18.00 during the non-breeding season. No such clearly demarked hours of intense feeding could be ascertained for Night Herons except that they were observed to hunt more in the late afternoon and early morning hours.

6.3.3.2 During breeding season

During breeding period, due to high energy demands for egg laying by female and collecting the food for nestlings by both the sexes feeding activity becomes more intense and extends beyond the usual schedule in both the species. Night Herons were observed to forage frequently during the day.

In about two or three days of their arrival in the sanctuary birds were found to change their foraging pattern. Their investment of time in foraging decreased abruptly until aquisition of a suitable mate and a nest site. The decrement is considerably more in males than the females probably because they had to invest more time in search of nest site and conflict with other males. But after pair formation and with the initiation of laying females became much more attached to the nest and invested lesser time in foraging than the male until the first half of incubation period. Thereafter their foraging time increased which attained a rapid momentum about the third week of hatching.

Males of both the species were observed (N=21) to provide food to their females during the laying and hatching period.

6.3.4. Depth of foraging

The Night Herons mostly foraged on food items that remain close to the surface while they stay above water. The Little Cormorants in contrast tended to forage more on food items that remain in mid and bottom water while they are under water. The spotting of prey items is done mainly from above water position in case of Night Heron whereas Little Cormorants mostly find their victims while they are under water. Thus the prey items of Night Herons are mainly surface water fishes with accessory respiratory devices and frogs and tadepoles. While those of Little Cormorant include column feeders much as *Labeo rohita*, *Labeo bata* and bottom feeders such as *Cirrhinus mrigala*, *Labeo calbasu* and so on. In the breeding season, however, the necessity of procuring large amount of food to feed the nestlings force the bird of both species to capture any suitable food items available and the species difference in food items of the two species becomes narrow.

6.3.5. Food items based on observations and stomach content and techniques of food capture both in the breeding and non-breeding season

6.3.5.1. Food items

The spatial distribution pattern of fish species in water bodies vary considerably during breeding and non-breeding seasons due to various biotic and abiotic factors such as difference in temperature, volume and depth of water, oxygen and carbondioxide content in the water and the fact that most fishes themselves breed in the monsoon,all of which influence the food composition of the birds. Again it must be remembered that Night Herons usually feed only by the night in the non-breeding season but almost round the clock in the breeding season whereas Little Cormorants feed solely by the day in both breeding and non-breeding season.

A. Food of adults

Both Little Cormorants and Night Herons are mainly piscivorous. The food items include a number of fishes, amphibians, reptiles and arthropods.

The main fish feed items of Little Cormorants viz. *Cirrhinus mrigala, Labeo calbasu, Labeo rohita, Labeo bata, Puntius ticto, Channa punctatus, Channa gachua, Rhynchobdella aculeate, Amphipnus cuchia, Heteropneustes fossilis, Anabus testudenus, Lepidocephalichthys guntea, Mystus vittatus, Paleomon sp. etc.*Besides these Little Cormorants also consume crabs, Frogs (*Rana tigrina*), Tadepoles of frogs and toads and snake (*Enhydris enhydris*) in varying degrees depending on season.

Night Herons, on the other hand, mainly consumed *Catla catla, Labeo rohita, Labeo bata, Labeo gonius, Puntius sarana, Channa punctatus, Channa gachua, Clarias batrachus, Heteropneustes fossilis, Anabus testudenus, Paleomon sp.* etc. They also took frogs, tadepoles, crabs, terrestrial and aquatic insects, some snake (*Enhydris enhydris*) etc.

The stomach contents of ten Little Cormorants and eleven Night Herons during premating period (May-June) are presented in Table 6.2 and Table 6.3 respectively. It is observed that four species i.e. *Channa punctatus, Channa gachua, Rhynchobdella aculeate and Heteropnentes fossilis* are consumed by both the bird species while *Cirrhinus mrigala, Puntius ticto, Mystus vittatus and Paleomon sp.* are consumed only by Little Cormorants. On the other hand *Labeo bata, Anabus testudenus and Rana tigrina* are consumed only by Night Herons. This data is in no way a complete picture of their food composition. However, it appears that Little Cormorants feed on larger fishes than Night Herons (eg.*Channa punctatus* and *Channa gachua*).

Analysis of the fresh regurgitates of Night Herons revealed that this nocturnal birds at least occasionally feed on crabs, beetles, grasshoppers and certain aquatic bugs. They were occasionally found to collect food items from dry and irrigated cultivated land. It was assumed that they collected mostly insects and or annelids under these conditions. Although the items collected could not be observed even with best efforts.

Table 6.4 and 6.5 show food items reported by various authorities for Little Cormorants and Night Herons respectively. Capture and intake of molluscs as reported for both the species by Mukherjee (1976), Davis (1993) and others were never observed in the present study although they were present in plenty in their foraging sites. Similarly consumption of algae and small rodents in case of Night Herons as reported by Dekay (1844), Davis (1993) and others were never observed in the present study.

Probably it was not necessay for Little Cormorants and Night Herons of this region to feed on molluscs, algae and small rodents because of rather abundant supply of choice food items i.e. fish in the water bodies in and around the sanctuary.

B. Food of Nestlings

Early nestlings of Little Cormorants and Night Herons were fed exclusively with semidigested fish, hatchlings and fingerlings of fish, Tadepoles, fleshy part of toads, frogs, crabs and *Paleomon* sp. etc. Gross (1923) reported similar observation in Night Herons.Detailed data on the food items of the developing nestlings are discussed under the chapter on parental care.

6.3.5.2. Techniques of food capture and intake

6.3.5.2.1. Structural adaptations for food capture

The bill, the tongue and associated epidermal structures form the main complex of feeding apparatus and together play a major role in the capture and ingestion of food. It may be mentioned here that at least fourteen species of finches live on the Galapagos and there is a precise match between a particular species beak dimendions and the type of food it consumes (Grant, 1986 ; Weiner, 1995). The epidermal structures which come in contact with the food, demonstrate seemingly obvious adaptations for a particular food habit. It may be pointed out that the hook-like structures on the palate and tongue of piscivorous birds not only assist in holding the prey, but also help in moving the food towards the oesophagus (Storer, 1960). The feeding apparatus of both species essentially consist of the bill, rhinotheca, gnathotheca, tongue and jaw muscles.

In Little Cormorants the bill is a stout structure that tapers gradually towards the tip. The maxilla is sharply hooked at the tip. It is horny brown to blackish at the tip and livid purple at the base. The males have a slightly longer bills (38.3 mm) than the females (33.5 mm).

The bill of the Night Heron is much longer, stouter and thicker than that of Little Cormorants. It is forcep-like the upper bill is redish brown while the lower beak is brownish yellow at the base. The males have a slightly longer and stouter bill (72.5 mm.) than the females (70.5 mm). Both the maxillary and mandibular tomia are very sharp and serreted anteriorly which ensures firm grip on the live prey.

The Little Cormorants and the Night Heron are predominantly fish-eaters. The fish-eaters are required to counter the force exerted by the struggling live prey. The large-sized beak and massive jaw muscles of the two birds are ideally suited for holding the prey. The movement of the live prey i.e. sliding forward coupled with their technique of engulfing the prey head first assist the intake operation.

6.3.5.2.2. Techniques

Little cormorant and Night Heron employ a host of techniques to capture food depending on various factors such as : prey size and species, its density, time of the day / night, breeding or non-breeding season and many others. Some of the techniques are common to both species and some others are unique possessions of the species concerned. Terminology of techniques are mostly based after Kushlan (1976).

The techniques are described under two main categories such as :-

A. Stand or Stalk B. Aerial and deep water feeding

Each technique, however, contained several sub-components which varried widely between the two species studied.

A. Stand or Stalk

i) Stand and Wait

The bird stood motionless in shallow water or on land ; watching and waiting for the prey to appear. Two basic postures were observed. In Upright posture the body was held erect with fully extended head and neck angled away from the body. In the Crouched posture, the body was held horizontal to the perch or the water surface with the bent legs while the head and neck were partially retracted.In this technique birds with a quick thrust of its bill into the water, caught small fish.

ii) Bill vibrating

The bird creates a disturbance or vibration in water by rapidly closing and opening the submerged bill while standing in a crouched posture i.e. stooping over the water surface for luring prey. After that it graps the prey with its bill.

iii) **Walk slowly**

The bird moves leisurely, stalking prey. Walking slows down as the bird inspects items or areas of interest.

B. Aerial and deep water feeding

i) **Hovering**

The bird hovers and remains static in the air above the water surface for a while and suddenly swoops down on the prey in the surface water. A variant of this pattern is "hovering stirring" in which a bird hovering above the surface of water stretches one foot and pats the surface of water stirring or raking surface vegetation and debris.

ii) **Plunging**

The bird suddenly plunges into the water surface to catch prey from a hovering or foward flight position. After plunging the bird may either fly away or stay at the water surface. It is assumed that the birds generally plunges in water bodies that are less than 2.5 m deep.

iii) **Diving**

The bird perched on shore or on branches of trees overhanging the water bodies dives precipituously head first from its perch deep into the water bodies that are more than 2.5 m. deep.

iv) **Feet first diving**

The bird alights on the water feet first, usually from a hovering position and stabs at prey immediately on landing.

v) **Swimming feeding**

The bird swimming at the surface of the water, suddenly stretches its neck and capture nearby prey with the beak.

Table 6.6 shows presence (P) or absence (A) of different techniques of food capture in Little Cormorants ande in Night Herons in the premating season (i.e. May-June).

A total of about 32 hours over six days incase of Night Herons and about 70 hours over thirteen days in case of Little Cormorants were solely devoted in determining the different feeding techniques used by the two birds in the sanctuary.

It was observed that although the two bird species lived in the same area and even on the same tree species and feed in the same waters ; there exists significant differences in their food capture techniques and in percent time employed to different techniques. This is probably one of the reasons that enabled the two species to coexit in the same habitat.

It is clear from the data presented in the table that while Night Herons predominantly depended on stand and stalk (85%) techniques for prey capture the reverse is true for Little Cormorants which almost always employed aerial and deep water feeding (98%). Thus there is a clear cut nieche segregation between the two bird species in regards to prey capture techniques.

The swimming feeding technique was observed both in Night Herons and Little Cormorants on rare occasions at seasons other than the specific period mentioned specifically for this section. Swimming feeding technique in Night Heron was also observed many others (Hancock and Elliott, 1978 ; Kushlan, 1978 and Parasharya, 1982).

Table 6.7 shows various activities in the different periods of daily feeding of Little Cormorant in premating stage. The commonest techniques used by Little Cormorants to catch prey was to dive into the water. From the table we find that number of dives /m in five phases are 2.4,2.3,2.27,2.13, and 2.28. Number of dives/m decreased continually with progress of the day except the last phase. This is because of more intense feeding during early morning and late afternoon phases. Duration of plunging are 21.90,20.19,21.36,22.07 and 21.09 and of deep dives are 27.70,32.81,30.37,34.72 and 33.29. Duration increased continually with progress of the day in the plunging as well as deep dives. Interval between plungings are 10.76,11.19,10.18,9.45 and 8.57 and those in deep dives are 9.70,10.37,10.44,8,88 and 9.75. These shows that interval between plungings & deep dives decreased with the day. Catches were distinctly high in phase I and V with little difference in plunging (31) and deep dives (28) with regard to number of catches. Number of catches in plunging and deep dives were almost the same (.0496 and .0482). Duration of both decreased with day. Chases were found only in the early morning and late afternoon.Duration of wing and tail shaking decreased in Phase II and Phase III but increased in Phase IV & V. Wing drying duration also increased with the day. Preening duration increased with the day, with a maximum in Phase IV.

Food items vomitted out by adults and nestlings of both the species are often collected back by parent birds who occasionally consume those food items themselves or feed those to their chicks. In fact a competition ensues particularly in the early morning hours among all the resident bird species of the sanctuary to collect those food items from the ground beneath the nests.

Table 6.1 **Traditional foraging grounds along with their total surface area in the breeding and non-breeding season and distance from the sanctuary.**

Traditional foraging grounds	Observed area of foraging water bodies			
	Breeding / Monsoon		Non breeding / Dry	
	Area (meter^2)	Range of Distance (meter)	Area (meter^2)	Range of distance (meter)
1. Ponds	1237.64	50 – 2000	1533.16	1500 – 7000
2. River	4461.78	120 -250	3246.34	200 – 550
3. Canals / Ditches	629.28	60 -200	308.98	200 - 300
4. Pools and Puddles	380.36	150 -200	76.36	150 - 300
5. Submerged cultivated Lands	1540.76	200 -1000	344.80	500 - 2000
6. Swamps or Marshes	2480.96	300 - 700	1331.32	500 - 2000
Total surface area of water bodies	10730.78		6840.96	

Table 6.2 : Stomach content during May – June of Little Cormorant (N = 10)

Food species	Number	Total weight (gm)	Average weight (gm) ± SE
Cirrhinus mrigala	04	85.20	21.30 ± 1.05
Puntius ticto	09	65.90	7.32 ± 0.67
Rhynchobdella aculeata	12	68.82	5.73 ± 0.52
Channa punctatus	08	187.32	23.41 ± 1.47
Channa gachua	02	40.50	20.25 ± 1.95
Heteropneustes fossilis	01	11.50	11.50 ± 00
Mystus vittatus	02	16.40	8.20 ± 0.18
Paleomon sp.	10	11.78	1.18 ± 0.01

Table 6.3 **Stomach content during May – June of Night Heron (N = 11)**

Food species	**Number**	**Total weight (gm)**	**Average weight (gm) ± SE**
Labeo bata	02	27.5	13.75 ± 0.22
Channa punctatus	12	138.6	11.55 ± 1.47
Channa gachua	13	160.16	12.32 ± 0.93
Anabus testudenus	09	80.7	8.96 ± 0.46
Rhynchobdella aculeata	09	80.28	8.92 ± 0.49
Heteropneustes fossilis	01	11.28	11.28 ± 00
Rana tigrina	02	88	44 ± 0.84

Table 6.4 : **Food items of Little cormorant as reported by various authors**

Food Items		Authority
Fish, Small Crabs, Tadpoles, Frogs		Blanford (1898), Mason & Maxwell – Lefroy (1912), Whistler (1928)
Rana sp.	Amphibia (14.14%)	Mukherjee (1975)
Mystus gulio *Mystus vittatus* *Puntius sarana* *Puntius ticto* *Catla catla* *Labeo bata* *Anguilla bengalensis* *Oryzias melastigmus* *Mugil parsia* *Channa punctatus* *Anabus testudenus* *Lates calcarifer* *Nandus nandus*	Fish (83.00%)	
Melanoides scabra *Lymnea acuminata*	Mollusca (1.37%)	
Macrobrachium lamarrei *Metapneus brevicornis*	Arthopoda (.85%)	
Vegetable matter	0.06%	
Fish, Tadpoles, Frogs, Crustaceans		Lack (1945), Ali & Ripley (1968), Gere and Andrikovies (1992)

Table 6.5 Food items of Night Heron as reported by various authors

Food Items		Authority
Alga, Sea Lettuce *(Ulva latissma)*		Dekay (1844)
Fish, Shrimps, Tadpoles, Frogs, Leeches		Jasper (1878)
Fish, Frogs		Blanford (1898)
Eels		Chapman (1900)
Water dogs *(Ambystoma)*, Frogs, Axolotls		Wetmore (1920)
Merluccius bilinearis *Clupea harengus* *Tautogolabrus adspersus* Sculpin, Puffer, Sea-Robins	80%	Gross (1923)
Nereis virens, Shrimp, Sand-hoppers, Crabs, Beetles, Dragon fly (nymph) Squids, Frogs, Salamander, Tadpoles, Adult of fowler's toad	20%	
Small Fish, Amphibia, Crustacea, Aquatic insects		Whistler (1928)
Fish, Frogs, Crabs, Crustacea, Worms		Baker (1929)
Natrix sp., Rana sp. (tadpoles), Mystus gulio, Anguilla bengalensis, Periopthalmus koelreuteri, Lymnaea sp., Viviparus bengalensis, Macrobrachium sp., Uca sp., Acrydium sp., Chrotognus sp., Pantala sp., Gerris sp., Nepa sp., Notonecta sp., Corixa sp., Pheretima sp.		Mukherjee (1975)
Cray Fish, Mussels, Squid, Amphibians, Lizards, Snakes, Rodents, Birds.		Davis (1993)
Dropped Open-bill stork nestling of 3 – 4 days old		Present study

Table 6.6 **Presence (P) or absence(A) of food capture in Little Cormorants and in Night Herons in the pre-mating season (May – June).**

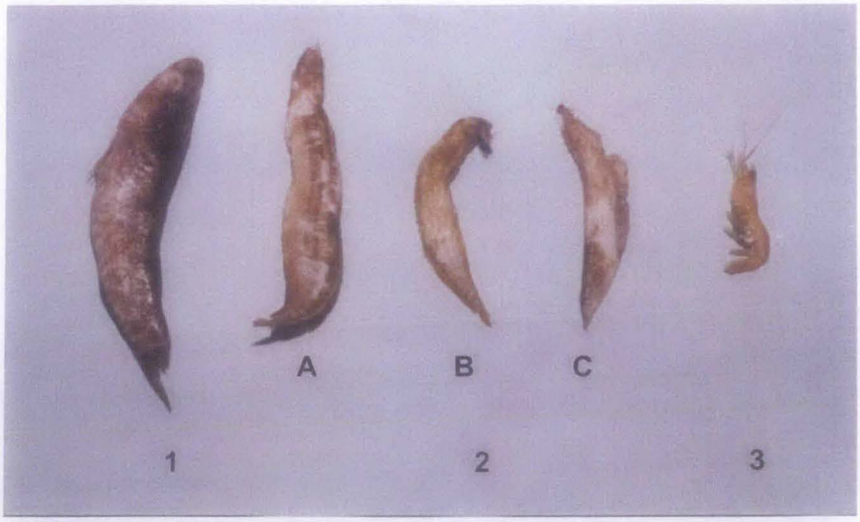
Techniques	Little Cormorant		Night Heron	
	Present / Absent	Percent Times Employed	Present / Absent	Percent Times Employed
1. Stand or stalk feedings:-				
a) Stand and wait	P	2	P	67
b) Walk slowly	A	--	P	12
c) Bill vibrating	A	--	P	07
	Total	2	Total	86
2. Aerial and deep feeding ;-				
a) Hovering	A	--	P	4
b) Plunging	P	42	P	3
c) Diving	P	56	A	--
d) Feet first diving	A	--	P	7
e) Swimming feeding	P	*	P	*
	Total	98	Total	14

* Indicates swimming feeding was observed in other seasons.

Table 6.7 Phases of daily feeding of Little Cormorant in pre-mating period

	Activity		Phase I (6.00 – 7.30)		Phase II (9.00 – 10.30)		Phase III (11.30 – 13.00)		Phase IV (14.00 – 15.30)		Phase V (16.30 – 18.00)	
			Below 2.5 m	Above 2.5 m	Below 2.5 m	Above 2.5 m	Below 2.5 m	Above 2.5 m	Below 2.5 m	Above 2.5 m	Below 2.5 m	Above 2.5 m
On Water	Plunging and Dives/bird	Total duration (Sec)	460	665	424	525	470	820	618	868	696	799
		$\bar{X}$ + SE	21.90 ± 3.21 N = 21	27.70 ± 6.34 N = 24	20.19 ± 2.59 N = 21	32.81 ± 7.43 N = 16	21.36 ± 3.40 N = 22	30.37 ± 5.41 N = 27	22.07 ± 3.8 N = 28	34.72 ± 4.2 N = 25	21.09 ± 3.64 N = 33	33.29 ± 4.50 N = 24
	Interval between Plunging and Dives/bird	Total duration (Sec)	226	233	235	166	224	282	265	222	283	234
		$\bar{X}$ + SE	10.76 ± 1.07 N = 21	9.70 ± 0.93 N = 24	11.91 ± 1.16 N = 21	10.37 ± 2.05 N = 16	10.18 ± 1.29 N = 22	10.44 ± 2.37 N = 27	9.45 ± 2.83 N = 28	8.88 ± 1.7 N = 25	8.57 ± 1.0 N = 33	9.75 ± 1.41 N = 24
	Catches	Number	7	8	5	4	4	6	7	4	8	6
		$\bar{X}$ N = 5	3.0		1.8		2.0		2.2		2.8	
	Baths	Total duration (Sec)	140		100		136		112		80	
		$\bar{X}$ + SE	10 ± 1.64 N = 15		9 ± 0.94 N = 10		7.5 ± 1.6 N = 22		18 ± 1.2 N = 14		10.83 ± 0.96 N = 12	
Outside Water	Chases by Conspecifics	Number	2		-		-		-		1	
	Wing and tail Shaking	Total duration (Sec)	150		90		165		252		130	
		$\bar{X}$ + SE	10 ± 1.64 N = 15		9 ± 0.94 N = 10		7.5 ± 1.6 N = 22		18 ± 1.2 N = 14		10.83 ± 0.96 N = 12	
	Wing spreading or Drying	Total duration (Sec)	1265		627		1260		1764		2672	
		$\bar{X}$ + SE	84.33 ± 3.75 N = 15		57 ± 2.83 N = 11		126 ± 3.45 N = 10		147 ± 3.31 N = 12		167 ± 2.64 N = 16	
	Preening	Total duration (Sec)	1315		1425		1836		2720		2360	
		$\bar{X}$ + SE	87.66 ± 3.80 N = 15		95 ± 2.68 N = 15		102 ± 3.20 N = 18		170 ± 3.92 N = 16		118 ± 2.75 N = 20	
	Excretion	Number	-		-		1		-		1	

Plate 5.1 A foraging group of Little Cormorants perched on bamboo poles and fences in the pond outside the sanctuary.

Plate 6.2


1. *Channa punctatus*, 2. (A,B,C) *Rhynochobdella aculeate*
3. *Paleomon sp.*

Plate 6.2


1. *Enhydris enhydris*

Plate 6.2


1. *Amphipnus cuchia* 2. *Rana tigrina*

Plate 6.2 Food of adult of Little Cormorants

Plate 6.3
Channa punctatus

Plate 6.3
Heteropneustes fossilis

Plate 6.3
1. Crab 2. *(A, B) Puntius sp.*
3. *Channa gachua*

Plate 6.3 Food of adult Night Heron

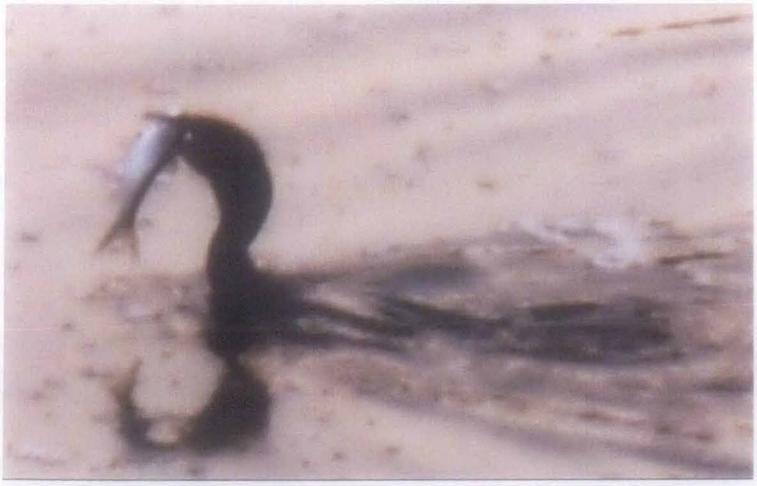


Plate 6.4
Adult Little Cormorant with a live *labeo bata* just captured in its bill.

Plate 6.5
Adult Night Heron in a stand and wait posture for capturing food.

Plate 6.6
Adult Night Heron collect food from the ground beneath a nesting tree.

Plate 6.7 Wing spreading(A) and preening (B) of Lilttle Cormorants after feeding while sitting on bamboo poles. outside the sanctury.

Plate 6.8 Resting of Little Cormorants after feeding outside the sanctury.

7. BEHAVIOURAL ECOLOGY OF REPRODUCTION

7.1 INTRODUCTION

Little Cormorants and Night Herons are colonial breeders. They use Raiganj Wildlife Sanctuary as a breeding colony. In this chapter attempts are made to correlate different reproductive behavioural patterns of Little Cormorants and Night Herons with various ecological situations.

Reproduction includes the process of mate selection in one hand and production of viable offspring on the other. In colonially nesting birds it begins with the arrival of the individuals at the colony and terminates with the laying of eggs. It is no longer a random process but a non-random one as some individuals perform better and fertilize more and some particular type of mating system attains advantage over others. This non-randomness of mating implies evolutionary importance with differential fitness consequences to different mating systems. On the whole, the interactions between intrasextual and epigamic selection determine the strategies of males and females and, therefore, control the evolution of the mating system of a species (Emlen & Oring, 1977).

Several aspects of mating systems of birds have been discussed by different authors (Khal, 1971 ; Kushlan, 1973 ; Sengupta, 1976 ; Greenwood, 1980 ; Parker, 1983 ; Moller, 1986 ; Frederick, 1985 ; 1987 ; Johnson, 1988 ; Yom-Tov, 1992 ; Singha *et. al.*, 2003) in a number of species. Some studies in Night Heron (Noble *et. al.*, 1938 ;Davis 1993) and in Little Cormorants (Baker, 1928 ; Ali & Ripley, 1968) are known to have discussed some of the aspects. Some aspects of mating have also been discussed for many other species of Cormorants (Potts *et. al.*, 1980 ; Boekelhelde and Ainley, 1989 ; Kortlandt, 1995 ; Bregnballe, 1996 ; Schjorring *et. al.*, 1999, 2000) and Night Herons (Braithwaite and Clayton 1976 ; Hancock and Elliot 1978 ; Chuan-Chiung, 2000) but no one provided detailed accounts of mating of

Little Cormorants and Night Herons apart from stereotyped analysis of patterns. This study attempts to present the basic structure of mating of Little Cormorant and Night Heron.

7.2 METHODS

Little Cormorant and Night Heron both are monomorphic species. To study the reproductive behaviour of these bird sexes could not be identified at sight which presented some difficulty to begin with. The behaviour of individual birds such as aggressiveness, territoriallity, postures and vocalization patterns actually helped in identification of its sex much more than the physical traits such as body weight, body length, wing span, bill shape, colour and so on. Banding (Table 7.1) and colour paintings of individual birds, however, were of help with time it was possible to form an idea regarding the sex and age of an individual depending on its behaviour patterns, body size and body length. Observation procedures and equipment used in this chapter have already been discussed in the general method section.

