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PARENTAL CARE AND CHICK DEVELOPMENT OF THE ASIAN OPEN-BILLED STORK (*Anastomus oscitans*) IN THE RAIGANJ WILDLIFE SANCTUARY, WEST BENGAL, INDIA

Alok Kumar Pramanik[1], Kalyan Brata Santra[2]* and Chanchal Kumar Manna[1]

[1]Endocrinology Laboratory, Department of Zoology, University of Kalyani, Kalyani-741235, West Bengal, India
[2]*Department of Biological Sciences, Jadupur Anchal High School (H.S.) Jadupur, Kamlabari-732103, Malda, West Bengal, India

ABSTRACT: The breeding behaviour of the Asian Open-billed stork, *Anastomus oscitans* was studied in the Raiganj Wildlife Sanctuary, Raiganj, Uttar Dinajpur, West Bengal, India in the year 2007 and 2008. Both male and female took part in nesting. The maximum eggs were laid by the female stork on the month of July and August of the year. Most of the eggs were laid by female at the interval of 1 to 3 days. The female stork started incubation immediately after laying the first egg. Male and female, both took part in incubation but female spent maximum time of the day to incubate the eggs. The egg hatched during day time with a crack on shell at an interval of 1 to 3 days. After the eggs hatched at first time, both brooding and incubation were simultaneously done by the parents. Feeding of nestling was done by both of the parents. The body of newly hatched nestlings were nacked and the body weight was approximately 138.6±0.018 gms. During hatching the eyes of the hatchlings were closed, opening gradually as time progressed. Within 10 days the primaries of the wing and rectrices of the tail feathers started to develop and the whole body was covered by down feathers at 21 days of age. The movement of chicks around the nest started from the age of 2 weeks. By 4 weeks the chicks were exercising their wings and they started to fly very short distance from the age of 6 weeks. The body length, wing length, beak length and leg length of 2,7, 14, 20, 30 and 45 days were measured. Parents tried to keep youngs cool by shadowing from the Sun and saved them from strom and heavy rain. The parents started to flight training after 60 days of age of the youngs, when the youngs could fly a short distance and it continued upto the age of 90 days. The breeding behavior of the Open-billed stork in the Raiganj Wildlife Sanctuary opened a new insight of diversity of nest pattern and parental care of this particular species.
Key words: Incubation, hatching, chick development, breeding behavior

*Corresponding author: Kalyan Brata Santra. Department of Biological Sciences, Jadupur Anchal High School (H.S.) Jadupur, Kamlabari-732103, Malda, West Bengal, India. kalyan_117@rediffmail.com

INTRODUCTION

The Asian Open-billed stork, *Anastomus oscitans* in the family Ciconiidae, is a resident colonial breeder in tropical southern Asia from India and Sri Lanka east to Southeast Asia. They breed near water bodies [2, 22]. High breeding densities are found near rivers, with regular flooded grass land [16, 21]. Ciconiforms generally forage in relatively shallow water [47], they synchronize their nesting with the draining stage of seasonal wetlands [9] to warrant food supply during the period of reproduction [20]. Raiganj Wildlife Sanctuary is a very important heronry of the Asian Open bills, that supports 32-40 per cent of the existing population of Asian Open bills of South Asia. Every year large number of this bird species come in the sanctuary only for breeding purpose. After just coming to this breeding area, storks show some activities such as aerial display, pair formation, allopreening, copulation, nest site selection, nest building, egg laying, incubation, hatching, parental care, nestlings growth patterns and antagonistic behaviour .

Avian species differ markedly in the extent to which males contribute to prehatching and posthatching parental care. Storks show an altricial type of development [48] with hatchlings unable to thermoregulate or locomote, depending completely on their parents for food and shelter, and staying in an open nest throughout 60-90 days of growth and development [44, 50].

Evidence from observational studies generally shows that larger families are dominant which leads to better access to high quality feeding areas and that growth and condition is enhanced, while no negative effects on adult survival or future reproduction are found [45, 52, 28, 31]. Among emperor goose (*Chen canagicus*) females those with larger families had higher survival than those with small families [41]. Both parents and juveniles gain benefits from large families and long family association on the wintering grounds [12, 13].

