

Some observations on the nest site selection, nesting and other breeding behaviors of Greater adjutant stork (*Leptoptilos dubios*) in the flood plains of Kosi river in district Bhagalpur, Bihar, India

Abstract

Greater adjutant stork (*Leptoptilos dubios*) is the largest and rarest stork belonging to the order Ciconiformes. It is one of the threatened bird species of the world and widely considered to be endangered. The present investigation was carried out to study the nest site selection, nest tree and other breeding behaviours of Greater adjutant stork on the flood plains of Kosi river in district Bhagalpur, Bihar, India in three breeding seasons from 2019 to 2021. Total 12 breeding colonies of Greater adjutant stork were recorded in 2019, 10 in 2020 and 2021 respectively. During these periods, 277 chicks were reared in 123 nests in 2019, 282 chicks in 126 nests in 2020 and 236 chicks in 105 nests in 2021 respectively. Most of the nest trees were located on the road side in and around the villages. Storks mainly selected Kadamb, Peepal, Pakar, Gamhar and Semel trees for the nest building but the Kadamb was the most preferred tree species. Nesting materials used by the GAS were mainly sticks, twigs and fresh leaves of Pigeon wood, Jalebia, Dhaincha, Jamun, Peepal, Gulmohar, Kadamb, and Semal tree. Nests were large spherical structure made of plant sticks mostly on the top of the tree and on the tip of large horizontal branches. Both the sexes alternately shared incubation and protection of the chicks after hatching. The parent birds also collected green leaves from nearby trees for cushioning the nest. The breeding season of Greater adjutant stork was recorded between September to April in Bihar. The incubation period was ranging between 37 to 39 days. Two to three chicks on one nest were common. The adult and juveniles finally vacated the nest before third week of April.

Key words : Greater adjutant stork, nest tree, nest site, breeding, Kosi flood plain.

Introduction

Stork is a group of large wetland bird belonging to order Ciconiformes [1,2]. There are 19 species of storks found worldwide, of which 15 are regionally threatened and tropical Asia and Africa have the largest concentrations of stork [3,4]. Out of 19 species of storks, eight species have been reported from India [2,5,6,4].

The Greater adjutant stork (GAS) is one of the most threatened stork species of the world and is widely considered to be the endangered [7,8,9]. The GAS is locally known as Hargila (in Assam and West Bengal) and Bara Garur or Dhenk or Ghagawala Garur in different parts of Biha [6,4,10]. GAS is named as adjutant because of its amazing military gait up and walking style [11]. Being carnivorous it occupies the top position in the food chain , plays significant role in wetland ecosystem [12,11,9]). This endangered stork appear as global stronghold species [13] confined only in some pockets in Assam [14,15,16,17,9] and in Bihar [12,18,19,20,6] and few in South East Asian countries [21,22].

At the beginning of the 20th century the GAS was distributed in large numbers in South and South East Asia from Pakistan through Northern India, Nepal, Myanmar, Bangladesh, Vietnam, Laos and Combodia [12,6,4] but declined dramatically during first half of the 20th century [7]. The sharp decline is due to the effect of pollutants and the continuous reduction in the availability of nesting and the quality of feeding sites [23, 4] in the recent past other than Assam in India.

There are few recent reports available about the occurrence of GAS from different parts of Bihar i.e from Vikramshila Gangetic Dolphin Sanctuary (VGDS) , Bhagalpur [20] and from the wetlands of Katihar and Khagaria districts [19] but the best count of 53 individuals recorded along with 57 painted storks from the island of river Ganga near Sultanganj, Bihar in May 2006 [24]. Before 2006, it was known to breed only in Assam (India) and Combodia [12,25,26] after that the GAS was also reported to be breeding in Bihar, India and a small breeding population was reported from the flood plains of river Kosi and Ganga [6,4]. Presently the population of GAS appears to be increasing in Kosi - kadwa flood plains in district Bhagalpur, Bihar [10].

Factors which are supporting the breeding success of birds are mainly the location of nesting site, nest tree species, tree height, canopy spread as well as source of food and water [27,28,29].