7.3 RESULTS AND DISCUSSION

7.3.1. Arrival of birds in the Sancutary

Arrival of the birds in the Sanctuary coincides with the onset of monsoon. But it is difficult to draw any significient relation between their arrival with any particular rainfall parameter (Table 7.2). Probably the birds follow the seasonal cycle to visit the sanctuary. Their arrival, however, is not indicative of the future water conditions in the area. Because in 1972, 1975 and 1976 birds had to desert the sanctuary after nesting due to very poor rainfall. So, it seems that the rainy season and not the actual amount of precipitation which triggers the intrinsic factors of Little Cormorants and Night Herons and other birds of the sanctuary to prepare to hit the sanctuary.

The first batch of birds start arriving at the sanctuary from the middle of June and in some years in the first week of July (Table 7.2). The periodicity of first arrival of the birds over the last 05 years varried within a range of 10-20 days.

Birds usually arrive in flocks. In Little Cormorants as well as in Night Herons each flock consisted of 20-60 birds. Flow of new members of both the species continued almost upto the first week of September.

The oldest males appeared first i.e. usually by June. Peak arrival for experienced breeders was in July. Experienced females (> 3 years) arrived slightly later than similarly aged males. Novice first year breeding males arrive at the end of July and first week of August, and 2 year old females come during mid-August. Therefore youngest males arrived 4-8 week later than older birds. The same patterns is followed by young females. Similar patterns were observed in Brandt's Cormorants (*Phalacrocorax penicillatus*) Boekelhelde and Ainley (1989).

7.3.2 Activities following arrival

On arrival in the sanctuary birds of both the species settle on higher branches of several tree species particularly Jarul, Chatim, Arjun in Little Cormorants and Eucalyptus, Sisoo, Jarul in Night Herons. Little Cormorants prefer specially the trees at the island of the sanctuary. They mostly settle on branches within a height range of 20-30 ft. from the ground. Just after arrival they settle on the top of the trees. Subsequently they make frequent movements from branch to branch. Little Cormorants also undertake short trips over the canals from one end to the other and visited the tree-stands. These appears to be some kind of appetitive act in search of a suitable nest site as also to advertize itself to members of the opposite sex in view of possible pair formation in a few days. This phase lasts for about 3-5 days. During this period both inter- and intraspecific interactions are observed.

7.3.2.1 Interspecific Interactions

This mostly involves threats by other inhabitants i.e. Night Herons Egrets and Open-bill storks, in case of Little Cormorant and Little Cormorants. Egrets and Open-bill storks in Night Herons when they unwttingly trespass into others territory or get very close to their nests. In most years Night Herons arrived first, so the Night Herons that come in the first batch do not have to face such situations. Interspecific squabbles, however, never escalated to real fights. In interspecific conflicts often the Cormorants retreated on being threatened by Night Herons, Egrets or Open-bill storks but the Night Herons most often showed aggressiveness.

7.3.2.2 Intraspecific Interactions

In Little Cormorant this mostly involve, one individual moving very close (6-12 inch) to a conspecific who in turn moves to another spot and sometimes this recurs to a maximum of three times. The motivation behind this activity appears to drive away a conspecific from a particular spot.

In Night Heron few number (3 to 5) stand on the branches of the tree for a long time. One individual move very close to the other and move spot to spot and at this time drive away the conspecific ones.

Territory an exclusive area is intensive use by breeding males for display, mating and for resource. Mostly nest-site territoriality is exhibited by the males.

In Little Cormorant on the third day of arrival the males successfully establish some sort of territory where from they start emiting charasteristic loud courtship calls.

In Night Heron breeding males defend an area around the immediate vicinity of their nests against any conspecific males. But if a female enters the territory, the resident male assumes a subservient attitude and in this way allows the trespasser to stay. A courting male never loses its territory. If a bird guarding a neighbouring territory should encroach upon his domain he thrusts his head forward, indicative of vigorous aggressive encounters.

In both species the females, actively defend nest-sites after pair-formation and are strongly territorial to any intruder.

7.3.3 Age of pair-forming birds

In Little Cormorants the male and females differed in the average age of first-breeding. Females first breed at 2.2 $\pm$ 0.5 year (n = 27) and males at 3.1 $\pm$ 0.6 year ($n = 21$; $t = 3.75$; $df = 46$; $P < 0.01$).

The male and female Night Herons mature roughly about 2 to 3 years of age.

7.3.4 Mating Type

Little Cormorants and Night Herons breed in monogamous pair bond. The males contribution to parental care is nothing less than that of females. However, in two cases two males and one female were found to breed as a unit.

7.3.5 Mating Display

After the establishment of the breeding territory the following components of displays were exhibited by the male. In monogamous species it is mostly divided in two main components : (1) Pre-fertilization display or pair forming display which enables the sexes to come together to ensure fertilization and (2) pair maintenance display which is necessary for better co-ordination between mates to raise youngs successfully.

7.3.5.1 Pairforming Display

Usually the males initiate the displays. They were also found to perform soliciting displays. Terminology of displays are mostly based after Kortlandt (1995) in Little Cormorant and Noble, Wurm and Schmidt (1938) and Davis (1993) in Night Heron.

In Little Cormorant

1) Wing-waving by male :- Male standing on a forked branch at and started wing-waving when he saw a female flying near by.

2) Raising of feathers :- Display of the male consist of the raising of feathers on crown, neck and back to full extent.

3) Puffed-up posture by female : Female shows puffed-up posture which consist of an S-shaping of the neck and protrusion of the hyoid.

Mating Call

Aroundt the third day of arrival the males usualy are able to successfully establish some sort of breeding territory where from they start emiting their characteristic loud mating call. As a response to the male calls a number of females appear at the stage who settle within a distance of 1.5 to 2.2m. They were observed to call from the same spot until pair formation is achieved, usually within 2-3 days. The characteristic call (Coo-Coo, Coo-Coo-Cooh, Coo-Coo-Cooh-Cook) continues until about two day prior to egg laying. Fig. 7.1 shows mating call frequency in the sanctuary.

Activity Flow-Chart leading to Pair formation in Little Cormorants

Male Activity / Response / Behaviour	Female Activity / Response / Behaviour
1. Calling	**2.** Approach within 4"-6" of the calling male.
3. Stops calling i) <u>Facultative motor Patterns</u> : a) Head/Neck/Back and wing feather raising b) Peening in the female crown ii) <u>Obligatory Motor Patterns</u> : a) Defecation b) Tail Raising	**4.** Female Retreats but remain close to the male.
5. Calling starts Emits several calls followed by body movement similar to calling but without emission of sound.	**6.** Female (same or different) approach.
7. (3) This acts alternate for a while. Repeats al the acts as in no. 3.	**8.** Female comes even closer.
9. Mounting ensues which is followed by several Psedomounting Playful mounting.	**10.** Stays and to him in the males territory.
11. Tail Raising. The male excites of the female by its beak	**12.** Remain side by side in parallel or antiparallel orientations.
13. Rerpeat Tail Raising	**14.** Stays on close to male.
15. Copulation	**16.** Mutual Tail raising
17. Mutual Tail Raising	**18.** Change position (within 2 ft.).
19. Calling	**20.** Come close to the male
21. Remain side by side (with body touch) and preening (self).	**22.** Remain side by side and preening (Self).

In Night Heron the males soon engages in two acts :

(a) **Snap Display & Snap-hiss or song and dance display**

The unmated male while standing alone on a forked branch or while moving alone about a tree, takes two or three steps forward, halts, arches its back, lowers the head until the bill comes down to its feet and then while raising one foot produces a click or snapping sound which is immediately followed by a prolonged hiss. The performance is repeated when either the same or the opposite foot is raised. Eight to ten such displays are performed in a minute and the series lasts for over two minutes, to be followed by another bout with an interval of a minute.

Peak-hiss display is a modification of snap-hiss call. It is given by the male soon after a female has joined him before pair bond is fully established.

(b) **'Twig ceremony' - symbolic of nest building**

The male standing over the crude nest platform, or at a distance from it, holds a stick in its bill and vocalize loudly while its head is moved rhythmically up and down. Frequently the neck is stretched vertically upwards to its full extent and the bill is brought close to the neck while the snapping vocalization continues. Although the stick may eventually be placed in the crude platform it is more often dropped.

The receptive females are attracted by one or both of these displays and settle down on the tree occupied by the male. When a female arrives in the vicinity of the territorial male he orients to her and instead of attacking, adopts a rather conciliatory attitude to her. The male often stretches his head until the head is parallel to the ground. Some times he greets the female with a guttural call which is indicative of his sex and motive. The female continues to stay in the males territory and with further displays from the male a pair bond is finally established.

Further displays of the male consists of raising the head and raising of the feathers on the crown, neck and back. He bows, his pupils contract, eyes bulge, exposing the red iris to its maximum. The plumes are erected and may even fall forward over the head as the male bows. In response to the male displays the females emit a characteristic loud call with erection of plumage, contraction of pupil and protrusion of eyeballs.

7.3.5.1.1 Preening

On most occasions after the just mentioned displays both the partners were found engage themselves in self preening.

7.3.5.2 Pair Maintenance Display

Activities designed to strengthen the pairbond and maintain it throughout the reproductive cycle are very important in monomorphic birds. Little Cormorants and Night Herons exhibit few pair maintenance activities almost throughout the breeding period. Pair Maintenance displays are :

(a) **Symbolic Nest Building**

Both the partners of a pair exhibit this display. It involves the picking up and manipulation of nest material on the nest.

(b) **Greeting**

The nest attending partner greets the incoming one with this display. The attendent immediately turns towards the incoming partner in a standing posture holding its head high and makes prominent hissing sound with widely open bills.

(c) **Gargling Call by Little Cormorant**

It is performed by both the sexes.The head and neck are repeatedly thrown backwards, accompanied by a loud call by the male and by a soft call by the female.

(d) **Snap-hiss Call by Night Heron**

Hissing in this behaviour is more prominent than on any other occasion. This activity continues almost in the same frequency throughout the breeding season but its duration and details gradually diminishes.

(e) **Mutual Displays by Night Heron**

Throughout the course of mutual displays the male always holds its head higher than the female. Mutual displays involves lowering of the head by the female and raising of the wing and back feathers by the male while perching on or close to the nest. This is followeded by billing ceremony i.e. mutual raising of the head while holding each others bill tightly. They lower and raise their head alternately in the bill locked condition.

7.3.6 Copulation

In Little Cormorant

The pair stand in opposite direction and raising their tail by bills.Then both the partners stand in parallel position. At this time female bent downwards and allow to stand the male on its back and to insert the penis into the cloaca of her. It is easy due to the presence of gap of tail feathers because these feathers are torned during tail raising.

In Night Heron

The pair usually takes position parallel to each other. The male preens the lateral and under neck feathers of the female several times.Then the female stoops with partially open wings and the male steps forward on her back and with shuffling movements of his partially open raised wings and feet secures a grip on the back of the female while the tail is sharply bent downwards and forwards until the penis of the male is inserted in to the cloaca of the female. Throughout this period of about 90 to 120 seconds the female stays in the same position and helped the partner with subtle adjustive movements.

7.3.6.1. Diurnal Rhythm

Both the bird species were observed to copulate at any hour of the day but with a distinct preference for morning and evening hours (Fig. 7.2 and Fig.7.3). Actually these two peaks follow respectively the departure and arrival of the mate to and from the foraging ground. A smaller peak at the midday was also observed. This diurnal pattern demonstrates that before leaving their partner alone male ensures their insemination. Peak copulation is also observed immediately before laying.

7.3.6.2. Influence of weather

Copulatory activities are negatively affected by rain and storms in both the bird species. With the onset of showers they immediately stop all copulatory activity.

7.3.7. Perpituation of pair maintenance

Generally speaking, any form of courtship, nest building etc. when performed together, exerts a bond-strenghening effect on the partners. In Little Cormorants and Night Herons both the sexes of a pair appeared to be equally interested in retaining the pair-bond throughout the season and in some cases the pair-bond probably were retained through several seasons. This is also found in stork (Cramp, 1977).

7.3.8. Pair Dissociation

Dissociation of pair-bonds is also observed in Little Cormorants and in Night Herons. Pair-bond dissociation over the four year study period ranged from 26 to 30% and 21-25% in Little Cormorants and Night Herons respectively.The causes of pair-bond dissociation are as follows :

A. **Unsuccessful copulation** :

i) **Copulatory failure**

After successful pairing and even after the initiation of proper nesting, pair-bond may break up due to copulation-failure. In most cases females were unable to maintain balance properly of their bodies during copulation. The males usually made further attempts for a few times and then readily drove out the females with vicious pecking. This, however, mostly happened in case of feeble novice females.

ii) **Female Noncooperation**

Here the females resist mounting by males probably because they are not receptive enough to go for the act. Female noncooperation may be due to lack of physiological or emotional maturity or failure of the male to gain acceptance by the female as a partner (female choice).

iii) **Damage of Plume**

In Little Cormorant when plumes are damaged males are rejected by the females. In Night Heron the plumes on the crown of the male are larger than those of his female and it acts as a seconday sexual character. It was observed that if those plumes are damaged the male is rejected.

B. Clutch or brood loss

At the post-laying phase both the partners of a pair become more interested to retain pair-bond as they have already invested a lot. However, when the clutch or brood is lost due to predation,storms or heavy shower, the partners dissociate and desert the nest.

C. Mortality

A small percentage of pair-bonds dissociated due to accidental death of either patner.

7.3.9. Extra Pair Copulation (EPC)

In both the species extra-pair copulation is almost absent. The partners were found to be faithful. However, nine cases of EPCs were found prior to laying in Little Cormorants and Night Heron over the whole duration of the study. This usually occurs when a stranger male visits a pair-bonded female in absence of the male. The stranger male departs before arrival of the pair-bonded male.

Table 7.1 Frequency of recovery of banded birds

Name of bird species	No. of birds banded			No of birds recovered			
	Year	Phase	No	2001	2002	2003	2004
Little Cormorant	2000	Young	100	08	19	15	11
		Adult	18	01	01	01	--
	2001	Young	100	--	10	14	12
		Adult	16	--	01	02	--
Night Heron	2000	Young	100	07	13	08	03
		Adult	22	--	02	--	--
	2001	Young	100	--	13	18	08
		Adult	18	--	02	01	01

Table 7.2 : **Date of arrival of Little Cormorants and Night Herons in the sanctuary in relation to rainfall**

Year	Name of Birds	Date of arrival	Amount of rain in arrival date (mm)	Amount of rain in preceding 3 days (mm)	Amount of rain in following 15 days (mm)	Amount of rain in following 15 days (mm)	Amount of Total rainfall in the preceding year (mm)
2002	Little Cormorant	17 June	2.0	0.0	52.3	446.4	2259
	Night Heron	14 June	0.0	2.4	49.8	283.7	
2003	Little Cormorant	19 June	0.6	0.0	58.5	229.3	1943
	Night Heron	12 June	4.3	10.9	59	115.3	
2004	Little Cormorant	21 June	6.6	28.7	73.4	171.0	1971
	Night Heron	15 June	2.2	24.1	63.7	168.7	
2005	Little Cormorant	24 June	1.0	6.0	56	178.4	1512
	Night Heron	18 June	0.0	26	65	114.3	
2006	Little Cormorant	22 June	0.1	4.0	60.2	47.1	1826
	Night Heron	17 June	0.1	8.0	98.3	37.2	

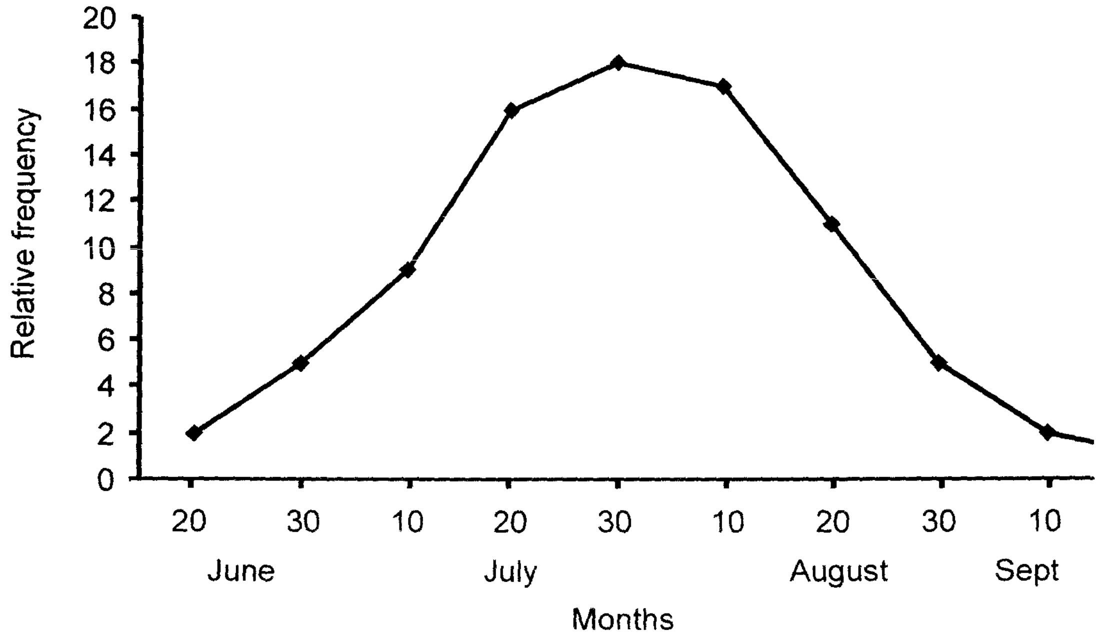


Fig. 7.1 : Mating call frequency of Little Cormorant

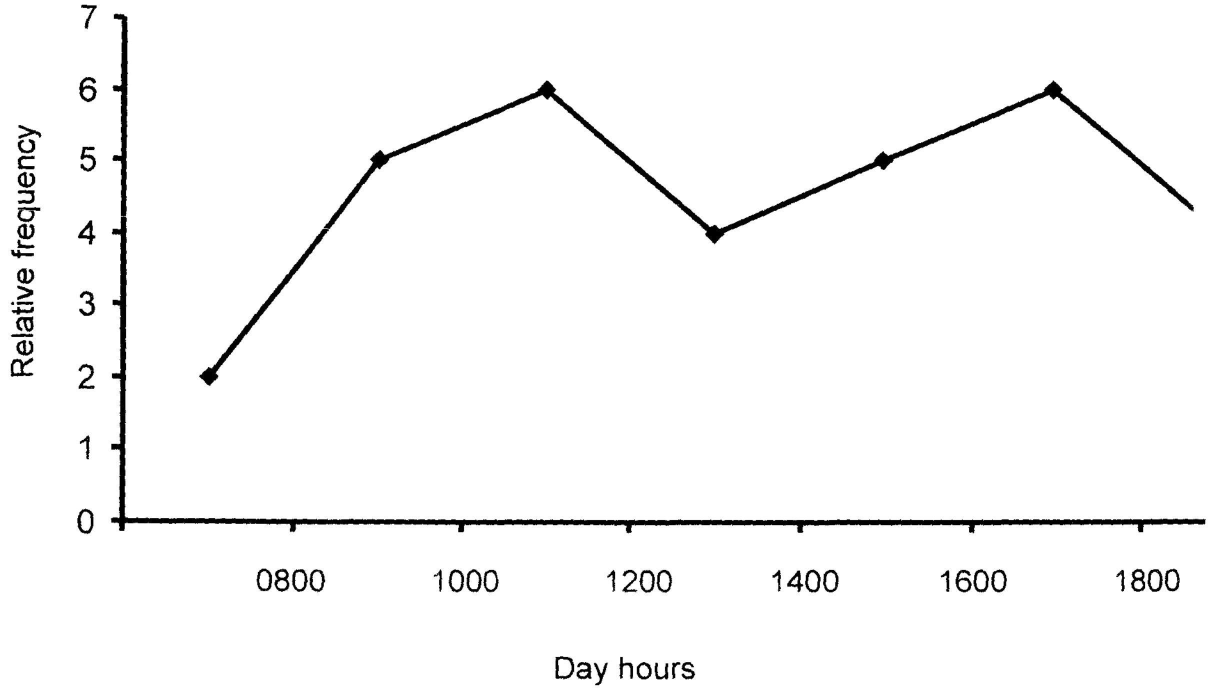


Fig. 7.2 : Diurnal rhythm of copulation in Little Cormorant

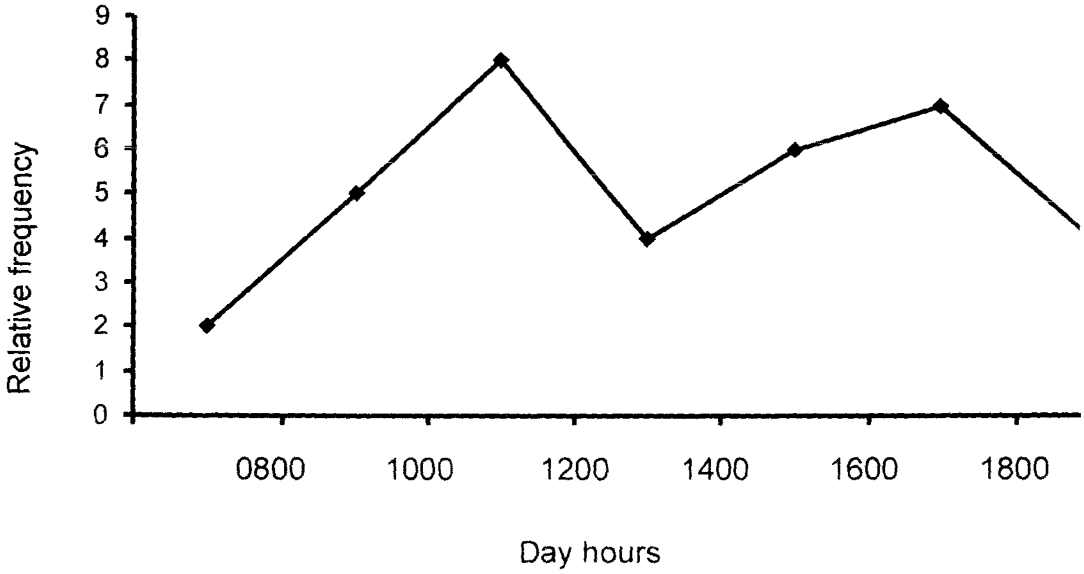


Fig. 7.3 : Diurnal rhythm of copulation in Night Heron

Plate 7.1 Adult Little Cormorants at the top of the canopy with an important purpose,-- to select a mate.

Plate 7.2 Adult Little Cormorants on the look out for a suitable mate.

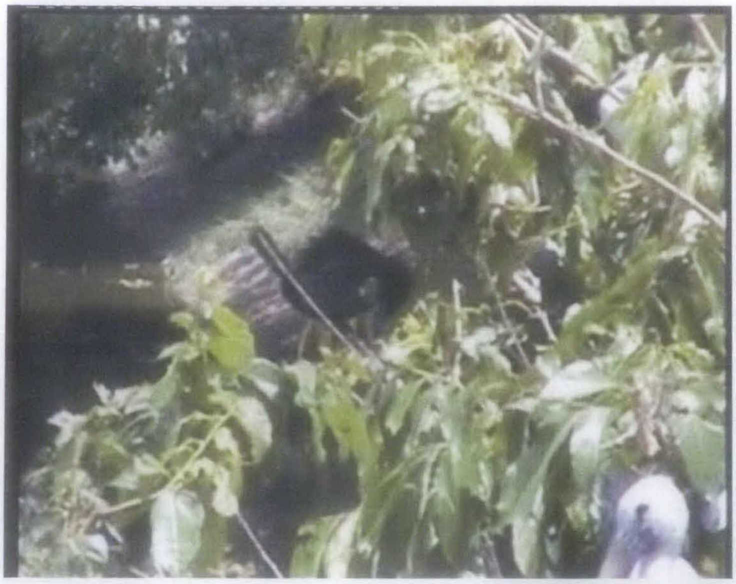


Plate 7.3
(A) Erect back and crown feathers by male adult Little Cormorant

Plate 7.3
(B) Excited posture at the time of mating call of male adult Little Cormorant.

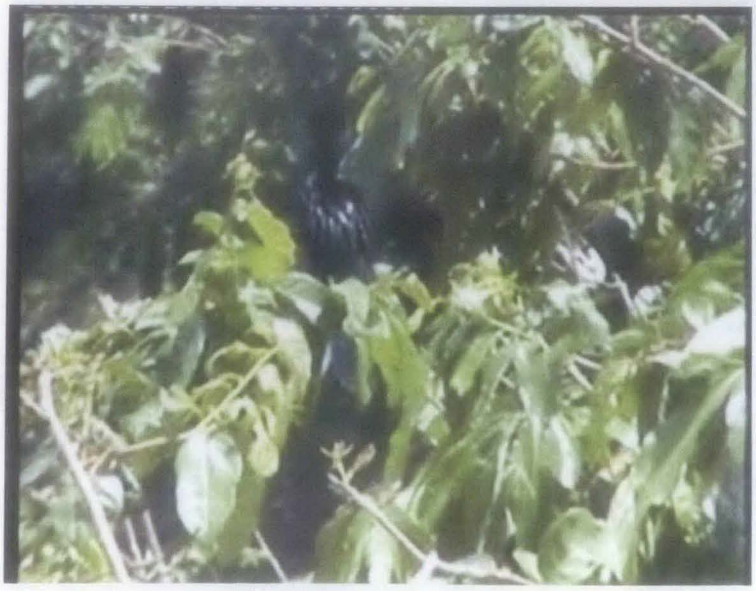


Plate 7.3
(C) Male and female adult Little Cormorants for pair formation

Plate 7.3 Pair forming display of Little Cormorant.

Plate : 7.4
Adult Night Herons on the top Canopy of a Jarul tree immediately before pair formation.

Plate : 7.5
Male and female adult Night Herons during pair formation.

Plate : 7.6
Adult Night Herons after pair formation.

8. NESTING

8.1 INTRODUCTION

Nest is an essential prerequisite for reproduction in birds. Nesting in birds is a long and elaborate process. Several factors play important role in various aspects of nesting such as : habitat selection (Hilden, 1965 ; Martin and Roper, 1988), nesting height (Marzluff, 1988 ; Dhindasa *et. al.*, 1989), nest defence (Trives, 1972 ; Dawkins and Carlisle, 1976 ; Curio, 1987) etc. which in turn influence reproductive success (Skutch, 1949 ; Lack, 1968 ; Shagsvold, 1982, 1989 ; Wicklund, 1982 ; Custer *et. al.*, 1983). Nesting requires proper harmony between different environmental factors, various requirements for survival of the species and its life cycle strategy. Coloniality provides many advantages to the birds (Lack, 1968 ; Robertson, 1973 ; Ward and Zahari, 1973 ; Krebs, 1974 ; Emlen and Demong, 1975 ; Robinson, 1985) but it also demands greater co-ordination with other conspecifies and allied species co-inhabiting the colony (Lowe-Meconnel, 1967 ; Martin, 1985; Stauffner and Best, 1986).