The natural history and morphology of Open-billed stork is well known [24, 25, 11, 8, 10, 1, and 46]. Very few research works on the breeding biology of the Open-billed stork exist [33, 14, and 17] in India. For scientific management of the Open-billed stork population and their conservation, it is imperative to study breeding ecology, survival and mortality and factors that influence their breeding success.

As there is some lacuna in the breeding behavior and reproductive performance of Open-billed stork, this study will highlight various aspects of breeding behavior of this particular species in the Raiganj Wildlife Sanctuary from arrival time of adult birds to fledgling activities. This paper describes some detailed information on nest building, egg laying, egg morphometry, incubation , hatching, parental care and nestlings growth patterns of Asian Open-billed stork in the Raiganj Wildlife Sanctuary, Raiganj, Uttar Dinajpur, West Bengal , India.

MATERIALS AND METHODS

This study was conducted in the Raiganj Wildlife Sanctuary, Raiganj, Uttar Dinajpur, West Bengal, India for two breeding seasons, 2007 and 2008. The observations were made at daytime (06.00 – 18.00 hrs). Daytime was divided into three periods namely morning (06.00 – 10.00), midday (10.00 – 14.00) and afternoon (14.00–18.00). The area was visited twice a week during breeding season. The observations were carried out from two 20m high tourist watch towers situated nearer to the core region, roof tops of 20m high constructed building made for museum, tourist lodge, forest office, 15m high tall trees in the core region and a boat. The observations were made from a distance of 1m to 20m and the data were recorded. The observations also were done from ground under the nesting trees. In all cases data were recorded only the normal behavior of storks. Fieldwork was conducted in two colonies one is the core region and other in the buffer region, comprising an average of 500 individuals, 250 breeding pairs, 250 nests, 700 eggs and 250 chicks in one breeding season. The nests of Open-billed stork were observed on 599 trees in 2007 and 615 trees in 2008 out of 645 trees belonging to 29 species.

All samples were collected and preserved in 4% formalin and photographs were taken by Kodak easy share digital camera (C713). ll types of activities like aerial display, pair formation, copulation, nest building, egg laying, incubation, hatching, parental care, antagonistic behaviour of the Open-billed stork were recorded using 10 x 50 binocular, 30x telescope,. stopwatch, pan-balance (0 – 2000g), spring balance (5 – 100g), slide calipers, steel scale (graduated up to 1mm), wooden scale (graduated up to 1mm), plastic scale (graduated up to 1mm), tape scale (1 – 150cm) and meter tape (1cm – 50 m) and relevant photographs were taken by Kodak easy share digital camera (C713).

Some of the behavioural activities were recorded with a movie camera for analysis later on. Observational data were recorded in the tally sheets prepared separately for different breeding activities and a separate note book was also maintained for special activities of breeding birds which were analysed in details after field work.

The freshly laid eggs were numbered with a marker pen and measured the length and width of each egg with calipers and weighed to the nearest 0.5 g in a plastic bag with a spring balance and care was taken to avoid excessive disturbance, which might have attracted predators. Clutches were inspected on alternate days. The number of eggs of a clutch was recorded only in completed clutches and only those nests which completed laying were taken.

Mean egg size was calculated by clutch size. Breeding success and productivity were determined as the number of fledglings per nest. Breeding time and nest occupation were monitored to record the dates of egg laying, to monitor the number of hatchings and to count the number of fledglings [19, 40].

The incubation period was determined from the first egg laid till the first egg hatched. The hatching success and fledgling success of Open- billed storks were calculated by a method [6].

Age of nestlings was determined from marked individuals. Growth changes in the Open -billed stork nestlings were measured from hatching and the method of Pettingil [43] was employed for measuring nestlings. All the nests were visited every three days for taking morphometric measurements of the body parts and the body weight of the nestlings. Disturbances were minimized by handling the nestlings very carefully during measurements.

All the nestlings were allotted individual identification marks. Totally 250 measurements in each year were made. Nest attendance and food provisioning to the chicks was invested in both the core and buffer regions of the sanctuary. Emphasis was given to two distinct periods, one is when the chicks were brooded by the parents and another is when they were left unattended in the nest. Data were collected by direct observation mostly with 'Continuous Sampling' procedure [3].