In the present investigation the nest site selection and nesting behaviour of GAS was studied in different breeding colonies located at the floodplains of river Kosi in district Bhagalpur, Bihar, in three breeding seasons from 2019 to 2021. During this investigation attempt was also made to study the nesting materials and other parameters related to nest building.

Materials and Methods

1. Study Area

The study area is a part of flood plain of river Kosi located in Kadwa panchayat under Naugachia block in district Bhagalpur, Bihar. This flood plain is locally known as Kosi - Kadwa

floodplain or Kadwa Diyara (Map 1). There are some small villages and tolas situated in Kadwa floodplains which are important roosting and breeding ground for Lesser and Greater adjutant storks [6].

Geographically these villages are situated in flood prone area and remain flooded during initial breeding season . This area is roughly surrounded on three sides by Kosi river and its tributaries . Besides, many wetlands are also present in the adjoining areas which provide suitable foraging ground for these storks and other resident and migratory birds too [10]. The river Ganges is flowing at about 15 kms south to Kadwa attracting this nesting birds and their juveniles for foraging . Kadwa is about 35 kms north from Bhagalpur district head quarter and is located near Bhagalpur – Madhepura highway [30]

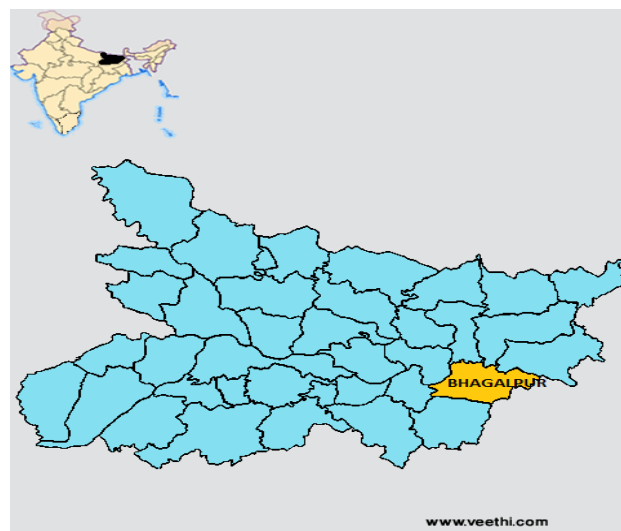


Fig 1 : Showing the geographical location of district Bhagalpur in Bihar, India.



Fig 2 : Showing the location of potential breeding sites (1 – 12 with red star mark) of GAS on the flood plains of river Kosi (Kosi – Kadwa flood plains) in district Bhagalpur, Bihar.

Flora of this region mainly consists of large trees like peepal (*Ficus religiosa*), Pakar (*Ficus virens*) Banyan (*Ficus bengalensis*), Semal (*Salmelia malaberrica*), Kadamb (*Anthocephalus cadamba*), Gamhar (*Gmelina arborea*), Neem (*Azadirachta indica*), Mango (*Mangifera indica*), Pigeon wood (*Trema orientalis*), Jamun (*Syzygium cumini*) and Bamboo (*Bambusa tulda*) species are in plenty. Main crop of this flood plain is paddy (*Oryza sativa*), Wheat (*Triticum aestivum*), Maize (*Zea mays*) and Mustard (*Brassica nigra*).

In summer the temperature varies between 25°C to 42°C while in winter, temperature ranges between 8°C to 18°C. Annual rainfall is recorded as 1130 mm approx [30]. Due to frequent occurrence and breeding of these storks at Kosi – Kadwa flood plain, this region has been selected for present investigation.

2. Methodology

Nesting habitat, nesting trees, nesting records and nest building behaviours of Greater adjutant stork (GAS) were studied at different villages of Kosi – Kadwa flood plain continuously in three breeding seasons between September, 2018 to April, 2021. Regular surveys were conducted to locate the nesting and breeding sites. Regular monitoring was done to study the nesting trees, collection of nesting materials and other activities related to nest building and breeding.