Proximate cues for nest-site selection may involve traditional species fidelity (Bongirno, 1970) pressure from conspecifics or other species and environmental factors. Little Cormorants usually perch and nest on trees near waterbodies (Ali and Ripley, 1968) while Night Herons prefer Mongrove trees or bushes standing near waterbodies or grooves of trees on dry land for nesting as well as nesting (Ali and Ripley, 1968 ; Soni, 1992). They were also reported to nest on trees as also in reed beds.

Thus Night Herons appear to enjoy more diverse habitats than Little Cormorants. Nest-site selection in both species is done by both the partners. It appears that experienced early breeders occupy the most preferred nest sites. Structural characteristics of the nest-site such as nest height, distance of nest from the tree center, diameter of the nest branch etc. and social factors such as : dominance, territoriality population density etc. play important role in nest-site selection of both the species. Nest materials of different sizes and dimensions are used at different phases of nesting. The Little Cormorants and the Night Herons were never found to use artificial materials for nesting. In both the species the male initiates nest building by collecting nesting materials which he transfers to the female who arranged the materials at the nest site. The male partner also collects most nest materials. The energy thus saved by the females is probably channelized towards egg production. Nest repairing acts are observed with the onset of incubation in both the birds. At the present study site the high population pressure seems to limit the distance between adjacent conspecific nests to a bear minimum.

During the early phase of nesting in both the species rampant poaching of nest materials take place mostly by neighbouring conspecifics which gradually decreases with time. Nest defence in Little Cormorants and Night Herons usually involves protection of the egg and brood from arian predators. Nest sanitation of both the birds on the other hand includes keeping the brood and the nest dry to avoid growth of microorganisms. It, however, does not necessitate cleaning of faecal materials as in the Catbirds, Songsparrows and Crows because both the adult Little Cormorants and Night Herons and their hatchlings defecate liquid wastes projected in a jet outside the nest.

8.2 METHODS

Observations were made from a bamboo "machan" suitably built on a tall tree in the island, roof of the Rest House, Watch tower, from some adjacent trees without nests aned also from some suitable sports on the ground.

The experimental nests were inspected daily throughout the season and ecological and behavioural data on nesting were collected. During nest visits, the nests were examined and occasionally photographs were taken.

Nest-site characteristics were measured and recorded after the emergence of first batch of hatchlings, when the nests became stable. Nesting tree height and nest height were measured by a measuring tape. Nests were measured with a 30-centimeter scale. Thickness of canopy cover was indexed by estimating the percent foliage cover which was calculated from the percentage of dark and light areas of the canopy shadow during the sunny midday hours when the sun attained the topmost position.

The experimental nesting trees and all the nests in each tree were individually marked with labeled aluminium plates. Nests that were attended by territorial birds or contained at least one egg was considered as active. To detect predation like Bengal monitors trums of some nesting trees located in innundated areas were covered with a thin uniform coating of mud.

The spatial and behavioural data were recorded instantaneously as far as possible and preference value (PV) of nesting trees was obtained following Altmann (1974).

8.3 RESULTS AND DISCUSSIONS

8.3.1. Nest-site selection

On arrival in the heronry Little Cormorants and Night Herons do not immediately engage themselves in finding a nest-site. At first they settle on some lofty trees which are not their usual nesting trees. During this period they moved from one tree to another in a rather restless condition. Most birds of both the species, however, spent most of their time outside the sanctuary. Gradually they settled on a tree at some particular spot and territoriality is established (Fig. 8.1 and Fig.8.2). So before the final choice they obviously followed a period of appetitive searching for nest-site. During this period birds try to find out the best available site which often determines their ultimate fitness (Walsberg,1981; Findholt, 1988 ; Grieco, 1995).

McCrimmon (1978) suggested that within a heronry, each species may be differentially responding to a number of physical, temporal, spatial and social variables, permitting a number of different species to occupy a colony for nesting. The idea is, however, anything but novel, Robert MacArthur as early as 1957 said almost the same thing in connection with his studies on five species of Warblers in the boreal forests. Essentially he pointed out that two or more species can survive in the same habitat due effective nieche segregation. As Little Cormorant and Night Heron nests in the Raiganj Wildlife Sanctuary along with four other avian species the situation is somewhat similar to that observed by MacArthur in case of Warblers.

Little Cormorants and Night Herons generally nest predominantly in the upper canopy layer and scarcely at the periphery. Little Cormorants use mainly top canopy layer. At the present study site, Little Cormorants selectively nest on only five tree species and Night Herons on eight tree species out of thirty available in the nesting area. Table 8.1 and 8.2 shows percent nests (PN), percent abundance (PA) and preference values (PV) of different plant species selected by Little Cormorants and Night Herons respectively for nesting. It may, however, be mentioned that prior to the devasting storm and flood in 1995 Night Herons used to nest extensively on *Eucalyptus* sp. trees in the nesting area of the sanctuary (Datta & Pal, 1990). Most of those trees fell victim to the storm. Subsequently, it was observed that Night Herons adopted other ttees in the same area for nesting. Presently Little Cormorants and Night Herons nest mainly on Jarul acquiring 85.02% and 84.21% respectively.

The high percentage of nests on Jarul indicate its characteristic branching pattern which provides stability at the same time exposure to sun, rain and winds. Soni (1992) reported similar observations in Night Heron at Keoladeo National Park, Bharatpur, Rajasthan. Most nests in Little Cormorants were at a node from which a cluster of branches originated (single, biforked, tri-formed and multiple forked).

On the other hand, selected nesting sports of Night Heron varied from a simple nook formed by two horizontal branches to a node from which a cluster of branches originated (Single, biforked, tri-forked and multiple forked).

8.3.2. Nests at unusal site

In Little Cormorant : Sometimes nests were also observed on a saucer-shaped curve of a single branch. However, only 3 nest were observed in this kind of untoward spots.

In Night Heron : Some nests were soptted at unusal sites such as : at the points where (a) two close, horizontal and parallelly (within 12-15 cm.) growing branches diverge and (b) at the upper form of the point of intersection of two separate branches from the same tree.

8.3.3 Nest Height

At the Kulik Little Cormorants and Night Herons were found to nest on mainly five and eight trees respectively but predominantly on Jarul trees (85.20% in Little Cormorant and 84.29% in Night Heron). Table 8.3 and 8.4 shows the average length of the tree, distance of the nest from peak canopy, distance of nest from canopy bottom line, height range of nests in the canopy, vertical expanse of the canopy with standard errors.

8.3.4. Role of sexes

At Kulik the males always choose the nest-sites. Such male biased behaviour is common to most species of the Cormorants species (Grieco,1995) and in Night Herons (Gross,1923). This is also common in storks. Firstly, the male choose an open vantage position for mate attraction and after that they finally choose the nesting site with proper basal support irrespective of its overhead cover. In the early stage the distance between the partners ranged from 0.5 to 1 meter after copulation and after final settlement they start nesting in the suitable position of the branches near the display spot. In Little Cormorants on the other hand the males display from a suitable spot which is selected only if the females respond appropriately. In 17.8% cases the spot was deserted by the male in absence of female response. Thus females appear to have a say in the final selection of the nest-spot.

Little Cormorants and Night Herons start nests about 3 to 4 days and 2 to 3 days repectively prior to egg laying. Most often the males collect the nest materials and transfer those to the partner who place the same in the desired position. The male gather materials by picking up dry branches, twigs from the ground as also by cutting parts from trees and uprooting green saplings. On occasions in Night Herons naive-first time breeders take considerable time in placing comparatively longer unsuitable sticks to lay the foundation. On the whole the Little Cormorants 46-50 hrs. and the Night Herons took 42-45 hrs. to construct the nest foundation. There is a clear division of labour between the sexes as the males are predominantly involved in nest material collection and the females in arranging the same and constructing the nest. However, at times both sexes were observed to perform any nest building activity. The division of labour might help the females in conserving energy which may be channelled for more egg production. Similar observations are reported in the Cranes (Johnsgard, 1983).

During incubation the female adds new materials and packs the old materials by small readjustments. On hatching one of the parents stay at the nest for attending the hatchlings while the other feeds itself and collects a man of food for the hatchlings. During their journey back to the nest they usually pick up nest materials. At this stage the parents take turns in feeding and collection of food and nest materials. The incubating bird periodically stood up and rolled the eggs and routinely carried out repair activities.

8.3.5. Nest Material

Little Cormorants and Night Herons strictly use plant materials for nest construction. None of the 988 nests observed (494 of Little Cormorant and 494 of Night Heron) in connection with various aspects of the present investication contained any artificial materials such as : metal wires, cloth, plastic, paper or nylon fibers as found in many species such as Eagles and House Crows (Pal, 1983). Open-bill storks that live in the sanctuary and Sarus Crane (Mukherjee *et. al.*, 2000) also never used any artificial materi also.

In Little Cormorants materials belonging to 18 to 22 different plant species were used to build a nest. Eleven entire nests were analysed for this purpose. Out of the species that were used as nest material, only 16 sere identified. It was observed that the bulk of the nest materials were from eight species viz. Jarul, *Casia*, Jigni, Hijal, Sisso, Akashmani, *Eucalyptus* and Pitali. The contribution of the remaining species were marginal. On the other hand nest materials used by Night Herons belonged to 16 to 19 different plant species. Twelve entire nests were analysed for this purpose. Out of the species that were used as nest material, only 14 have were identified. It was observed that the bulk of the nest materials were from six species viz. Jarul, Kadam, Eucalyptus, Shegun, Akashmoni and Gokul. The contribution of the remaining species were marginal.

Table 8.5 and 8.6 shows the relative importance of various plant species used by Little Cormorants and Night Herons respectively as nesting materials. Plant materials of varried length, shapes and nature i.e. soft-hard stem, dry-wet twigs with leaves, inflorescence, fruits etc. were used to construct different parts of the nest at different phases.

8.3.6. Nest Construction

At the initial stages of nest construction Little Cormorants and Night

Herons males brought most of the nest materials from the nesting tree or other adjacent trees in the sanctuary. This is also found in Greater Adjutant Stork (Singha *et. al.*, 2003) and in the Sarus Crane (Ramchandra and Vijayan, 1994). At this phase males of both species colected nest materials within a radius of 25-50m. of the nest.

In Little Cormorant

At the beginning the pair placed dry long sticks 20 to 40 cm. in length and 0.8 to 1.2 cm. in diameter at the nest-site with a lot of caqre. Occassionaly they took rather long time (50-90m.) in placing the single stick. These sticks are meant to care the weight of the evolving nest and the developing brood. Thus, they must be strong and are usualy from hardwood trees.

Once the foundation is made the next job is to lay the floor of the nest. Here they use slender sticks of 10-15 cm. length. This twigs are often with dry or green leaves which are used as packing materials. Then sticks of even smaller dimensions (6-15 cm. length) are used to form the wal of the nest. It was observed that most of the sticks were curved and or semi-dry so that they are plastic enough to be curved as per required. Finally bed of the nest is made of small sticks (2-10 cm.), green-leaves and gren or dry saplings. Thus a nest, i.e. cup-shaped, untidy structure of sticks and twigs takes shape.

In Night Heron

At the very outset the mating pair placed rather long dry sticks (45-72 cm. in length and 1.2 to 1.6 cm. in diameter) at the nesting spot with lot of care and attention, spending 40-120 minutes in placing a single stick. Occasionally sticks as long as 110 cm. were used. Sometimes it takes more than 3 hours to place a single stick in the right position. It is probable that first time, novice breeders are involved in these exceptional cases. They set and reset the sticks with lot of care. These stick function as foundation and are meant to bear the weight of the evolving nest and the developing brood.

Subsequently, dry sticks ranging from 30 to 46 cm. in length and 0.8 to 0.4 cm. in diameter are suitably arranged on the weight bearing sticks towards the formation of the nest floor. Dry as wel as wet twigs with leaves of 8 to 16 cm. length are then used as a sort of packing material. Finally sticks of even smaller length along with green leaves are set to form the bed of the nest. Thus a nest, " a rough untidy platform of twigs, sometimes quite flimsy" (Ali and Ripley, 1968) i.e. a more or less shalow sancer-shaped structure takes shape.

In most instances egglaying occurs long before (7 to 10 days) the construction of the nest bed. However, laying was never observed before at least 25-30 sticks are suitably placed on the weight bearing foundation structure. The pattern of placement of the stick roughly simulates weaving of buskets.

In construction of the wall of the saucer-shaped nest often small dry and curved stick, 15-30 cm. long and 0.4 to 0.2 cm. in diameter, green twigs with inflorescence and fruits, and long saplings with soft stems were used.

Apparently the Little Cormorants and the Night Herons do not seem to require a full fledged nest to start egg laying. Mukherjee *et. al.*, (2000) reported similar observations.

Poaching of nest materials by other conspecifics goes on predominantly during the early nesting phase in both Little Cormorants and Night Herons. During poaching the poacher usualy reaches the host-nest by stealthy movements and departs with a stick as quickly as possible. Usualy unattended nests fall victim to poaching. This practice sometimes necessitates urgent repair of the host nest. Poaching, however, diminishes progressively with the breeding season. Singha *et. al.* (2003) reported loss of nest materials even in presence of the owner in Greater Adjutant Storks. No such activity was observed in

Little Cormorants and Nitght Herons.

In both the species addition - alteration-extention and repair activity of nests continues throughout the breeding season until all the chicks are fledged. Due to these activities the nest volume and weight increases considerably. Fig. 8.3 & Fig. 8.4 shows the regression line of nest volume in cubic cm. at egg stage, hatchling stage and fledgling stage in Little Cormorants and Night Herons. It also shows that the overall regression line for nest volume over the entire period of nesting activity is statistically significant at 0.001% level in Little Cormorant ($r = 0.97$, $t = 12.51$, $df = 10$) and in Night Heron ($r = 0.92$, $t = 7.26$, $df = 10$). The regression lines for nest volume at various stages of chick development are even more significant. The dots under egg laying phase present nest volume at two, three, four and five egg stages in Little Cormorant and at one, two, three and four egg stages in Night Herons. Each dot shows the average volume of four different nests. Similarly the dots under hatching and fledging phases indicate nest volume with one, two, three and four hatching and fledging phases respectively. It is observed that the first eggs are laid after 3 days of the onset of nest construction in both the species. In Little Cormorants hatching of the first egg and fledging of the first hatchling occurs on the 25th and 55th day of nesting while the same for Night Herons occurs on the 26th and 56th day nesting.

It may be pointed out that nest addition-alteration-repair etc. goes on, even in absence of any damage because it is necessary to prevent loss of chicks due to fall from nests.

8.3.7. Nest Distance

Of the six bird species that live in the sanctuary four i.e. Open-bill Stork (*Anastornus oscitans*), Little Cormorant (*Phalacrocorax nigler*), Night Heron (*Nycticorax nycticorax*) and Little Cormorant (*Egretta garzetta*) are considered to be major species. The total populations of the major species according to Forest Department, Raiganj Social Forestry Division census ranged from about 43500 to 81300 over the last ten years. The range presented is wide mainly because of large scale mortality of nestlings as wel as adults in years of severe rains-storms and floods. However, despite significant losses in some years eg. 1995, 1999, the population of all the bird species is increasing handsomely particularly for the four major bird species. As stated earlier the six bird species inhabiting the sanctuary utilize roughly about 15.871 ha i.e. 12.2% of a total area of 130.09 ha. Thus there is tremendous intra and interspecific competition with regard to almost all aspects of survival particularly for nesting sites. As a result distances between nests of the same as well as other species is very small inducing lot of conflicts at the early phase. However, once the nests are constructed the birds get summarily busy with reproduction and parental care activities and aggression with neighbours assumes a secondary position.

Table 8.7 and 8.8 shows inter-nest distance of Little Cormorant-Little Cormorant of Little Cormorant- Open-bill Stork, Little Cormorant-Night Heron, Little Cormorant-Little Egret and Night Heron-Night Heron, Night Heron-Open-bill Stork, Night Heron-Little Cormorant and Night Heron-Little Cormorant. It is observed that average distance between Little Cormorant-Little Cormorant with exception to Little Cormorant-Little Egret and Night Heron-Night Heron nests is maximum.

Little Cormorants and Night Herons nested closer to contraspecific nests than to conspecific ones. This was also found in Cattle Egrets, Little Blue Herons and in Louisiana Herons. This, however, was not the case in Great Egrets (McCrimmon, 1978). This observation supports the contention that intraspecific competition is most severe. On the basis of this it may be assumed that inter-nest distance can be used as an index of ecological separation between two species. In otherwords ecological requirements of two species is most different when distance between their nest is least.

8.3.8 Nest defence behaviour

Although predation by mammals (Southern and Southern, 1979 ; Rodgers, 1980), birds (Baker, 1940 ; Dusi and Dusi, 1968 ; Nisbet, 1975 ; Burger, 1982 ; Shield and Parnell, 1986) ande snakes (Dusi and Dusi, 1968) are common to wading bird colonies, in this sanctuary only the house crow was found to be the most dominant predator. Prerdation of egg by crows, however, has been reported for various bird species (Baker, 1940 ; Picozzi, 1975; Verbeek, 1982 ; Salathe, 1987). Actually the crows scavenged nest contents (Eggs and one to three days hatchlings) only when the nests were left unguarded. Thus no special antipredatory behaviour was observed in either species.

8.3.9 Nest Sanitation

Nest sanitation is important, in the over all perspective of nest success in bird life. It protects the young from infectious micro-organisms and insect parasites. It also helps to keep the predators away from the nests. It is established that different predators are attracted to the nests by different cues such as olfactory, auditory and visual. The degree of sanitation is also influenced by the nature of habitat and quantum of predator-pressure. Little Cormorants and Night Herons in the present study at Kulik exhibited several nest sanitation behaviours. It was observed that both the birds remove the empty egg shells from the nest and drop them on the ground beneath the nests within approximately one hour of hatching. The Greater Adjutant Storks also cleaned the nest by disposing egg shels (Singha *et al.*, 2003). Apprantly this could be due to at least three reasons : 1) The inside of egg could attract micro-organisms that could infect the hatchlings. 2) The white inside of the broken egg shell could attract the attention of the airborne predators such as : eagles and crows. Now although eagles are rather rare in the area both jungle and house crows regularly visit the sanctuary in large number from nearby localities and tend to stay in the sanctuary almost over the whole day. The crows particularly the house crows continuously look for opportunities to predate on eggs and hatchlings. Thus it appears to be beneficial for the Little Cormorants and Night Herons to get rid of the empty egg shells at the earliest. 3) Again the sharp edges of the broken shell is potentially dangerous as it could damage the soft tissue of the hatchlings. Hence, removal of the broken egg shell is beneficial.

It was also observed that adult Little Cormorants and Night Herons excrete liquid defecates along with nitrogenous wastes force-fully in a jet directed outside their nests. Prior to the act they orient the posterior part of their body including the cloaca outside the rim of the nest. Similar observations were made by Maxwell and Putnam (1968) in Black Crowned Night Herons at Western Lake Erie. The older hatchlings also do the same thing at about 2-3 weeks of hatching. However, the younger hatchlings less than 15-20 days do excrete inside the nest in both the bird species.

Again parent birds are in the habit of dropping unhatched eggs and dead youngs to the ground from the nest. This behaviour is possible only if groundborne predators are absent in the area. Infact although there are some ground dwelling predators such as : Bengal monitors, domestic dogs, the Bengal foxes, the Indian grey mongoose, and jungle cats their numbers are low and they were never in need of attacking nests because of abundance of food at the ground level itself. No attempts to climb up to the nests was observed in the course of over 10 years study period by any of the predators.

Parent birds were also observed to drop the parts of food items such as : spines of fish, heavily chitinized parts i.e. carapace, legs and the chela of crustaceans. Again during rains the parents shield the young and the nest with expanded wings in order to keep them dry. This act retard the growth of the microbs which flourish at high moisture / humidity and temperature situation.

Table 8.1 : **Percent nests of Little Cormorant on nesting tree species with percent abundance (PA) and preference values (PV) at Raiganj Wildlife Sanctuary.**

Serial No	Common / Local Name	Scientific Name	Percent Nest (N=494)	PA Nesting Tree species N=78	PV (PV=Percent Nest on a tree sp)
1.	Jarul	*Lagerstroemia flosregnae*	85.2	62.5	1.36
2.	Bamboo	*Bamboosa sp.*	5.66	19.44	0.27
3.	Pithali	*Trewia nudiflora*	5.06	8.33	0.60
4.	Chatim	*Alstonia seholaris*	3.03	5.55	0.54
8.	Jigni	*Lannea coromandetica*	1.21	4.16	.29

Table 8.2 : **Percent nests of Night Heron on nesting tree species with percent abundance (PA) and preference values (PV) at Raiganj Wildlife Sanctuary.**

Serial No	Common / Local Name	Scientific Name	Percent Nest (N=494)	PA Nesting Tree species N=78	PV (PV=Percent Nest on a tree sp)
1.	Jarul	*Lagerstroemia flosregnae*	84.21	57.69	1.46
2.	Bamboo	*Bamboosa sp.*	7.08	17.94	0.39
3.	Pithali	*Trewia nudiflora*	2.02	7.69	0.26
4.	Chatim	*Alstonia seholaris*	1.82	6.41	0.28
5.	Hijal	*Brringtonia acutangnla*	1.01	2.56	0.39
6.	Sisso	*Dalbergia sissoo*	1.61	2.56	0.62
7.	Sheora	*Streblus asper*	1.41	1.28	1.10
8.	Jigni	*Lannea coromandetica*	.81	3.84	0.21

Table 8.3 **Spatial Distribution of nests in Little Cormorants in the tree canopy at Raiganj Wildlife Sanctuary**

Name of tree	Sl. No.	Peak canopy to nest (m)	Bottom canopy to nest (m)	Height range of nest in canopy (m)	Vertical expanse of Canopy (m)	Length of tree (m)
Jarul ***(Lagerstroemia flosregnae.)***	1	1.47	1.62	1.58	4.67	15.23
	2	0.48	1.80	1.37	3.65	14.62
	3	0.76	1.53	1.40	3.69	7.93
	4	0.83	1.33	0.32	2.48	6.85
	5	0.73	1.44	0.82	2.99	7.00
	6	1.32	1.51	0.67	3.50	7.77
	7	0.76	1.51	0.60	2.87	6.55
	8	0.86	1.10	0.33	2.89	6.35
	9	1.42	2.82	2.13	6.37	11.70
	10	0.96	2.15	0.85	3.97	9.27
	11	0.99	1.20	0.76	2.95	8.13
	12	0.71	1.17	0.45	2.33	6.70
	13	0.91	2.23	0.57	3.71	8.54
	14	1.11	1.91	0.94	3.96	9.09
	15	0.76	1.39	0.85	3.00	7.37
	16	0.56	4.04	1.82	6.42	10.46
	17	1.67	1.03	0.73	3.43	8.08
	18	0.60	1.12	0.97	2.69	8.23
	19	1.11	0.87	0.64	2.62	8.79
	20	0.91	1.11	0.51	2.53	7.00
	$\overline{X} \pm$ S.E.	0.94 ± 0.07	1.64 ± 0.16	0.91 ± 0.11	3.53 ± 0.79	8.78 ± 0.55

Table 8.4 **Spatial Distribution of nests in Night Herons in the tree canopy at Raiganj Wildlife Sanctuary**

Name of tree	Sl. No.	Peak canopy to nest (m)	Bottom canopy to nest (m)	Height range of nest in canopy (m)	Vertical expanse of Canopy (m)	Length of tree (m)
Jarul ***(Lagerstroemia flosregnae.)***	1	1.88	1.22	1.57	4.67	15.23
	2	0.53	1.65	1.47	3.65	14.62
	3	0.46	0.94	2.29	3.69	07.93
	4	0.76	0.81	0.91	2.48	06.85
	5	0.68	0.86	1.45	2.99	07.00
	6	0.91	0.91	1.68	3.5	07.77
	7	1.68	0.84	0.35	2.87	06.55
	8	1.02	0.81	0.46	2.29	06.35
	9	1.73	0.91	3.73	6.37	11.70
	10	0.89	0.97	1.09	2.95	08.13
	11	1.80	1.08	1.07	3.96	09.27
	12	1.09	0.86	0.38	2.33	06.70
	13	1.22	1.02	1.47	3.71	08.54
	14	2.06	0.99	0.91	3.96	09.09
	15	1.27	0.97	0.76	3.0	07.37
	16	2.89	1.09	2.44	6.42	10.46
	17	1.83	0.94	0.66	3.43	08.08
	18	0.94	0.86	0.89	2.69	08.23
	19	1.32	0.46	0.84	2.62	08.79
	20	0.71	0.53	1.29	2.53	07.00
	$\bar{X}$+S.E.	1.28 $\pm$ 0.13	0.93 $\pm$ 0.04	1.28 $\pm$ 0.17	3.50 $\pm$0.25	8.78 $\pm$ 0.55

Table. 8.5 : Contribution of different tree species in the construction of various parts of Little Cormorant Nests (N=11)

Tree species	FOUNDATION	FLOOR	WALL	BEDDING
	Range of length & diameter 20 to 72 cm 40 to 1.6 cm	**Range of length & diameter 30 to 46 cm .4 to .8 cm**	**Range of length & diameter 50 to 30 cm .2 to .4 cm**	**Range of length & diameter 3 to 16 cm .2 to .3 cm**
1. Jarul (*Lagerstroemia flosregnae.*)	68 (45.33)	185 (39.36)	773 (54.74)	132 (31.35)
2. Jigni (*Lannea coromandelica*)	42 (28.00)	23 (4.89)	169 (11.96)	22 (5.22)
3. Hijal (*Barringtonia acutangula*)	23 (15.33)	---	147 (10.41)	110 (26.12)
4. Casia (*Casia sophera*)	---	35 (7.44)	68 (4.81)	---
5. Eucalyptus (*Eucalyptus sp.*)	---	77 (16.38)	90 (6.37)	66 (15.67)
6.Akashmani (*Acacia moniliformis*)	---	23 (4.89)	46 (3.25)	13 (3.08)
7. Sisso (*Dalbergia sissoo*)	08 (5.33)	12 (2.55)	20 (1.41)	---
8. Pitali (*Trewia mudiflora*)	09 (6.00)	34 (7.23)	---	---
9. Subabul (*Lencina leucocephala*)	---	20 (4.25)	---	---
10.Durba grass (*Cynodon dactylon*)	---	18 (3.82)	12 (0.84)	25 (5.93)
11.Napea grass(*Pennisetum sp.*)	---	13 (2.76)	32 (2.26)	12 (2.85)
12. Bamboo (*Bamboosa sp.*)	---	14 (2.97)	22 (1.55)	---
13. Kash (*Saccharum spontaneum*)	---	10 (2.12)	13 (0.92)	---
14. Toss Jute (*Corchorus olitorius*)	---	---	---	20 (4.75)
15. Biskatali (*Persicaria sp.*)	---	---	20 (1.41)	10 (2.37)
16. Chatim (*Alstonia scholaris*)	---	6 (1.27)	---	---
Total	150	470	1412	421
Average	13.63	42.72	128.36	38.27

The figure in the parentheses indicate percentage

Table 8.6 : Contribution of different tree species in the construction of various parts of Night Heron Nests (N=12)

Tree species	FOUNDATION		FLOOR		WALL		BEDDING	
	Range of length & diameter 50 to 72 cm 1.2 to 1.6 cm		Range of length & diameter 30 to 46 cm .4 to .8 cm		Range of length & diameter 50 to 30 cm .2 to .4 cm		Range of length & diameter 3 to 16 cm .2 to .3 cm	
1. Jarul (*Lagerstroemia flosregnae.)*	108	(64.3)	480	(63.5)	1932	(72.9)	522	(47.5)
2. Kadam *(Acanthocaphalus cadamba.)*	24	(14.3)	60	(7.9)	324	(12.2)	348	(31.7)
3. Eucalyptus *(Eucalyptus globulus.)*	---		120	(15.9)	96	(3.6)	108	(9.8)
4. Shegun *(Tectona grandis.)*	24	(14.3)	24	(3.2)	72	(2.7)	---	
5. Akashmani *(Acacia moniliformis.)*	---		24	(3.2)	48	(1.8)	48	(4.4)
6. Gokul *(Allanthus grandis.)*	12	(7.1)	12	(1.6)	12	(0.5)	---	
7. Bamboo *(Bamboosa sp.)*	---		12	(1.6)	24	(0.9)	---	
8. Napea grass *Pennisetum sp.)*	---		12	(1.6)	36	(1.4)	---	
9. Lichu *(Litchi chinensis.)*	---		12	(1.6)	36	(1.4)	---	
10. Guava *(Pisidum guajava.)*	---		---		48	(1.8)	---	
11. Karanj *(Pongamia pinnata)*	---		---		---		24	(2.2)
12. Bakul *(Mincosops elengi.)*	---		---		---		24	(2.2)
13. Subabul *(Lencina leucocephala.)*	---		---		---		24	(2.2)
14. Bougan vallia *(Bougainvillea sp.)*	---		---		24	(0.9)	---	
Total	168		756		2652		1098	
Average	14		63		221		91.5	

Table 8.7 : Nest distance as an index of ecological closeness in Little Cormorant

Sl No.	Species	Ave (m)	SD	df	t	P
1	LC-LC	1.21	0.94	30	7.16	<0.01
2	LC-OBS	1.13	0.62	30	10.14	<0.01
3	LC-NH	1.18	0.60	30	10.94	<0.01
4	LC-LE	1.30	0.55	30	13.16	<0.01

LC=Little Cormorant, OBS = Open-bill stork, NH = Night Heron LE = Little Egret.