Training for flight to the grown up Open-billed stork was observed with the binocular. Fledglings were identified by their beak size and beak colour during flying in the sky with their parents.

Data of all the parameters were calculated with the help of Windows spread sheet programme Excel – 2007. All the values are provided with the mean ± standard error of the mean.

RESULTS

Incubation

The female stork started incubating immediately after laying the first egg (Figure 1). The bird incubated the eggs by moving themselves with minimum 14.00±0.052 minutes (number of observation=200) interval. The incubating bird changed their position (head and whole body) by moving at different angles. They changed the position minimum 03.60±0.035 times per day per bird (number of observation =200) during incubation was observed. Male and female both took part in incubation. The incubation period varied from 25.1±0.100 to 27.2±0.107 days depending upon clutch size (Table -1). Female spent maximum time of the day to incubate the eggs. But male brought nesting materials for nest repairing and collected food for female during incubation period. The incubating bird stood for arrangement the supplied nesting materials by the partner and then rotated the eggs by their bill (Figure 2) and again started incubation. During incubation 03.76±0.030 (number of observation =200) times water sprinkling on eggs by parent was seen in scorching sunny day. Flapping and shading by feathers of parents were also observed to bring down temperature of clutch in high temperature days (Figure 3). The earliest time for relief from incubation was recorded at 9.10 hrs and the latest at 17.25 hrs. The maximum frequency of nest relief was recorded during the midday hours between 10.45 hrs to 12.15 hrs. During incubation period male stork took relief 346.25±1.626 (number of observation =200) minutes and female took relief 184.70±1.166 (number of observation =200) minutes at the day time (06.00-18.00 hrs).

Table-1: Incubation period in relation to clutch size of Open-billed stork in the Raiganj Wildlife Sanctuary.

Clutch size	Number of observations	Incubation period (days)
2	50	25.1±0.100*
3	50	25.7±0.065
4	50	26.4±0.070
5	50	27.2±0.107

*Mean±SE

Hatching and fledging success

The eggs hatched during daytime with a crack on shell and the chicks comes out from the egg (Figure 4). It was observed that most of the eggs were hatched at 1 to 3 days interval (Figure 5). Hatching started from second week of the month of July and the last hatching observed on the second week of the month of October of the year. The peak time of egg hatching was noticed during the month of August and September of the year.

Out of 700 eggs examined for the purpose, 642 and 664 hatched; hatching success was 91.71% and 94.86 % in 2007 and 2008 respectively. Of the remaining eggs, 30 eggs and 15 eggs were damaged by predation, strom and heavy rain in 2007 and 2008 respectively. 28 eggs and 21 eggs remained unhatched in 2007 and 2008 respectively. From the 642 and 664 hatched eggs, 539 and 584 nestlings were successfully flown out the nest and making the fledging success of 83.96% and 87.95 % in 2007 and 2008 respectively. The hatching and fledging success was higher in small clutch size containing nests and lower in big clutch size containing nest was observed in the sanctuary (Table – 2). Nesting place was also affect hatching success. The high percentage of hatching success was noticed in core region (96.29 % in 2007 and 96.86 % in 2008) than in buffer region (87.14 % in 2007 and 92.86 % in 2008) of the sanctuary (Table –3). The fledging success was 87.83 % in core region and 79.67 % in buffer region in 2007 and which increased as 90.56 % in core region and 85.23 % in buffer region in 2008 of the Raiganj Wildlife Sanctuary.

Table-2: Hatching success according to clutch size of Open-billed stork in the Raiganj Wildlife Sanctuary in 2007 and 2008.

Clutch size	Number of observations		Unhatched eggs		Damaged eggs		Hatched		Dead nestlings		Fledgings	
	Nests	Eggs	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
2	50	100	02	01	03	01	95 (95.00 %)	98 (98.00 %)	05	04	90 (94.74 %)	94 (95.92 %)
3	50	150	05	03	07	03	138(92.00 %)	144 (96.00 %)	12	09	126 (91.30 %)	135(93.75 %)
4	50	200	06	06	08	04	186(93.00 %)	190 (95.00 %)	34	27	152 (81.72 %)	163(85.79 %)
5	50	250	15	11	12	07	223(89.20 %)	232 (92.80 %)	52	40	171 (76.68 %)	192(82.76 %)
Total	200	700	28	21	30	15	64 (91.71 %)	664 (94.86 %)	103	80	539 (83.96%)	584(87.95 %)

Table-3: Hatching success according to nesting place of Open-billed stork in the Raiganj Wildlife Sanctuary in 2007 and 2008.