Monitoring of breeding of storks in these sites was done by us separately or sometimes together. We were more vigilant during their breeding season particularly from September to April. We visited the site once in a week but during breeding season we spent 5-6 hours from morning to evening every 2-3 days in a week. Observational recordings were done using data sheets. All observations were recorded visually from a closer distance without disturbing the birds. Sometimes binoculars (NIKON 8x42) were also used to record the activities. Observations were conducted on foot from the village street and from the roof of nearby houses and school building following the method adopted by Choudhary *et al* [10,30]. Main observations were listed accordingly. Observation points were partly screened by vegetation to avoid disturbing birds on

the nest. Nest site characteristics were recorded during the nonbreeding period to avoid disturbing the breeding birds. The number and location of nests, tree species, nest height, nest diameter, distance of nest site from main pitch road, river and wetland were also recorded (Table 1 & 2). The land use within 500 meter radius was also assessed. Distance to the nearest road and house and altitude were measured subsequently from maps. Description of old nest trees and sites were also made. Chicks deemed to be present when adult brought food to the nest.

. Data were collected. Maps and tables were prepared accordingly. Photographic and video records were also taken on the spots for evidence by using Camera (Nikon D-5600 with 70-300 mm lens). Original Photographs of different stages of breeding were arranged for evidential support.

Results

During our regular survey, we recorded 12 breeding colonies of Greater adjutant stork (GAS) in 2019, 10 in 2020 and 2021, respectively in three breeding seasons from September, 2018 to April, 2021 (Table 1 & Fig 3). These breeding colonies were distributed in different tolas and villages of Kosi – Kadwa flood plain in district Bhagalpur, Bihar, India. These breeding sites were Pratapnagar, Bagri tola, Bharosasingh tola, Kasimpur, Kartiknagar, Lachminia tola, Lukmanpur, Thakurji Kachhari tola, Ganganagar, Khairpur Middle school, Ashram tola and Bharwa tola located beside the Kosi river and Bhagalpur – Madhepura Highway (Table 1 & 2). In total 277 chicks were raised from 123 nests in 2019, 282 chicks from 126 nests in 2020 and 236 chicks from 105 nests in 2021 respectively (Table – 1 & Fig 4).

Table 1. : Showing distribution and number of nests and chicks raised by GAS in different breeding locations (villages) of Kosi - Kadwa flood plains during three breeding seasons (2019 – 2021).

S.N .	Name of Nesting villages (Breeding sites)	Breeding Year 2019		Breeding year 2020		Breeding year 2021		Nesting Tree
		No of Nests	No of chicks	No of Nests	No of chicks	No of Nests	No of chicks	

1.	Pratapnagar	03	07	06	11	06	14	Semal, kadamb
2.	Bagri tola	20	47	23	56	22	47	Semal, Kadamb
3.	Kartiknagar	11	25	12	27	06	14	Kadamb
4.	Bharosa singh tola	11	26	12	26	08	18	Kadamb
5.	Thakurji Kachhari tola	07	16	06	15	06	13	Kadamb
6	Kasimpur	18	40	19	41	16	37	Kadamb, Peepal
7.	Ganganagar	18	39	22	48	21	49	Kadamb, Gamhar
8.	Khairpur Mid School	11	25	09	19	06	14	Peepal
9.	Ashram tola	15	33	12	2 7	09	21	Kadamb, peepal, pakar
10	Lachminia tola	07	15	05	1 2	05	09	Kadamb Peepal
11	Barwa tola	01	02	00	00	00	00	Kadamb
12	Lukmanpur	01	02	00	00	00	00	kadamb
	Total	123	277	126	282	105	236	