Table 8.8 : Nest distance as an index of ecological closeness in Night Heron

Sl No.	Species	Ave (m)	SD	df	t	P
1	NH-NH	1.76	0.90	40	12.51	<0.01
2	NH-OBS	1.31	0.69	30	10.57	<0.01
3	NH- LC	1.18	0.60	30	10.94	<0.01
4	NH-LE	1.68	0.72	26	11.89	<0.01

LC=Little Cormorant, OBS = Open-bill stork, NH = Night Heron LE = Little Egret.

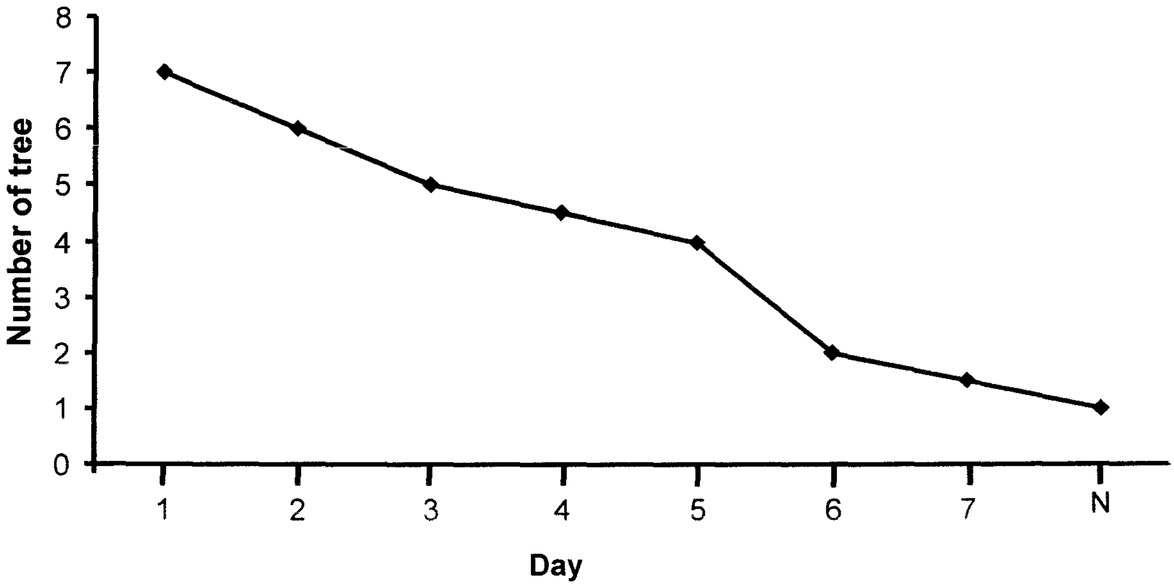


Fig. 8.1 Number of tree used to exhibit nest-site territoriality before the initiation of true nesting ("N") by Little Cormorant

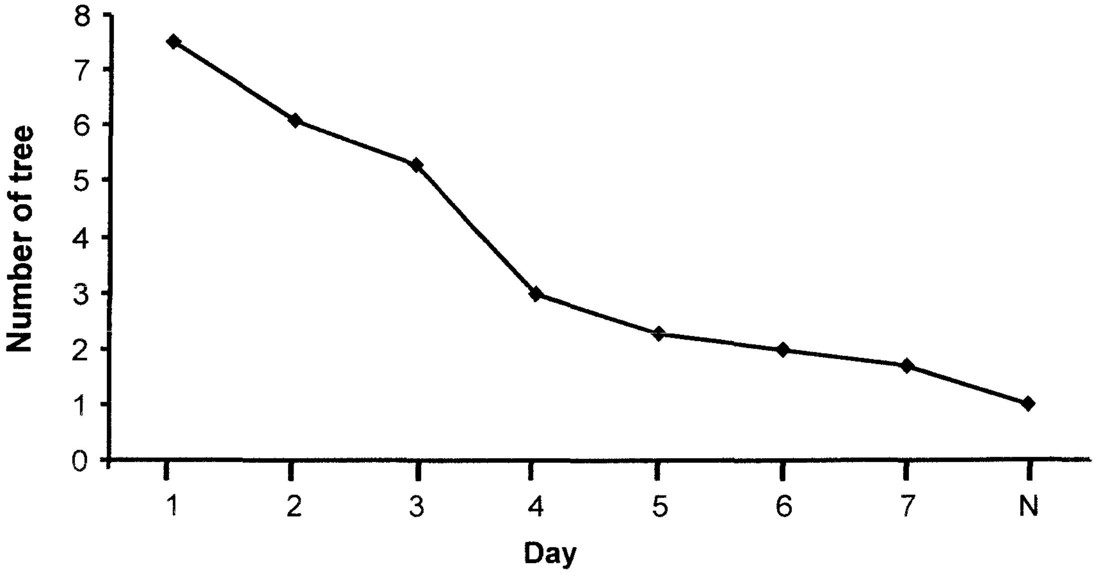


Fig. 8.2 Number of tree used to exhibit nest-site territoriality before the initiation of true nesting ("N") by Night Heron

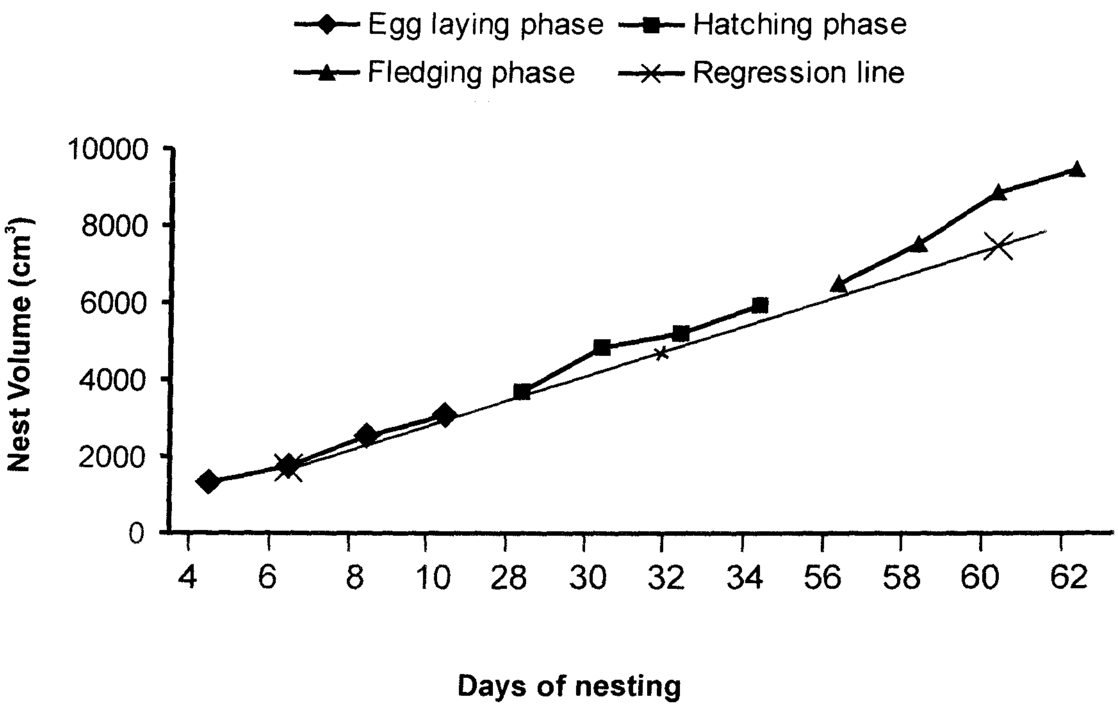


Fig. 8.3 Nest size of Little Cormorants at different developmental stages.

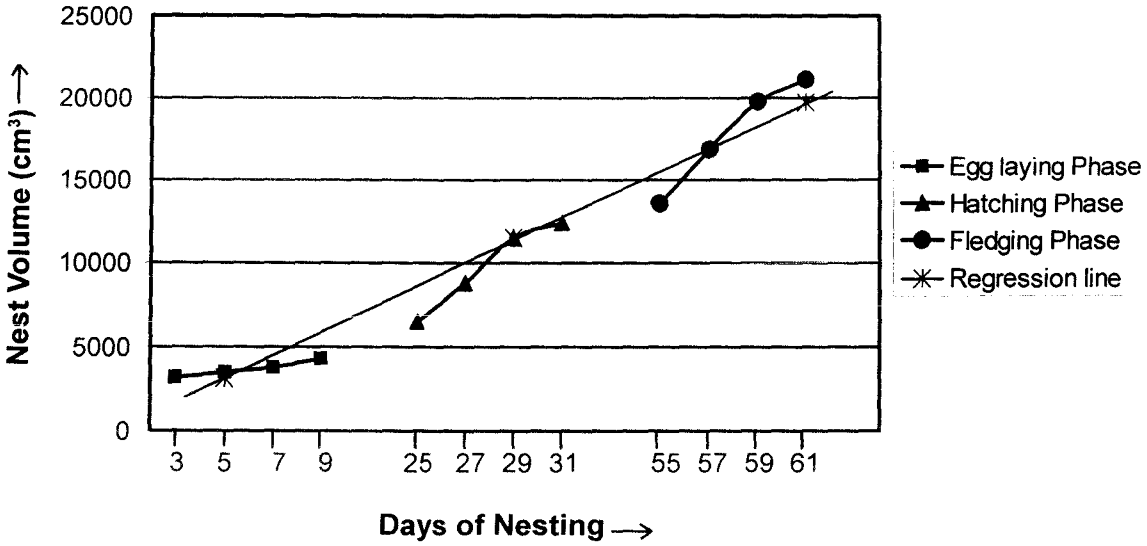


Fig. : 8.4 Nest size of Night Herons at different developmental stages

Plate 8.1 A nest of Little Cormorant in the early stage on a Jarul tree.

Plate 8.2 A clutch of three eggs in a Little Cormorant nest on a Jarul tree.

Plate 8.3 A Night Heron nest at the early nesting phase on Jarul tree.

Plate 8.4 A clutch of four eggs in a Night Heron nest.

Plate 8.5 A damaged nest of Night Heron

Plate 8.6 A nest of Night Heron at an unusual spot.

9. CLUTCH SIZE, EGG CHARACTERISTICS, LAYING AND INCUBATION

9.1 INTRODUCTION

Clutch size in most birds in determined by several counteracting factors operating in the life cycle strategy of the bird species. The optimum clutch size should be within the capacity of the mating pair to rear them to fledgling phase at the same time it should not be anything less than their capacity. Because, if the clutch size is smaller than their capacity some of their competence is left unutilized while if it is more than their capacity to raise there is a wastage of energy inputs contained in the eggs. Usually in most species the number is kept at a point which is a little above their capacity so as to make a room for unavoidable losses.

This is a hot topic for quite a long time and many renowned ornithologists worked on these problems. Some of the notable workers in this field are Lack (1966) ; Slagsvold (1982) ; Morris (1982) ; Custer *et al.*, (1983) ; Prat and Winkler (1985) ; Godfrays (1987) ; Lloyd (1987) ; Nur (1988) ; Magrath (1992) ; Stearns (1992) ; Vander Werf (1992) ; Meathrel *et al.*,(1993); Wiliams (1994) ; Risch *et al.*,(1996) ; Reed *et al.*,(1999) ; Sing *et. al.*(2000); Singha *et al.*,(2003).

However, it requires detailed account of laying, egg characteristics, Clutch size and incubation to evaluate the inter-relationship of these parameters and their implication on reproduction. But only some limited information about these parameters regarding Little Cormorants and Night Herons are available (Gross , 1923, Baker, 1929, Felix, 1975 ; Davis, 1993 ; Ali, 2002).

9.2 METHODS

During the study period a total of 222 nests of Little Cormorants and 301 nests of Night Herons were observed from a 10 m. high bamboo 'manchan' (platform) suitably built in the island, roof of the Rest House, some suitable sports on the ground, from the nesting trees and from the adjacent trees without nests. Normally the visitors are not allowed to the island. A paddle-boat was used by the investigator to get to the island and to the 'machan' from where most of the observations were made. The nesting trees were below the 'machan', so it was possible to lok into the nests. To begin with, the birds showed alarm response to the presence of the investigator but after a few days they got habituated to the condition and there was little or no adverse response from the birds.

The usual observation schedule was 0600 to 0900 hours and 1500 to 12800 hours. On sundays and other holidays, however, obsertations were often taken throughout the day.

The nests were inspected daily during the egg-laying period. Efforts were taken to complete nest inspection as quickly as possible and in a way so as to make negligible disturbance to the birds. Binoculars (7-15 x 35 with zoom) were used whenever required. The eggs were numbered along with the date with a marker pen soon after laying and the process was continued until the last egg was laid. Thus the clutch size for each pair was determined. The nesting trees ande al the nests in each tree were also marked. Only the nests which were occupied by a nesting pair and those that were not damaged, destroyed or deserted during the laying phase were considered in the study.

Change of egg colour was recorded during nest inspection. Length and breadth of eggs were measured by a Vernier calipers. Weight of egg was determined with a spring balance with a sensitivity of 0.5 gm. Egg volume was calculated from the equation $V=Kv.Lb^2$ folowing Hyot (1979). Where viz the volume (cm3), L is the length and B in the bredth of the egg and Kv is a constant. Hyot (1979) showed that Kv varried little both within and between species. So his mean value of 0.507 was used in this study to calculate the volumes.

The laying period was divided into three phases : early, median and late i.e. from 1st July to 31st July, 1st August to 31st August and 1st September to 30th September to the date last laying respectively in Little Cormorants and from 25th June to 24th July, 25th July to 24th August and 25th August to the date of last laying respectively in Night Herons. Clutch size was divided into four classes i.e. very small (clutch of 2), small (clutch of 3), medium (of 4) and large (of 5 to 6) in Little Cormorants but (of 5) in Night Herons.

Fresh egg weight were taken only from those eggs which were completely white in Little Cormorants and light greenish in Night Herons. This ensured that the egg was laid not earlier than two days and have lost only a negligible weight due to incubation.

9.3 RESULTS AND DISCUSSIONS

9.3.1. Laying

Over the ten years study period the first clutch was initiated on or around the 1st week of July (Table 9.1). Although the arrival of first batch of the birds during the study period was spaced over a period of 12 days in Little Cormorants and 13 days in Night Herons.

Upto the 3rd week of July only a few pairs (about 17% in Little Cormorants and 20% in Night Herons) started to lay eggs. Laying gradually gained momentum and after July it attained the peak. By the third week of August about 61% of Little Cormorant and 64% of Night Heron nests contained eggs. In September the rate of laying gradually decreased and ceased on or around the 3rd week of September (Table 9.1). Actually only a few nests were initiated after the first week of September and only few pairs started laying during 2nd week of September.

The laying period spanned over a period of about 85 days in both Little Cormorants and Night Herons. The peak laying period was 25th July to 15th August in Little Cormorants and 20th July to 10th August in Night Herons. According to Grau (1984), Brandt's Cormorants require 16 days for yolk development, plus additional time for albunen synthesis and shell deposition . Thus in most females yolks deposition seem to start before they first reach the colony. In Bran Swallows, females expend as much energy per day during egg formation and incubation as they do during brood rearing (Ward 1996, Monaghan and Nager, 1997).

The parent study supports the contention of Drent and Dann (1980) that the natural variation in laying date should be reflected as a phenotypic tuning to nutritional circumstances rather than genetic variability. Generally date of laying is a function of heritability which emerges through non-genetic maternal nutritional conditions (e.g. Huck *et al.*, 1987 ; Price *et al.*, 1988).

9.3.2 Laying in relation to nesting settlement

Both Little Cormorants and Night Herons were found to take different time intervals between nest-site selection and laying. At the first part of the breeding season birds took longer time to lay after the initiation of nesting. Whereas, at the end of the season birds tried to start nesting and laying as early as possible. On an average (2001-2006) birds who settled on or before 5th July took 7.9 days to lay the first egg in Little Cormorants and 8.6 days in Night Herons. Whereas, this interval was only 6.2 daqys and 4.5 days respectively at the middle (20th July to 15th August) and at the concluding part (5th September to onwards) of the season 5.6 in Little Cormorants and 4.1 days in Night Herons.

9.3.3. Time of laying

As in most birds, Little Cormorants and Night Herons also lay in the morning. Although no direcdt observations on such events were made. However eggs were found to have been laid in the afternon i.e. 16.00 to 18.00 hours.

9.3.4. Laying intervals

Usually laying of successive eggs occurred on alternate days. This schedule was maintained strictly upto the laying of the 4th egg in Little Cormorant and 3rd egg in Night Heron. However, the interval between laying of fourth and fifth or fifth and sixth egg in Little Cormorant and 3rd or 4th egg in Night Heron was occasionally irregular. ($\overline{X}$ = 3.22, SD = 1.48, n = 10 in Little Cormorant and $\overline{X}$ = 3.4, Sd = 0.72, n = 9 in Night Heron). In few cases the last egg of the clutch appeared after an unusually long gap i.e. about 6-7 days in both the species .

9.3.5. Factors affecting laying date

9.3.5.1. Breeding Synchrony

Breeding synchrony has been reported by many investigations in colonially bring birds. The Little Cormorants and Night Herons at Kulik do breed in synchrony. Most authors advocated that synchronous breeding reduce predation (Patterson, 1965 ; Birkhead, 1977 ; Findley and Cooke, 1982). In this sanctuary avian predation is very common (Datta and Pal, 1990 ; Pal and Das, 2003), so breeding in synchrony would be advantageous to minimize the effect of predation (Wittenberger and Hunt, 1985 ; Reville, 1988).

9.3.5.2 Age

Older birds usualy lay first in both Little Cormorants and Night Herons. It was observed that older birds settleded first probably through experience they have understood the advantage of early settlement and as a consequence they also lay earlier in comparison to the younger late comers.

9.3.6. Behaviour of Sexes

No special behaviour of the male was observed except food gathering in the nest for the female partner when laying has already started. However, behaviour of the female changed significantly during the laying period. The changes appeared one to two days before laying and gradually the incubation behaviour appeared. The behaviour patterns are as follows :

(1) After partial completion of the rim of the nest female spent more time in nest and cut down its outside trips. She involves herself in the rearrangement and care of the nest.

(2) She frequent took incubation posture. When her partner returned to the nest they jointly rearranged the nest materials. On the egg laying day she sat on the nest for long periods.

9.3.7. Egg

9.3.7.1. Colour :

In Little Cormorant

Immediately after laying the eggs are chalky white and gradually attained dawn colour. In the first two to three days the egg gradually becomes dull and looked dirty white in appearance. Porcelain colour gradually covers the whole egg shell within 12th day. At the end of the incubation period colour of the eggs faded and dawn colour cover the whole egg shell. It was also observed that before three or two days of hatching 3-4 spots of Satin blue colour was appeared on the egg shell.

In Night Heron

The colour of eggs are variously described by different authors as clear blue, Pale bluish green, blue, bluish green to greenish yellow (Hatch, 1892; Reed,1904 ; Finley, 1907 ; Barrows, 1912). Gross (1923) mentioned that folowing Ridgway's colour standards the Night Herons freshly laid egg was Glaucous-green colour. Ali (1968) described the colour as pale blue green.

The Night Heron's freshly laid eggs were light green which gradually attained light bluish green colour. With the progress of time small patches of whitish colour were appeared at some spots. The moisture content of the nest probably facilitates staining procedure through the generation of need from fermentation procedure.

9.3.7.2. Shape

Eggs are blunt oval and narrow and pointed towards the smaller end in Little Cormorants and longish oval in Night Herons. Average elongation index (Length / bredth) and egg shape index or ESI (bredth / length x 100) which gives an idea about the shape of eggs are shown in Table 9.2. Table shows that the present data is closely identical with that of Baker (1929).

9.3.7.3. Size

Average size of eggs, however, were much smaller than that of Baker (1928) but the range of variation was appreciably large in this sanctuary (Table 9.2). Average egg volume was 17.82 ($\pm$ 1.22)cm^3 in Little Cormorant and 30.46 ($\pm$ 2.61) inNight Heron.

A considerable variations in egg diametrics was observed not only among different clutches but also within the same clutch. In both the species the 2nd egg was the largest in clutch size of 3 and 4 while the 3rd was the largest in clutches of 5 and 6. Intraclutch variation in egg size is also observed in many Water bird species (Snow, 1960 ; Coulson *et al.*, 1969 ; O'Connor, 1985 ; Leblane, 1987 ; Borad, 1988).

9.3.7.4. Factors affecting size of egg

9.3.7.4.1. Clutch size

Egg volume decreased significantly as the clutch size increased. During 1st to 10th August for Little Cormorant and 4th July to 5th August for Night Heron average egg volumes of 3 - , 4 - , and 5 - egg clutches were respectively. Decline of egg volume in ralation to larger clutch was reported in bird species of birds (Slagsvold et. al., 1984). Correlation off egg size and clutch size serves to reduce the sibling competition in longer clutches.The average egg volume decreased gradualy in both the species as the season advanced. Average egg volume of early raised ($\overline{X}$ = 22.65), median raised ($\overline{X}$=18.17) and late raised ($\overline{X}$= 16.85 in Little Cormorant and in Night Heron $\overline{X}$ = 33.85, $\overline{X}$ =30.55, $\overline{X}$ = 26.58 respectively. Such seasonal decline in egg volume was also observed in many other bird species (Coulson *et al.*, 1969 ; Mills, 1979 ; Hill, 1984). The trend of seasonal decline of egg volume is assumed to be a consequence of later breeding by younger birdfs who lay smaller eggs.

9.3.7.5. Weight of Egg and Shell

Average weight of fresh egg was 18.24 gm. (SD = 1.22, n = 50) in Little Cormorant and 30.46 gm. (SD = 2.61, n = 60) in Night Heron. The average weight of one hundred eggs obtained by Gross (1923) in Night Heron was 33.92 grams. Thus, the weight of Night Herons egg is less at the sanctuary than that of Gross.

Weight of egg was significantly correlated with the volume of egg. In Little Cormorant the value was found to be 0.78 (n = 46 ; P< 0.01) and in Night Heron, value was 0.87 (n = 40 ; P< 0.01).

Average weight of egg shell was 2.39 gm. (SD = 0.12, n = 15) in Little Cormorant and 3.17 gm (Sd = 0.28, n = 22) In Night Heron.

9.3.8 Clutch Size

In Little Cormorant

Mean clutch size of three years (1996 to 1998) study period was 3.69 ± .25(n = 54) clutch size ranged from 2 to 6 but occurance clutches of 6 was rather rare.

Table 9.3 shows that out of 96 clutches in the first phase 6.25% were very small, 29.16% were small, 36.45% of medium size and 28.12% of large size. Similarly, of the 7b clutches in the second phase and 50 of the third phase the percent distribution in the very small, small, medium and large categories were 6.57, 46.05, 28,94 and 18.42 ; and 24.00, 42.00 and 6 respectively. Over al clutch size varied from 2 to 6 with a frequency distribution of 23 clutches of 2 (10.36%), 77 clutches of 3 (34.68%), 78 clutches of 4 (35.13%), 33 clutches of 5 (14.86%) and 11 clutches of 6 (4.05%).

The mean clutch size in the first, second and in the third phase was 3.92, 3.65 and 3.30 respectively.

In Night Heron

The Mean clutch size of three year (1999-2001) study period was 3.15± 0.32 (n = 68). Clutch size ranged from 2 to 5.

Table Y shows that out of 126 clutches in the first phase 7.93% were very small, 54.76% were small, 31.74% of medium size and 5.55% of large size. Similarly, of the 113 clutches in the second phase and 62 of the third phase the percent distribution in the very small, small, medium and large categories, were 13.27, 66.37,17.69 and 2.65 ; and 29.03,58.06,11.29 and 1.61 respectively.