Nesting place	Number of observations		Unhatched eggs		Damaged eggs		Hatched		Dead nestlings		Fledgings	
	Nests	Eggs	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
Core region	100	350	10	06	09	05	337(96.29%)	339 (96.86 %)	41	32	296(87.83 %)	307(90.56 %)
Buffer region	100	350	18	15	21	10	305(87.14%)	325 (92.86 %)	62	48	243(79.67 %)	277(85.23 %)
Total	200	700	28	21	30	15	642(91.71%)	664 (94.86 %)	103	80	539(83.96 %)	584(87.95 %)

Brooding and nest attendance

After the first of the eggs hatched, both brooding and incubation were simultaneously done by parent. The shell and other materials were cleaned from the nest by both the parent. Except feeding time constant brooding was noticed by parent up to the age of one week of the nestling. The amount of time that the nests were under parental supervision was negatively correlated with the chicks age (Table – 4). Up to the age of 4 weeks the nestling was almost constantly accompanied by one of the parents. At the age of 6 weeks, the nestlings remained unattended for small periods of time up to 17.6±0.282 minutes. However when 8 weeks old nestling remained without parent for long periods of time up to 74.62±1.809 minutes. At the age of 10 weeks of nestlings, no parental supervision for significant longer periods (141.52±4.147 minutes) were noticed. After the age of 10 weeks the chicks were left alone in the nest throughout the morning and midday hours until their parents returned from foraging (Figure 7). At night the female brooded continuously and the male sat on the branch beside the nest. Continuous attendance at the nest by parent birds during the first two months of the chick's life was probably to protect it from extreme sunlight, rain and predators (Figure 6).

Table-4: Nest attendance by Open-billed stork in relation to the chick's age during day time.

Age of chick (weeks)	No. of nest observations	Chick alone at nest (min.)
4	250	No
6	250	17.6±0.282* (10 – 25)**
8	250	74.62±1.809 (30 – 120)
10	250	141.52±4.147 (45 – 250)
12	250	Alone

* Mean±SE **Range

Food Provision

Feeding of nestlings was done by both the parents during rearing stage of youngs. The parent regurgitated the food onto the nest base and the nestlings picked it up from there. Such regurgitated food was the only food provided for nestlings after hatching (Figure 8,9). The parent gave soft body of small bellamya as food for 1 to 3 weeks aged chicks. 4.3±0.029 times food was delivered for 1 week aged chicks by the parent was recorded during observation. The observations of feeding took place early in the morning at about 7.30hrs, later 10.00 hrs. , 12 .00 hrs., 14.30 hrs. and 16.30 hrs. (N = 250 Chicks). The nestlings took food either directly from the parent beak during the parent regurgitated the food or from the regurgitated food onto the nest base (Figure 10,11, 12).

In a similar way, the nestlings received water from the parent beak 2 to 3 times in a day. Parents carried water in their throats back to the nest to dribble over the young. The nestlings swallowed some of this water but most of it evaporated from their heads and bodies. 2 days old chicks took 8.3±0.070 gms soft body of small bellamya in a meal and 21.9±0.140 gms of food in a meal was received by 7 days aged chcks. The amount of food that the nestlings received during 14 days of age was 45.4±0.193 gms soft body of small bellamya in a meal. 2 to 4 weeks aged chicks took food 3 to 4 times in a day from their parents at 8.00 hrs., 10.30 hrs. 13.00 hrs. and 16.00 hrs respectively (Table-5). The soft body of large bellamya was delivered to the nest by parents for 21 days old chick was 62.7±0.102 gms of food per meal. 102.8±0.297 gms of food per meal was served for 30 days aged chicks. In relation to nest attendance the average minimum time lag between two successive feedings when the chick was constantly accompanied by one parent was 20 minutes. However this time was greater, i.e. 240 to 270 minutes when the chicks were left alone in the nest and both parents were able to search for food.

Table-5: Food delivered by Open-billed stork in relation to the chick's age at day time.