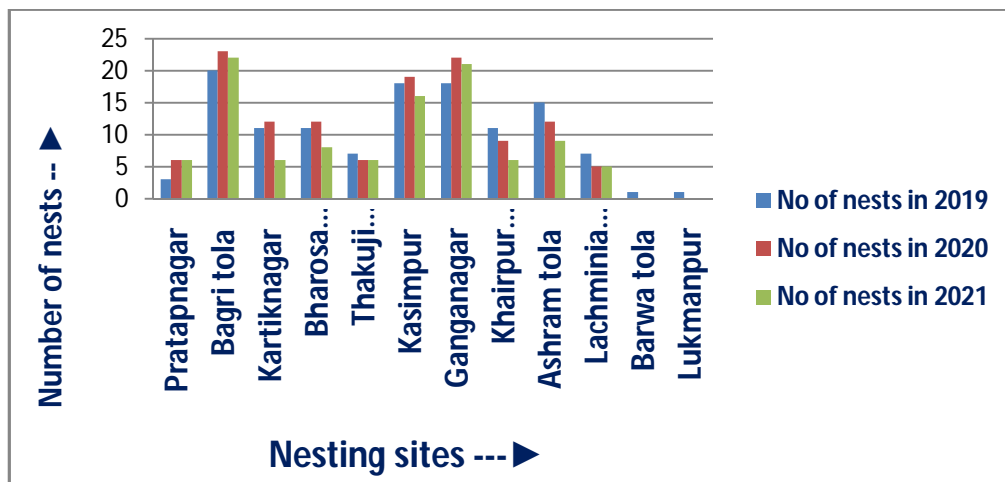


Fig 3 : showing the number of nests built at different nesting sites (villages) in three breeding seasons from 2019 to 2021

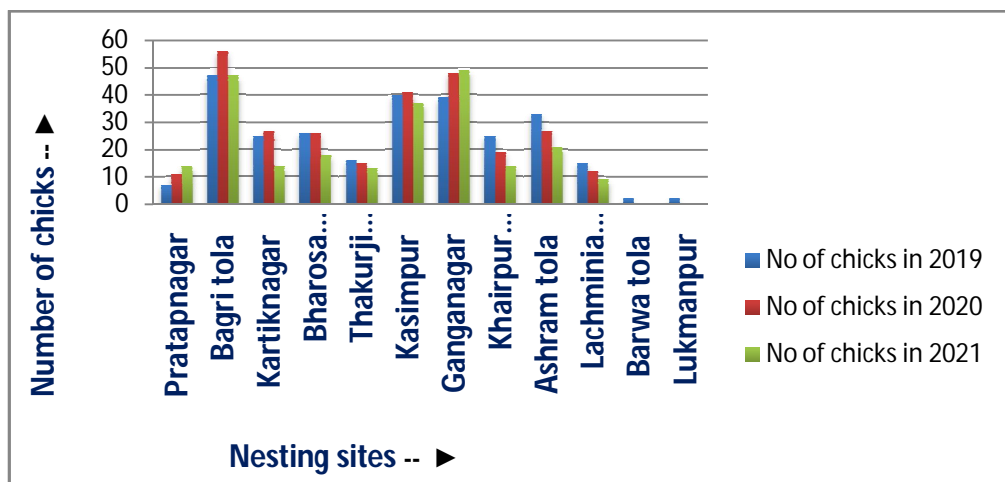


Fig 4 : showing the number of chicks raised at different nesting sites in three

i. Selection and location of nesting site :

Breeding colonies were distributed within 8 sq km area. Most of the nest trees were located on the road side in and around the villages. Few nest trees were recorded within the premises of houses. Most of the nests were located 400 to 800 meters away from the main pitch road (Bhagalpur – Madhepura road) crossing through Kadwa flood plain (Table 2).

During nonbreeding season the birds collect their food (mainly fishes, crabs, molluscs and animal carcasses) from the bank of river Ganga and its small water logged wetlands formed in and around it. These feeding regions become waterlogged in rainy season. During these days birds collect their food (mainly fishes, molluscs, snakes and rats) from the river Kosi , its tributaries and cultivated lands located on the Kosi flood plain. At that time river Kosi, its tributaries and nearby wetlands were the main source of food and water for them and storks were seen foraging in most of these wetlands.

Table 2. : Distance of different nesting sites(breeding locations) from the river Kosi and main pitch road .