Clutch size varied from 2 to 5 with a frequency distribution of 43 clutches of 2 (14.28%), 180 clutches of 3 (59.80%), 67 clutches of 4 (22.25%) and 11 clutches of 5 (3.65%).

The mean clutch size in the first, second and in the third phase was 3.34, 3.09 and 2.85.

9.3.8.1 Factors affecting clutch size :

9.3.8.1.1. Laying Date

Clutch size was found to be influenced by the laying date. From Table 9.3 and 9.4 it in evide3nt that clutch size declines with the advancement of the season. The mean clutch size of Little Cormorant in the firswt, second and in the third phase was 3.92, 3.65 and 3.30 and in Night Heron was 3.34, 3.09 and 2.85 respectively. This study supports that clutch size tended to be smaller as the season progressed. Similar observation were made in the Little Blue Heron (Rodgers, 1980), in Blackcrowned Night Heron (Custer *et al.*,1983) in precocial birds (Winkler and Walters, 1983), in Great Blue Heron and Great Egrets (Pratt and Winkler, 1985).

9.3.8.1.2. Age of female

Seasonal decline of clutch size resulted probably due to the nesting of younger birds at the later part of the season whose clutches invariably tended to be smaller.

A significantly high percent i.e. 24% in Little Cormorant and 29.03% in Night Heron (Table 9.3 and 9.4) of Pairs in the third phase opted for clutches of 2. This unmistakably points out to the fact that a large proportion of the third phase breeders were young first time breeders or physiologically incapable to go for higher clutch sizes. This data supports the contention that small clutch size and prolonged parental care have evolved to avoid complete reproductive failure due to physiological and environmental stress conditions.

9.3.9. Incubation

9.3.9.1 Commencing of Incubation

The conventional method of calculating the incubation period is from the laying of the last egg to the hatching of that egg. Baker (1929), Kendeigh (1952) opined that serious incubation commences usually after the second egg has been laid. In Little Cormorant and Night Heron incubation started before the completion of laying. Although birds were found in incubation posture even before laying, actual incubation was marked by a sudden increase in incubation length and decrease in recesses, between two successive incubation bouts. During egg laying phase females were observed at the incubation posture at stretch for 25 m. to 35 m. with a maximum 2.10 m. to 2.20 m. in Night Heron but after completion of egg laying recesses attained a definite pattern at an interval of 10-20 m. she stands for 1-3 minutes. This pattern persisted throughout the incubation period. In Little Cormorant at egg laying phase females were observed at the incubation posture at a stretch for 37.87 m ($\pm$ 15.68) with a maximum of 84-98m after completion of egg laying recesses appeared at a difinite pattern usually at an interval of 22.57 m ($\pm$ 10.30) she stand for 1-3 m.

9.3.9.2 Incubation shift

During the day hours incubation activity resumed for several time but clutches never remained unguarded. Breaks in incubation occurred mostly in the form of standing, shifts of incubation between partners and greeting of incoming partner. In each day on an average Little Cormorants halted

incubation and stood for about 30-32 times and in Night Heron for 36-40 times. In most of the cases (52.6%) incubating bird stood upoto change its own position for relaxation or for sun and wind and after rains in Little Cormorants and 59.4% in Night Herons.

9.3.9.3. Activity of birds during recess of incubation

The following activities were found during the recess period .

a) Preening at different parts of the body by beak, which also recorded.Maxwell and Putnam in Night Heron (1968).

b) Rolling of egg by beak and breast or abdomen.

c) Arrangement of nest materials by standing in one or different position of the nest.

d) Defecation

e) Only standing and sitting.

f) Shaking of wings after rain spreading of wings and tail feathers.

g) Spending a minute or two outside the nest but within 30 cm. of the nest.

9.3.9.4. Role of Sexes

In Little Cormorants and in Night Herons both the sexes take part in incubation. Similar observation were recorded by many authors (Baker, 1929 ; Ali and Ripley, 1968 ; Urban E.K. 1979). The male actively assisted the female during incubation. At the starting time males also remains on or close to the nest while the female continues incubation. Actually the male incubated only when the female was out of the nest. In Little Cormorant the female leave the nest only 3 to 5 times a day mainly for food collection. But at the egg laying and at the hatching stage food were collected by the males for the partners and the hatchlings.

In Night Heron at the egg laying phase and at the hatching phase foods were reserved by male at the nest during the night.

9.3.9.5. Length of incubation

The total length of incubation i.e. from initiation of proper incubation to the end of hatching varied greatly among individuals and it ranged from 22 to 28 days in Little Cormorant and 23 to 29 days in Night Heron. It largely depended upon clutch size and experience of the parents. Parents of larger clutches invested more time in incubation (Table 9.5).

Abnormal long length of incubation was also found in the unhatched egg. This case is observed in 3rd phase when youngs birds lay eggs. Eg. 34 days in Night Heron and 39 days in Little Cormorant of last egg was observed.

Birds of various species were also found to incubate for much longer time when the eggs failed to hatch in due time (Kirkman, 1975 ; Skutch, 1962 ; Drent, 1975 ; Powers, 1978 ; Afik and Ward, 1989).

Table 9.1 : Arrival of first batch of Little Cormorant and Night Heron and initiation of first and last clutch in different seasons

Year	Name of birds	Arrival date of first batch	Initiation of first clutch	Initiation of last clutch
1996	Little Cormorant	24.6.96	08.7.96	20.9.96
	Night Heron	20.6.96	03.7.96	18.9.96
1997	Little Cormorant	27.6.97	12.7.97	23.9.97
	Night Heron	21.6.97	04.7.97	20.9.97
1998	Little Cormorant	25.6.98	10.7.98	27.9.98
	Night Heron	22.6.98	08.7.98	21.9.98
1999	Little Cormorant	26.6.98	13.7.99	19.9.99
	Night Heron	21.6.99	06.7.99	16.9.99
2000	Little Cormorant	29.6.00	12.7.00	25.9.00
	Night Heron	25.6.00	10.7.00	20.9.00
2001	Little Cormorant	25.6.01	11.7.00	24.9.01
	Night Heron	18.6.01	02.7.06	18.9.01
2002	Little Cormorant	17.6.02	04.7.02	20.9.02
	Night Heron	14.6.02	08.6.02	14.9.02
2003	Little Cormorant	19.6.03	30.6.03	71.9.03
	Night Heron	12.6.02	25.6.03	12.9.03
2004	Little Cormorant	21.6.04	02.7.04	20.9.04
	Night Heron	15.6.04	29.6.04	16.9.04
2005	Little Cormorant	24.6.05	07.7.04	24.9.05
	Night Heron	18.6.05	03.7.06	15.9.05
2006	Little Cormorant	22.6.06	03.7.06	22.9.06
	Night Heron	17.6.06	30.6.06	17.9.06

Table 9.2 : Diametric of eggs of Little Cormorants and Night Herons

Study	Name of Bird Species	Length (mm)			Breadth (mm)		Maxima	Minima	Average volume (cm^3)	Average Wt. (gm)	Average elongation index (AEI)	Egg shape index (ESI)
		$\bar{X}$ + S.D.	N	Range	$\bar{X}$ + S.D	Range			$\bar{X}$ + S.D	$\bar{X}$ + S.D		
In this study	Little Cormorant	44.3 $\pm$ 0.17	52	41.5 -- 48.5	28.5 $\pm$ 0.13	26.3 -- 34.0	48.5 x 28.6 43.3 x 32.0	41.5 x 28.9 46.7 x 26.3	17.82+1.22	18.14+1.42	1.55	64.33
In Baker's Study (1929)		44.8	100	48.1-41.1	29	26.3 – 31	48.1 x 28.4 45.1 x 31.0	41.1 x 28.7 44.8 x 26.3	---	---	1.54	64.73
In this study	Night Heron	49.2 $\pm$ 4.9	104	43.2 – 57.0	35 $\pm$ 1.7	32.4 – 38	57.0 x 35.2 50.0 x 38.0	43.2 x 33.4 46.0 x 32.4	30.46 $\pm$ 2.61	31.03 $\pm$ 3.08	1.40	71.13
In Baker's Study		49.9	50	46.1 – 54.1	35.1	32.2-- 37.3	54.1 x 35.8 51.3 x 37.3	46.1 x 35.9 47.2 x 32.2	---	---	1.42	70.34
In Gross's Study (1923)		51.4	100	---	36.7	---	---	---	---	---	---	---

Table 9.3 : Clutch size of Little Cormorant at different phases of breeding season.

Clutch size	Year	Phases of breeding season					
		First Phase		Second Phase		Third Phase	
		Total No. of eggs	Total No. of clutches and Percentage	Total No. of eggs	Total No. of clutches and Percentage	Total No. of eggs	Total No. of clutches and Percentage
2	1996 1997 1998	0 6 6	6	8 0 2	5	4 12 8	12
	Total	12	(6.25)	10	(6.57)	24	(24)
3	1996 1997 1998	36 24 24	28	48 27 30	35	3 18 21	14
	Total	84	(29.16)	105	(46.05)	42	(28)
4	1996 1997 1998	64 24 52	35	44 20 24	22	36 24 24	21
	Total	140	(36.45)	88	(28.94)	84	(42)
5	1996 1997 1998	50 25 30	21	35 5 5	9	10 0 5	3
	Total	105	(21.87)	45	(11.84)	15	(6)
6	1996 1997 1998	18 12 06	6	24 0 6	5	0 0 0	0
	Total	36	(6.25)	30	(6.57)	0	(0)
Grand Total		377	96	238	76	165	50

The figure in the parentheses indicate percentage of clutches.

Table 9.4 : Clutch size of Night Heron at different phases of breeding season.

Clutch size	Year	Phases of breeding season					
		First Phase		Second Phase		Third Phase	
		Total No. of eggs	Total No. of clutches and Percentage	Total No. of eggs	Total No. of clutches and Percentage	Total No. of eggs	Total No. of clutches and Percentage
2	1999 2000 2001	04 10 06	10	12 10 08	15	12 14 10	18
	Total	20	(7.93)	30	(13.27)	36	(29.03)
3	1999 2000 2001	54 81 72	69	63 87 75	75	36 48 24	36
	Total	207	(54.76)	225	(66.37)	108	(58.06)
4	1999 2000 2001	44 64 52	40	28 32 20	20	08 16 04	7
	Total	160	(31.74)	80	(17.69)	28	(11.29)
5	1999 2000 2001	15 10 10	7	0 10 5	3	0 5 0	1
	Total	35	(5.55)	15	(2.65)	5	(1.61)
Grand Total		442	126	350	113	177	62

The figure in the parentheses indicate percentage of clutches.

Table 9.5 : **Time requirements in incubation of different clutch sizes in Little Cormorant and in Night Heron**

Name of bird species	Clutch Size	N	Total length of incubation (days)	Incubation periods (days)
Little Cormorant	2	12	23.64	22.32
	3	26	28.56	24.46
	4	32	30.82	26.58
	5	14	31.22	29.14
Night Heron	2	16	25.54	24.42
	3	48	29.66	26.76
	4	34	31.24	28.84
	5	12	33.44	30.53

Plate 9.1 A clutch of four fresh eggs of Little Cormorant in a well constructed nest.

Plate 9.2 A clutch of four eggs of Little Cormorant after incubation in a well constructed nest.

Plate 9.3 A clutch of three fresh eggs of Night Heron on nest.

Plate 9.4 Change of colour and shell surface speck pattern in Night Heron eggs.

Plate 9.5 An incubating Little Cormorant parent

Plate 9.6 An incubating Night Heron parent

10. HATCHING, GROWTH AND BEHAVIOURAL DEVELOPMENT OF YOUNG

10.1 INTRODUCTION

Hatching and further development of the young usually follow species specific pattern that had been developed through a long course of evolution. The main objective of reproduction and parental care is to attain a high individual fitness which is measured in terms of number of fledglings that successfully leave the nest and are able to fend for themselves. (Lack, 1948 ; 1949 ; 1966 ; Perrins, 1964 ; 1965 ; Schifferli, 1973 ; 1978 ; Moss et. al., 1981). So to study hatching and development of birds its interrelationship with other components should be considered.

Attempts have been made to discuss to the general trend of hatching, hatching success, hatchling growth pattern young and some early behavioural aspects of the young.

10.2 METHODS

The nests were inspected daily during the hatching period. Efforts were taken to complete inspection as quickly as possible in a way so as to make negligible disturbance to the birds and hatchlings. The progress and development of al nests were followed until the last young left the nest. Binoculars (7.15 x 35x with Zoom) were used whenever required. The nesting trees as also the nests in each tree were marked.

Hatching success is calculated as a percentage of eggs that produced hatchlings. Fledging success is calculated as a percentage of hatchlings which developed to fledglings. Over al reproductive success, however, is measured as the percentage of eggs which developed to fledgings. The ability of the fledglings to fly across the trees away from the nests was considered to be successful fledgings.

A spring balance, Pesola scale of 2000 gm with 0.5 gm. sensitivity was used to weight the nestlings. Measurements of tarsal and wings was taken by a metal scale graduated to 1 mm.

Egg disappearance factors were identified according to the following assumptions. In case of egg predation, the predator which is most cases were crows, usually pick up the egg with the beak and fly away to a far off safe place to consume the booty.

10.3. RESULTS AND DISCUSSION

10.3.1 Hatching

Brood reduction in Little Cormorants and Night Herons is accomplished through asynchronous hatching, variation in egg size (as per laying order), low fledging weight but with small variation in clutch size. Asynchronous hatching is also common among storks (Coulter *et. al.*, 1989 ; Datta and Pal, 1990). Like other birds they are also nidicolous, eyes remain open in Night Heron and closed in Little Cormorant at hatching. Interval between piping to hatching ranged between 10-22 hours in Little Cormorant and 14-25 hours in Night Heron.

Harching interval between successive youngs was 34$\pm$ 6 hours in Little Cormorant and 33$\pm$8 hours in Night Heron.

10.3.1.1. Hatching and fledging success at different phases of breeding season

In Little Cormorant

Table 10.1 shows the hatching and fledging success at different phases of breeding season in Little Cormorants out of a total of 820 eggs studied, overall hatching and fledging success increased as the laying date progressed. Hatching success was 68.96% in the first phase, 74.46% in the second and 79.39% in the third phase. Fledging success was 56.49% in the first phase, 61.15% in the second and 64.24% in the third phase. Table 10.1 also shows that this is the general trend for all the clutch size categories.

In Night Heron

Table 10.2 shows the hatching and fledging success at different phases of bereeding season in Night Herons out of a total of 949 eggs studied, overall hatching and fledging success increased as the laying date progressed upto second phase. Hatching success was 69.90% in the first phase, 73.42% in the second and 72.88% in the third phase. Fledging success was 54.26% in the first phase, 56.28% in the second and 53.67% in the third phase. Table 10.2 also shows that this is the general trend for all the clutch size categories.

Table 10.3 and Table 10.4 shows the main factors responsible for loss of egg and hatchling, and success of hatchling and fledgling in Little Cormorant and in Night Heron. In Little Cormorant predation accounted for a maximum of (10.87%) egg loss in the first phase but subsequently declined to 3.03% in the third phase. Similar declines in percent egg loss are also observed for rain / storm and nest-material stealing. Percent egg loss due to failure of hatching on the other hand increased from 10.34% in the first phase to 14.54% in the third phase. On the whole 72.92% eggs hatched into hatchlings.

In Night Herons predation accounted for a maximum of (9.47%) egg loss in the first phase which subsequently declined to 3.95% in the third phase. Similar declines in percent egg loss are also observed for nest material stealing. Percent egg loss due to rain / storm decreased in the second phase but increased in the third phase. But percent egg loss due to failure of hatching increased from 10.90% in the first phase to 11.86% in the third phase. On the whole 71.75% egg hatched into hatchlings.

It was found that number of unhatched eggs increased as the breeding season progrased while mortality due to other factors such as predation, fall from nest due to rain / storm and fall due to stealing of nest materials declined with season. It is already mentioned that the late layers mostly comprised of young first time breeders and less-mature birds who may actually fail to fertilise the eggs due to behavioural or physiological constraints. On the other hand predation, comptition and environmental factors are at their most in the first phase of breeding than at any other time which causes increased egg loss in the first phase. Predation of egg by crows has been reported for various bird species (Baker, 1940 ; Picozzi, 1975 ; Verbeek, 1982 ; Salathe, 1987).

Table 10.3 and 10.4 also shows that the main factors for hatchling loss are starvation, fall from the nest and predation. Out of these factors starvation appeared to be responsible for maximum loss, amounting for 5.97% in Little Cormorants and 9.37% in Night Herons on the whole. Predation and fall from the nest on the other hand accounted for 3.04% and 4.14% in Little Cormorant and 2.52% and 5.05% in Night Heron respectively.

Loss of hatchlings was highest due to starvation probably for two reason : one is behavioural and the other ecological. It is a well known fact that there is intense competition among known fact that there is intense competition among hatchlings from the time of hatching. As a result the heavier hatchlings get more and more heavier and stronger while the lighter hatchlings get relatively more and more lighter and weaker in time and ultimately succumb to death. The ecological reasons on the other hand is availability of adequate food materials. It is seen that starvation death is highest in the second phase on the whole is highest. It may be mentioned that the hatchling period extends over a period of fours weeks so that hatchlings of the first phase overlap in time with those of the second phase, similarly hatchlings of the second phase overlap with the hatchlings of the third phase. As such, it is reasonable to believe that scarcity of food materials suitable for hatchlings is adequately available in the second phase. The reason for the decline of the hatchling predation is similar to that stated for egg predation. Loss of hatchlings due to fall from the nest was found to be maximum in the third phase. This is probably due to three reasons : sudden appearance of post-monsoon storms which are quite violent, breeders of the third phase are young and inefficient in nest construction and over crowding of nestlings.

Fledging success increased upto second phase and decreased in the third phase in both the bird species. This is probably because of the fact that both biotic and environmental constraints decreased as also due to the fact that the nesting pairs had to attend or rear lesser number of hatchlings per pair in Little Cormorants and in Night Herons.

10.3.1.2. Clutch size and Productivity

Productivity (number of fledglings / nest) was higher at larger clutches in both the bird species (Table 10.5and 10.6). Similar observations were made by various authorities in diverse bird species (Perrins, 1965 ; Tomilson, 1975 ; Rodgers, 1980 ; Prat and Winkler, 1985). The common clutch size was not always most productive. In Little Cormorants and in Night Herons clutch of 4 and clutch of 3 were most common in the sanctuary but the most productive were the broods of 5 (Pal & Das, 2003) and broods of 4 respectively. In a number of bird species including Great tit, the most common clutch size is smaller than the most productive one (Klomp, 1970 ; Perrins and Moss, 1975). These data contradicts Lack's (1954) theory that parents raise as many young as they can do with existing food supply. In essence Lack's prediction states that the most common clutch size should be the most productive one. Results of the present study and similar other studies are probably quite consistent with the view that selection maximizes lifetime reproductive success rather than the effort during any particular season. The relationship between resources and effort should vary alongwith different other factors (Williams, 1966 ; Pianka and Parkar, 1975).

10.3.1.3. **Adaptive significance of hatching asynchrony**

Asynchronous hatching produces size heirarchies in broods. Such size hierarchiers is interpreted as adaptive because they can allow elimination of smaller chicks by selective starvation, when it appears difficult to sustain the entire brood (Lack, 1954 ; Ricklefs, 1965). Asynchronous hatching was not advantageous in terms of productivity but surely it was advantageous in terms of "parental investment" (Trivers, 1972). In the present study asynchronous hatching in both the birds species, the early mortality of nestlings resulted brood reduction at an early phase for the better survival of the remaining youngs and saves parental investment which enhances future reproductive output of the parents. The last egg was probably used by the mother as a hedge against other eggs or hatchlings of early age and thus it acted as an "insurance" (Nisbet, 1973 ; Stinson, 1979).

10.3.2. **Hatchling growth**

Table 10.7 and 10.8 shows the growth of hatchlings in body weight and length and linear dimensions of four body parts i.e. beak, wing, tarsus and tail in Little Cormorants and Night Herons. Little Cormorant hatchlings on emergence appear black, covered with naked skin, fleshing bald head and on naked scrawny neck. Eyes remain closed and it opens on the fifth day. Tail feather is also absent. Feet are webbed. On sixth day tail (rectrices) appears. One week old body covered with dingy black down. Body feathers appear on the 14th day and afterwards.

In the other hand chicks in Night Heron chicks appear rather mature as a day old chick is covered with natal plumage or down on the head, neck and dorsal portions of the body which varies from a dark mouse gray to a deep neutral gray. The outer three fourths of the crown filaments are white. These white lips are very conspicuous in the freshly hatched chick but after a few days exposture to the sun and air they because in conspicuous. The down of the crown is much longer than that of the body so that conspicuous crest is fromed. The first juvenile plumage make their apearance in the region of the flank and scapulars on the fifth day after hatching. The adult plumages are acquired in the Night Herons by partial most within two years at Kulik. Fig. 10.1 and 10.2 shows the weight gain of the nestlings and fig 10.3 and fig 10.4 shows the tarsal and wing growth in the two species studied.

10.3.3. **Behavioural Development**

On the day of hatchling chicks remain motionless which persists for two to three days in Little Cormorant and one to two days in Night Heron. At the stage their movements lack co-ordination and neither species are able to stand on their feet. They go on sleeping in the nest and are constantly protected by the parents. With progress of time food begging behaviour and other associated nestling motor patterns appear.

10.3.3.1. **Food Begging Behaviour**

One to three day old chicks stried to swallow any food materials inserted into their mouths by the parents but soon rejected the same. At this stage almost al the ventral part of the body touches the substratum with tarsi laying on its two sides and the head laid on the substrate laterally. At five-six day begging response appeared with the return of parents during feeding hours. The nestlings appears be able to recognize their parents and the parents seemed to recognize and feed only their youngs. At that stage nestlings continued begging for 20-40 seconds. At 13th or 14th day begging continue until food is received. However, food begging response ceases after 5-10 minutes. This scheme of begging continues irregularly and less vigorously until they are feed. Parents seem to feed the most active and stongest hatchling at first and then the others. Feeding of nestlings is discussed in the chapter on parental care.

Table 10.9 shows the age of first emergence and frequent occurence of seven basic hatchling motor patterns in Little Cormorants and Night Herons. The seven basic motor patterns are standing on tarsii, wing flapping, preening and clearing, hopping around the nest, bouncing over the nest, flying around the trees and flying out of trees. From the data in clear that Night Herons performed all the activities 2-8 days earlier. It may be mentioned that Night Herons actually take more time to hatch out from the shell, i.e. approximately 2-3 days in comparison to Little Cormorants. Thus the contention that the phenomenon of altricial-precocial condition may be minimized if time is counted from the day of fertilization. However, the condition is heavily influenced by environmental compulsion and genetic capability.

Table 10.10 and 10.11 shows the dawdling movements Little Cormorants and Night Herons fledglings respectively in relation to age. It is seems that the Little Cormorants leave the nest for the first time around 28th day of hatching while the same is done by Night Heron fledglings on 26th day. Initially the 1st hatchling of Little Cormorants and Night Heron move only 27.00 cm. and 31.75 cm. respectively from the nest. The first hatchlings of the two species stay outside their nests for about 9 minutes on 28th day in case of Little Cormorant and 8 minutes in case of Night Heron on 26th day of hatching. Maximum distance travelled by nestlings and average time away from nest gradually decrease in the second and third hatchlings in both species. This pattern continues throughout the nesting period until the nestlings stay outside the nest and never return to the nest. This happens around 32nd to 35th day of hatching in case of Little Cormorant for all the hatchlings and 31st to 35th day of hatching in case of Night Herons. Around this time the parents of both species were observed to dismentale the nest. To induce the nestlings to be on their old. The parents probably also can not tolerate to bear the cost of parenting in further. Any further this, however, does not mean they discontinued al parental activities. They were observed to continue to feed their youngs and actively deter predation.