Age of chick (days)	Number of observations	Times of food delivered /day	Amount of food delivered /meal (gm.)
2	250	4.5±0.032*	8.3±0.070
7	250	4.3±0.029	21.9±0.140
14	250	3.6±0.031	45.4±0.193
21	250	3.45±0.031	62.7±0.102
30	250	3.25±0.027	102.8±0.297
45	250	2.7±0.029	142.7±0.098

*Mean±SE

Figure1. The Open-billed stork incubated eggs on the nest.
Figure 2. The Open-billed stork rotated eggs on the nest during incubation period.
Figure 3. The Open-billed stork shaded eggs from the sun during the incubation period by spreading both the wings.
Figure 4. The chick waiting for coming out from the egg shell.
Figure 5. The newly hatched nestling on the nest.
Figure 6. The Open-billed storks brooded their chicks on the nest in the rainy seasson .
Figure 7. Young Open-billed storks remained alone on the nest without their parent for a long time.
Figure 8. The chicks of stork begged food from the parent.
Figure 9. The stork regurgitating food to the young.

The parent gave soft body of pila as food for 45 days old youngs at about 10.30 hrs. 13.00 hrs. and 16.30 hrs. 45 days old young's received 142.7±0.098 gms soft body of large pila per meal from their parent for 2.7±0.029 times in a day. Food provisioning by the parent was observed upto the age of 12 weeks of youngs. The young chicks begged in the nest with wings spread slightly and nodding their heads up and down while uttering a braying sound. The begging cry gets deeper and lower as the chicks grow older. Chicks begged as long as a parent was near the nest even if they had been well fed.

The daily pattern of food provisioning to the chick demonstrated three peaks namely between 10.00 – 11.00 hrs (25% of the cases), 12.00 – 13.00 hrs. (15 % of the cases) and 16.00 – 17.00 hrs (20% of the cases). The earliest observation was recorded at 7.00 hrs and the latest one at 16.55 hrs.

Figure 10. The stork arrived on the nest after collecting food for the young's.
Figure 11. The young chicks are taking food directly from the parent beak.
Figure 12. The stork spreaded wings to avoid disturbances during feeding of youngs .
Figure 13. 1- day old chick of Open-billed stork.
Figure 14. 7- days old chicks of Open-billed stork.
Figure 15. 14-days old chicks of Open-billed stork.
Figure 16. 21- days old chicks of Open-billed stork.
Figure 17. 30- days old chicks of Open-billed stork.
Figure 18. The stork protecting chicks from the sun by spreading both wings.

Development of Chicks

Development of young's started after hatching of the eggs (Table-6). The body of newly hatched nestlings were naked and weight was approx.138.6±0.018 gms .During hatching the eyes of the hatchlings were closed, opening gradually as time progressed and as they grew. The chicks sleep whole day except food taking time (Figure 13). They opened their eyes completely when the chicks were 2.6±0.031 days old (n = 250). At that time of the opening of the eyes the weight of the chicks varied from 158.13±0.299 gms. The whole body length was 11.46±0.014 cm. Wing, beak and legs length were3.71±0.008 cm, 1.44±0.006 cm and 4.69±0.007 cm respectively. At the age of 7 days the chicks (Figure 14) can not move around the nest and the weight remained 199.2±0.404 gms. Wing, beak, legs and whole body length of 7 days old chicks were 5.34±0.007 cm, 2.26±0.008 cm, 6.58±0.006 cm and15.87±0.032 cm respectively. At the age of 14 days (Figure 15) on wards the chicks were able to stand on the nest and started to move slowly around the nest.