S.N.	Name of breeding villages	Geographical Coordinates	Distance from main pitch road In mtrs.	Distance from river Kosi in mtrs.
1.	Pratapnagar	25 ⁰ 5' 40" NL & 87 ⁰ 3' 16" EL	600	300
2.	Bagri tola	25 ⁰ 5' 42" NL & 87 ⁰ 3' 14" EL	800	200
3.	Kartiknagar	25 ⁰ 26' 51" NL & 87 ⁰ 1' 44" EL	700	300
4.	Bharosa sing tola	25 ⁰ 27' 03" NL & 87 ⁰ 2' 33" EL	750	200
5.	Thakuji kachhari tola	25 ⁰ 25' 09" NL & 87 ⁰ 2' 28" EL	800	250
6.	Kasimpur	25 ⁰ 28' 09" NL & 87 ⁰ 3' 02" EL	550	300
7.	Ganganagar	25 ⁰ 28' 10" NL & 87 ⁰ 03' 21" EL	450	400
8.	Khairpur Middle school	25 ⁰ 5' 46" NL & 87 ⁰ 3' 17" EL	00	600
9.	Ashram tola	25 ⁰ 21' 27" NL & 87 ⁰ 3' 22" EL	500	700

10	Lachminia tola	25 ⁰ 27' 20" NL & 87 3' 59" EL	700	800
11	Bharwa tola	25 ⁰ 38 70" NL & 87 ⁰ 9' 85" EL	600	700
12	Likmanpur	25 ⁰ 5 47" NL & 87 ⁰ 3' 19" EL	650	200

These wetlands were located 200 to 1300 meters away from these nesting sites (Table 2). The nearest houses to nests ranged from 10 meters to 200 meters in distance. Only 3 – 5 nests were recorded every year (from 2019 – 2021) in the isolated areas about 400 meters away from Ashramtola village and about 500 meters from the main pitch road. Nest trees were mainly surrounded by gardens, cultivated lands and grazing areas.

ii. Nest Trees : Greater adjutant stork (GAS) mainly selected Kadamb (*Anthocephalus cadamba*), Pakar (*Ficus virens*), Peepal (*Ficus religiosa*), Gamhar (*Gamelina arborea*) and Semal (*Salmelia malabérica*) trees for their nest building. The Kadamb was the most preferred nest tree species (72.6 %) in this area followed by Peepal (17.2 %), Gamhar (4.6 %), Pakar (4.2 %) and 1.4 % Semal (Fig 5).

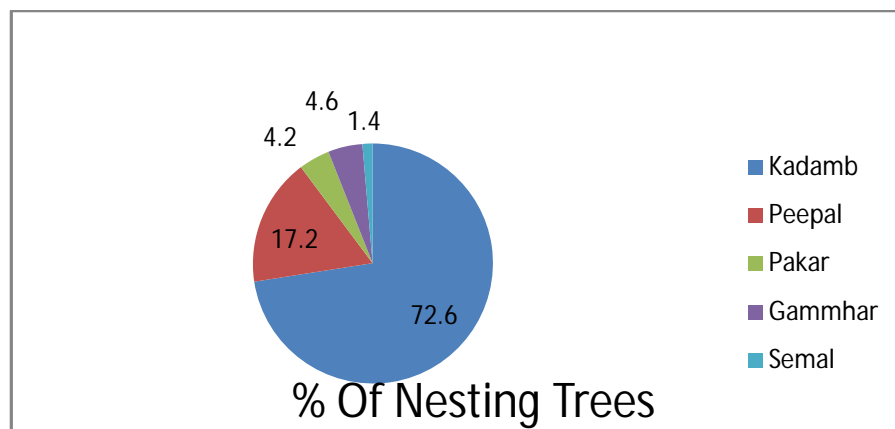


Fig 5 : Showing percentage of nesting trees selected by GAS in different nesting sites

iii. Nest and nesting materials :

Nest of GAS was large spherical structure made up of plant sticks mostly built on the top of the trees and occasionally on the tip of large horizontal branches. Nesting materials were mainly sticks, twigs and fresh leaves of Pigeon wood (*Trema orientalis*), Jalebia (*Pithecollobium dulce*), Dhaincha (*Sesbania bispinosa*), Jamun (*Syzigium cumini*), Peepal (*Ficus religiosa*), and Kadamb (*Anthocephalus cadamba*) as depicted in Fig 6. Nests were lined with leaves of Neem (*Azadirachta indica*), Peepal (*Ficus religiosa*) and Eucalyptus (*Eucalyptus teretocornis*). Nests were built at different heights ranging from 7 meters to 14 meters. Both the sexes were found indulged in collecting nesting materials one by one from nearby trees.