Table 10.1 : Hatching and fledging success at different phases of breeding season in Little Cormorant

Clutch Size	Year	Phases of breeding season								
		First Phase			Second Phase			Third Phase		
		Total no. of eggs	No. of successful fledglings	Success %	Total no. of eggs	No. of successful fledglings	Success %	Total no. of eggs	No. of successful fledglings	Success %
2	1996	00	00	00.00	80	50	62.50	40	20	50.00
	1997	06	03	50.00	00	00	00.00	12	06	50.00
	1998	06	03	50.00	02	01	50.00	8	05	62.50
	Total	12	06	50.00	10	06	60.00	24	13	54.16
3	1996	36	20	55.55	48	28	38.33	03	03	100.00
	1997	24	15	62.50	27	17	62.96	18	14	77.78
	1998	24	12	50.10	30	16	53.33	21	11	52.38
	Total	84	47	55.95	105	61	58.09	42	28	66.66
4	1996	64	33	51.56	44	29	65.90	36	25	69.44
	1997	24	14	58.33	20	14	70.00	24	17	70.83
	1998	52	32	61.53	24	14	58.33	24	13	54.16
	Total	140	49	56.42	88	57	64.77	84	55	65.47
5	1996	50	28	56.00	35	23	65.71	10	08	80.00
	1997	25	15	60.00	05	03	60.00	0	00	00.00
	1998	30	21	70.00	05	03	60.00	5	02	40.00
	Total	105	64	60.95	45	29	64.44	15	10	66.66
6	1996	18	08	44.44	24	15	62.50	0	00	00.00
	1997	12	07	58.33	00	00	00.00	0	00	00.00
	1998	06	02	66.66	06	02	33.33	0	00	00.00
	Total	36	07	52.77	30	17	56.66	0	00	00.00
Grand Total		377	213	56.49	278	170	61.15	165	106	62.24

Table 10.2 : Hatching and fledging success at different phases of breeding season in Night Heron

Clutch Size	Year	Phases of breeding season								
		First Phase			Second Phase			Third Phase		
		Total no. of eggs	No. of successful fledglings	Success %	Total no. of eggs	No. of successful fledglings	Success %	Total no. of eggs	No. of successful fledglings	Success %
2	1999	04	02	50.00	12	07	58.33	12	07	58.33
	2000	10	05	50.00	10	06	60.00	14	07	50.00
	2001	06	03	50.00	08	04	50.00	10	05	50.00
	Total	20	10	50.00	30	17	56.66	36	19	52.77
3	1999	54	30	55.55	63	38	60.31	36	20	55.55
	2000	81	43	53.08	87	46	52.87	48	23	47.91
	2001	72	40	55.55	75	41	54.66	24	15	62.50
	Total	207	113	54.58	225	125	55.55	108	58	53.70
4	1999	44	26	59.09	28	17	60.71	08	05	62.50
	2000	64	35	54.68	32	18	56.25	16	08	50.00
	2001	52	29	55.76	20	13	65.00	04	02	50.00
	Total	160	90	56.25	80	48	60.00	28	15	53.57
5	1999	15	07	46.66	00	00	00.00	00	00	00.00
	2000	10	05	50.00	10	04	40.00	05	03	60.00
	2001	10	04	60.00	05	03	60.00	00	00	00.00
	Total	35	16	45.71	15	07	46.66	05	03	60.00
Grand Total		422	229	54.26	350	197	56.28	177	95	53.67

Table 10.3 : Loss of eggs Hatchings and fledging success at different phases of breeding seasons in Little Cormorants

Phases of breeding cycle	Year	No. of egg	Egg loss					No. of hatchlings	Hatchling loss				No. of fledgling
			Predation	Rain/storm	Nest material stealing	Unhatched	Total		Starvation	Predation	Fall from the nest	Total	
	1996	168	26	13	5	17	61	107	11	4	3	18	89
	1997	91	7	6	2	10	25	66	4	5	3	12	54
1^{st}	1998	118	8	8	3	12	31	87	5	4	8	17	70
	Total	377	41	27	10	39	117	260	20	13	14	47	213
			(10.87)	(7.16)	(2.65)	(10.34)	(31.03)	(68.96)	(5.30)	(3.44)	3.71)	12.46)	(56.49)
	1996	159	11	11	5	15	42	117	10	4	3	17	100
	1997	52	2	2	0	8	10	42	5	2	1	8	34
2^{nd}	1998	67	3	5	1	10	19	48	4	3	5	12	36
	Total	278	16	18	6	33	71	207	19	9	09	27	170
			(5.75)	(6.47)	(2.15)	11.87	(25.53)	(74.46)	(6.83)	(3.23)	(3.23)	(9.71)	(61.15)
	1996	53	2	0	1	7	10	43	3	0	2	5	38
	1997	54	1	1	0	8	10	44	4	1	2	7	37
	1998	58	2	3	0	10	15	44	3	2	7	12	31
	Total	165	5	4	1	24	35	131	10	3	11	24	106
			(3.03)	(2.42)	(0.60)	(14.54)	(21.21)	(79.39)	(6.06)	(1.81)	(6.66)	(14.54)	(64.24)
Grand Total		820	62	49	17	96	223	598	49	25	34	98	489
			(7.56)	(5.97)	(2.07)	(11.70)	(27.19)	(72.92)	(5.97)	(3.04)	(4.14)	(11.95)	(59.63)

Table 10.4 : **Loss of eggs hatchlings and fledging success at different phases of breeding season in Night Heron**

Phases of the breeding cycle	Year	No of eggs	Egg loss					No of hatchlings	Hatchling loss				
			Predation	Rain / storm	Nest material stealing	Unhatched	Total		Starvation	Predation	Fall from the nest	Total	No. of fledglings
1st	1999	117	08	07	03	11	29	88	14	03	06	23	65
	2000	165	17	13	04	19	53	112	13	05	06	24	88
	2001	140	15	11	03	16	45	95	10	04	05	19	76
	Total	422	40	31	10	46	127	295	37	12	17	66	229
			(9.47)	(7.34)	(2.36)	(10.90)	(30.09)	(69.90)	(8.76)	(2.84)	(4.02)	(15.63)	(54.26)
2nd	1999	103	06	06	01	08	21	82	12	03	05	20	62
	2000	139	11	10	03	18	42	97	12	04	07	23	74
	2001	108	07	08	02	13	79	78	09	02	06	17	61
	Total	350	24	24	06	39	93	257	33	09	18	60	197
			(6.85)	(6.85)	(1.71)	(11.14)	(26.57)	(73.42)	(9.42)	(2.57)	(5.14)	(17.14)	(56.28)
3rd	1999	56	01	04	00	08	13	43	06	01	04	11	32
	2000	83	04	09	01	10	24	57	09	02	06	17	41
	2001	38	02	04	00	03	09	29	04	00	03	07	22
	Total	177	07	17	01	21	46	129	19	03	13	35	95
			(3.95)	(9.60)	(0.56)	(11.86)	(25.98)	(72.88)	(10.73)	(1.69)	(7.34)	(19.77)	(53.67)
Grand Total		949	71	72	17	106	266	681	89	24	48	161	521
			(7.48)	(7.58)	(1.79)	(11.16)	(28.02)	(71.75)	(9.37)	(2.52)	(5.05)	(16.96)	(54.89)

Table 10.5 : **Clutch size and productivity in Little Cormorants**

Year	Clutch Size	Total no. of eggs	Total no of nests	Total no of fledglings	Productivity (No. of fledglings / nests
1996 – 1998	2	46	23	25	1.08
	3	231	77	136	1.76
	4	312	78	191	2.44
	5	165	33	103	3.12
	6	66	11	34	3.09

Table 10.6 : **Clutch size and productivity in Night Herons**

Year	Clutch Size	Total no. of eggs	Total no of nests	Total no of fledglings	Productivity (No. of fledglings / nests
1999 – 2001	2	86	43	46	1.06
	3	540	180	296	1.64
	4	268	67	153	2.28
	5	55	11	16	1.45

Table 10.7 : Growth in body weight, length and linear dimensions of four body parts in Little Cormorant Nestlings

Age (Days)	Average weight (gm) ($\bar{X}$ + S.D.)	Average length of body (cm) ($\bar{X}$ + S.D.)	Average length of bill (mm) ($\bar{X}$ + S.D.)	Average length of wing (mm) ($\bar{X}$ + S.D.)	Average length of tarsus (mm) ($\bar{X}$ + S.D.)	Average length of tail (mm) ($\bar{X}$ + S.D.)
01	17.8 ± 3.30	9.32 ± 0.67	11.10 ± 0.09	29.50 ± 0.18	7.10 ± 0.11	0
03	39.8 ± 8.50	10.5 ± 1.20	14.0 ± 0.15	32.0 ± 0.21	9.0 ± 0.12	0
07	150.09 ±17.68	21.48 ±1.88	24.6 ± 0.18	96.5 ± 1.10	22.3 ± 0.16	9.5 ±0.21
14	352.0 ± 26.72	32.0 ± 2.40	30.7 ± 0.22	166.7 ± 1.86	29.0 ± 0.20	32.0 ± 0.42

Table 10.8 : Growth in body weight, length and linear dimensions of four body parts in Night Heron Nestlings

Age (Days)	Average weight (gm) ($\bar{X}$ + S.D.)	Average length of body (cm) ($\bar{X}$ + S.D.)	Average length of bill (mm) ($\bar{X}$ + S.D.)	Average length of wing (mm) ($\bar{X}$ + S.D.)	Average length of tarsus (mm) ($\bar{X}$ + S.D.)	Average length of tail (mm) ($\bar{X}$ + S.D.)
01	27.88±6.15	10.21±0.96	15.4±0.30	34.0±0.27	14.10±0.14	0.0
03	66.3±10.26	12.0±1.40	22.2±0.26	46.0±0.86	21.0±0.26	0.0
07	198.5±15.33	23.44±1.39	40.8±0.46	108.3±0.93	34.2±0.16	4.4±0.08
14	382.96±23.45	33.8±0.85	65.8±0.51	223.0±1.77	52.8±0.51	19.2±2.8

Table 10.9 : Behavioural development of the nestlings of Little Cormorants & Night Herons

Motor patterns	Approximate average age (in days) of nestlings when the pattern appear			
	First emergence		Frequent occurrence	
	Little Cormorant N =12	Night Heron N = 13	Little Cormorant N = 15	Night Heron N = 16
Standing on tarsi	16	13	20	18
Wing flapping	14	12	23	19
Preening and clearing	13	11	25	22
Hopping around the nest	25	17	28	23
Bouncing over the nest	28	21	32	29
Flying around the trees	33	30	42	38
Flying out of trees	45	38	50	45

Table 10.10 : Dawdling movements of fledglings of Little Cormorant in relation to age.

Days of hatchlings	1st hatchling (N=11)		2nd hatchling (N=14)		3rd hatchling (N=15)	
	Ave. Max movement distance from nest (cm)	Ave. time outside nest (m/hr)	Ave. Max. movement distance from nest (cm)	Ave. time outside nest (m/hr)	Ave. Max. movement distance from nest (cm)	Ave. time outside nest (m/hr)
28	27.00	8.33	17.50	5.00	13.50	7.83
29	47.00	21.67	35.00	15.00	28.50	14.17
30	95.00	50.00	60.00	36.67	37.50	20.00
31	100.00	60.00	77.50	33.00	55.00	35.00
32	105.00	55.00	97.50	25.00	81.50	45.75
33	115.00	60.00	120.00	60.00	85.00	50.00
34	140.00	60.00	145.00	60.00	117.00	55.00
35	185.00	60.00	165.00	60.00	149.00	60.00
36	225.00	60.00	210.00	60.00	200.00	60.00
37	260.00	60.00	245.00	60.00	240.00	60.00
38	375.00	60.00	335.00	60.00	310.00	60.00
39	472.00	60.00	450.00	60.00	420.00	60.00
40	550.00	60.00	520.00	60.00	470.00	60.00
41	580.00	60.00	560.00	60.00	510.00	60.00

Table 10.11 : Dawdling movements of fledglings of Night Herons in relation to age.

Days of hatchlings	1st hatchling (N=11)		2nd hatchling (N=14)		3rd hatchling (N=15)	
	Ave. Max movement distance from nest (cm)	Ave.time outside nest (m/hr)	Ave. Max. movement distance from nest (cm)	Ave. time outside nest (m/hr)	Ave. Max. movement distance from nest (cm)	Ave. time outside nest (m/hr)
26	31.75	8.00	19.05	6.00	16.08	4.00
27	43.18	14.00	27.86	16.65	20.16	15.00
28	57.50	33.00	42.38	22.00	28.12	24.00
29	76.20	50.00	68.54	38.00	38.10	34.00
30	92.44	55.00	102.40	43.00	55.88	38.00
31	167.64	60.00	152.40	50.00	82.00	46.00
32	198.12	60.00	160.22	55.00	120.00	50.00
33	213.36	60.00	182.88	60.00	168.00	52.00
34	280.52	60.00	210.22	60.00	187.00	55.00
35	335.28	60.00	245.84	60.00	254.00	60.00
36	410.20	60.00	365.76	60.00	320.00	60.00
37	457.00	60.00	410.00	60.00	380.00	60.00
38	535.00	60.00	490.00	60.00	420.00	60.00

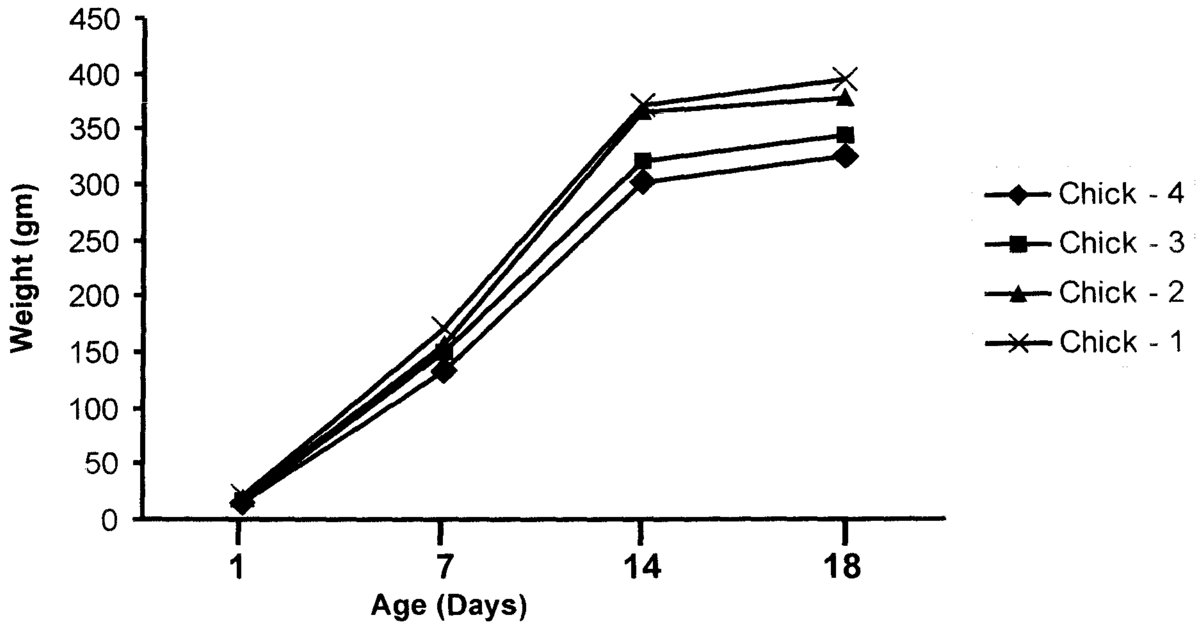


Fig. 10.1 : Weight gain of Little Cormorant nestlings according to their status in the brood

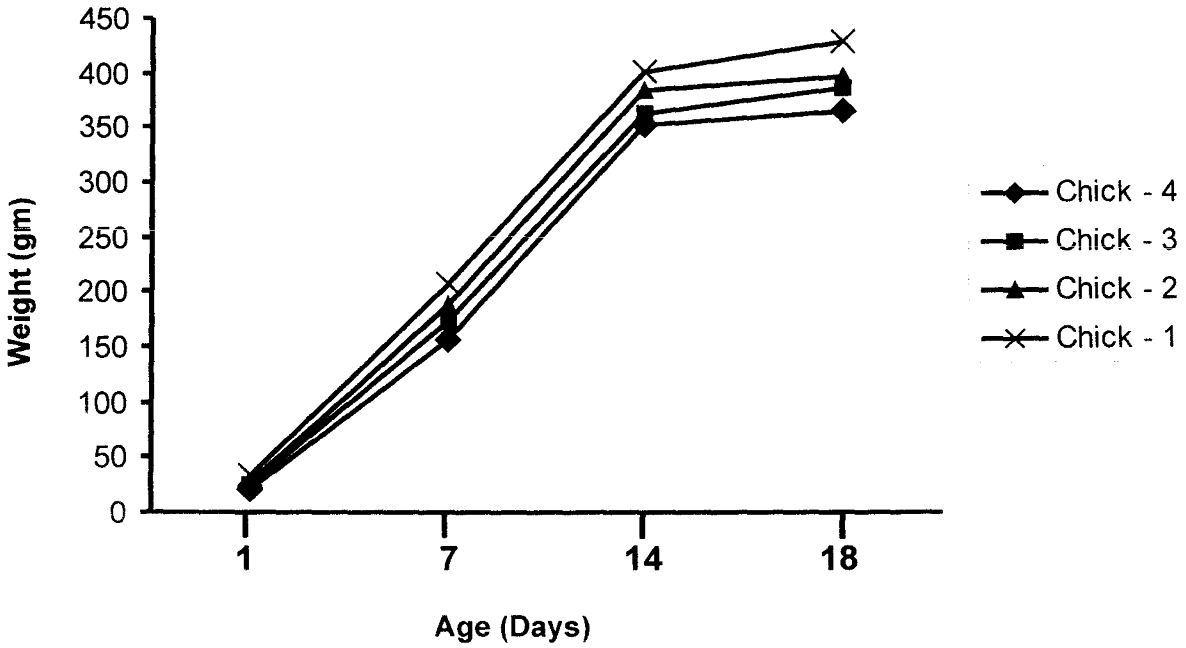


Fig. 10.2 : Weight gain of Night Heron nestlings according to their status in the brood

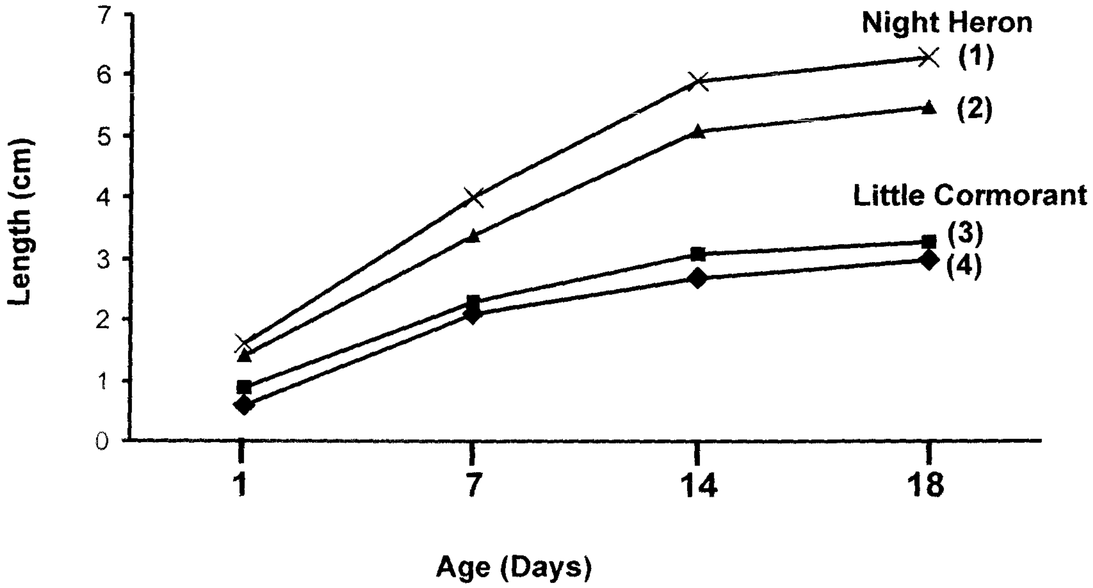


Fig. 10.3 : Tarsal growth of oldest (3 & 1) and youngest (4 & 2) nestlings of Little Cormorant and Night Heron.

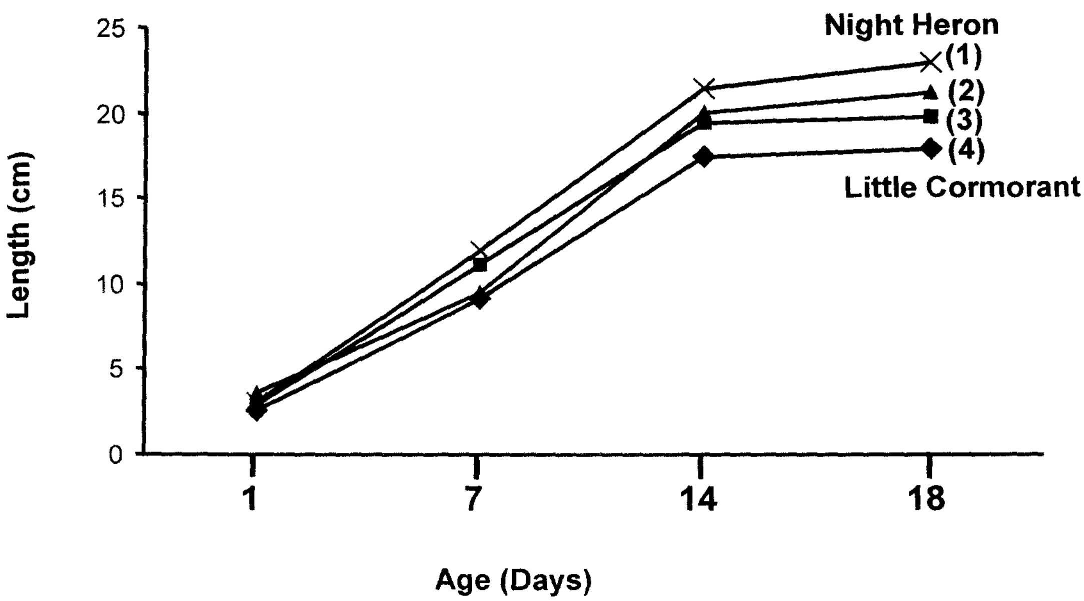


Fig. 10.4 : Wing growth of oldest (3 & 1) and youngest (4 & 2) nestlings of Little Cormorant and Night Heron.

Plate 10.1 House Crow in the sanctuary waiting for egg predation from the nest

Plate 10.2 An one-day and a fifth-day hatchlings of Little Cormorant in a nest.

Plate 10.3 A two-day hatchling of Little Cormorant.

Plate 10.4 A four-day hatchling of Little Cormorant.

Plate 10.5 A six-day hatchling of Little Cormorant.

Plate 10.6 Two Little Cormorant hatchlings at mid-hatchling phase

Plate 10.7(A) A Little Cormorant hatchling at post-hatchling phase

Plate 10.7 (B) Two Little Cormorant hatchlings
at post-hatchling phase

Plate 10.8 A Night Heron hatchling resting just after emergence from the shell.

Plate 10.9 A three day Night Heron hatchling covered with luxurious down, open eyes.

Plate 10.10 Two Night Heron hatchlings at mid-hatchling phase, the dominant one with open-bill probably orienting to an incoming parent.

Plate 10.11 Two Night Heron hatchlings at late hatchling stage.

Plate 10.12 An early fledgling of Night Heron at post hatchling phase.

Plate 10.13 Two Night Heron fledglings after molting.

Plate 10.14 Food begging behavior of Little Cormorant hatchlings.

Plate 10.15 Self-preening of Little Cormorant hatchlings

11. PARENTAL CARE

11.1 INTRODUCTION

Successful parenting is the ultimate step that enhances individual fitness and play a vital role in the evolution of social systems. Life-history theory predicts that as parents increase their investment in individual offspring, the survival rates of those offspring increase (Stearns, 1992). Parents of altricial young birds spend a large amount of efforts during the breeding season feeding and caring for the young in relation to parents of precocial youngs because altricial young hatch from energy-poor eggs and are helpless at birth. Again in biparental care both parents share incubation, brooding and caring of youngs (Borowik and Mclennan, 1999).

In Little Cormorants and Night Herons, prolonged parental care is accomplised by both the partners (Gross, 1923 ; Nobel *et. al.*, 1938 ; Baker, 1929 ; Maxwell and Putnam, 1968 ; Ali and Ripley, 1968 ; Davis, 1993). This chapter attempts to discuss some specific aspects of parental care behaviour.

11.2 METHODS

During the study period the experimental nesting trees and all the nests in each tree were marked. The marked nests were inspected daily during the nesting phase. Efforts were taken to complete inspection as quickly as posible so as to make negligible disturbance to the birds and nestlings. Data were collected by direct observation mostly with "continuous sampling" procedure (Altmann, 1974). Departure and arrival of the parents and possible foraging sites actually used were recorded.

Little Cormorant and Night Heron chicks are in the habit of vomiting almost the entire stomach content when alarmed. This behaviour was utilized in order to obtain information on the composition of chick feed items. The food samples were identified, weighed and preserved in appropriate percentages of formaldehyde, depending on their nature. The day of hatching was taken to be day-1. Each chick was marked by non-toxic paints of different colours to denote its hatching order. This also helped in determining the age of chicks.

11.3. RESULTS AND DISCUSSIONS

11.3.1. Brooding

With the hatching of the first egg brooding starts which involves covering of the youngs by the parent's body to Receipt warm. In almost all the nests parents sat over the brood even upto the day after the hatching of the last young. After the emergence of the first chick incubating birds stood up often, again sat over the clutch or brood as a regular feature. Covering of the brood in the incubating posture during rains was found upto 10-12 day age of the first young. Thereafter, during rains the chicks took shelter under the parent's body. During the warmer part of the day parents were also found to shade their youngs from the sun. At this time incubating parents obstructed the sun and the youngs gathered in the shade produced. In the midday the parenting birds occasionally spread the wings while standing on the nest which provided additional shade to the youngs. As in incubation brooding also is accomplised by both the partners.

11.3.2. Feeding of young

11.3.2.1. Early hatchling stage

In Little Cormorant

In the early stage of chick development i.e. upto 6th day of hatching at least one of the parents attends the nest . As the other parent returns from foraging grounds, the chicks rise and move their heads in a horizontal plane orienting to the incoming parent. Soon the chicks raise their heads stil further with open beaks and the parent regurgitates a bit of semi-digested food material into their mouth. In this way the parents feed one, two or all the chicks depending on the behaviour of the chicks as expressed by lateral movement of the head and open beak. On several occasions around the 5th / 6th day of hatching, the parents were observed to insert one fry of *Channa sp.* into the mouth of each chick. It is to be mentioned that the eyes of the chicks open on 5th day so that prior to that visual perception and response is nil or negligible. Predation of chicks by avian predators is highest at this stage. Thus with the onset of solid food (not processed by parents) intake and visual communication the early chick phase terminates.

In Night Heron

At this stage i.e. upto the 4th day of hatching at least one of the parents attends the nest all the time. When parents return from the foraging grounds, the chicks raise and move their head in a horizontal plane. The parents regurgitate liquid or a bit of semi-digested food material into their mouth. On several occasions on the 3rd / 4th day of hatching, the parents were observed to insert fleshy part of fish or crab or *Paleomon sp.* into the mouth / of the hatchlings.

11.3.2.2. Mid-hatchling stage

In Little Cormorant

During this period the hatchlings can see the world around them including their siblings, parents and food materials. This period continues until 16th day of hatching. The parents continue to feed the chicks more or less in the same manner as in the earlier phase. However, the feeding frequency and duration of feeding increased considerably. Occasionally the parents were found to place their lower beak beneath the lower beak of the chicks while feeding. The eldest chick (usually larger and heavier) solicited food more often in comparison to others and the parents most often obliged them. While one of the parents continues to attend the nest throughout this phase, they most often took position at a little distance from the nest but close to it (within 25 to 40 cm.). At the fag end of this phase, however, the nests were found unattended by parents for short period of times (less than 10 minutes). Predation by avian predators and damage to the chicks and the nest by nesting neighbours of the same and others species are high upto this stage. At this phase the parents were found to store some food materials in the nest for later consumption of the chicks in addition to usual mode of feeding. Small sized fish (around 7.5 cm.) thus stored are swallowed whole by the chicks while the larger ones (around 12.5 cm.) were often shared. The chicks actually hold the fish by their feet and cut out small pieces of flesh by the beak one at a time and swallowed the morse.

In Night Heron

This period continues until 13th day of hatching. The parents continue to feed the chicks more or less in the same manner as in the earlier phase. However, feeding frequency and duration of feeding, increased greatly. Although the adult herons are nocturnal, they were found to feed their chicks during early morning hours regularly. They also feed the chicks several times even during the day. At the fag end of this phase, however, the nests were not attended by parents for short periods (less than 15 minutes). The parents at this phase were also found to store some food materials in the nest for later consumption of chicks as in Little Cormorants.