At that age the weight remained 229.6±0.345 gms and wing, beak, legs and whole body length were 10.45±0.010 cm, 3.16±0.008 cm, 11.78±0.012 cm and 21.75±0.022 cm respectively. The movement of the chicks gradually improved day by day. Strong movement of the chicks was noticed after the age of 3rd weeks of chick. Within 10 days the primaries of the wing and the rectrices of the tail feathers started to develop and the whole body was covered by down feathers at 21 days of age. The weight of juvenile birds at 21 days (Figure 16) after hatching were 629.3±1.129 gms and wing, beak, legs, tail and whole body length were measured 15.65±0.018 cm., 4.62±0.009 cm., 19.63±0.029cm., 1.63±0.009 cm. and 30.82±0.022 cm. respectively. At the age of 4 weeks on wards the chicks were able to move around the nest freely and weight were 845.5±2.967 gms. The wing, beak, legs, tail and whole body length of 30 days old chicks (Figure 17) were 25.28±0.047 cm., 5.76±0.012 cm., 29.83±0.032 cm., 2.77±0.011 cm. and 39.16±0.028 cm. respectively. After 4 weeks of age, the chicks started wing movement strongly and then they flapped both of the wings at the standing and sitting position on the nest. They jumped up and down on the nest and flapped their growing wings with increasingly effective strokes. Then the chicks tried to glyde nearer branches around the nest and came back to the nest. At about 45 days the young could fly very short distance from one branch to another branch of the nesting tree around the nest. At that age of chicks the body weights were 1062.3±1.844 gms. Wing, beak, legs, tail and whole body length of the youngs were measured 28.33±0.041 cm., 6.93±0.023 cm., 31.07±0.030 cm., 4.72±0.013 cm. and 49.27±0.093 cm. respectively. At about 60 days the youngs could fly a short distance ranged from 75 m to 100 m. But most of the time of the day the young's remained at the nest with one of the parent or without parent and waited for food from their parent. The youngs of about 75 days were able to fly in the sky freely with their parent or without parent.

Table: 6. Development of chick of the Open-billed stork.

Age of chick(days)	No.of observations	Wing length(cm.)	Beak length(cm.)	Leg length(cm.)	Tail length(cm.)	Body length(cm.)	Body weight(gm.)
02	250	3.71± 0.008*	1.44± 0.006	4.69± 0.007	----	11.46± 0.014	158.13± 0.299
07	250	5.34± 0.007	2.26± 0.008	6.58± 0.006	----	15.87± 0.032	199.2± 0.404
14	250	10.45± 0.010	3.16± 0.008	11.78± 0.012	----	21.75± 0.022	229.6± 0.345
21	250	15.65± 0.018	4.62± 0.009	19.63± 0.029	1.63± 0.009	30.82± 0.022	629.3± 1.129
30	250	25.28± 0.047	5.76± 0.012	29.83± 0.032	2.77± 0.011	39.16± 0.028	845.5± 2.967
45	250	28.33± 0.041	6.93± 0.023	31.07± 0.030	4.72± 0.013	49.27± 0.093	1062.3± 1.844

*Mean±SE

Shadowing

To protect the nestlings from the direct sun or in bad weather conditions (heavy rain) shadowing behavior is shown by both sexes. An adult standing above the nestlings and spread their wings (even though it did not spread whole wings) were assumed to be performing shadowing behaviour. Parents tried to keep young birds cool by shading from sun (Figure 18) and saved them from strom and heavy rain.

Flight Training

The parents started to flight training after 60 days of age of the youngs, when the youngs could fly a short distance. The youngs followed the parent's flying path in the sky at about the age of 75 days. It was observed as like as the aerial display behaviour of adult storks. The young birds were identified by their black bill colour, bill size, wing span, feather colour and leg colour. During flight training many adults and youngs were observed altogether in a group.

In the first stage, the duration of flight training was 10 to15 minutes. It was extended upto 60 minutes when the youngs grown up by the age of 90 days. The youngs did not fly with their parent all time but it was noticed that they fly also with adult storks.

Feeding training

Although young birds know instinctively how to feed, they need experienced birds to show them where to feed. The parent helped their youngs to search food on the feeding areas. Young birds foraged with adults in a group on the canal side of the sanctuary, cultivated areas, kulik river bank and other feeding areas. Young birds that were deserted just before the youngs were fledged, were found searching food in inappropriate places such as dry ground.

DISCUSSION

The breeding of the Open-billed stork began in the last week of May of the year. The peak nesting period of stork was from the mid of June to last week of July of the year. In the present study, the stork built their nests on trees those were situated near to water body as well as close to human habitation and road side because they can tolerate human interference. Nest defense was noticed normally including the assurance of resource such as a nest site, food or a mate [36].