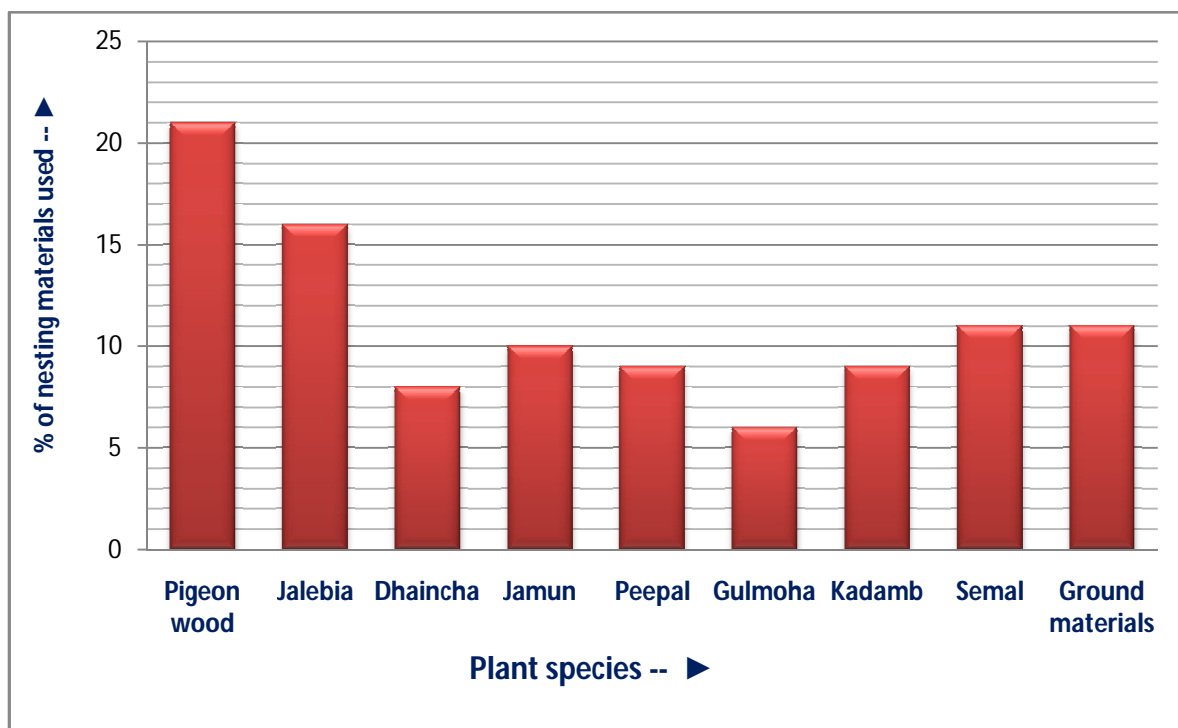


Fig 6 : Showing percentage of nesting materials collected by GAS from different plant species .

Before egg laying we recorded 123 attempts, the storks took to pluck and carry the nesting materials from nearby trees and other sources. Pigeon wood (*Trema orientalis*) is grown in large number by the villagers due to its high growth rate. Branches of this tree are easily breakable. The stork birds were frequently observed on this tree for plucking the nesting material. They carried about 21 % nesting materials from Pigeon wood , about 16 % from Jalebia (*Pithecollobium dulce*), about 07 % from Dhaincha (*Sesbania bispinosa*), 10% from Jamun (*Syzigium cumini*), 09% from Peepal (*Ficus religiosa*), 09% from Kadamb (*Anthocephalus cadamba*) 11% from Gamhar (*Gmelina arborea*) 06% from Goldmuhar (*Delonix regia*) and about 11% from Semal (*Salmelia malaberrica*) depicted in **Fig 5**. Nests were rearranged regularly by adding new and replacing old and decayed plant sticks (Photographs 7 -9). Most nests were difficult to see from the ground and were only detected when birds were present. Storks always used living plants for nest building and the nests were constructed in colonies. No successful isolated nest was observed. The late comer storks also preferred these sites and built their nests with older ones in colonies. In many of the trees nests were located very close to each other but there was no any obvious case of chasing observed among them.