11.3.2.3. Late hatchling stage

In Little Cormorant

This phase extends from 17th to 26/27th days of hatching. Parental feeding in this stage involves several new aspects while the usual patterns are modified substantially both in frequency and quantum. Usual procedure of chick feeding and storing of food materials in the nest continues. But there is a substantial increase both in diversity and size of the stored food. Feeding frequency also increases considerably. The chicks in this phase feed from the crop of the parents directly by inserting their beaks into the open mouth of the parents. In the process sometimes the chicks insert their beaks as well as the head into the mouth of the parents. On rare occasions smaller chicks were found to feed by inserting their beaks into the mouth of the older ones. On all such occasions, however, both the chicks were fed by the parents immediately prior to the appearance of this peculiar altruistic acts. The chicks at this phase are quite grown up and require huge amounts of food. To meet the huge demand it is necessary for both the parents to be on their foraging trips simultaneously on most of the times and the chicks at the nest are left unguarded. The demand for food of grown-up chicks is so high that on being fed by a parent they are seldom satisfied and continue to force the parent to feed them over and over again. The parents, however, try to feed all the chicks at least once. When a particular chick usualy the oldest one continues to press the parent for more food, parents first try to evade them by moving their head sideways or by lifting the head higher beyond the chicks reach. If the chick continues to persuade the parent further the parent usually leave the nest and settle at a distance (1 - 1.5 metre) from the nest but return shortly (2 - 3 minutes) and feeds the other chicks. The chicks often touch one another's beak. This may help them in kin recognition in later life.

In Night Heron

At this phase few new patterns are observed in the feeding procedure. The hatchlings at this stage exhibit billing amongst themselves which has been ascribed by Nobel *et al.* (1938) as indicative of dominance among themselves. On arrival to the nest the parents show a forward thrust movement of the head towards the chick who actually approach the incoming parent randomnly so that it becomes difficult for the parent to start the feeding procedure. Lorenz (1938) used the term repelling reaction for this behaviour which, however, does not seem to be appropriate. In the present study food transfer was always achieved by the parents inserting the bill into the gapping mouth of the chicks. Herrick (1935) on the other hand stated that herons transfer regurgittated food by a cross or juxta-position of bills rather than by inserting of the parents bills into young ones mouth. The manner of food transfer described by Herrick (1935) was never observed at Kulik. Feeding bouts varried in duration and sequence of events. Usually multiple transfer of food occurred during a feeding bout. Most often the parents feed the most dominant chick twice right after arrival to the nest. Then it fed the other chicks in turn. As many as 4 to 5 transfers have been observed. In general this patterns continues upto the fledgling stage.

11.3.2.4. Post hatchling / Fledgling stage

In Little Cormorant

This phase starts around 27/28 days and continues to 55/60 days when they are able to fly and fend for themselves. The fledglings, however, continue to seek food from the parents for a much longer time even after this period. Some of the characteristics of this phase are : the parents no more store food in the nest, most feedings by the parents are done outside the nest, the chicks hop outside the nest and stay away from the nest for most of the time. Distance hopped gradualy increases from 5/6 cm. on 27th day to a maximum of 150 cm. for the oldest chick and 120 cm. for younger chicks around 32/33 days of hatching. Around this time the chicks start flying little distances (110 to 150 cm.) for the first time in life which gradually increases to about 300 to 36o cm. on 40 days of hatching. They switch from hoping to flying at around 32/33 days of hatching but use both the modes of locomotion throughout life. As in earlier phases they continue to vomit when disturbed even in this stage.

In Night Heron

This phase starts around 25th or 26th days and continues to 53/58 days when they are able to fly and try to capture food from the nearest canal along with parents. At this stage the parents mainly feed the nestlings outside the nest. When they return to close to the nest the nestlings hop out of the nest and beg for food. The parents regurgitate some food to the older nestlings and then the younger ones. However, they feed the nestlings mainly at night and on some occasions also in the day time. The nestlings at this phase also vomit as in the earlier phases when alarmed.

Figure 11.1 shows the diversity of feed items and average weight of feed per chick in the four stages in Little Cormorants and Night Herons. It shows that both diversity of feed items and weight of feed / chick increases continuously in both the bird species. Of the two species Night Heron chicks receive higher amount of feed as also more diverse feed items in all the developmental stages in comparison to Little Cormorant chicks.

Table 11.1 : **Feed items at various phases of chick development in Little Cormorants.**

Feed species	Early hatchling phase (1 – 6) days, N = 5			Mid hatchling phase (7 – 16 days), N = 12			Late hatchling phase (17-26/27 day), N = 12			Fledgling phase (27/28 – 40 days), N=10		
	No.	Total wt. (gm)	Ave. wt. ± S.E.	No.	Total wt. (gm)	Ave. wt. ± S.E.	No.	Total wt. (gm)	Ave. wt. ± S.E.	No.	Total wt. (gm)	Ave. wt. ± S.E.
Channa punctatus	05	5.10	1.02±0.02	01	21.23	21.23 ±0	02	42.74	21.37 ±0.02	02	45.08	22.54 ±1.03
Labeo rohita	--	--	--	02	38.50	19.25±1.59	02	49.50	24.75 ±1.06	01	25.00	25± 0
Puntius ticto	--	--	--	05	21.60	4.32±0.15	04	22.40	5.6±0.94	12	81.37	7.68±0.75
Cirrhinus mrigala	--	--	--	01	22.50	22.50±0	03	76.50	22.50±1.31	02	42.14	21.07±1.32
Paleomon sp.	--	--	--	02	2.60	1.30±0.07	06	6.84	1.14 ±0.01	04	4.60	1.15±0.02
Channa gachua	--	--	--	--	--	--	02	44.10	22.05±0.67	02	48.56	24.28±1.33
Anabus testudenus	--	--	--	--	--	--	01	16.84	16.84±00	--	--	--
Channa striatus	--	--	--	--	--	--	--	--	--	01	22.26	22.26 ± 0
Rhynchobdella aculeata	--	--	--	--	--	--	--	--	--	01	9.33	9.33 ± 0
Rana tigrina	--	--	--	--	--	--	02	40.44	20.22±1.43	02	47.80	23.90±0.99
Ave. feed/hatchling ($\bar{X}$ + S.E.)	1.02 ±0.02			8.86 ±0.11			24.94 ±0.39			32.61±0.28		

Table 11.2 : **Feed items at various phases of chick development in Night Heron.**

Feed species	Early hatchling phase (1 – 4) days, N = 04			Mid hatchling phase (5 – 13 days), N = 09			Late hatchling phase (14-24/25 day), N = 11			Fledgling phase (25/26 – 38 days), N=13		
	No.	Total wt. (gm)	Ave. wt. ± S.E.	No.	Total wt. (gm)	Ave. wt. ± S.E.	No.	Total wt. (gm)	Ave. wt. ± S.E.	No.	Total wt. (gm)	Ave. wt. ± S.E.
Predigested liquid material, semidigested fish, fleshy parts of crabs & *Paleomon sp.*	04	12.10	3.02±0.08	--	--	--	--	--	--	--	--	--
Paleomon sp.	--	--	--	05	8.56	1.71± 0.04	10	13	1.3±0.07	08	17.12	2.14±0.80
Channa punctatus	--	--	--	05	30.0	6.00 ±1.21	06	48	8.0 ±1.24	06	121.80	20.30±1.03
Labeo bata	--	--	--	--	--	--	04	66	16.5± 1.40	--	--	--
Catla Catla	--	--	--	--	--	--	--	--	--	01	9.00	9.00±0
Channa gachua	--	--	--	04	32.0	8.00±0.07	04	26	6.5±1.03	09	99.0±00	11.0± 1.06
Puntius ticto	--	--	--	07	22.40	3.2±0.65	08	18.4	2.3±0.15	18	61.20	3.4±0.08
Rhynchobdella aculeata	--	--	--	03	12.3	4.10±0.07	06	37.2	6.2±0.74	06	52.7	8.7±0.92
Heteropneustes fossilis	--	--	--	--	--	--	04	30.48	7.62±0.75	09	17.10	1.9±0.59
Colisha chuna	--	--	--	--	--	--	03	3.6	1.2±0.03	--	--	--
Amblypharyngodon mola	--	--	--	--	--	--	02	3.8	1.9±0.02	--	--	--
Colisha lalius	--	--	--	--	--	--	--	--	--	11	19.80	1.80±0.05
Rana tigrina	--	--	--	--	--	--	02	56.68	14.17±1.22	07	134.40	19.2±1.15
Tadpoles	--	--	--	04	6.48	1.68±0.03	--	--	--	--	--	--
Ave. feed/hatchling ($\bar{X}$ + S.E.)	3.02 ± 0.08			12.41 ± 0.17			27.56 ± 0.32			40 93± 0.36		

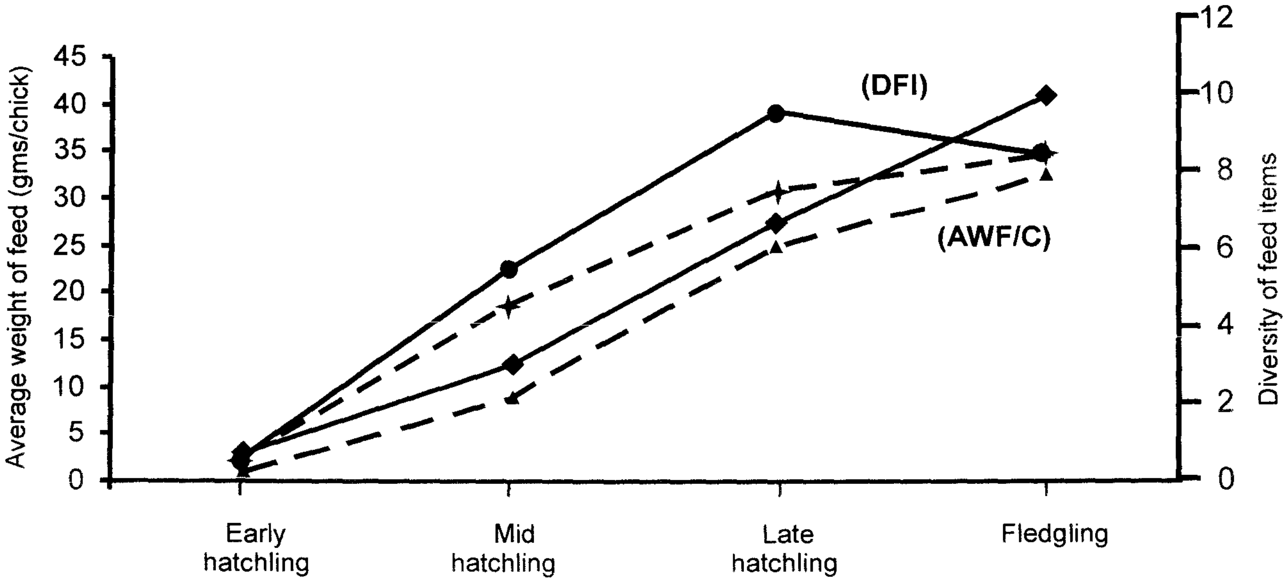


Fig. 11.1 Shows average weight of feed/chick (AWF/C) and the diversity of feed items (DFI) in the four stages of chick development in Little Cormorant (dotted line) and Night Heron (solid line)

Plate 11.1 Food of early hatchling of Little Cormoran.

Plate 11.2 Food of mid hatchling of Little Cormorant.

1. Channa punctatus 2. Puntius sp.

Plate 11.3 Food of late hatchling stage of Little Cormorant

Plate 11.4 Semi-digested food of early hatchling stage of Night Heron

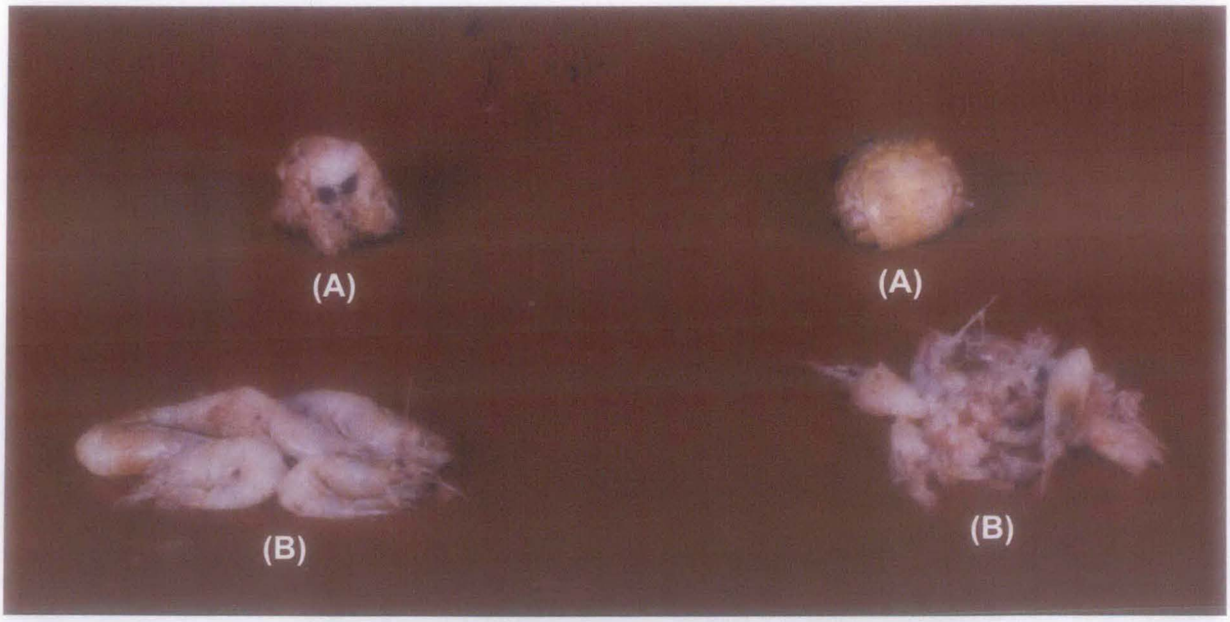


Plate 11.5 Food of mid-hatchling stage of Night Heron
(A) Crab (B) *Paleomon sp.*

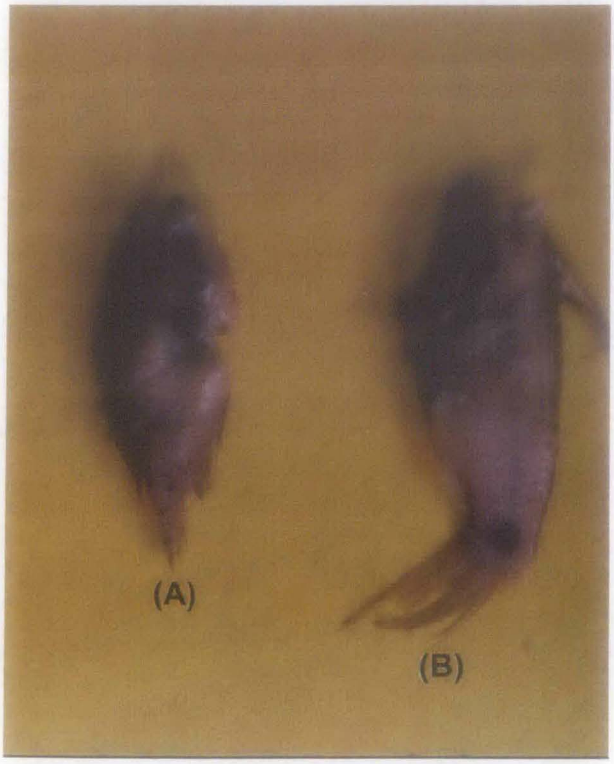


Plate 11.6 Food of post-hatchling stage of Night Heron
(A) *Colisa sp.* (B) *Puntius sp.*

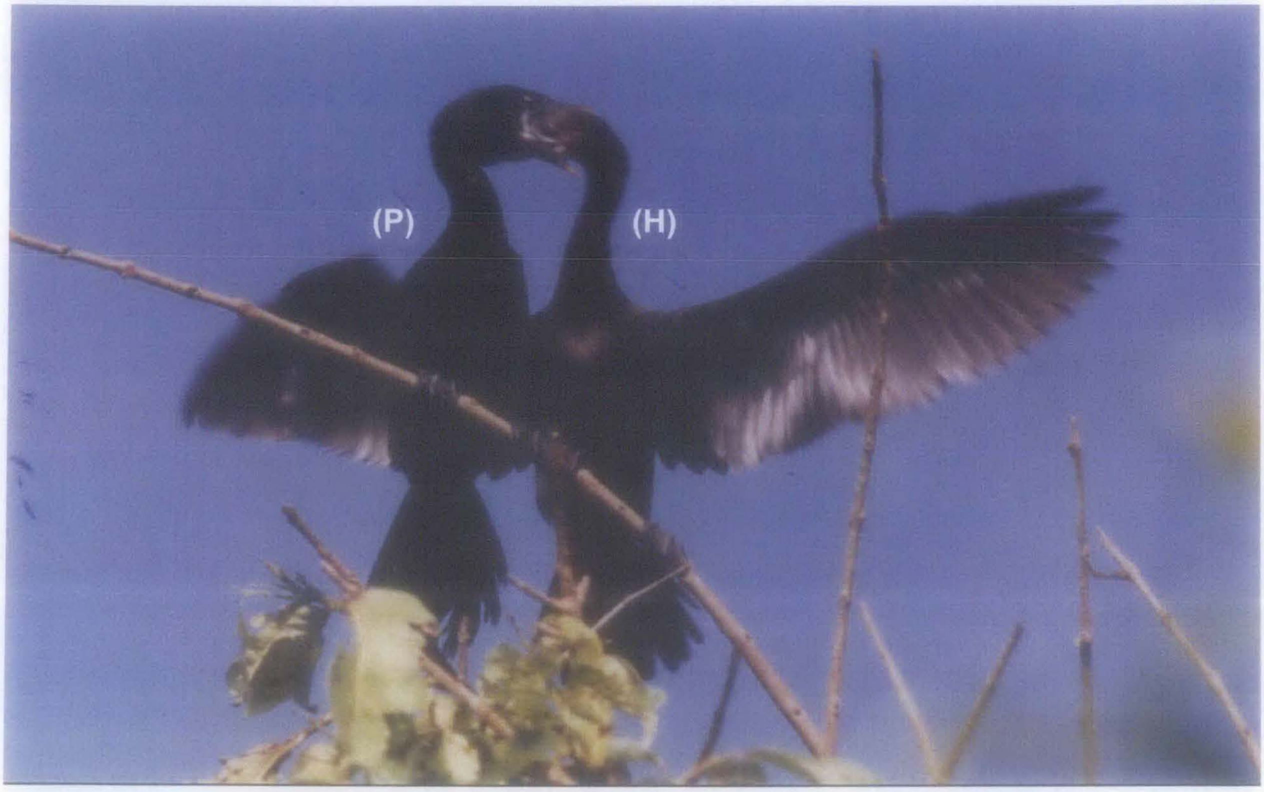


Plate 11.7 Adult Little Cormorant feeding a grown-up hatchling
(P) Parent (H) Hatchling

12. HUMAN INTERFERENCE, CYCLONIC STORMS AND MANAGEMENT

12.1. INTRODUCTION

The response of colonial birds to human and other biotic interference on their breeding success varies greatly depending upon the species, timing of interference and nature it. Milstein *et al.* (1970) cited several European studies showing a correlation between corvid predation, particularly by the Eurasian Crow (*Corvus corone*), and human disturbance in heronries. Drent *et al.* (1974) and Pratt (1970) took the advantage of colonial birds nesting on cliffs in their studies of herons and cormorants to obtain data on breedings sucess without human interference. Goering and Cherry (1971) concluded from their study of a heronry inhabited by colonial birds visited four times vs. one visited 16 times that human disturbance was "not necessarily detrimental during the later stages of reproduction." Ellison and Cheary (1978) on the other hand suggested another effect of human interference is, to discourage late nesters from settling in the disturbed sites in Double-crested cormorant of Gross Pelerim. Tremblay and Elison (1979) found in *Nycticorax nycticorax* that human disturbance reduced nesting success by inhibiting laying, increasing either nest desertion, egg predation, and increasing nestling mortality. It is obvious that human interference affects breeding bird populations more adversely than many other factors (Anderson and Keith, 1980 ; Anderson 1988 ; Keller, 1989). However, some bird species are knwon to have successfuly develop counter adaptive measures in order to increase their individual fitness (Knight & Fitzner 1985 ; Dhindsa *et. al* 1989 ; Keller, 1989) despite these interferences.

Raiganj Wildlife Sanctuary, popularly known as Kulik bird sanctuary, is one of the largest bird sanctuary in the world. It is already mentioned that in this sanctuary six species of Pelecaniformes and Ciconiiformes birds live together in close association with man. Pelecaniformes and Ciconiiformes breed colonialy but lack precise nest-defence behaviour. The effects of human interference on the nesting of the Little Cormorants and Night Herons were studied in the present study and attempts were made to assess possible adaptations of the birds to the prevailing situation.

12.2. METHODS

Data on disturbance due to human activities were collected mostly by direct observations. Number of days affected by human interference was recorded. For convenience the nesting area of the two bird species was divided into two zones. Zone I is in the tongue-shaped island of the sanctuary surrounded by manmade canal and Zone II is the bank of the canal close to rest house and living quarters of the forest personnel. The visitors are not allowed to visit Zone I but they can get close to Zone II. Thus the Zones are different from one another in the level of protection.

12.3. PROTECTIVE MEASURES OF THE SANCTUARY

Although this breeding population is one of the largest breeding group of its kind its protective measures are very poor. A 1845 metre long barbed-wire fencing around the core nesting area was erected 1996 to 1998 by Forest Department for protection. However, fencing is lacking at many other areas. Besides the conditions of the fencing is very poor which affords little resistance to the unwanted human invasion. There is only one permanent security guard for the whole sanctuary. Again the guard is neither trained nor capable of watching tresspassing round the clock. Actually the river and the canals provides the most effective security to the sanctuary.

12.4 HUMAN INTERFERENCE

Kulik Sanctuary is subjected to varying degrees of human interference since its very inception. Starting from 1984, the factor of human interference has attained new dimension with the settlement of a colony of low-income labourers in close vicinity of the sanctuary (Fig. 3.1). For convenience the nature of human interference in this sanctuary is discussed under the following heads.

12.4.1. Indirect interference

The sanctuary is a common destination for ornithologists, birdlovers, bird-watches, photographers and tourists. local inhabitants and even press-reporters visit the sanctuary regularly. They visit the sanctuary mainly because it is a pleasurable feeling to watch and listen to the birds in their natural habitats. Besides many students of higher secondary schools and colleges visit the sanctuary along with their teachres to fulfil their academic requirements particularly following inclusion of 'Environmental Science' as a compulsory. They almost always also visit the newly constructed eco-tourism park in the south-western part of the sanctuary. Again due to the presence of forest office, rest house, residential quarters and movement of automobiles in the NH 24 the birds in Zone II receive lot of disturbance almost daily round clock. As a result they soon get habituated to these kinds of stimuli i.e. they learn not to make any response as they are mostly harmless. However, in case of extremely noisy movements of man or incidents of pelting stones the birds do get frightened and fly away from their nests leaving it unguarded. When such incidents occurred by day during the laying period the crows invariably utilize this opportunity and attacked the clutch or nestlings.

12.4.2. Direct Interference

Mainly three types of human activities seriously impair bird life which are as follows :

a) **Poaching of egg, young and adult birds**

Local people and day labourers in the sanctuary reported poaching incidents of eggs, nestlings and adults. During the study period a number of such incidents were observed which are as below :

i) An elderly man was found capture two nestlings and an adult Night Heron for selling in the hotel. He was caught and handed over to the police.

ii) A teenage boy was found to collects eggs of Little Cormorants and Open-bil Storks for selling in the market. He was also caught and handed over to the police.

ii) It is reported that selling of eggs and meat of sanctuary birds along with poultry birds in the local markets is not of infrequent occurrance.

b) **Attack for breeding plumage**

Ormental plumage of large, median and Little egrets is of demand for fancy use, especially among the ladies. A number of children of neighbouring low income people collect shedded feathers form the ground as also from the nesting trees for money. Collection of feathers from the nesting trees by climbing up hinder breeding of egrets along with other bird species nesting on the same and nearby trees.

c) **Firewood collection**

This is the most serious problem to the birds of the sanctuary. Everyday women and children of the neighbouring labourer settlement roam around the sanctuary to collect firewood for domestic purposes. Usually they enter the sanctuary in a group in the noon period of the day. They indiscreminately cut lower branches of nesting trees and collected dry leaves from the ground and dry branches high up the nesting trees with a long bamboo pole fitted with a iron hook at the tip. These activities frightened the birds who desert the nest, move to higher branches or to nearby trees. During this activity many grown up nestlings fall down and die. Firewood collectors even do not hesitate to collect the nests with their hooked poles when forest people are not around. This incident of total nest collection becomes more frequent after the second week of October and a regular feature after October.

From the results (Table 12.1) it is clear that indirect human interference is very common to both the nesting zones of Little Cormorants and Night Herons. Direct human interference is, however, more common in zone I.

12.5 DISCUSSION

The Little Cormorants and Night Herons nest predominantly in the island (Zone I). This area is encircled by a man made canal with perennial water. So at the early phase of the breeding season direct human interference is almost absent in this zone. On the other hand Zone II is closer to the Rest House and Forest quarter complexes and the area meant for visitors. Thus although disturbance due to human is more in this zone invasion by firewood collectors is less than in Zone I. At the end of the breeding phase the water level of the canal recedes permitting easy invasion by firewood-collectors increase.

It may be mentioned that the Little Cormorants and Night Herons nest in many areas close to human settlements that are without much disturbance and breed successfully. The Zone II of Kulik substantiate the earlier statement in that breed successfully although breeding seasons appears to be a little less than in Zone I. This, however, is only a reasonable surmise and cannot be substantiated with adequate data. From 1997 to 1998 it is observed that they also nest in the Raiganj Township area. Birds are known to use their prior experience in nest-site selection (Wicklund, 1982 ; Marzluff 1988) and it was found that to minimize the menace of human interference they nested on taller trees mainly in the island of the sanctuary. Such type of nest placement is also found in many other species (Dhindsa *et al.*, 1989 ; Datta and Pal, 1993 ; Grieco, 1995).

12.6 CYCLONIC STORMS

Death of birds due to heavy cyin clonic storms and rains during the study period occurred in many years. During this time nests and branches of nesting trees with nests are damaged and break off causing extensive damage and death of nestlings and adults. Sometimes nestlings that fell from the trees were also predated by fox and jungle cats. Therefore devastating violent storms as observed to recur in the sanctuary is worrisome for the bird populations. Table 12.2 shows the date of occurrance of cyclonic storms and death of total number of birds (irrespective of species) inhabiting the sanctuary during the 5 year study period (2002-2006).