The female open-billed stork started incubating immediately after laying the first egg. Both male and female took part in incubation, [1] but female incubated most of the time. The incubating bird incubated the eggs by moving themselves with minimum 14.00±0.052 minutes interval. This bird also stood from incubating stage for arrangement the nesting materials which was supplied by the partner. They rotated the eggs by their bill when they stood or moved from the first incubating position. This behavior pattern usually occurred due to proper incubation of all eggs of the clutch. The incubation period of the stork varied from 25.1±0.100 to 27.2±0.107 days depending upon their clutch size. The length of the incubation period was 24 to 30 days was supported with Datta's [17] observations. The number of times that partners were relieved at the nest was 2 to 5 changeovers/ day. The incubation change over is related to the frequency of successful foraging [23, 38], all these variations may reflect food availability in the vicinity of the colonies and the distance of the nests from the feeding areas. This type of incubation shift was observed by Xirouchakis and Mylonas [54] in the griffon vulture (*Gyps fulvus*) on the island of Crete (Greece) . In the present study ,the incubation changeover among Open-billed stork in the sanctuary may also depend on water sprinkling on eggs in hot The number of times that partners were relieved at the nest was 2 to 5 days and required further nesting materials.

The eggs are hatched during day time with a crack on shell at an interval of 1 to 3 days. Similar hatching interval was observed in little cormorant in Bangladesh by Naher et.al. [35]. The hatching success was 91.71 % in2007 and 94.86 % in 2008 in the present study, while in a previous study it was 61.35% reported by Datta [17] . During the present study the incubation and hatching success was found to be asynchronous. The majority of altricial bird species hatch their young asynchronously because incubation begins before the clutch is complete and eggs, therefore, hatch over a period of one or more days in approximately the order in which they were laid [6]. Wrege and Emlen and Asokan [53, 5] have recorded asynchronous hatching patterns in bee-eater species. In the present study, the hatching success was related to the number of unhatched eggs. The number of unhatched eggs was more in larger clutches than in smaller ones. The birds did not incubate properly all the eggs in big clutch size nests, because their abdomen was not so much big to proportionate the big clutch size .The hatching success was higher in core region than in buffer region in the sanctuary because the predation on eggs was more in buffer region. In the present study, the fledging success of Open-billed stork was 83.96% in 2007 and 87.95 % in 2008.These values are relatively similar which reported in Open- billed stork (81.4%) by Datta [17]. This shows that lower clutch size for Open-billed stork in the present study was compensated by relatively high fledging success, thereby ensuring overall reproductive success of this species. The fledging success was high in the core region than in the buffer region of the sanctuary. The nestlings were died mainly due to heavy rain, strom, fall down from nest during first flight, predation by crow, varanus etc. and human disturbances.

After first of the eggs hatched, both brooding and incubation were simultaneously done by the parents. Brooding continued until the development of primaries and secondaries. After 7 days of chick's age, when the feathers developed densely, the brooding was discontinued. Naher et.al. [35] observed that the brooding was continued for 7^{th} to 10^{th} day of chick's age in Little Cormorant in Bangladesh. At night the female brooded continuously and male sat on the branch beside the nest. The nestling was almost constantly accompanied by one of the parents up to the age of four weeks. The purpose of the continuous attendance at the nest by parent birds during the first one month of the chick's life is probably to protect it from inclement weather (mainly rain and sunlight) and predators. This type of nest attendance was observed by Xirouchakis and Mylonas [54] in the Griffon Vulture in Crete (Greece). After the age of 10 weeks the chicks were left alone in the nest throughout the morning and midday hours as both parents devoted more time to food searching. This behaviour might correspond to the greater food demands of the chicks [27] or it could simply reflect the greatest distance between the nests and the foraging areas. Open nests on the tree, which were completely exposed to dorsally feathered [34].

Feeding of nestling was done by both the parents during rearing stage of youngs. The chicks were born helpless but a well-developed digestive system allowed them to consume enormous quantities of food. By three days old, chicks could visually locate and took food on the nest floor.

The regurgitated food of the parent was the only food provided for nestlings after hatching. The parent fed their chicks early in the morning shortly after sunrise, suggesting that the food originated from the stomach and not from the crop. Mendelssohn and Leshem (1983) mentioned that the nestling receives digested food until it is at least 5 weeks old, when this is gradually replaced by food that has been stored in the crop.