Mating and Courtship behavior: First arrival of GAS was recorded at the nesting site in the last week of August. After the selection of nesting trees the breeding pair was found sitting on a particular branch for 3 – 5 days. During this period the adult birds were indulged in some kind of courtship display like preening of feathers of each other, bill touching, bill chattering with stretching head and neck upward.

Adult male was identified by observing its hanging neck pouch. The neck pouch was large and more prominent in male during breeding season. The colour of the neck pouch was also found slightly different. It looked bright orange red in colour in the breeding season while the normal colour of the neck pouch is pink in both male and female.

Mating occurred on the nest and was witnessed only during nest building in the month of September (first week to third week). It was only recorded in the pre egg laying or early stage of incubation. After mating male bird immediately left the tree for collecting nesting materials from nearby areas. The arrangement of nest with new nesting materials continued up to the first week of March. It was also observed that the nests which are built before the month of October survived well. Few nests were also built in the month of January and February but these were not successful and abandoned later on.

During the breeding period (at Incubation and early nursing stage) we could record one incidence in which one adult bird arrived at the nest to relieve the other. One bird started the display by spreading its wing and tail, the other bird also joined it and copied its partner with both shaking their wing vigorously and stretching their neck upwards. It was accompanied by a loud clapping of their bills. The whole display took about 20 to 30 seconds. This type of courtship rituals is known as “up – down display” [31].

Incubation and Clutch size :

The incubation period was recorded as of 38 days with slight variation of 2-3 days. The clutch size could not be determined due to the height and inaccessibility of active nest. But 2 to 3 chicks were very common . Parent and juveniles vacated the nests finally before third week of April and dispersed in nearby wetlands, river Kosi and Ganga for foraging.

The adult birds again start to assemble at their old breeding sites after 4 months in August - September and the breeding process goes on.

Discussion

Greater adjutant storks (GAS) were found colonial breeders and they built their nests on the large trees like Kadamb, Semal, Peepal and Banyan . These birds selected large and widely branched living trees because of their large size and large diameter of the nest and breed in colony for getting much protection from predators [32,14,15]. They were also found nesting communally with other bird species like Lesser adjutant storks [4] and Painted storks [30].

The number of nests and chicks of GAS in the Kosi- Kadwa flood plains were found higher in 2019 and 2020 thus showed an increasing trend may be due to their successful breeding and protection provided by the local villagers [9] or may be due to presence of suitable nesting trees and availability of foraging grounds near the breeding sites [4, 10].

Site selection : GAS selected different villages of Kadwa flood plains in district Bhagalpur for their nesting and mostly preferred trees which are located inside the villages where there is human habitation. Regarding the site selection GAS showed strong loyalty to their breeding sites and were found to prefer places among human habitation irrespective of anthropogenic disturbances and noise pollution [32,33,30]. Selection of nest site is often considered as an

important determinant of reproductive success in bird species and major selective factor favoring colonial nesting chiefly enhancing avoidance of predators and efficient exploitation of food resources [34]. The presence of Kosi river its tributaries and other smaller and larger wetlands in the vicinity of Kadwa flood plain (breeding site) could be crucial for the selection of these sites because it is well known that the foraging ground is also an important factor in colony site selection [36]. The other important factor affecting the nest site selection was availability of food. The nesting sites were very close to rivers (Kosi and Ganga) and wetlands providing high availability of fishes and other food items thus enhancing the chances of site selection [37].