12.7 SUGGESTIONS

1. No. of permanent security guards should be increased as per requirement .
2. The whole sanctuary should be protected by a tough and durable fencing to prohibit trespassing.
3. Area of the sanctuary should be increased. Some populations inhabiting the sanctuary are already invading nearby suitable human settlements which is not desirable in view of the fact that birds are in zoonotic association with a large number of human diseases. Thus increase of the sanctuary area is a necessity.

4. A buffer-area around the sanctuary should be established.+
5. No outsiders should be allowed inside the nesting zone particulary during the breeding season.
6. All sorts of human settlements close to the sanctuary should be removed.
7. A Rescue Center for dropped and morbid nesting birds.
8. Effective education and publicity in relation to Wildlife Management should be undertaken, so that people become aware of the value of Wildlife.
9. Nature Interpretation Center (NIC), Watch Tower should be established and Wildlife Conservational Education arrange ments should be provided.
10. Library, Documentation Center, Information Center should be established immediately.
11. A research wing whould be created to study the bird populations to frame out suitable conservation strategy.

Table 12.1 Average numbers of days affected by human interference in the two nesting zones during the breeding season in 1997, 1998 and 1999.

<table>
<tr><th colspan="2" rowspan="2">Type of interference</th><th rowspan="2">Month</th><th colspan="2">Zone –I (Island)</th><th colspan="2">Zone –II (Bank of canal near Rest House)</th></tr>
<tr><th>No of days</th><th>Total</th><th>No of days</th><th>Total</th></tr>
<tr><td colspan="2">Indirect human interference</td><td>July
Aug
Sept
Oct
Nov
Dec</td><td>02
04
05
08
10
03</td><td>32</td><td>0
08
10
18
12
02</td><td>50</td></tr>
<tr><td rowspan="3">Direct human interference</td><td>Attack on clutch or brood</td><td>July
Aug
Sept
Oct
Nov
Dec</td><td>-
-
-
03
02
-</td><td>05</td><td>-
-
01
-
-
-</td><td>01</td></tr>
<tr><td>Attack for breeding plumage</td><td>July
Aug
Sept
Oct
Nov
Dec</td><td>-
-
02
05
01
-</td><td>08</td><td>-
-
03
07
01
-</td><td>11</td></tr>
<tr><td>Invasion for firewood</td><td>July
Aug
Sept
Oct
Nov
Dec</td><td>-
-
-
20
23
15</td><td>58</td><td>-
02
04
07
10
04</td><td>27</td></tr>
<tr><td></td><td>Grand Total</td><td></td><td></td><td>71</td><td></td><td>38</td></tr>
</table>

Table 12.2 : Death of birds by cyclonic storms in the sanctuary.

Date of occurrence of cyclonic storms	Death of total no. of birds inhabiting the sanctuary
24-09-02 to 25-09-02	16721
08-10-03 to 10-10-03	3645
05-10-04 to 07-10-04	2500
22-08-05 and 22-10-05	1032
21-09-06 to 24-09-06	1148

Plate 12.1 A firewood collector collecting dried tree branches of nest with a bamboo pole.

Plate 12.2 Death of two Little Cormorant nestlings as a consequence of human disturbance.

Plate 12.3 Death of a Night Heron nestling as a consequence of human disturbance.

Plate 12.4 Barbed-wire fencing around the core nesting area of birds

Plate 12.5 Water flowing into the sanctuary after heavy rain.

Plate 12.6 A dead Little Cormorant Nestling after cyclonic storm

Plate 12.7 Birds fall from the nests on the ground after cyclonic storm.

13. SUMMARY

There are about 2100 species and sub-species of birds in India. Many of these species are at present threatened due to growing human population necessitating destruction of Wildlife habitats. The piscivorous waterbirds are particularly endangered because of filling up of low-land,ponds and bheries despite laws prohibiting it.The Kulik Bird Sanctuary at Raiganj provides an unique habitat for the colonial Pelicaniformes and Ciconiiformes to nest and increase in number without much disturbance. Six species of colonial birds such as : Open-bill Stork, Little Cormorant, Night Heron, Large Egret, Median Egret and Little Egret nest in this sanctuary for more than three decades. The present study analyses mainly feeding, reproductive and parental care behaviour and ecology ; and a note on interference due to human, cyclonic storms and management etc. on two species i.e. Little Cormorants and Night Herons.

The Kulik Sanctuary is located in the District of Uttar Dinajpur, 2 Km. North-West of the district town Raiganj and is 174 Km. South of North Bengal University. High way NH-34 runs by its southern border. The sanctuary covers an area of only 321.23 acres. It receives an annual average rainfall of about 2081.38 mm. with a maximum recorded temperature of 39°C in May and a minimum temperature of 4.7°C in January during the study period.The maximum and minumum relative humidity were 41.96% in March and 21.40% in September. The nature of soil in the sanctuary is mostly loamy with colour varying from yellowish grey to grey. The present vegetation in the sanctuary is mostly planted and the resulting forest may be described as tropical semi-evergreen type.

Little Cormorant is a diurnal bird and feeds mainly during the day time. Main feeding activity of this bird was found to be in the early morning and late afternoon hours. It mostly depends on Plunging-diving techniques to capture food. Thus its victims were mostly column and bottom feeding fishes Occasionally it takes crustaceans, frogs and snakes. It usually takes 40 - 50 gm of food per bout with approxmately 5-6 bouts per day. Usually it forages within 2 Km. and 10 Km. radius from the sanctuary in the breeding and non-breeding seasons respectively.

The Night Herons on the other hand are nocturnal and feeds during the night in the non-breeding season. However, during the breeding season it was observed to feed in the early morning and late afternoon hours and even at other times of the day. It captures its victims mostly by stand and wait technique and its victims are mainly surface feeding fishes. It takes about 50 - 60 gms. of food per bout with a maximum of 6-8 bouts per day.

With the onset of the monsoon the birds of both species start flocking in the sanctuary specifically from mid June. Usually experienced males arrive first while the novice first time breeders come late. On arrival the males settle at suitable high up positions to attract members of the opposite sex and in a few days pair formation is achieved. Both Little Cormorants and Night Herons are known to be strictly monogamous although several incidednts of EPC's were observed in both the species. Several specific displays and calls for pair formation, mating and pair maintenance are described. Males of both species possess intromittant organs and copulations take place in the usual bird pattern. Pair dissociation, however, is not infrequent. About 26 - 30% and 21 - 25% pairs dissociated in Little Cormorants and Night Herons respectively during the 4 year study period.

Although the males initiate nest-site selection and nesting ; the females also participate in the whole process. Jarul trees are preferred most by both the species i.e. 85.2% and 84.21% nests of Little Cormorants and Night Herons with a P.V. value of 1.36 and 1.46 respectively. In regard to nest material Jarul tree again contribute approximately 40-42%. It was observed that in both the species intraspecific nest distance was higher than interspecific nest distance. Most nests of Little Cormorants and Night Herons in the sanctuary are at a height of 7.0-8.5 meters. The birds of both the species tended to keep their nests clean in order to avoid growth of unwanted micro-organisms. The nest sanitation was particularly enhanced by the pehenomenon of defecating liquid wastes and ejecting it outside the nest in a jet.

Usually the first clutch is initiated around the first week of July. Laying occurs on alternate days. The mean clutch size in Little Cormorants was 3.69 with a range of 2 to 6. Mean clutch size of Night Heron on the otherhand was 3.15 with a range of 2 to 5. Clutches of four was maximum i.e. over 36% in Little Cormorants while clutches of three was highest in Night Herons comprising over 54%. A total of 377, 238 and 165 eggs of Little Cormorants were observed in the first, second and third phase respectively. The same for Night Heron was 422, 350 and 177. Hatching and fledging success increased as the laying date progressed. Hatching success was 68.96% in the first phase 74.46% in the second, 79.39% in the third phase. Fledging success for the same phases were 56.49%, 61.15% and 64.24% in case of Little Cormorant. In Night Heron hatching success were 69.90% in the first phase 73.42% in the second and 72.88% in the third phase. Fledging success for the same periods were 54.26%, 56.28% and 53.67% respectively. Predation accounted for a maximum of 10.87% egg loss in the first phase and at 3.03% in third phase in case of Little Cormorant. In Night Heron predation accounted for 9.47% egg loss in the first phase and 3.95% in the third phase. Overall 72.92% eggs hatched into hatchling in Little Cormorants and 71.75% in Night Herons. It was observed that starvation is the main cause of loss of hatchlings amounting to 5.97% in case of Little Cormorants and 9.37% in Night Herons. Average body weight of Little Cormorants hatchling increased from 17.8 gms. on day-1 to 352.0 gm on day-14. While the same for Night Herons was 27.88 gm to 382.0 gms. An increase in body weight of over 19 times and over 13 times respectively. Incubation was performed by both the partners. However, the females did most of it in both the species.

Feeding of the hatchlings was also done by both the partners. At the early stage the parents insert the feed into the gaping mouth of the chicks. Sibling rivalry was frequently observed. The dominant chick managed more feeds became heavier and stonger than others. Parents were occasionally found to store food materials in the nest for later consumption of the chicks. The diversity of feed items increased progressively with the development of the chicks.

Although the sanctuary was relatively free from human interference, some forms of human interference such as poaching of egg, young and adults for human consumption, disturbance due to breeding plumage collection and firewood collectionwas observed. The last mentioned factor did the most damage. in a number of seasons cyclonic storms rendered havoc in all the years of its occurance causing extensive damage to the nestlings as well as the adult birds.

Employment of adequate security personnel, increase in area of the sanctuary, proper fencing, creation of a buffer zone, public awareness campaign and a research wing are suggested as measures for proper conservation of the birds.

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Clutch size, laying date and reproductive success of Little Cormorant

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ABSTRACT

Clutch size, laying date and reproductive success of little cormorant *Phalacrocorax niger* (Vieillot) were studied in the Kulick Bird Sanctuary, Raiganj, Uttar Dinajpur, West Bengal. Observations were made mostly in the morning and afternoon hours except on holidays. Clutch size of little cormorant varied from two to six. The most common clutch size was four and broods of five were most productive. Mean clutch size declined with the advancement of season. Fledging success was lower early in the season due to intense competition and adverse environmental conditions. The present study contradicts Lack's (1947, 1954) arguments.

Key words : Clutch size ; Fledging success ; Nest predation ; Reproduction.

INTRODUCTION

Most models of evolution of clutch size and life history strategies of birds and other organisms (Godfrays, 1987 ; Lloyd, 1987 ; Morris, 1982 , Risch *et al.*, 1996) are heavily influenced by Lack's (1947, 1954) arguments that among altricial birds clutch size corresponds to the maximum number of hatchings that parents can feed and rear. However, in many bird species Lack's prediction does not hold. Clutch size actually represents a trade off between current and future reproduction, with birds producing fewer, higher-quality offsprings in the current year while increasing their chances of survival and reproduction in the next year. This at present appears to be the most acceptable explanation but deviates substantially from Lack's prediction (Nur, 1988 ; Stearns, 1992 and Vander Werf, 1992).

STUDY AREA

The Kulick Bird Sanctuary extends over 130.09 ha. The nesting zone, however, spans over an area of about 16 ha. This includes a tongue-shaped island, which is encircled by a man-made canal with perennial water. Although little cormorants inhabit along with five other bird species, namely two species of egrets, two species of herons and open-bill stork in the sanctuary ; their nesting activity is predominantly concentrated in the island. The existence of the birds in the sanctuary is recorded since 1975. The sanctuary is only 2 km northwest of Raiganj town (25°36' N, 38°10' E). Data were collected from June to January in 1996-97 and 1997-98. Most part of the nesting area was covered by a mixed vegetation of *Lagerstromia flosregnae* and *Barringtonia acutacula* which together consituted 87% of the tree species population in the sanctuary.

MATERIALS AND METHODS

During the study period a total of 154 nests of little cormorant *Phalacrocorax niger* (Vieillot) were observed from a 10m high bamboo 'machan' (platform) suitably built in the island, roof of the Rest House, some suitable spots on the ground, from the nesting trees and from the adjacent trees without nests. Normally visitors are not allowed to the island. A paddle-boat was used by the investigators to get to the island and to the 'machan' from where most of the observations were made. The nesting trees were below the "machan", so looking into the nest was possible. To begin with, the birds showed alarm response to the investigators while getting on the "machan" or climbing trees by moving away from the nest to a nearby tree but after a few days they got habituated to the condition and there was little or no response from the birds.

The usual observation schedule was 0600 to 0900 hours and 1500 to 1800 hours. On Sunday and other holidays, however, observations were taken throughout the day.

The nests were inspected daily during the egg-laying and hatching periods. Efforts were taken to complete

Table 1. Clutch size and fledging success at different phases of breeding season.

Clutch Size	Year	Phases of breeding season								
		First phase			Second phase			Third phase		
		Total no. of eggs	No. of successful fledglings	Success (%)	Total no. of eggs	No. of successful fledglings	Success (%)	Total no. of eggs	No. of successful fledglings	Success (%)
2	1996-97	0	0	0	8	5	62.50	4	2	50
	1997-98	6	3	50	0	0	0	12	6	50
	Total	6 (3)	3	50	8 (4)	5	62.50	16 (8)	8	50
3	1996-97	36	20	55.55	48	28	38.33	3	3	100
	1997-98	24	15	62.50	27	17	62.96	18	14	77.78
	Total	60 (20)	35	58.33	75 (27)	45	60	21 (7)	17	80.95
4	1996-97	64	33	51.56	44	29	65.90	36	25	69.44
	1997-98	24	14	58.33	20	14	70	24	17	70.83
	Total	88 (22)	47	53.40	64 (16)	43	67.18	60 (15)	42	70
5	1996-97	50	28	56	35	23	65.71	10	8	80
	1997-98	25	15	60	5	3	60	0	0	0
	Total	75 (15)	43	57.33	40 (8)	26	65	10 (2)	8	80
6	1996-97	18	8	44.44	24	15	62.50	0	0	0
	1997-98	12	7	58.33	0	0	0	0	0	0
	Total	30 (5)	15	50	24 (4)	15	63.50	0 (0)	0	0
Grand Total		259	143	55.21	211	134	63.50	107	75	70.09

The figures in the parentheses indicate number of clutches inspection as quickly as possible in a way so as to make negligible disturbance to the birds and hatchlings. The progress and development of all the nests were followed until the last young left the nest. Binoculars (7-15 × 35 with zoom) were used whenever required. It was observed that the female partners laid the first egg within one or two days on completion of the floor and partially the rim of the nest. However, both the partners continually added nest materials to the nest until the fledglings fly out of the nest. The eggs were numbered along with the date with a marker pen soon after laying and the process was continued until the last egg was laid. Thus the clutch size for each pair was determined. The nesting trees and all the nests in each tree were also marked. The incubation phase generally extends over 23 to 24 days. Only the nests which were occupied by a nesting pair and those that were not damaged, destroyed or deserted during the laying phase were considered in the study.

The laying period was divided into three phases : early, median and late i.e. from 10th July to 9th August, 10th August to 9th September and 10th September to the date of last laying respectively. Clutch size was divided into four classes i.e. very small (clutch of 2), small (of 3), medium (of 4) and large (of 5 to 6). The ability of the hatchlings to fly across the trees away from the nests was considered to be successful fledging. This situation was usually observed at about 4 weeks after hatching.

Egg disappearance factors were identified according to the following assumptions. In case of egg predation, the predator which in most cases were crows, usually pick up the egg with the beak and fly away to a far off safe place to consume the booty. Thus no traces of egg-shells are found beneath the nest. Disappearance due to storms or rains were detected by inspection of the nests and the ground beneath for dropped eggs within 12-15 hours of the storm. Detection of dropped eggs on the ground under the nest in absence of rain or storms was taken to be due to poaching of nest materials by other birds. The unhatched eggs on the other hand are maintained and incubated in the nest for 3-8 days following hatching of all the other eggs. Those finally, however, are rejected by the parents and are dropped from the nest.

In case of death of hatchling due to starvation the dead body of the hatchling remains in the nest. Disappearance of hatchlings from the nest and absence of the carcass on the ground beneath were taken to be due to predation which as in the case of eggs was mainly done by crows. In death of hatchlings due to fall from nest fresh dead bodies of hatchlings were detected beneath the nest during routine inspection.

RESULTS

Birds of both sexes start arriving in the sanctuary from the last week of June (25th June in 1996 and 29th June in 1997). Generally, little cormorants prefer to assemble at the top branches of Jarul trees (*L. flosregnae*) which are free from nests. In about a couple of days the males try to attract the attention of the females by emitting calls and visual displays. The females on the other hand watch the males from a distance of about 1.5m and move from male to male. Ultimately a female approached very close (15cm) to a male and mate selection is completed in about 3-4 days following arrival. The pair then hops from spot to spot usually in the same tree apparently looking for a suitable nest-site. They usually select a point where the stem bifurcates or trifurcates as the nesting site. After nest site selection the nest building activity starts around the first week of July. At the outset the floor of the nest is constructed. When the rim of the cup-shaped nest is prepared at least partially, the female occupies it and start laying eggs.

Laying starts from the second week of July. The first egg was observed on 8th and 12th July in 1996 and 1997 respectively. A considerable degree of variation was observed in clutch size in the different phases of the prolonged egg laying period.

Table 1 shows that out of 65 clutches in the first phase 4.61% were very small, 30.77% were small, 33.85% of medium size and 30.77% of large size. Similarly, of the 57 clutches in the second phase and 32 of the third phase the percent distribution in the very small, small, medium and large categories were 7.02,43.86, 28.07 and 21.05 ; and 25.00,21.87,46.87 and 6.25 respectively.

Clutch size varied from 2 to 6 with a frequency distribution of 15 clutches of 2 (9.74)%, 52 clutches of 3 (33.77%), 53 clutches of 4 (34.41%), 25 clutches of 5(16.23%) and 9 clutches of 6 (5.84%). The overall mean clutch size was 3.75 ± 0.5 (n = 154). The mean clutch size

Table 2. Loss of eggs, hatchlings and fledging success at different phases of breeding season.

Phases of the Breeding Cycle	Year	No. of eggs	Egg loss					No. of hatchlings	Hatching loss				No. of fledglings
			Predation	Rain / storm	Nest material stealing	Unhatched	Total		Starvation	Predation	Fall from the nest	Total	
1st	1996-1997	168	26	13	5	17	61	107	11	4	3	18	89
	1997-1998	91	7	6	2	10	25	66	4	5	3	12	54
	Total	259	33	19	7	27	86	173	15	9	6	30	143
			(12.74)	(7.33)	(2.70)	(10.42)	(33.20)	(66.79)	(5.79)	(3.47)	(2.32)	(11.58)	(55.21)
2nd	1996-1997	159	11	11	5	15	42	117	10	4	3	17	100
	1997-1998	52	2	0	0	8	10	42	5	2	1	8	34
	Total	211	13	11	5	23	52	159	15	6	4	25	134
		(6.16)	(6.16)	(5.21)	(2.23)	(10.90)	(24.64)	(75.35)	(7.11)	(2.84)	(1.89)	(11.85)	(63.50)
3rd	1996-1997	53	2	0	1	7	10	43	3	0	2	5	38
	1997-1998	54	1	1	0	8	10	44	4	1	2	7	37
	Total	107	3	1	1	15	20	87	7	1	4	12	75
		(2.80)	(2.80)	(0.93)	(0.93)	(14.02)	(18.69)	(81.31)	(6.54)	(0.93)	(3.74)	(11.21)	(70.09)
Grand Total		577	49	31	13	65	158	419	38	15	14	67	352
			(8.49)	(5.37)	(2.25)	(11.26)	(27.38)	(72.62)	(6.58)	(2.60)	(2.43)	(11.61)	(61.00)

The figures in the parentheses indicate percentage in the first, second and in the third phase was 3.98, 3.70 and 3.02 respectively.

Out of a total of 577 eggs studied, overall fledging success increased as the laying date progressed. It was 55.21% in the first phase, 63.50% in the second and a maximum of 70.09% in the third phase. Table 1 shows that this is the general trend for all the clutch size categories except for the clutch of 2.

It was observed that both number of eggs and number of clutches declined as the laying season progressed. Number of eggs declined from 259 in the first phase to 211 in the second and 107 in the third. Similarly, number of clutches were 65, 57 and 32 in first, second and third phases respectively. The data indicates that older mature birds laid more in the first phase whereas younger first-time-breeders laid more in the subsequent phases.

Table 2 shows the main factors responsible for loss of egg, hatchling, and success of hatching and fledging. Predation accounted for maximum (12.74%) egg loss in the first phase but subsequently declined to 2.80% in the third phase. Similar declines in percent egg loss are also observed for rain / storm and nest material stealing. Percent egg loss due to failure of hatching on the other hand increased from 10.42% in the first phase to 14.02% in the third phase. On the whole 72.62% eggs hatched to viable hatchlings.

The main factors for hatchling loss are starvation, predation and fall from the nest. Out of these factors starvation was responsible for maximum loss, accounting for 6.58% on the whole. Predation and fall from the nest on the other hand accounted for 2.60 and 2.43 percent respectively. Overall 61.00% eggs mature to successful fledglings.

DISCUSSION

It is evident from the study that clutch size declines with the advancement of the season. Similar observations were made in the Little Blue heron (Rodgers, 1980), in Black-crowned Night heron (Custer *et al.*, 1983), in precocial birds (Winkler and Walters, 1983), in Great Blue heron and Great egrets (Pratt and Winkler, 1985). Early clutches, however, were less successful than later ones. Wolford and Boag (1971) and Custer *et al.* (1983) obtained identical data in Black-crowned Night herons. Mean clutch size on the other hand declined with the advancement of season. A significantly high percent (25.00%) of pairs in the third phase opted for clutches of 2. This unmistakably points out to the fact that a large proportion of the third phase breeders were young first time breeders or physiologically incapable to go for higher clutch sizes. The data supports the contention that small clutch size and prolonged parental care have evolved to avoid complete reproductive failure due to physiological and environmental stress conditions.

The most common clutch size was four and the broods of five were the most productive. In a number of bird species including Great tit, the most common clutch size is smaller than the most productive one (Klomp, 1970 ; Perrins and Moss, 1975).

It was found that number of unhatched eggs increased as the breeding season progressed while mortality due to other factors such as predation, fall due to rain / storm and fall due to stealing of nest materials decreased with season. It is already mentioned that the late layers mostly comprised of young first time breeders and less-mature birds who may actually fail to fertilise the eggs due to behavioural or physiological constraints. On the other hand predation, competition and environmental factors are at their most in the first phase of breeding than at any other time which causes increased egg loss in the first phase. Predation of eggs by crows has been reported for various bird species (Baker, 1940 ; Picozzi, 1975 ; Verbeek, 1982 ; Salathe, 1987).

Loss of hatchlings was highest due to starvation probably for two reasons : one is behavioural and the other ecological. It is a well known fact that there is intense competition among hatchlings to obtain most feedings from the parents right from the time of hatching. As a result the heavier hatchlings get more and more heavier and stronger while the lighter hatchlings get relatively more and more lighter and weaker in time and ultimately succumb to death. The ecological reason on the other hand is shortage of food material. It is seen that starvation death is highest in the second phase probably because of the fact that number of hatchlings in the second phase on the whole is highest. It may be mentioned that the hatchling period extends over a period of four weeks so that hatchlings of the first phase overlap in time with those of the second phase, similarly hatchlings of the second phase overlap with the hatchlings of the third phase. As such, it is reasonable to believe that scarcity of food materials suitable for hatchlings is more predominant in the second phase. The reason for the decline of the hatchling predation is similar to that stated for egg predation. Loss of hatchlings due to fall from the nest was found to be maximum in the third phase. This may be due to three reasons : sudden appearance of post-monsoon storms which are quite violent, breeders of the third phase are young and inefficient in nest construction and paucity of nest materials which need to be added to the nest throughout the nesting period.

Fledging success increased as the season progressed probably because of the fact that both biotic and environmental constraints decreased as also due to the fact that the nesting pairs had to attend or rear lesser number of hatchlings per pair. This was also observed in Open-bill stork (Datta and Pal, 1990)

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IV O-17. Parental Feeding Behaviour in Little Cormorant, *Phalacrocorax niger* (Vieillot) in Kulck Bird Sanctuary, Raiganj, Uttar Dinajpur, West Bengal

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Little Cormorants are one of the six avian species that inhabit the Kulick Bird Sanctuary. Parental season stars from July and continues upto January. Both parents participate in feeding of the young. Usually the parents regurgitate food materials into the mouth of the early chicks, but the grown-up ones pick up food items from the open mouth of the parents. Occasionally the parents store some food items in the nest itself for consumption of the grown-up-chicks. Parental feeding continues even after fledging usually at the spots where the fledglings venture to move. Feed composition was obtained through analysis of regurgitations of the chicks who actually vomit when disturbed. Besides feed items stored by the parents in the nest were also considered. Frequency of feeding at different hours of the day and in different stages of chick-development were analyzed. Foraging duration, frequency and area covered in relation to chick-development were also considered. The growth rate of early chicks upto seven days age in terms of body weight were also determined.

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Biodiversity in avian populations in the Raiganj Wildlife Sanctuary West Bengal, India.

CP-13

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ABSTRACT

Six migratory bird species nest and breed in the Raiganj Wildlife Sanctuary, Uttar Dinajpur, West Bengal. Their arrival time, morphological features, habitat preference, nesting date and structure, food items and population sizes were studied. The vegetation structure particularly tree species, fauna both aquatic and terrestrial species, soil composition at different spots within the sanctuary were analysed. The six species of birds successfully nest and reproduce within the sanctuary due to effective niche segregation. The situation is similar to the study site of Robert MacArthur in the Boreal Forest of New England, U.S.A. in late nineteen fifties.

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This is to certify that the paper entitled : Biodiversity in avian populations in the Raiganj Wildlife Sanctuary, West Bengal, India, read by Sri A.K. Das (A.K. Das & B.C. Pal) Department of Zoology, University of North Bengal, Darjeeling 734013, India. on Nov 10-11, 2006 in the National seminar at Raiganj University college. That he was not given any T.A. or D.A. for the above purpose. This paper has been accepted for publication in the proceedings of the said national seminar.

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9. Publications

a) Clutch size, laying date and reproductive success of Little Cormorant. Proceedings of the Zoological Society, Calcutta 56 (2) : 97 - 102, 2003.

b) Parental Feeding Behaviour in Little Cormorant, *Phalacrocorax niger* (Vieillot) in Kulik Bird Sanctuary, Raiganj, Uttar Dinajpur, W.B. (Abstract), paper presented in National Symposium on "Assessment and Management of Bioresources" May 28-30, 2003.

c) Biodiversity in avian populations in the Raiganj Wildlife Sanctuary, West Bengal, India. (Accepted).

d) Nesting in Night Heron, *Nycticorax nycticorax* (Linnaeus) at Raiganj Wildlife Sanctuary, West Bengal India. Accepted in the Journal Environment and Ecology.

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