The stork parent delivered 21.9±0.140 gm. of soft body of small bellamya in a meal for one week aged chicks. The food demands by the chicks increased as the chicks grow older. The 45 days old stork youngs received 142.7±0.098 gm. of soft body of large pila per meal from their parent. Datta [17] reported that an average 228.78 (±48.63) gm. of food was delivered to each brood per day by the Open bills. According to Komen [26,27] the average amount of food that a griffon nestling needs is 598.7 gm. meal /day from hatching to fledging. In the present study, the food consumption by the stork chicks started to increase at the age of 4 weeks for their rapid growth. As the chicks became older, the number of feedings decreased but the amount in each feeding increased. The amount of food delivery was elevated when both parents were able to forage on the same day. This type of observation was made by Xirouchakis and Mylonas [54] in Grifton Vulture *Gyps fulvus* on the island of Crete (Greece). In the present study, the average minimum time lag between two successive feedings increased from 20 minutes to 270 minutes in relation to nest attendance. This fact implied that parent birds were obliged to forage at greater distance from the nest because of food scarcity or gradual depletion around the colony. The variations in the parents' investment in nest attendance as well as in the rate of food provisioning to the young is related to its age [37, 15, 27]. Parent storks carried water in their throats for 2 to 3 times per day to serve water demand of chicks. Sprinkling of water on nest of Open bills was also observed by Datta [17]. Food provisioning by the parent was continued upto the age of 12 weeks of young when they abled to forage for food. Lessels and Krebs [29] reported that Bee-eaters continue to feed their young even after fledging because the capture of fast flying insects is a skill which may require time to acquire. The body of newly hatched nestlings were nacked and weight was approximately 138.6±0.018gms. During hatching the eyes of the hatchlings were closed, opening gradually as time progressed. They opened their eyes completely when the chicks were 2.6±0.031 days old. Palmer [39] described that eyes opened between 4 to 5 days of age in case of Large Cormorant. The weight of 7 days old stork chick was 199.2±0.404 gm. which increased to 1062.3±1.844 gm. at 45 days of age. However, there was no drop in the mean weight of nestlings in the last few days. Many observers [51, 30, 18] have noted a decrease in rate-of -gain in weight in several bird species. The development of the different structure of the stork nestling was not uniform throughout the nestling period. The body length, wing length, beak length and leg length of 2 days old chicks were 11.46±0.014cm., 3.71±0.008 cm., 1.44±0.006 cm. and 4.69±0.007 cm. which increased to 49.27±0.093 cm., 28.33±0.041cm., 6.93±0.023 cm. and 31.07±0.030 cm. at the age of 45 days respectively. Within 10 days the primaries of the wing and the rectrices of the tail feathers started to develop and the whole body was covered by down feathers at 21 days of age. The body length, wing length, beak length, leg length and tail length attained the maximum maturity at the time of fledging stage. The growth allomentry in the adaptive parts had been observed in several avian species [49, 4, 42, 7]. The movement of stork chicks around the nest started from the age of 2 weeks. By 4 weeks the chicks were exercising their wings and by 6 weeks they started to fly very short distance. The development of chicks was rapid in this stage. Rapid growth means hard work for the parents but also assures that this vulnerable, helpless stage was as short as possible. The fledging period was 45.3±1.904 days. The stork youngs of 75 days were able to fly in the sky freely. Variability in nestling growth might be related to limitations in food availability, weather, competition between nest mates and parental abilities. The parents stood above the nestlings and spreaded their wings or even did not spread whole wings for shadowing during bad weather. It means that parents tried to keep youngs cool by shadowing from sun and saved them from storm and heavy rain. The parents started to flight training after 60 days of age of the youngs when the youngs could fly a short distance and it was continued up to the age of 90 days. It indicated that storks performed flight training behaviour during parental care stage.Young birds foraged with their parents in a group on the canal side of the sanctuary, cultivated areas, Kulik river bank and other feeding areas for food collection. Although young birds know instinctively how to feed, they need experienced brids to show them where to feed.

The behaviour of the Asian Open-billed stork in the Raiganj Wildlife Sanctuary would greatly benefit in understanding the breeding biology of this particular bird species and this would be helpful for better management because conservation efforts need to focus on protection of different breeding stages,not only in Open-billed stork but in other bird species present in the sanctuary.

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