Selection of Nesting trees : GAS usually selected Kadamb, Semal, Peepal , Pakar and Gamhar trees for their nest building purposes. But Kadamb was found the most preferred tree among them. Selection of Kadamb tree as a most preferred nesting tree in the midst of the villages was very specific and interesting may be due to sufficient space or platform present among the radiating branches of Kadamb tree [30]. According to Singha *et al* [26] about 90% of GAS nests in India were built on the top of the canopy and most nest trees are belonged to the family Murtaceae because these are the most common long trees.

Mating display : Mating was only recorded in the pre egg laying or early stages of incubation and occurred on the nest during nest building may be described as a courtship display known as copulation clattering [38,39] which involved both sexes spreading their wings and the male bill clattering.

Incubation and other tasks : Stork pairs shared the duties of incubation, feeding, nursing and guarding their chicks regularly. Adult bird returned with food and water and regurgitated them over the nest. Water was transported to the nest during the dry season may be due to increase the moisture of the nest and eggs rather than to regulate temperature [40].

Incubation period was of 37 - 39 days. According to Del Hoyu *et al* [41] , most of the stork species have an incubation period of 25 – 38 days .The nests of GAS were large platform of twigs and lined with green and delicate leaves of mainly three plants namely Neem (*Azadirachta indica*), peepal (*Ficus religiosa*) and Eucalyptus (*Eucalyptus tereticornis*)after hatching may be due to cushioning the nest [42, 43, 10]. As the leaves of Neem and Eucalyptus have insect repellant properties may be the another important reason [30].

The total number of GAS (breeding and non breeding) in this locality of Naugachiya block in district Bhagalpur, Bihar may be around 700-800 as per our regular survey , certainly a matter of great concern. The number is increasing every year in this area. This rapid increase in their number may be due to availability of plenty of food and water from the nearby Kosi river and its tributaries, suitable climates , security provided by the local villagers and presence of large nesting trees such as Peepal, Gamhar, Pakar, Semal and Kadamb [6,10,30].

Conclusion : The above investigation clearly revealed that the Greater adjutant storks are breeding successfully and their number is increasing every year in the Kosi -Kadwa flood plains in district Bhagalpur, Bihar. These are colonial breeders and they are very perfect in their site selection and mostly preferred those places for their nesting and breeding which are located near the water resources like rivers and wetlands. Kadamb was the most preferred nesting tree. Breeding season of GAS in Bihar was estimated between September to April and incubation period ranges between 37 – 39 days. They again appeared in their old breeding sites in the next breeding season. Kosi - kadwa flood plains in district Bhagalpur, Bihar have become the potential breeding ground for these endangered storks in the World.

Tolerance of villagers towards the birds and awareness created by the members of our Research team and local Mandar Nature Club of Bhagalpur for the protection and conservation of these endangered storks help in their successful breeding. Traditional beliefs of farmers combined with relatively simple awareness programs to ensure villagers retain pride can add to improve number of species that are of global conservation concern.

Photographs of Greater Adjutant Storks (GAS) showing different stages of nesting and breeding in kosi – Kadwa flood plains, Bhagalpur, Bihar.



Photo 1 – 3 : A view of nest tree and nest site selection by the adult GAS.



Photo 4 -6 : A view of mating and mating displays by both the adult GAS before egg laying.

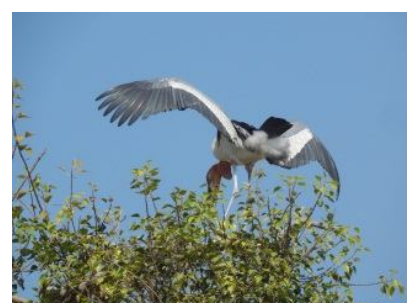


Photo 7 – 9 : A view of collection of nesting materials by adult GAS from nearby trees.



Photo 10 – 12: showing the changes in colour of feather and hanging neck pouch during breeding season (feathers became light black, white band on the wing became more prominent and neck pouch became enlarged and orange pink).



Photo 13 – 18 : A view of juvenile chicks (2 – 3) on the nest.

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